Haryana Rail Infrastructure Development Corporation Ltd

Tender No. HORC/HRIDC/C-4/2022 Date 16.01.2023

Reference: Specific Procurement Notice dated 04.11.2022.

CORRIGENDUM No. 4

Name of Work: C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system, etc. from km *24.843* to km 29.680;

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.

The E-tender No. 2022_HBC_245165_1 for the above-mentioned work was published on 07.11.2022.

Final Tender Documents is hereby issued with Corrigendum No. 4 incorporating all the modifications carried out vide Corrigendum No. 1 dated 06.12.2022 Corrigendum No. 2 dated 04.01.2023 and Corrigendum No. 3 dated 12.01.2023. Final Tender Documents issued on 16.01.2023 supersedes previously issued Tender Documents dated 07.11.2022 which was available to Tenderers for downloading from 07.11.2022.

Tenderers are advised to download Final Tender Documents issued vide Corrigendum No. 4 dated 16.01.2023 on e-procurement portal of Govt. of Haryana (https://etenders.hry.nic.in) and submit their Tenders based on the requirements of Final Tender Documents. In order to facilitate Tenderers with high quality of drawings, Section VII-8: Tender Drawings and Documents is available for downloading in Active Tender section on HRIDC website (http://www.hridc.co.in/active-tender.php). Tender drawings uploaded on HRIDC website for Package C-4 shall be deemed to form part of Final Tender Documents.

In case of any discrepancy noticed at any stage i.e. evaluation of Tenders, execution of work or final payment of the Contract, the contents of Final Tender Document shall supersede previously issued Tender Documents dated 07.11.2022 & Corrigendum No. 1, Corrigendum No.2 and Corrigendum No. 3.

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED

Specific Procurement Notice (SPN)

Procurement of Works

(e-Tendering Process Without Prequalification)

Tender No. HORC/HRIDC/C-4/2022 **Date: 04.11.2022**

Country **:** India

Employer **:** Haryana Orbital Rail Corporation Limited

Tender Inviting Authority: Haryana Rail Infrastructure Development Corporation Limited (HRIDC)

Project **:** Haryana Orbital Rail Corridor Project

Loan No 000370

Contract Title:C4- Composite Works Contract (Civil, Ballastless Track and General Electrical Services) on EPC basis

Tender Document to be Issued on: 07.11.2022

1. The Government of Haryana (GoH) has applied for financing from the **Asian Infrastructure Investment Bank (AIIB or the Bank)** towards the cost of the **Haryana Orbital Rail Corridor (HORC) Project**, and intends to apply part of the proceeds toward payments under the contract for "C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:
   (i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;
   (ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;
   (iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system, etc. from km *24.843* to km 29.680;
   (iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.

2. Haryana Rail Infrastructure Development Corporation Limited (HRIDC), an implementing agency, now invites online Tenders through e-tendering portal of Govt of Haryana from eligible Tenderers for **Package C-4** fulfilling the qualification criteria as mentioned in the Tender Document. The completion period of work is ***1460*** **days**. Tenderers are advised to refer the clauses on eligibility (Section I-ITT, Clause 4) and minimum qualification criteria (Section III – Evaluation and Qualification Criteria) given in Part 1 of Tender Document, to qualify for the participation in the Tender.

3. Tendering will be conducted through International Open Competitive Tendering (IOCT)

procedures as specified in the Bank's Procurement Instructions for Recipients (PIR) and is open to all eligible Tenderers.

4. Interested eligible Tenderers may obtain further information from the office of Chief Project Manager, HRIDC and inspect the Tender Document during office hours from 0930 to 1800 hours at the address given below:

   Chief Project Manager,
   Haryana Rail Infrastructure Development Corporation Limited,
   Plot No 143, 5th Floor, Railtel Tower,
   Sector-44, Gurugram,
   Haryana-122003
   Tel No: +91 9311478893
   Email id: horc.etendering@gmail.com

5. The Tender Document in English will be available online on e-procurement portal of Govt.of Haryana (https://etenders.hry.nic.in) from **07.11.2022 at 1700 hrs IST** till ***03.02.2023*** **at 1500 hrs. IST.** The start date of submission of tender on e-procurement portal is ***19.01.2023*** **at 1100 hrs. IST**. There is no cost of Tender Document. However, at the time of submission of Tender, the Tenderer is required to submit a non-refundable E-Service fee of **INR 1180** as indicated in the table at the end of this SPN. The method of payment of E-Service fee will be online in the e-procurement portal using the electronic payment gateway service. Tenderers will be required to register in the above website.

6. For submission of the tenders, the tenderer is required to have Digital Signature Certificate (DSC) from one of the Certifying Authorities (CAs), authorized by Government of India for issuing DSC. Tenderers can see the list of licensed CAs from the link (www.cca.gov.in). Aspiring Tenderers who have not obtained the user ID and password for participating in e-procurement in this Project, may obtain the same from the website: https://etenders.hry.nic.in.

7. Tender comprise two Parts, namely the Technical Part and the Financial (Price) Part, and both parts must be simultaneously submitted online on e-procurement portal (https://etenders.hry.nic.in) before ***03.02.2023*** **at 1500 hrs. IST**. Tender validity shall be 180 days from the last date of submission of tenders. Any tender or modifications to tender received outside e-procurement system will not be considered. The electronic tendering system would not allow any late submission of tenders. The "TECHNICAL PART" of the Tender will be opened online on ***03.02.2023*** **at 1530 hrs. IST** and this could be viewed by the Tenderers online on e-procurement Portal. The "FINANCIAL PART" shall remain in encrypted form in the e-procurement system until the opening. If the office happens to be closed on the date of opening of the tenders as specified, the tenders will be opened on the next working day at the same time and venue.

8. All Tenders must be accompanied by a Tender Security of the amount in the currency specified for the Work in the table at the end of this SPN. Tender Security can be paid online on e-procurement Portal in INR in favour of Haryana Rail Infrastructure Development Corporation Limited using the electronic payment gateway service or Tender Security can be submitted in the form of unconditional Bank Guarantee in INR or USD as per Clause ITT 19.3 of TDS. In case the Tenderer has opted for Tender security in the form of an unconditional Bank guarantee, the Tenderer should upload the scanned copy of Bank Guarantee with the Tender. The original Bank Guarantee shall be delivered either by

Registered Post / Speed Post/Courier or by hand within ten (10) days of deadline of submission of Tender at the address given below:

Chief Project Manager,
Haryana Rail Infrastructure Development Corporation Limited,
Plot No 143, 5th Floor, Railtel Tower,
Sector-44, Gurugram,
Haryana-122003

9. **Site Visit and Pre-Tender Meeting:** Site Visit will be conducted on **24.11.2022 at 1100 hrs. IST**. A **Pre-Tender Meeting** will be held on **25.11.2022 at 1100 hrs. IST** through online video conferencing as well as offline in the Conference room of HRIDC office, Plot No 143, Railtel Tower, Sector-44, Gurugram, Haryana-122003 to clarify the issues and to answer questions on any matter that may be raised at that stage as stated in ITT Clause 7.4 of 'Instructions to Tenderers' of the tender document. Tenderers are advised to download the tendering document prior to the Pre-Tender Meeting in order for Tenderers to have a good understanding of the scope of the requirements under this contract for discussion and clarification at the Pre-Tender Meeting. Last date for submission of Pre-tender queries to the Employer is **23.11.2022 by 1800 hrs. IST** after which no queries will be acknowledged. HRIDC's response to Pre-Tender queries will be uploaded on or before ***13.12.2022***.

10. Other details can be seen in the Tender Document. The Employer shall not be held liable for any delays due to system failure beyond its control. Even though the system will attempt to notify the Tenderers of any updates, the Employer shall not be liable for any information not received by the Tenderer. It is the Tenderers' responsibility to verify the HRIDC website (http://www.hridc.co.in) and e-procurement portal of Govt. of Haryana (https://etenders.hry.nic.in) for the latest information related to this Tender.

TABLE

Package No.	**Name of Work**	**Tender Security**	**Cost of Tender Document**	**E-Service fee**	**Time for Completion**
1	2	3	4	5	6
C-4	C-4: Composite Contract package in connection with New BG Railway Line of HORC project for: (i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580; (ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680; (iii) Detailed Design, Supply, Installation, Testing & Commissioning of General	**INR 10 Million** **OR** **USD 121,000**	**NIL**	**INR 1180** (Including GST)	***1460*** **days**

	Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system, etc. from km *24.843* to km 29.680; (iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.				

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Chief Project Manager,
Haryana Rail Infrastructure Development Corporation Limited
Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram, Haryana-122003

Final Tender Document for Works

(Two-Envelope Tendering Process Without Prequalification)

Procurement of:

C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system, etc. from km *24.843* to km 29.680;

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.

Tender No: HORC/HRIDC/C-4/2022
Contract title: Composite Works Contract (Civil, Ballastless Track and General Electrical Services) on EPC basis (C-4)
Project: Haryana Orbital Rail Corridor Project
Loan No.: 000370
Employer: Haryana Orbital Rail Corporation Limited
Country: INDIA
Issued on: ***16.01.2023***

Summary

Specific Procurement Notice (SPN)

PART 1 – Tendering Procedures

Table of Contents

Section I - Instructions to Tenderers (ITT)

Contents

Section I - Instructions to Tenderers (ITT)

A. General

1. Scope of Tender

1.1 In connection with the Specific Procurement Notice (SPN) indicated in the **Tender Data Sheet (TDS)**, the Employer, as specified in the **TDS**, issues this Tender Document for the provision of Works on EPC basis as specified in Section VII, Employer's Requirements. The name, identification, and number of lots (contracts) of this tender are specified in the **TDS.**

1.2 Throughout this Tender Document:

(a) the term "in writing" means communicated in written form (e.g., by mail, e-mail, fax, including, if specified in the **TDS**, distributed or received through electronic-procurement system used by the Employer) with proof of receipt;

(b) if the context so requires, "singular" means "plural' and vice versa;

(c) "Day" means calendar day, unless otherwise specified as a "Business Day." A Business Day is any day that is a working day of the Recipient. It excludes the Recipient's official public holidays;

(d) "ESHS" means environmental, social, health and safety; and

(e) the word "tender" is synonymous with "bid" and "tenderer" with "bidder", and the words "tender documents" with "bidding documents".

2. Source of Funds

2.1 The Recipient specified in the **TDS** has received or has applied for financing (hereinafter called "funds") from the Asian Infrastructure Investment Bank (hereinafter called ("AIIB" or "the Bank") in an amount specified in the **TDS**, toward the project named in the **TDS**. The Recipient intends to apply a portion of the funds to eligible payments under the contract(s) for which this Tender Document is issued.

2.2 Payment by the Bank will be made only at the request of the Recipient and upon approval by the Bank, and will be subject, in all respects, to the terms and conditions of the Loan (or other financing) Agreement. The Loan (or other financing) Agreement prohibits a withdrawal from the loan account for the purpose of any payment to persons or entities, or for any import of goods, equipment, plant, or materials, if such payment or import is prohibited by a decision of the United Nations Security Council taken under Chapter VII of the

Charter of the United Nations. No party other than the Recipient shall derive any rights from the Loan (or other financing) Agreement or have any claim to the proceeds of the Loan (or other financing).

3. Prohibited Practices

3.1 The Bank requires compliance with the Bank's Policy on Prohibited Practices as set forth in Section VI.

3.2 In further pursuance of this policy, Tenderers shall permit and shall cause their agents (whether declared or not), subcontractors, sub-consultants, service providers, suppliers, and their personnel, to permit the Bank to inspect all accounts, records and other documents relating to any prequalification process, tender submission, proposal submission, and contract performance (in the case of award), and to have them audited by auditors appointed by the Bank.

4. Eligible Tenderers

4.1 A Tenderer may be a firm that is a private entity, a state-owned enterprise or institution subject to ITT 4.6 or any combination of such entities in the form of a joint venture (JV) under an existing agreement or with the intent to enter into such an agreement supported by a letter of intent. In the case of a joint venture, all members shall be jointly and severally liable for the execution of the entire Contract in accordance with the Contract terms. The JV shall nominate a Representative who shall have the authority to conduct all business for and on behalf of any and all the members of the JV during the Tendering process and, in the event the JV is awarded the Contract, during contract execution. Unless specified in the **TDS**, there is no limit on the number of members in a JV.

4.2 A Tenderer shall not have a conflict of interest. Any Tenderer found to have a conflict of interest shall be disqualified. A Tenderer may be considered to have a conflict of interest for the purpose of this Tendering process, if the Tenderer:

a) directly or indirectly controls, is controlled by or is under common control with another Tenderer; or
b) receives or has received any direct or indirect subsidy from another Tenderer; or
c) has the same legal representative as another Tenderer; or
d) has a relationship with another Tenderer, directly or through common third parties, that puts it in a position to influence the Tender of another Tenderer, or influence the decisions of the Employer regarding this Tendering process; or
e) or any of its affiliates participated as a consultant in the preparation of the design or technical specifications of the Works that are the subject of the Tender; or
f) or any of its affiliates has been hired (or is proposed to be hired) by the Employer or Recipient as Engineer for the Contract implementation; or

g) would be providing goods, works, or non-consulting services resulting from or directly related to consulting services for the preparation or implementation of the project specified in the TDS ITT 2.1 that it provided or were provided by any affiliate that directly or indirectly controls, is controlled by, or is under common control with that firm; or

h) has a close business or family relationship with a professional staff of the Recipient (or of the project implementing agency, or of any other beneficiary of the Bank's financing, or of any other party representing or acting on behalf of the Recipient) who: (i) are directly or indirectly involved in the preparation of the Tender Document or specification of the Contract, and/or the Tender evaluation process of such Contract; or (ii) would be involved in the implementation or supervision of such Contract unless the conflict stemming from such relationship has been resolved in a manner acceptable to the Bank throughout the Tendering process and execution of the Contract; or

i) is an affiliate of the Recipient, or of a procurement agent engaged by the Recipient, unless the Recipient demonstrates to the satisfaction of the Bank that there is no significant degree of common ownership, influence or control between the Recipient on the one hand, and the Recipient's agent and the affiliate on the other.

4.3 A firm that is a Tenderer (either individually or as a JV member) shall not participate in more than one Tender, except for permitted alternative Tenders. Such participation shall result in the disqualification of all Tenders in which the firm is involved. However, this does not limit: (a) the inclusion of the same Subcontractor in more than one Tender for the same contract; or (b) the ability of one Tenderer to be a Subcontractor in another Tender for the same contract.

4.4 A Tenderer may have the nationality of any country, subject to the restrictions pursuant to ITT 4.8. A Tenderer shall be deemed to have the nationality of a country if the Tenderer is constituted, incorporated or registered in and operates in conformity with the provisions of the laws of that country, as evidenced by its articles of incorporation (or equivalent documents of constitution or association) and its registration documents, as the case may be. This criterion also shall apply to the determination of the nationality of proposed subcontractors or sub-consultants for any part of the Contract including related Services.

4.5 A Tenderer that has been declared, and remains, as at the relevant date, ineligible pursuant to the Bank's Policy on Prohibited Practices as described in Section VI, shall be ineligible to be prequalified for,

tender for, propose for, or be awarded a Bank-financed contract or benefit from a Bank-financed contract, financially or otherwise, during such period of time as the Bank shall have determined. The list of debarred firms and individuals is available at the electronic address specified in the **TDS**.

4.6 Tenderers that are state-owned enterprises or institutions in the Employer's Country may be eligible to compete and be awarded a Contract(s) only if they can establish, in a manner acceptable to the Bank, that they (i) are carrying-out or are established for a business purpose, and are operating on a commercial basis; (ii) are financially and managerially autonomous; (iii) are not controlled by the government on day-to-day management; and (iv) are not under the supervision of the Employer or its procuring agency.

4.7 A Tenderer shall not be under suspension from Tendering by the Employer as the result of the operation of a Tender–Securing or Proposal-Securing Declaration.

4.8 Firms and individuals may be ineligible if so indicated in Section V and (a) as a matter of law or official regulations, the Recipient's country prohibits commercial relations with the firm or individual's country, provided that the Bank is satisfied that such exclusion does not preclude effective competition for the supply of goods or the contracting of works or services required; or (b) by an act of compliance with a decision of the United Nations Security Council taken under Chapter VII of the Charter of the United Nations, the Recipient's country prohibits any import of goods or contracting of works or services from the firm or individual's country, or any payments to any country, person, or entity in that country. When the Works are implemented across jurisdictional boundaries (and more than one country is a Recipient, and is involved in the procurement), then exclusion of a firm or individual on the basis of ITT 4.8 (a) above by any country may be applied to that procurement across other countries involved, if the Bank and the Recipients involved in the procurement agree.

4.9 A Tenderer shall provide such documentary evidence of eligibility satisfactory to the Employer, as the Employer shall reasonably request.

4.10 A firm that is under a sanction of debarment by the Recipient from being awarded a contract is eligible to participate in this procurement, unless the Bank, at the Recipient's request, is satisfied that the debarment; (a) relates to fraud or corruption or other prohibited practices, and (b) followed a judicial or administrative proceeding that afforded the firm adequate due process.

5. Eligible Materials, Equipment, and Services

5.1 The materials, equipment and services to be supplied under the Contract and financed by the Bank may have their origin in any country subject to the restrictions specified in Section V, Eligible Countries, and all expenditures under the Contract will not contravene such restrictions. At the Employer's request, Tenderers may be required to provide evidence of the origin of materials, equipment and services.

B. Contents of Tender Document

6. Sections of Tender Document

6.1 The Tender Document consists of Parts 1, 2 and 3, includes all the sections specified below, and should be read in conjunction with any Addenda issued in accordance with ITT 8.

PART 1 Tendering Procedures

- Section I - Instructions to Tenderers (ITT)
- Section II - Tender Data Sheet (TDS)
- Section III - Evaluation and Qualification Criteria
- Section IV - Tender Forms
- Section V - Eligible Countries
- Section VI - Prohibited Practices

PART 2 Employer's Requirements

Section VII - Employer's Requirements

PART 3 Conditions of Contract and Contract Forms

- Section VIII - General Conditions of Contract (GCC)
- Section IX - Particular Conditions of Contract (PCC)
- Section X - Contract Forms

6.2 The Specific Procurement Notice issued by the Employer is not part of the Tender Document.

6.3 Unless obtained directly from the Employer, the Employer is not responsible for the completeness of the Tender Document, responses to requests for clarification, the minutes of the pre-Tender meeting (if any), or Addenda to the Tender Document in accordance with ITT 8. In case of any contradiction, documents obtained directly from the Employer shall prevail.

6.4 The Tenderer is expected to examine all instructions, forms, terms, and specifications in the Tender Document and to furnish with its

Tender all information and documentation as is required by the Tender Document.

7. Clarification of Tender Document, Site Visit, Pre-Tender Meeting

7.1 A Tenderer requiring any clarification of the Tender Document shall contact the Employer in writing at the Employer's address specified in the **TDS** or raise its enquiries during the pre-Tender meeting if provided for in accordance with ITT 7.4. The Employer will respond in writing to any request for clarification, provided that such request is received no later than 2 days before the Pre-Tender Meeting. The Employer shall forward copies of its response to all Tenderers who have acquired the Tender Document in accordance with ITT 6.3, including a description of the inquiry but without identifying its source. If so, specified in the **TDS**, the Employer shall also promptly publish its response at the web page identified in the **TDS**. Should the clarification result in changes to the essential elements of the Tender Document, the Employer shall amend the Tender Document following the procedure under ITT 8 and ITT 22.2.

7.2 The Tenderer is advised to visit and examine the Site of Works and its surroundings and obtain for itself on its own responsibility all information that may be necessary for preparing the Tender and entering into a contract for construction of the Works. The costs of visiting the Site shall be at the Tenderer's own expense.

7.3 The Tenderer and any of its personnel or agents will be granted permission by the Employer to enter upon its premises and lands for the purpose of such visit, but only upon the express condition that the Tenderer, its personnel, and agents will release and indemnify the Employer and its personnel and agents from and against all liability in respect thereof, and will be responsible for death or personal injury, loss of or damage to property, and any other loss, damage, costs, and expenses incurred as a result of the inspection.

7.4 If so specified in the **TDS**, the Tenderer's designated representative is invited to attend a pre-Tender meeting and/or a Site of Works visit. The purpose of the meeting will be to clarify issues and to answer questions on any matter that may be raised at that stage.

7.5 The Tenderer is requested to submit any questions in writing, to reach the Employer not later than one week before the meeting.

7.6 Minutes of the pre-Tender meeting, if applicable, including the text of the questions asked by Tenderers, without identifying the source, and the responses given, together with any responses prepared after the meeting, will be transmitted promptly to all Tenderers who have acquired the Tender Document in accordance with ITT 6.3. If so, specified in the **TDS,** the Employer shall also promptly publish the Minutes of the pre-Tender meeting at the web page identified in the **TDS**. Any modification to the Tender Document that may become necessary as a result of the pre-Tender meeting shall be made by the Employer exclusively through the issue of an Addendum pursuant to ITT 8 and not through the minutes of the pre-Tender meeting. Nonattendance at the pre-Tender meeting will not be a cause for disqualification of a Tenderer.

8. Amendment of Tender Document

8.1 At any time prior to the deadline for submission of Tenders, the Employer may amend the Tender Document by issuing addenda.

8.2 Any addendum issued shall be part of the Tender Document and shall be communicated in writing to all who have obtained the Tender Document from the Employer in accordance with ITT 6.3. The Employer shall also promptly publish the addendum on the Employer's web page in accordance with ITT 7.1.

8.3 To give Tenderers reasonable time in which to take an addendum into account in preparing their Tenders, the Employer may, at its discretion, extend the deadline for the submission of Tenders, pursuant to ITT 22.2.

C. Preparation of Tenders

9. Cost of Tendering

9.1 The Tenderer shall bear all costs associated with the preparation and submission of its Tender, and the Employer shall not be responsible or liable for those costs, regardless of the conduct or outcome of the Tendering process.

10. Language of Tender

10.1 The Tender, as well as all correspondence and documents relating to the Tender exchanged by the Tenderer and the Employer, shall be written in the language specified in the **TDS**. Supporting documents and printed literature that are part of the Tender may be in another language provided they are accompanied by an accurate translation of the relevant passages in the language specified in the **TDS**, in which case, for purposes of interpretation of the Tender, such translation shall govern.

11. Documents Comprising the Tender

11.1 The Tender shall comprise two Parts, namely the Technical Part and the Financial Part. These two Parts shall be submitted simultaneously in two separate sealed envelopes (two-envelope tendering process). One envelope shall contain only information relating to the

Technical Part and the other, only information relating to the Financial Part. These two envelopes shall be enclosed in a separate sealed outer envelope marked "ORIGINAL TENDER".

11.2 The Technical Part shall contain the following:

(a) Letter of Tender – Technical Part: prepared in accordance with ITT 12;

(b) Tender Security or Tender-Securing Declaration: in accordance with ITT 19.1;

(c) Alternative Tender – Technical Part: if permissible, in accordance with ITT 13;

(d) Authorization: written confirmation authorizing the signatory of the Tender to commit the Tenderer, in accordance with ITT 20.3;

(e) Eligibility: documentary evidence in accordance with ITT17.1 establishing the Tenderer's eligibility to tender;

(f) Qualifications: documentary evidence in accordance with ITT 17.2 establishing the Tenderer's qualifications to perform the Contract if its Tender is accepted;

(g) Conformity: a technical proposal in accordance with ITT 16;

(h) Any other document required in the **TDS**.

11.3 The Financial Part shall contain the following:

(a) Letter of Tender – Financial Part: prepared in accordance with ITT 12 and ITT 14;

(b) Price Schedule: completed in accordance with ITT 12 and ITT 14;

(c) Alternative Tender - Financial Part: if permissible in accordance with ITT 13; and

(d) Any other document required in the **TDS**.

11.4 The Technical Part shall not include any information related to the Tender price. Where material financial information related to the Tender price is contained in the Technical Part, the Tender shall be declared non-responsive.

11.5 In addition to the requirements under ITT 11.2, Tenders submitted by a JV shall include a copy of the Joint Venture Agreement entered into by all members. Alternatively, a letter of intent to execute a Joint Venture Agreement in the event of a successful Tender shall be

signed by all members and submitted with the Tender, together with a copy of the proposed Agreement.

11.6 The Tenderer shall furnish in the Letter of Tender – Financial Part information on commissions and gratuities, if any, paid or to be paid to agents or any other party relating to this Tender.

12. Letter of Tender and Schedules

12.1 The Letter of Tender – Technical Part, the Letter of Tender – Financial Part, Schedules and all documents listed under ITT 11 including the Price Schedule*,* shall be prepared using the relevant form*s* furnished in Section IV, Tender Forms. The forms must be completed without any alterations to the text, and no substitutes shall be accepted except as provided under ITT 20.3. All blank spaces shall be filled in with the information requested.

13. Alternative Tenders

13.1 Unless otherwise specified in the **TDS**, alternative Tenders shall not be considered.

13.2 When alternative times for completion are explicitly invited, a statement to that effect will be included in the **TDS**, and the method of evaluating different alternative times for completion will be described in Section III, Evaluation and Qualification Criteria.

13.3 Except as provided under ITT 13.4 below, Tenderers wishing to offer technical alternatives to the requirements of the Tender Document must first price the Employer's design as described in the Tender Document and shall further provide all information necessary for a complete evaluation of the alternative by the Employer, including drawings, design calculations, technical specifications, breakdown of prices, and proposed construction methodology and other relevant details. Only the technical alternatives, if any, of the Tenderer with the Most Advantageous Tender conforming to the basic technical requirements shall be considered by the Employer.

13.4 When specified in the **TDS**, Tenderers are permitted to submit alternative technical solutions for specified parts of the Works. Such parts will be identified in the **TDS** and described in Section VII, Employer's Requirements. The method for their evaluation will be stipulated in Section III, Evaluation and Qualification Criteria.

14. Tender Prices and Discounts

14.1 The prices and discounts (including any price reduction) quoted by the Tenderer in the Letter of Tender – Financial Part and in the Price Schedule shall conform to the requirements specified below.

14.2 Unless otherwise specified in the TDS, Tenderers shall quote for the entire Works on a "single responsibility" basis such that the total lump sum Tender price, subject to any adjustments, in accordance with the Contract, covers all the Contractor's obligations mentioned in or to be reasonably inferred from the Tendering document for complete execution of the Works on EPC basis. This includes all

requirements under the Contractor's responsibilities for design, construction, procurement, erection, installation, subcontracting (if any), testing, pre-commissioning and commissioning (as applicable) of the Works and, where so required by the Tendering document, the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services as may be specified in the Tendering document, all in accordance with the requirements of the General Conditions.

Tenderers shall give a breakdown of the prices in the manner and detail called for in the Schedule of Rates and prices (if any) included in Section IV, Tender Forms. These will not in any way limit the Tenderers' single point total responsibility for the complete Scope of Work and for all contractual responsibilities/ obligations as stated in the Tendering Document.

14.3 The price to be quoted in the Letter of Tender – Financial Part, in accordance with ITT 12.1, shall be the total price of the Tender, excluding any discounts offered.

14.4 The Tenderer shall quote any discounts and the methodology for their application in the Letter of Tender – Financial Part, in accordance with ITT 12.1.

14.5 Unless otherwise specified in the **TDS** and the Conditions of Contract, the rates and prices quoted by the Tenderer are subject to adjustment during the performance of the Contract in accordance with the provisions of the Conditions of Contract. In such a case, the Tenderer shall furnish the indices and weightings for the price adjustment formulae in the Table of Adjustment Data in Section IV, Tender Forms, and the Employer may require the Tenderer to justify its proposed indices and weightings.

14.6 If so specified in ITT 1.1, Tenders are being invited for individual lots (contracts) or for any combination of lots (packages). Tenderers wishing to offer discounts for the award of more than one Contract shall specify in their Tender the price reductions applicable to each package, or alternatively, to individual Contracts within the package. Discounts shall be submitted in accordance with ITT 14.4, provided the Tenders for all lots (contracts) are opened at the same time. If, however, rated criteria are used in accordance with ITT 30.2, discounts on condition of award of more than one Contract shall not be used for Tender evaluation purpose.

14.7 All duties, taxes, and other levies payable by the Contractor under the Contract, or for any other cause, as of the date 28 days prior to the deadline for submission of Tenders, shall be included in the rates and prices and the total Tender Price submitted by the Tenderer.

15. Currencies of Tender and Payment

15.1 The currency (ies) of the Tender and the currency (ies) of payments shall be the same and shall be as specified in the **TDS.**

15.2 Tenderers may be required by the Employer to justify, to the Employer's satisfaction, their local and foreign currency requirements, and to substantiate that the amounts included in the unit rates and prices and shown in the Table of Adjustment Data in the Appendix to Tender in Section IV, Tender Forms, are reasonable, in which case a detailed breakdown of the foreign currency requirements shall be provided by Tenderers.

16. Documents Comprising the Technical Proposal

16.1 The Tenderer shall furnish a technical proposal in the Technical Part of the Tender including a statement of work methods, equipment, personnel, schedules and any other information as stipulated in Section IV, Tender Forms, in sufficient detail to demonstrate the adequacy of the Tenderer's proposal to meet the Employer's requirements and the completion time.

17. Documents Establishing the Eligibility and Qualifications of the Tenderer

17.1 To establish Tenderer's eligibility in accordance with ITT 4, Tenderers shall complete the Letter of Tender – Technical Part, included in Section IV, Tender Forms.

17.2 In accordance with Section III, Evaluation and Qualification Criteria, to establish its qualifications to perform the Contract, the Tenderer shall provide the information requested in the corresponding information sheets included in Section IV, Tender Forms.

17.3 If provisions for development of domestic industry (such as a margin of domestic preference) apply as specified in accordance with ITT 38.1, domestic Tenderers, individually or in joint ventures, applying for eligibility for domestic preference shall supply all information required to satisfy the criteria for eligibility specified in accordance with ITT 38.1.

18. Period of Validity of Tenders

18.1. Tenders shall remain valid for the Tender Validity period specified in the **TDS**. The Tender Validity period starts from the date fixed for the Tender submission deadline (as prescribed by the Employer in accordance with ITT 22). A Tender valid for a shorter period shall be rejected by the Employer as nonresponsive.

18.2. In exceptional circumstances, prior to the expiration of the Tender validity period, the Employer may request Tenderers to extend the period of validity of their Tenders. The request and the responses shall be made in writing. If a Tender Security is requested in accordance with ITT 19, it shall also be extended for a corresponding period. A Tenderer may refuse the request without forfeiting its Tender security. A Tenderer granting the request shall not be required or permitted to modify its Tender, except as provided in ITT 18.3.

18.3. If the award is delayed by a period exceeding fifty-six (56) days beyond the expiry of the initial Tender validity period, the Contract price shall be determined as follows:

(a) in the case of fixed price contracts, the Contract price shall be the Tender price adjusted by the factor specified in the **TDS**;

(b) in the case of adjustable price contracts, no adjustment shall be made; or

(c) in any case, Tender evaluation shall be based on the Tender price without taking into consideration the applicable correction from those indicated above.

19. Tender Security

19.1 The Tenderer shall furnish as part of the Technical Part of its Tender, either a Tender Security or a Tender-Securing Declaration, as specified in the **TDS**, in original form and, in the case of a Tender Security, in the amount and currency, or in the case of a Tender-Securing Declaration, for the period of ineligibility, as specified in the **TDS**.

19.2 A Tender-Securing Declaration shall use the form included in Section IV, Tender Forms.

19.3 If a Tender Security is specified pursuant to ITT 19.1, the Tender Security shall be a demand guarantee in any of the following forms at the Tenderer's option:

(a) an unconditional guarantee issued by a bank;

(b) an irrevocable letter of credit;

(c) a cashier's or certified check; or

(d) another security specified in the **TDS**,

from a reputable source from an eligible country. In the case of a bank guarantee, the Tender Security shall be submitted either using the Tender Security Form included in Section IV, Tender Forms, or in another substantially similar format approved by the Employer prior to Tender submission. The Tender Security shall be valid for twenty-eight (28) days beyond the original validity period of the Tender, or beyond any period of extension if requested under ITT 18.2.

19.4 If a Tender Security or Tender-Securing Declaration is specified pursuant to ITT 19.1, any Tender not accompanied by a substantially responsive Tender Security or Tender-Securing Declaration shall be rejected by the Employer as non-responsive.

19.5 If a Tender Security is specified pursuant to ITT 19.1, the Tender Security of unsuccessful Tenderers shall be returned as promptly as

possible upon the successful Tenderer's signing the Contract and furnishing the Performance Security pursuant to ITT 50.

19.6 The Tender Security of the successful Tenderer shall be returned as promptly as possible once the successful Tenderer has signed the Contract and furnished the required Performance Security.

19.7 The Tender Security may be forfeited, or the Tender-Securing Declaration executed:

(a) if a Tenderer withdraws its Tender during the period of Tender validity specified by the Tenderer on the Letter of Tender, or any extension thereto provided by the Tenderer; or

(b) if the successful Tenderer fails to:

(i) sign the Contract in accordance with ITT 49; or

(ii) furnish a Performance Security in accordance with ITT 50.

19.8 The Tender Security or the Tender-Securing Declaration of a JV shall be in the name of the JV that submits the Tender. If the JV has not been legally constituted into a legally enforceable JV at the time of Tendering, the Tender Security or the Tender-Securing Declaration shall be in the names of all future members as named in the letter of intent referred to in ITT 4.1 and ITT 11.5.

20. Format and Signing of Tender

20.1 The Tenderer shall prepare one original set of the Technical Part of the Tender and one original set of the Financial Part of the Tender as described in ITT 11 and ITT 21, and clearly mark them "ORIGINAL". Alternative Tenders, if permitted in accordance with ITT 13, shall be clearly marked "ALTERNATIVE." In addition, the Tenderer shall submit copies of the Tender, in the number specified in the **TDS** and clearly mark them "COPY". In the event of any discrepancy between the original and the copies, the original shall prevail.

20.2 Tenderers shall mark as "CONFIDENTIAL" all information in their Tenders which is confidential to their business. This may include proprietary information, trade secrets, or commercial or financially sensitive information.

20.3 The original and all copies of the Tender shall be typed or written in indelible ink and shall be signed by a person duly authorized to sign on behalf of the Tenderer. This authorization shall consist of a written confirmation as specified in the **TDS** and shall be attached to the Tender. The name and position held by each person signing the authorization must be typed or printed below the signature. All pages of the Tender where entries or amendments have been made shall be signed or initialed by the person signing the Tender.

20.4 In case the Tenderer is a JV, the Tender shall be signed by an authorized representative of the JV on behalf of the JV, and so as to be legally binding on all the members as evidenced by a power of attorney signed by their legally authorized representatives.

20.5 Any amendments such as inter-lineation, erasures, or overwriting shall be valid only if they are signed or initialed by the person signing the Tender.

D. Submission of Tenders

21. Sealing and Marking of Tenders

21.1 Tenderers may submit their Tenders by mail or by hand. If so specified in the TDS, Tenderers shall have the option of submitting their Tenders electronically. Procedures for submission, sealing, and marking are as follows:

(a) Tenderers submitting Tenders by mail or by hand shall enclose the original Technical Part of the Tender, the original Financial Part of the Tender, and the respective copies of the Tender, including Alternative Tenders if permitted in accordance with ITT 13, in separate sealed envelopes. The envelopes shall be duly marked as "ORIGINALTECHNICAL PART", "ORIGINAL-FINANCIAL PART", "COPY-TECHNICAL PART", "COPY-FINANCIAL PART", "ALTERNATIVE-ORIGINAL-TECHNCIAL PART", "ALTERNATIVE-ORIGINAL-FINANCIAL PART", "ALTERNATIVE-COPY-TECHNCIAL PART", and "ALTERNATIVE-COPY-FINANCIAL PART". These envelopes shall then be enclosed in one single package. The rest of the procedure shall be in accordance with ITT 21.2 through ITT 21.5.

(b) Tenderers submitting Tenders electronically shall follow the electronic tender submission procedures specified in the **TDS**.

21.2 The inner and outer envelopes shall:

(a) bear the name and address of the Tenderer;

(b) be addressed to the Employer in accordance with ITT 22.1; and

(c) bear the specific identification of this Tendering process specified in accordance with TDS ITT 1.1.

21.3 The outer envelopes and the inner envelopes containing the Technical Part of Tender shall bear a warning not to open before the time and date for the opening of Technical Part of Tender, in accordance with ITT 25.1.

21.4 The inner envelopes containing the Financial Part of Tender shall bear a warning not to open until advised by the Employer in accordance with ITT34.

21.5 If all envelopes are not sealed and marked as required, the Employer will assume no responsibility for the misplacement or premature opening of the Tender.

22. Deadline for Submission of Tenders

22.1 Tenders must be received by the Employer at the address and no later than the date and time specified in the **TDS**.

22.2 The Employer may, at its discretion, extend the deadline for the submission of Tenders by amending the Tender Document in accordance with ITT 8, in which case all rights and obligations of the Employer and Tenderers previously subject to the deadline shall thereafter be subject to the deadline as extended.

23. Late Tenders

23.1 The Employer shall not consider any Tender that arrives after the deadline for submission of Tenders, in accordance with ITT 22. Any Tender received by the Employer after the deadline for submission of Tenders shall be declared late, rejected, and returned unopened to the Tenderer.

24. Withdrawal, Substitution, and Modification of Tenders

24.1 A Tenderer may withdraw, substitute, or modify its Tender after it has been submitted by sending a written notice, duly signed by an authorized representative, and shall include a copy of the authorization in accordance with ITT 20.3 (except that withdrawal notices do not require copies). The corresponding substitution or modification of the Tender must accompany the respective written notice. All notices must be:

(a) prepared and submitted in accordance with ITT 20 and ITT 21 (except that withdrawals notices do not require copies), and in addition, the respective envelopes shall be clearly marked "WITHDRAWAL", "SUBSTITUTION", "MODIFICATION"; and

(b) received by the Employer prior to the deadline prescribed for submission of Tenders, in accordance with ITT 22.

24.2 Tenders requested to be withdrawn in accordance with ITT 24.1 shall be returned unopened to the Tenderers.

24.3 No Tender may be withdrawn, substituted, or modified in the interval between the deadline for submission of Tenders and the expiration of the period of Tender validity specified by the Tenderer on the Letter of Tender or any extension thereof.

E. Public Opening of Technical Parts of Tenders

25. Technical Part Opening

25.1 Except in the cases specified in ITT 23 and ITT 24.2, the Employer shall publicly open and read out in accordance with this ITT all Tenders received by the deadline, at the date, time and place specified in the **TDS**, in the presence of Tenderers' designated representatives and anyone who chooses to attend. Any specific electronic Tender opening procedures required if electronic Tendering is permitted in accordance with ITT 21.1, shall be as specified in the **TDS**.

25.2 First, envelopes marked "Withdrawal" shall be opened and read out and the envelope with the corresponding Tender shall not be opened, but returned to the Tenderer. No Tender withdrawal shall be permitted unless the corresponding withdrawal notice contains a valid authorization to request the withdrawal and is read out at Tender opening.

25.3 Next, envelopes marked "Substitution" shall be opened and read out and exchanged with the corresponding Tender being substituted, and the substituted Tender shall not be opened, but returned to the Tenderer. No Tender substitution shall be permitted unless the corresponding substitution notice contains a valid authorization to request the substitution and is read out at Tender opening.

25.4 Next, envelopes marked "Modification" shall be opened and read out with the corresponding Tender. No Tender modification shall be permitted unless the corresponding modification notice contains a valid authorization to request the modification and is read out at Tender opening.

25.5 Next, all remaining envelopes marked "TECHNICAL PART" shall be opened one at a time. All envelopes marked "FINANCIAL PART" shall remain sealed, and kept by the Employer in safe custody until they are opened, at a later public opening, following the evaluation of the Technical Part of the Tenders. On opening the envelopes marked "TECHNICAL PART" the Employer shall read out: the name of the Tender, the presence or the absence of a Tender Security, or Tender-Securing Declaration, if required, and whether there is a modification; and Alternative Tender - Technical Part; and any other details as the Employer may consider appropriate.

25.6 Only Technical Parts of Tenders and Technical Parts of Alternative Tenders that are opened and read out at Tender opening shall be considered further for evaluation. The Letter of Tender – Technical Part and the separate sealed envelopes marked "FINANCIAL PART" are to be initialed by representatives of the Employer attending Tender opening in the manner specified in the **TDS**.

25.7 At the tender opening the Employer shall neither discuss the merits of any Tender nor reject any Tender (except for late Tenders, in accordance with ITT 23.1).

25.8 The Employer shall prepare a record of the Technical Part of Tender opening that shall include, as a minimum:

(a) the name of the Tenderer and whether there is a withdrawal, substitution, or modification;

(b) the receipt of envelopes marked "FINANCIAL PART;

(c) the presence or absence of a Tender Security or Tender-Securing Declaration, if one was required any alternative Tenders; and

(d) if applicable, any Alternative Tender – Technical Part.

25.9 The Tenderers' representatives who are present shall be requested to sign the record. The omission of a Tenderer's signature on the record shall not invalidate the contents and effect of the record. A copy of the record shall be distributed to all Tenderers who submitted Tenders in time and posted online when electronic Tendering is permitted.

F. Evaluation of Tenders – General Provisions

26. Confidentiality

26.1 Information relating to the evaluation of Tenders and recommendation of contract award shall not be disclosed to Tenderers or any other persons not officially concerned with the Tendering process until information on Intention to Award the Contract is transmitted to all Tenderers in accordance with ITT 45.

26.2 Any attempt by a Tenderer to influence the Employer in the evaluation of the Tenders or Contract award decisions may result in the rejection of its Tender.

26.3 Notwithstanding ITT 26.2, from the time of Tender opening to the time of Contract award, if a Tenderer wishes to contact the Employer on any matter related to the Tendering process, it shall do so in writing.

27. Clarification of Tenders

27.1 To assist in the examination, evaluation, and comparison of the Tenders, and qualification of the Tenderers, the Employer may, at its discretion, ask any Tenderer for a clarification of its Tender, allowing a reasonable time for response. Any clarification submitted by a Tenderer that is not in response to a request by the Employer shall not be considered. The Employer's request for clarification and the

response shall be in writing. No change, including any voluntary increase or decrease, in the prices or substance of the Tender shall be sought, offered, or permitted, except to confirm the correction of arithmetic errors discovered by the Employer in the evaluation of the Tenders, in accordance with ITT 36.

27.2 If a Tenderer does not provide clarifications of its Tender by the date and time set in the Employer's request for clarification, its Tender may be rejected.

28. Deviations, Reservations, and Omissions

28.1 During the evaluation of Tenders, the following definitions apply:

(a) "Deviation" is a departure from the requirements specified in the Tender Document;

(b) "Reservation" is the setting of limiting conditions or withholding from complete acceptance of the requirements specified in the Tender Document; and

(c) "Omission" is the failure to submit part or all of the information or documentation required in the Tender Document.

29. Nonmaterial Nonconformities

29.1 Provided that a Tender is substantially responsive, the Employer may waive any nonconformities in the Tender.

29.2 Provided that a Tender is substantially responsive, the Employer may request that the Tenderer submit the necessary information or documentation, within a reasonable period of time, to rectify nonmaterial nonconformities or omissions in the Tender related to documentation requirements. Requesting information or documentation on such nonconformities or omissions shall not be related to any aspect of the price of the Tender. Failure of the Tenderer to comply with the request may result in the rejection of its Tender.

29.3 Provided that a Tender is substantially responsive, the Employer shall rectify quantifiable nonmaterial nonconformities related to the Tender Price. To this effect, the Tender Price shall be adjusted, for comparison purposes only, to reflect the price of a missing or non-conforming item or component in the manner specified in the **TDS**.

G. Evaluation of Technical Parts of Tenders

30. Evaluation of Technical Parts

30.1 In evaluating the Technical Parts of each Tender, the Employer shall use the criteria and methodologies listed in this ITT and Section III, Evaluation and Qualification Criteria. No other evaluation criteria or methodologies shall be permitted.

30.2 If specified in the **TDS**, the Employer's evaluation will be carried out by applying rated criteria that take into account technical factors, in addition to cost factors. An Evaluated Tender Score will be calculated for each responsive Tender using the formula specified in Section III, Evaluation and Qualification Criteria. The scores to be given to technical factors and sub-factors are specified in the **TDS**. The weights to be given to the cost and the total technical score are specified in the **TDS**.

31. Determination of Responsiveness

31.1 The Employer's determination of a Tender's responsiveness is to be based on the contents of the Tender itself, as defined in ITT 11.

31.2 A substantially responsive Tender is one that meets the requirements of the Tender Document without material deviation, reservation, or omission. A material deviation, reservation, or omission is one that:

(a) if accepted, would:

(i) affect in any substantial way the scope, quality, or performance of the Works specified in the Contract; or

(ii) limit in any substantial way, inconsistent with the Tender Document, the Employer's rights or the Tenderer's obligations under the proposed Contract; or

(b) if rectified, would unfairly affect the competitive position of other Tenderers presenting substantially responsive Tenders.

31.3 The Employer shall examine the technical aspects of the Tender submitted in accordance with ITT 16, in particular, to confirm that all requirements of Section VII, Employer's Requirements have been met without any material deviation, reservation or omission.

31.4 If a Tender is not substantially responsive to the requirements of the Tender Document, it shall be rejected by the Employer and may not subsequently be made responsive by correction of the material deviation, reservation, or omission.

32. Qualification of the Tenderers

32.1 The Employer shall determine to its satisfaction whether the eligible Tenderers that have submitted substantially responsive Tender - Technical Parts meet the qualifying criteria specified in Section III, Evaluation and Qualification Criteria.

32.2 The determination shall be based upon an examination of the documentary evidence of the Tenderer's qualifications submitted by the Tenderer, pursuant to ITT 17. The determination shall not take into consideration the qualifications of other firms such as the Tenderer's subsidiaries, parent entities, affiliates, subcontractors

(other than Specialized Subcontractors if permitted in ITT 33.3), or any other firm(s) different from the Tenderer.

32.3 If a Tenderer does not meet the qualifying criteria specified in Section III, Evaluation and Qualification Criteria, its Tender shall be rejected by the Employer and may not subsequently be made responsive by correction of the material deviation, reservation, or omission.

32.4 Only Tenders that are both substantially responsive to the Tender Document, and meet all Qualification Criteria shall have their envelopes marked "FINANCIAL PART" opened at the second public opening.

33. Subcontractors

33.1 Unless otherwise stated in the **TDS**, the Employer does not intend to execute any specific elements of the Works by subcontractors selected in advance by the Employer.

33.2 Tenderers may propose subcontracting up to the percentage of total value of contracts or the volume of works as specified in the **TDS**. Subcontractors proposed by the Tenderer shall be fully qualified for their parts of the Works.

33.3 The subcontractor's qualifications shall not be used by the Tenderer to qualify for the Works unless their specialized parts of the Works were previously designated by the Employer in the **TDS** as can be met by subcontractors referred to hereafter as 'Specialized Subcontractors', in which case, the qualifications of the Specialized Subcontractors proposed by the Tenderer may be added to the qualifications of the Tenderer.

H. Public Opening of Financial Parts of Tenders

34. Public Opening of Financial Parts

34.1 Following the completion of the evaluation of the Technical Parts of the Tenders, and the Bank has issued its no objection (if applicable), the Employer shall notify in writing those Tenderers whose Tenders were considered non-responsive to the Tender Document or failed to meet the Qualification Criteria, advising them of the following information:

(a) the grounds on which their Technical Part of Tender failed to meet the requirements of the Tender Document;

(b) their envelopes marked "FINANCIAL PART" will be returned to them unopened after the completion of the selection process and the signing of the Contract; and

(c) notify them of the date, time and location of the public opening of the envelopes marked "FINANCIAL PART".

34.2 The Employer shall, simultaneously, notify in writing those Tenderers whose Tenders - Technical Parts have been evaluated as substantially responsive to the Tender Document and met all Qualifying Criteria, advising them of the following information:

(a) their Tender has been evaluated as substantially responsive to the Tender Document and met the Qualification Criteria;

(b) When rated criteria are used, the evaluated technical scores;

(c) their envelope marked "FINANCIAL PART" will be opened at the public opening of the Financial Parts; and

(d) notify them of the date, time and location of the second public opening of the envelopes marked "FINANCIAL PART" as specified in the **TDS**.

34.3 The opening date should allow Tenderers sufficient time to make arrangements for attending the opening. The Financial Part of the Tender shall be opened publicly in the presence of Tenderers' designated representatives and anyone who chooses to attend.

34.4 At this public opening the Financial Parts will be opened by the Employer in the presence of Tenderers, or their designated representatives and anyone else who chooses to attend. Tenderers who met the Qualification Criteria and whose Tenders were evaluated as substantially responsive will have their envelopes marked "FINANCIAL PART" opened at the second public opening. Each of these envelopes marked "FINANCIAL PART" shall be inspected to confirm that they have remained sealed and unopened. These envelopes shall then be opened by the Employer. The Employer shall read out the names of each Tenderer, and the total Tender prices, per lot (contract) if applicable, including any discounts and Alternative Tender - Financial Part, and any other details as the Employer may consider appropriate.

34.5 Only envelopes of Financial Part of Tenders, Financial Parts of Alternative Tenders and discounts that are opened and read out at tender opening shall be considered further for evaluation. The Letter of Tender – Financial Part and the Priced Bill of Quantities are to be initialed by representatives of the Employer attending the tender opening in the manner specified in the **TDS**.

34.6 The Employer shall neither discuss the merits of any Tender nor reject any envelopes marked "FINANCIAL PART".

34.7 The Employer shall prepare a record of the Financial Part of the Tender opening that shall include, as a minimum:

(a) the name of the Tenderer whose Financial Part was opened;

(b) the Tender price, per lot (contract) if applicable, including any discounts; and

(c) if applicable, any Alternative Tender – Financial Part.

34.8 The Tenderers whose envelopes marked "FINANCIAL PART" have been opened or their representatives who are present shall be requested to sign the record. The omission of a Tenderer's signature on the record shall not invalidate the contents and effect of the record. A copy of the record shall be distributed to all Tenderers.

I. Evaluation of Financial Parts of Tenders

35. Evaluation of Financial Parts

35.1 To evaluate the Financial Part, the Employer shall consider the following:

(a) the Tender price, excluding Provisional Sums and the provision, if any, for contingencies in the Price Schedule, but including Daywork items, where priced competitively;

(b) price adjustment for correction of arithmetic errors in accordance with ITT 36.1;

(c) price adjustment due to discounts offered in accordance with ITT 14.4;

(d) converting the amount resulting from applying (a) to (c) above, if relevant, to a single currency in accordance with ITT 37;

(e) price adjustment due to quantifiable nonmaterial nonconformities in accordance with ITT 29.3; and

(f) the additional evaluation factors are specified in the **TDS** and Section III, Evaluation and Qualification Criteria.

35.2 The estimated effect of the price adjustment provisions of the Conditions of Contract, applied over the period of execution of the Contract, shall not be taken into account in Tender evaluation.

35.3 If this Tender Document allows Tenderers to quote separate prices for different lots (contracts), the methodology to determine the lowest evaluated cost of the contract combinations, including any discounts offered in the Letter of Tender – Financial Part, is specified in Section III, Evaluation and Qualification Criteria. If, however, rated criteria are used in accordance with ITT 30.2, discounts on

condition of award of more than one contract shall not be used for Tender evaluation purpose.

36. Correction of Arithmetical Errors

36.1 If Tenders have been invited on single responsibility basis in terms of ITT 14, the Tenderer is deemed to have included all prices in the quoted lump sum Tender Price. Arithmetical corrections shall therefore not be made, except that where there is a discrepancy between the amount in words and the amount in figures, the amount in words shall prevail.

36.2 If Tenders have been invited to include any part of the Works to be paid according to quantity supplied or work done in terms of ITT 14, the Employer shall correct arithmetical errors only for the price for such part of the Works on the following basis:

(a) where there are errors between the total of the amounts given under the column for the price breakdown and the amount given under the Total Price, the former shall prevail and the latter will be corrected accordingly; and

(b) if there is a discrepancy between words and figures, the amount in words shall prevail, unless the amount expressed in words is related to an arithmetic error, in which case the amount in figures shall prevail subject to (a) above.

36.3 Tenderers shall be requested to accept correction of arithmetical errors. Failure to accept the correction in accordance with ITT 36.1, shall result in the rejection of the Tender.

37. Conversion to Single Currency

37.1 For evaluation and comparison purposes, the currency(ies) of the Tender shall be converted into a single currency as specified in the **TDS**.

38. Provision for Development of Domestic Industry

38.1 Unless otherwise specified in the **TDS**, provision for development of domestic industry (such as a margin of preference for domestic Tenderers[1]) shall not apply.

39. Comparison of Tenders

39.1 The Employer shall compare the evaluated costs of all substantially responsive Tenders established in accordance with ITT 35.1 to determine the Tender that has the lowest evaluated cost.

39.2 If ITT 30.2 is applicable, the Employer shall evaluate the technical score and financial score of each tender and determine the Tender

[1]An individual firm is considered a domestic Tenderer for purposes of the margin of preference if it is registered in the country of the Employer, has more than 50 percent ownership by nationals of the country of the Employer, and if it does not subcontract more than 10 percent of the contract price, excluding provisional sums, to foreign contractors. JVs are considered as domestic Tenderers and eligible for domestic preference only if the individual member firms are registered in the country of the Employer or have more than 50 percent ownership by nationals of the country of the Employer, and the JV shall be registered in the country of the Employer. The JV shall not subcontract more than 10 percent of the contract price, excluding provisional sums, to foreign firms. JVs between foreign and national firms will not be eligible for domestic preference.

with the highest combined technical and financial score in accordance with TDS ITT 30.2.

40. Abnormally Low-Priced Tenders

40.1 An Abnormally Low-Priced Tender is one where the Tender price, in combination with other elements of the Tender, appears so low that it raises material concerns as to the capability of the Tenderer in regard to the Tenderer's ability to perform the Contract for the offered Tender Price.

40.2 In the event of identification of a potentially Abnormally Low-Priced Tender, the Employer shall seek written clarifications from the Tenderer, including detailed price analyses of its Tender price in relation to the subject matter of the contract, scope, proposed methodology, schedule, allocation of risks and responsibilities and any other requirements of the Tender Document.

40.3 After examining the clarifications given and the detailed price analyses presented by the Tenderer, the Employer may as appropriate:

(a) accept the Tender, if the evidence provided satisfactorily accounts for the low tender price, in which case the Tender is not considered abnormally low; or

(b) accept the Tender, but require that the amount of the Performance Security be increased at the expense of the Tenderer to a level sufficient to protect the Employer against financial loss. The amount of the Performance Security shall generally be not more than 20% of the Contract Price; or

(c) reject the Tender, if the evidence provided does not satisfactorily account for the low tender price and make a similar determination for the next ranked Tender, if required.

41. Unbalanced or Front-Loaded Tenders

41.1 If the Tender that is evaluated as the Most Advantageous Tender is, in the Employer's opinion, seriously unbalanced or front loaded, the Employer may require the Tenderer to provide written clarifications. Clarifications may include detailed price analyses to demonstrate the consistency of the Tender prices with the scope of works, proposed methodology, schedule and any other requirements of the Tender Document.

41.2 After the evaluation of the information and detailed price analyses presented by the Tenderer, the Employer may as appropriate:

(a) accept the Tender; or

(b) accept the Tender, but require that the total amount of the Performance Security be increased at the expense of the Tenderer to a level not exceeding 20% of the Contract Price; or

(c) reject the Tender and make a similar determination for the next ranked Tender.

42. Most Advantageous Tender

42.1 The Employer shall determine the Most Advantageous Tender. The Most Advantageous Tender is the Tender of the Tenderer that meets the Qualification Criteria and whose Tender has been determined to be substantially responsive to the Tender Documents and:

(a) when rated criteria are used, is the tender with the highest combined technical and financial score; or

(b) when rated criteria are not used, is the tender with the lowest evaluated cost.

43. Employer's Right to Accept Any Tender, and to Reject Any or All Tenders

43.1 The Employer reserves the right to accept or reject any Tender and to annul the Tendering process and reject all Tenders at any time prior to Contract Award, without thereby incurring any liability to Tenderers. In case of annulment, all Tenders submitted and specifically, Tender securities, shall be promptly returned to the Tenderers.

44. Standstill Period

44.1 The Contract shall not be awarded earlier than the expiry of the Standstill Period. The Standstill Period shall be ten (10) Business Days unless extended in accordance with ITT 48. The Standstill Period commences the day after the date the Employer has transmitted to each Tenderer the Notification of Intention to Award the Contract. Where only one Tender is submitted, or if this contract is in response to an emergency situation recognized by the Bank, the Standstill Period shall not apply.

45. Notification of Intention to Award

45.1 The Employer shall send to each Tenderer the Notification of Intention to Award the Contract to the successful Tenderer. The Notification of Intention to Award shall contain, at a minimum, the following information:

(a) the name and address of the Tenderer submitting the successful Tender;

(b) the Contract price of the successful Tender;

(c) the names of all Tenderers who submitted Tenders, and their Tender prices as readout, and as evaluated, and when rated criteria are used, the evaluated technical and financial scores, and the combined total scores;

(d) a statement of the reason(s) the Tender (of the unsuccessful Tenderer to whom the notification is addressed) was unsuccessful, unless the price or score information in (c) above already reveals the reason;

(e) the expiry date of the Standstill Period; and

(f) instructions on how to request a debriefing and/or submit a complaint during the standstill period.

J. Award of Contract

46. Award Criteria

46.1 Subject to ITT 43, the Employer shall award the Contract to the successful Tenderer. This is the Tenderer whose Tender has been determined to be the Most Advantageous Tender.

47. Notification of Award

47.1 Prior to the expiry of the Tender Validity Period and upon expiry of the Standstill Period specified in ITT 43.1 or any extension thereof, and, upon satisfactorily addressing any complaint that has been filed within the Standstill Period, the Employer shall notify the successful Tenderer, in writing, that its Tender has been accepted. The notification of award (hereinafter and in the Conditions of Contract and Contract Forms called the "Letter of Acceptance") shall specify the sum that the Employer will pay the Contractor in consideration of the execution of the Contract (hereinafter and in the Conditions of Contract and Contract Forms called "the Contract Price").

47.2 Within ten (10) Business Days after the date of transmission of the Letter of Acceptance, the Employer shall publish the Contract Award Notice which shall contain, at a minimum, the following information:

(a) name and address of the Employer;

(b) name and reference number of the contract being awarded, and the procurement method used;

(c) names of all Tenderers that submitted Tenders, and their Tender prices as read out at Tender opening, and as evaluated, and when rated criteria are used, the evaluated tender scores;

(d) names of all Tenderers whose Tenders were rejected either as nonresponsive or as not meeting qualification criteria, or were not evaluated, with the reasons therefor;

(e) the name of the successful Tenderer, the final total contract price, the contract duration and a summary of its scope; and

(f) successful Tenderer's Beneficial Ownership Disclosure Form, if specified in TDS ITT 49.1.

47.3 The Contract Award Notice shall be published on the Employer's website with free access if available, or in at least one newspaper of national circulation in the Employer's Country, or in the official

gazette. The Employer shall also publish the contract award notice in UNDB online and AIIB website.

47.4 Until a formal Contract is prepared and executed, the Letter of Acceptance shall constitute a binding Contract.

48. Debriefing by the Employer

48.1 On receipt of the Employer's Notification of Intention to Award referred to in ITT 44.1, an unsuccessful Tenderer has three (3) Business Days to make a written request to the Employer for a debriefing. The Employer shall provide a debriefing to all unsuccessful Tenderers whose request is received within this deadline.

48.2 Where a request for debriefing is received within the deadline, the Employer shall provide a debriefing within five (5) Business Days, unless the Employer decides, for justifiable reasons, to provide the debriefing outside this timeframe. In that case, the standstill period shall automatically be extended until five (5) Business Days after such debriefing is provided. If more than one debriefing is so delayed, the standstill period shall not end earlier than five (5) Business Days after the last debriefing takes place. The Employer shall promptly inform, by the quickest means available, all Tenderers of the extended standstill period.

48.3 Where a request for debriefing is received by the Employer later than the three (3)-Business Day deadline, the Employer should provide the debriefing as soon as practicable, and normally no later than fifteen (15) Business Days from the date of publication of Contract Award Notice. Requests for debriefing received outside the three (3)-day deadline shall not lead to extension of the standstill period.

48.4 Debriefings of unsuccessful Tenderers may be done in writing or verbally. The Tenderer shall bear its own costs of attending such a debriefing meeting.

49. Signing of Contract

49.1 The Employer shall send to the successful Tenderer the Letter of Acceptance including the Contract Agreement, and, if specified in the **TDS**, a request to submit the Beneficial Ownership Disclosure Form providing additional information on its beneficial ownership. The Beneficial Ownership Disclosure Form, if so requested, shall be submitted within eight (8) Business Days of receiving this request.

49.2 The successful Tenderer shall sign, date and return to the Employer, the Contract Agreement within twenty-eight (28) days of its receipt.

50. Performance Security

50.1 Within twenty-eight (28) days of the receipt of the Letter of Acceptance from the Employer, the successful Tenderer shall furnish the Performance Security in accordance with the General Conditions of Contract, subject to ITT 40.3 (b) and ITT 41.2 (b), using for that

purpose the Performance Security Form included in Section X, Contract Forms, or another form acceptable to the Employer.

50.2 Failure of the successful Tenderer to submit the above-mentioned Performance Security or sign the Contract shall constitute sufficient grounds for the annulment of the award and forfeiture of the Tender Security. In that event the Employer may award the Contract to the Tenderer offering the next Most Advantageous Tender.

51. Procurement Related Complaint

51.1 The procedures for making a Procurement-related Complaint are as specified in the **TDS**.

Section II - Tender Data Sheet (TDS)

The following specific data for the Works to be procured shall complement, supplement, or amend the provisions in the Instructions to Tenderers (ITT). Whenever there is a conflict, the provisions herein shall prevail over those in ITT.

A. General	
ITT 1.1	The reference number of the SPN/Tender is: **HORC/HRIDC/C-4/2022** The Employer is*:* **Haryana Orbital Rail Corporation Limited (HORCL)** The name of the Tender is: **C-4:** Composite Contract package in connection with New BG Railway Line of HORC project for: (i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580; (ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680; (iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680; (iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00. The number and identification of lots (contracts) comprising this Tender is: **Contract Package (C-4)**
ITT 1.2	Add new sub-paragraphs (f) and (g) after sub-paragraph (e) as follows: (f) "Joint Venture" shall be replaced with "Joint Venture or Consortium" (g) "JV" shall be replaced with "JV or Consortium"
ITT 1.2(a)	**Electronic – Procurement System** The Employer shall use the following electronic-procurement system to manage this Tendering process: **E-procurement portal of Govt. of Haryana (https://etenders.hry.nic.in)**

ITT 1.3	**Add new sub-clause ITT 1.3** **Instructions for Online Tender Submission:** The Tenderers are required to submit soft copies of their Tenders electronically on the e-procurement portal of Government of Haryana i.e. https://etenders.hry.nic.in, using valid Digital Signature Certificates. The instructions given below are meant to assist the Tenderers in registering on the e-procurement Portal, prepare their Tenders in accordance with the requirements and submitting their Tenders online on the e-procurement Portal. **Registration:** i) Tenderers are required to enroll on the above-mentioned e-Procurement portal by clicking on the link "Online Bidder Enrollment" on the Portal which is free of charge. ii) As part of the enrolment process, the Tenderers will be required to choose a unique username and assign a password for their accounts. iii) Tenderers are advised to register their valid email address and mobile numbers as part of the registration process. These would be used for any communication from the e-procurement Portal. **A. Obtaining a Digital Certificate:** i. The Tenders submitted online should be encrypted and signed electronically with a Digital Certificate to establish the identity of the Tenderer online. These Digital Certificates are issued by an Approved Certifying Authority, by the Controller of Certifying Authorities, Government of India. ii. A Digital Certificate is issued upon receipt of mandatory identity (i.e. Applicant's PAN Card) and Address proofs and verification form duly attested by the Bank Manager / Postmaster / Gazetted Officer. Only upon the receipt of the required documents, a digital certificate can be issued. For more details please visit the website – https://etenders.hry.nic.in iii. The Tenderers may obtain Class-II or III digital signature certificate from any Certifying Authority or Sub-certifying Authority authorized by the Controller of Certifying Authorities or may obtain information, application format and documents required for the issue of digital certificate. iv. The Tenderer must ensure that he/she comply by the online available important guidelines at the portal https://etenders.hry.nic.in for Digital Signature Certificate (DSC) including the e-Token carrying DSCs.

	For any queries related to e-tendering process (registration, online e-bid submission/withdrawal, uploading of documents), Tenderer may contact the below representative of NIC: **Ms. Manju Aggarwal** **Technical Director,** **Scientist-E, NIC.** **Panchkula.** **E - mail:** a.manju@nic.in **Help Desk:** 0172 – 584257, 94170-69017. v. Tender for a particular tender must be submitted online using the digital certificate (Encryption & Signing), which is used to encrypt and sign the data during the stage of Tender preparation. In case, during the process of a particular tender, the user loses his digital certificate (due to virus attack, hardware problem, operating system or any other problem) he will not be able to submit the Tender online. Hence, the users are advised **to keep a backup of the certificate** and also keep the copies at safe place under proper security (for its use in case of emergencies). vi. In case of online tendering, if the digital certificate issued to the authorized user of a firm is used for signing and submitting a Tender, it will be considered equivalent to a no-objection certificate/power of attorney/lawful authorization to that User. The firm has to authorize a specific individual through an authorization certificate signed by all partners to use the digital certificate as per Indian Information Technology Act 2000. Unless the certificates are revoked, it will be assumed to represent adequate authority of the user to Tender on behalf of the firm in the department tenders as per Information Technology Act 2000. The digital signature of this authorized user will be binding on the firm. vii. In case of any change in the authorization, it shall be the responsibility of management/ partners of the firm to inform the certifying authority about the change and to obtain the digital signatures of the new person/ user on behalf of the firm/ company. The procedure for application of a digital certificate however will remain the same for the new user. viii. The same procedure holds true for the authorized users in a private/Public limited company. In this case, the authorization certificate will have to be signed by the directors of the company.

	B. Opening of an Electronic Payment Account: For purchasing the tender documents online, Tenderers are required to pay the tender documents fee online using the electronic payment gateway service through their Debit Cards & Internet Banking accounts. For online payments guidelines, please refer to the Home page under tab "Guidelines for hassle free Bid Submission" of the e-procurement Portal of Government of Haryana, https://etenders.hry.nic.in **C. Pre-requisites for online Tendering:** In order to operate on the electronic tender management system, a user's machine is required to be set up. A help file on system setup/Pre-requisite can be obtained from National Informatics Center or downloaded from the home page of the website - https://etenders.hry.nic.in the link for downloading required java applet & DC setup are also available on the Home page of the e-procurement Portal. **D. Online Viewing of Specific Procurement Notice (SPN):** The Tenderers can view the SPN and the time schedule (Key Dates) through the single portal e-procurement system on the Home Page at https://etenders.hry.nic.in **E. Downloading of Tender Documents:** The Tender Documents can be downloaded free of cost from the e-procurement portal https://etenders.hry.nic.in **F. Key Dates:** The Tenderers are strictly advised to follow dates and times as indicated in the online Specific Procurement Notice. The date and time shall be binding on all Tenderers. All online activities are time tracked and the system enforces time locks that ensure that no activity or transaction can take place outside the start and end dates and the time of the stage as defined in the online Specific Procurement Notice. **G. Online Payment of E-Service Fee:** The online payment for E-Service Fee in INR shall be made using the secure electronic payment gateway by Tenderers online directly through Debit Cards & Internet Banking accounts.

	The secure electronic payments gateway is an online interface between Contractors and Debit card/online payment authorization networks. **H. Preparation & Submission of online Applications/Tenders:** i. Detailed Tender documents may be downloaded from e-procurement website (https://etenders.hry.nic.in) from **07.11.2022 (17:00 Hrs. IST) to *03.02.2023* (15:00 Hrs IST.)** and tender shall mandatorily be submitted online following the instruction appearing on the screen. ii. **Scan copy of Documents to be submitted/uploaded for Technical Part under online PQQ/ Technical Envelope:** All documents shall be prepared and scanned in file formats PDF /JPEG/MS WORD format such that file size does not exceed 10 MB and uploaded during the on-line submission of PQQ or Technical Envelope. **iii. FINANCIAL PART shall be submitted mandatorily online under Commercial Envelope and original not to be submitted manually.** ***NOTE:*** ***(A) Tenderers participating in online tenders shall check the validity of his/her Digital Signature Certificate before participating in the online Tenders at the portal*** https://etenders.hry.nic.in**.** (B) ***For help manual, please refer to the 'Home Page' of the*** **e-procurement** ***website at*** https://etenders.hry.nic.in
ITT 2.1	The Recipient is: **Haryana Orbital Rail Corporation Limited (HORCL) through Government of Haryana** The Bank Loan amount: **USD 400 million** The name of the Project is: **Haryana Orbital Rail Corridor (HORC)**
ITT 4.1	Maximum number of members in the JV shall be: **Three (03)**

ITT 4.1	**Add the following after the last sentence of Clause 4.1** Highest shareholding member in the JV/Consortium shall be the Lead member of JV/Consortium. Minimum percentage share of each JV member shall be as specified in Sub-Clause 3.1.6, Section III, EQC. No change in constitution or percentage share shall be permitted at any stage after the Tender submission, failing which the Tenderer shall be treated as non-responsive. Authorized Representative of JV/Consortium shall be from Lead Member of JV/Consortium.
ITT 4.4	**Add the following after the last sentence of Clause 4.4** In the event that the Contract is awarded to a foreign Tenderer or to a JV/Consortium having foreign lead Member, such foreign Tenderer/foreign lead Member shall be required to set up a project office in India in accordance with applicable laws in India, and shall be required to submit a proof of having opened a project office in India along with statutory approvals, if any, prior to submitting any interim payment certificate in accordance with the Contract, failing which no payment shall be made to the Contractor by the Employer (in accordance with the Contract) until such requirement has been complied with by the foreign Contractor. The aforesaid condition of establishing a project office in India shall not be applicable in case the selected Tenderer is a joint venture between an Indian entity and a foreign entity where Indian Member is lead Member.
ITT 4.5	A list of debarred firms and individuals is available on the Bank's external website: https://www.aiib.org/debarment/
ITT 6.3	**Replace ITT 6.3 with the following:** The complete Tender Document can be viewed/ downloaded by the Tenderer from e-procurement portal of Govt. of Haryana https://etenders.hry.nic.in. The Employer is not responsible for the completeness of the Tender Document and their addenda if they were not obtained directly from e-procurement portal of Govt. of Haryana https://etenders.hry.nic.in .
B. Contents of Tender Document	
ITT 7.1	For **Clarification of Tender purposes** only, the Employer's address is: **Attention:** Chief Project Manager **Street address:** Haryana Rail Infrastructure Development Corporation Limited (HRIDC), Plot no.143, Railtel Tower, Sector-44 **Floor:** 5th floor

	City: Gurugram **ZIP code:** 122003 **Country:** India **Telephone:** +91 9311478893 **E-mail:** horc.etendering@gmail.com
ITT 7.2	**Add the following at the end of Para 7.2:** *The Tenderer must obtain for themselves information related to site conditions, traffic, location, surroundings, climate, hydrology, meteorological conditions, weather data, availability of power, water, other utilities for construction, access and approach roads to the Site, handling and storage of materials, Waste disposal, applicable laws and regulations and any other matter considered relevant and necessary by them required for submitting their Tender and performance of all of its obligations in accordance with the requirements of Tender Documents.* Site visit with the Employer's Representative will be conducted on the date and time specified below. **Date: 24.11.2022** **Time: 1100 hrs. IST** Tenderers who wish to participate in site visit on the given date should assemble at the location given below: Nuh Toll Plaza at KMP Expressway & Sohna-Nuh Road (NH 248A crossing) Haryana **Country:** India **For coordination regarding Site visit, Tenderers may contact:** Sh. Amarendra Singh Kundu, AM/Civil/Plg. /HRIDC **Telephone:** +91 7015249184 The costs of visiting the Site shall be at the Tenderer's own expense.
ITT 7.4	**Replace the entire Sub-Clause 7.4 with the following:** A Pre-Tender meeting will take place through online Video conferencing (VC) as well as offline in the Conference room of HRIDC office, Plot No 143, Railtel Tower, Sector-44, Gurugram, Haryana-122003 at the following date and time. The purpose of the meeting will be to clarify issues and to answer questions on any matter that may be raised at that stage. **Date: 25.11.2022** **Time: 1100 hrs IST**

<table>
<tr><td></td><td>
The prospective Tenderers who wish to join the Pre-Tender meeting through VC shall send a request (giving details of the Company, its address, and the name, designation and email of the person attending the VC) through email along with an editable soft copy (MS Word) of the queries raised by them on the email id (i.e.horc.etendering@gmail.com) so that a link for Video Conferencing can be sent by HRIDC. The Tenderers should use the following format for any Pre-Tender queries:
<table>
<tr><th>Query No.</th><th>Reference to Tender Document

(Clause/ Para No. & Page No.)</th><th>Brief Description of Clause/ Para No.</th><th>Query Raised</th></tr>
<tr><td>1.</td><td></td><td></td><td></td></tr>
<tr><td>2.</td><td></td><td></td><td></td></tr>
<tr><td>3.</td><td></td><td></td><td></td></tr>
<tr><td>4.</td><td></td><td></td><td></td></tr>
<tr><td>5.</td><td></td><td></td><td></td></tr>
<tr><td>etc.</td><td></td><td></td><td></td></tr>
</table>
HRIDC will allow maximum of one email Id for one company to participate in the VC. Any request for VC received after the given date and time for sending the link for VC may not be entertained by HRIDC. Prospective Tenderers will be able to join the VC through the link provided to them on their Email ID.
</td></tr>
<tr><td>ITT 7.5</td><td>Replace ITT 7.5 with the following:

The Tenderer is requested to submit any questions in writing, to reach the Employer not later than 2 days before the Pre-Tender Meeting.</td></tr>
<tr><td>ITT 7.6</td><td>Replace ITT 7.6 with the following:
Minutes of the Pre-Tender Meeting, including the text of the questions raised, without identifying the source, and the responses given, together with any responses prepared after the meeting will be uploaded on e-Procurement portal, https://etenders.hry.nic.in. Any modification to the Tender Document that may in the sole discretion of the Employer become necessary as a result of the Pre-Tender meeting shall be made by the Employer exclusively through the use of an Addendum pursuant to ITT 8.</td></tr>
</table>

ITT 8.2	**Replace ITT 8.2 with the following:** Any addendum issued shall be part of the Tender Documents and shall be uploaded on e-Procurement portal, https://etenders.hry.nic.in. The onus is on the Tenderers to visit the e- Procurement portal to see the addenda published by the Employer.
C. Preparation of Tenders	
ITT 10.1	The language of the Tender is: **English** All correspondence exchange shall be in **English** language. **Add the following at the end of Sub-Clause ITT 10.1** In case the Certificates/ documents other than Power of Attorney are in foreign language, the translation of the same shall be submitted in English language. The translation of Certificates / documents in foreign language shall be done by the licensed translator. Tenderer must submit copy of license issued by the competent authority in their country of origin. .
ITT 11.1	**Replace ITT 11.1 with the following:** The Tenderer shall submit their tender online on e-procurement portal https://etenders.hry.nic.in as mentioned in para ITT 21. The Tender shall comprise two parts submitted simultaneously, one called the Technical Part containing the documents listed in ITT 11.2 and the other the Financial Part containing the documents listed in ITT 11.3**.** The Tenderer shall upload only the above mentioned documents in its submission on e-procurement portal and is not required to upload Part 1, Part 2 and Part 3 of the Tender document issued by the Employer. The master copy of Tender Document published on e-Procurement portal shall be available with HRIDC which shall be final and binding.
ITT 11.2	**Replace the entire Sub-Clause 11.2 with the following:** The Tenderer shall submit all the documents in its Technical Part as per the Checklist CL (A. Technical Part) given in Section III: Evaluation and Qualification Criteria.
ITT 11.3	**Replace the entire Sub-Clause 11.3 with the following** The Tenderer shall submit all the documents in its Financial Part as per the Checklist CL (B. Financial Part) given in Section III: Evaluation and Qualification Criteria
ITT 13.1	Alternative Tenders **shall not be** considered.
ITT 13.2	Alternative times for completion **shall not be** permitted.

ITT 13.4	Alternative technical solutions **shall not** be permitted**.**
ITT 14.2	**Replace ITT 14.2 with the following: -** The Tenderer shall quote the total lump sum price for Schedule 'A' in the prescribed place of Price Schedule in MS-Excel file. The Tenderer shall quote single percentage (%) Excess (+) or Less (-) on the estimated amount for Schedule 'B' and Schedule 'C' in the prescribed place of Price Schedule in MS-Excel file.
ITT 14.4	**Replace ITT 14.4 with the following: -** As there is no lot in this Contract Package, no discounts shall be quoted by the Tenderers.
ITT 15.1	The currency(ies) of the Tender and the payment currency(ies) shall be as described below: The prices shall be quoted by the Tenderer in the Price Schedule in Indian Rupees (**INR)** only. A Tenderer expecting to incur expenditures in other currencies for inputs to the Works supplied from outside the Employer's Country (referred to as "the foreign currency requirements") shall indicate in the Appendix A to Financial Part - Table B, Section IV-Tender Forms the percentage(s) of the Tender Price (excluding Provisional Sums), needed by the Tenderer for the payment of such foreign currency requirements, limited to United States Dollar (USD), European Euro (EUR) and Japanese Yen (JPY).
ITT 18.1	The Tender validity period shall be 180 days after the Tender submission deadline date.
ITT 19.1	The Tenderer shall furnish a Tender Security for an amount of **INR 10,000,000.00 (INR Ten Million only) or USD 121, 000.00 (USD One Hundred Twenty One Thousand Only).**
ITT 19.2	Not Applicable
ITT 19.3	**Replace the ITT 19.3 with the following:** The amount for Tender Security specified in ITT 19.1 above can be paid online by eligible Tenderers on e-procurement Portal in INR in favour of Haryana Rail Infrastructure Development Corporation Limited using the electronic payment gateway service or Tender Security can be submitted in the form of unconditional and irrevocable Bank Guarantee in INR or USD from the specified banks using the Tender Security Form included in Section IV, Tender Forms. The Bank Guarantee shall be issued from: (i) a scheduled bank (excluding co-operative banks) in India, or (ii) a Foreign Bank having arrangement with a nationalized bank or scheduled banks (excluding co-operative banks) in India;

	The scheduled bank issuing the bank guarantee shall be on "Structure Financial Messaging System (SFMS)" platform. A separate advice of the Bank Guarantee shall invariably be sent by the issuing bank to the Employer's Bank through SFMS and only after receipt of the same by the Employer's Bank, the bank guarantee shall become operative and acceptable to the Employer. Further, the bank guarantee in original form along with a copy of "MT760COV (in case of bank guarantee message)/ MT767COV (in case of bank guarantee amendment message) Report" sent by the concerned issuing bank sealed in an envelope shall be submitted to the Employer within ten (10) days of deadline of submission of Tender. The Issuing Bank shall send the SFMS to: Beneficiary: Haryana Rail Infrastructure Development Corporation Limited Bank Name: *State Bank of India* Branch: *HNI Branch, Chandigarh* IFSC Code: *SBIN0018249* The Tender Security shall be valid for twenty-eight (28) days beyond the original validity period of the Tender, or beyond any period of extension if requested under ITT 18.2. In case the Tenderer has opted for Tender Security in the form of an unconditional Bank guarantee, the Tenderer shall upload the scanned copy of Bank Guarantee with the Tender. The original Bank Guarantee shall be delivered either by Registered Post/Speed Post/Courier or by hand within ten (10) days of deadline of submission of Tender at the address given below: **Chief Project Manager,** Haryana Rail Infrastructure Development Corporation Limited, Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram, Haryana-122003 Non submission of scanned copy of Bank Guarantee with the Tender on e-Procurement portal and/or no submission of original Bank Guarantee within the specified period shall lead to summary rejection of Tender. The details of the Original Bank Guarantee should match with the details available in the scanned copy and the data entered during Tender submission time, failing which the Tender shall be rejected. **Note:** 1. *Original copy of BG received in such a manner will be sent to the concerned Bank for its verification and only after its confirmation from the Bank, BG shall be acceptable by the Employer and Tender shall be evaluated.*

	2. *Option of Exemption from payment of EMD mentioned in the module of e-Procurement portal is only for exemption of online payment of Tender Security to the Tenderers who wish to submit Tender Security in the form of Bank Guarantee.*
ITT 20.1	**Replace ITT 20.1 with the following:** The Technical Part (comprising of documents specified in ITT 11.2) and Financial Part (comprising of documents specified in ITT 11.3) shall be submitted online on e-procurement portal of Government of Haryana (**https://etenders.hry.nic.in)** only in accordance with the requirements of the Tender Documents.
ITT 20.3	The written confirmation of authorization to sign on behalf of the Tenderer shall consist of: (a) In case of Private/Public Companies, a Power of Attorney from the Director of the Company who has been authorized by the Board of Directors through resolution to sign on behalf of the Company. Copy of Board Resolution shall also be submitted. In case of Foreign Members, Power of Attorney(s) and Board Resolution confirming authority on the persons issuing the Power of Attorney for such actions shall be submitted duly notarized by the notary public of country of origin and should be either stamped by Indian Embassy/High Commission or Member Countries of Hague convention may submit these document with "Apostille" stamp. (b) In case of Proprietory Tenderers, Power of Attorney by the Proprietor. (c) In case of Partnership firms, Power of Attorney duly signed by all the Partners. (d) In case of Limited Liability Partnership (LLP) firms, a Power of Attorney issued by the LLP in favour of the individual to sign the Tender on behalf of the LLP and create liability against the LLP. (e) In case of Joint Venture/Consortium, Power of Attorney duly signed by authorized representative of individual Member in favour of the Lead Member and Authorized representative of JV/Consortium. The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executant(s) and when it is so required the same should be under common seal affixed in accordance with the required procedure.
D. Submission of Tenders	
ITT 21	**Replace ITT 21 with the following:** 21.1 Tenderers shall upload their tender submission online on e-procurement portal (i.e. https://etenders.hry.nic.in) within the stipulated date and

	time as mentioned in ITT 22.1. The Tenderer shall ensure that they retain a copy of the receipt/ acknowledgement of their Tender submission which is generated by the system upon successful submission of Tender online. 21.2 Tenders sent telegraphically or through any other means of transmission except as mentioned above shall be treated as invalid and shall stand rejected. 21.3 No details about Financial Part shall be submitted/ disclosed directly or indirectly in the Technical Part failing which the employer has the right to reject the Tender.
ITT 22.1	**Replace ITT 22.1 with the following:** The Tender submission is through the e-procurement portal only (i.e. https://etenders.hry.nic.in) as specified in ITT 21.1 The Tenderer shall submit its Tender before expiry of the date and time for tender submission as specified herein. **The start date for Tender submission is:** **Date: 05.01.2023** **Time: 1100 hrs. IST** **The deadline for Tender submission is:** **Date: *03.02.2023*** **Time: 1500 hrs IST**
ITT 23.1	**Replace ITT 23.1 with the following:** Submission of Tenders shall be closed on e-procurement portal on the date & time of submission as prescribed in ITT 22.1 after which no tender can be uploaded.
ITT 24	**Replace ITT 24 with the following:** 24.1 The Tenderer may modify, substitute or withdraw its e-Tender after submission prior to the deadline for submission of Tenders. For modification of e-Tender, Tenderer has to detach its old Tender from e-procurement portal (https://etenders.hry.nic.in) and upload/ resubmit digitally signed modified tender. For withdrawal of tender, Tenderer has to click on withdrawal icon at e- procurement portal and can withdraw its e-tender. Before withdrawal of a tender, it may specifically be noted that after withdrawal of a tender for any reason, Tenderer cannot re-submit e-tender again.

	24.2 No Tender may be withdrawn, substituted, or modified in the interval between the deadline for submission of Tenders and the expiration of the period of Tender validity specified by the Tenderer on the Letter of Tender or any extension thereof.
E. Public Opening of Technical Parts of Tenders	
ITT 25	**Replace ITT 25 with the following:** 25.1 The Employer shall conduct the electronic opening of Technical Part on e-procurement portal on the date, time and place as specified below: **Street Address:** Haryana Rail Infrastructure Development Corporation Limited (HRIDC), Plot no.143, Railtel Tower, Sector-44 **Floor/ Room number:** 5th floor **City:** Gurugram **Zip code:** 122003 **Country:** INDIA **Date:** ***03.02.2023*** Time: **1530 hrs IST** The opening of the Technical Part and subsequent details can be viewed by the tenderers by logging on the e-procurement portal. Alternatively, any Tenderer who wish to attend the Technical Part opening can be present during the opening. The Tenderer's representatives who are present shall be requested to mark their attendance on the format available with the Employer. 25.2 The Financial Part submitted online on e-procurement portal will remain unopened in the e-procurement portal until the date and time of opening of Financial Part. The date and time of the opening of the Financial Part will be notified to all the Tenderers on e-procurement portal whose tender is found to be substantially responsive and qualified in technical evaluation as specified in ITT 34.2. 25.3 At the time of opening of Technical Part, the following shall be read out and recorded: (a) the name of the Tenderer; (b) the presence of a Tender Security; and

	(c) any other details as the Employer may consider appropriate. Only Technical Part read out and recorded at Tender opening shall be considered for evaluation. 25.4 The Employer shall prepare a record of the opening of Technical Part that shall include, as a minimum, the name of the Tenderer and the presence or absence of Tender Security. The Tenderers' representatives who are present shall be requested to sign the record available with the HRIDC. The omission of a Tenderer's signature on the record shall not invalidate the contents and effect of the record. 25.5 At the tender opening the Employer shall neither discuss the merits of any Tender nor reject any Tender.
F. Evaluation of Tenders – General Provisions	
ITT 27	**Replace ITT 27 with the following:** 27.1 To assist in the examination, evaluation and comparison of the Tenders, the Employer may, at its discretion, ask any Tenderer for a clarification of its Tender. Any clarification submitted by a Tenderer that is not in response to a request by the Employer shall not be considered. The Employer's request for clarification and the response shall be in writing and delivered to concerned Tenderers (by courier or e-mail through PDF attachment). The due date and time to respond to these queries will also be communicated. No change in the prices or substance of the Tender shall be sought, offered, or permitted, except to confirm the correction of errors discovered by the Employer in the evaluation of the Financial Part, in accordance with ITT Clause 35. 27.2 If a Tenderer does not provide clarifications of its Tender by the date and time set in the Employer's request for clarification, their Tender shall be evaluated as per the available information in the submitted Tender.
ITT 29.3	Not Applicable
G. Evaluation of Technical Parts of Tenders	
ITT 30.2	Not Applicable

ITT 32.4	**Replace ITT 32.4 with the following:** Only Tenders that are both substantially responsive to the Tender Document, and meet all Qualification Criteria, shall be notified on e-procurement portal for the public opening of "FINANCIAL PART".
ITT 33.1	Subcontractor is permitted for the activity specified in ITT 33.3.
ITT 33.2	Maximum allowable accumulated value of work to be subcontracted (as a percentage of the Accepted Contract Amount)- 30%
ITT 33.3	Sub-Contractor is permitted for Construction of Ballastless Track system.
H. Public Opening of Financial Parts of Tenders	
ITT 34	**Replace ITT 34 with the following:** 34.1 Following the completion of the evaluation of the Technical Parts of the Tenders, and the Bank has issued its no objection (if applicable), the Employer shall notify in writing those Tenderers whose Tenders were considered non-responsive to the Tender Document or failed to meet the Qualification Criteria, advising them of the following information: (a) the grounds on which their Technical Part of Tender failed to meet the requirements of the Tender Document; (b) their "FINANCIAL PART" shall remain unopened on the e-procurement portal; (c) notify them of the date, time and location of the public opening of "FINANCIAL PART" on the e-procurement portal; 34.2 The Employer shall, simultaneously, notify in writing those Tenderers whose Tenders - Technical Parts have been evaluated as substantially responsive to the Tender Document and met all Qualifying Criteria, advising them of the following information: (a) their Tender has been evaluated as substantially responsive to the Tender Document and met the Qualification Criteria; (b) their "FINANCIAL PART" on e-procurement portal will be opened at the public opening of the Financial Parts; and (c) notify them of the date, time and location of the public opening of the "FINANCIAL PART" as specified below: i. The Employer shall publish a notice of the public opening of the Financial Parts on e-procurement portal.

	ii. Any interested party who wishes to attend this public opening may contact: **For the attention:** Chief Project Manager **Employer:** Haryana Rail Infrastructure Development Corporation Limited **Email address:** horc.etendering@gmail.com 34.3 The "FINANCIAL PART" of Tenderers who met the Qualification Criteria and whose Tenders were evaluated as substantially responsive, will be opened on e-procurement portal. The Employer shall read out the names of each Tenderer, and the total Tender prices, per lot (contract) if applicable, including any discounts and any other details as the Employer may consider appropriate. 34.4 The Employer shall neither discuss with Tenderer's representative present, if any, the merits of any Tender nor reject any "FINANCIAL PART". 34.5 The Employer shall prepare a record of the Financial Part of the Tender opening that shall include, as a minimum: (a) the name of the Tenderer whose Financial Part was opened; (b) the Tender price, per lot (contract) if applicable, including any discounts; and (c) if applicable, any Alternative Tender – Financial Part. 34.6 The Tenderer's representatives who are present at the time of opening of Financial Part shall be requested to sign the record. The omission of a Tenderer's signature on the record shall not invalidate the contents and effect of the record. A copy of the record (i.e. summary of rates quoted) can be viewed by all eligible Tenderers after opening of the Financial Part.
I. Evaluation of Financial Parts of Tenders	
ITT 37.1	The currency that shall be used for tender evaluation and comparison purposes is **Indian Rupees (INR) only.**
ITT 38.1	Provisions for development of domestic industry (such as a margin of domestic preference shall not apply.
J. Award of Contract	
ITT 47.1	**Add the following to ITT 47.1**

	The Accepted Contract Amount shall be in **INR** only. However, the payments will be made in currencies as quoted by the Tenderer in Appendix A, Table B, Section IV-Tender Forms.
ITT 49.1	The successful Tenderer shall submit the Beneficial Ownership Disclosure Form.
ITT 51.1	The procedures for making a Procurement-related Complaint are detailed in the Bank's Procurement Instructions for Recipients (Annex IV). A Tenderer may make a Complaint in writing, to: **For the attention:** Chief Project Manager **Employer**: Haryana Rail Infrastructure Development Corporation Limited **Email address***: horc.etendering@gmail.com*

Section III. Evaluation and Qualification Criteria

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1. General Provisions

1.1 Evaluation Sequence

(a) Tenders will be evaluated through the following four stages:

(i) Stage 1: Evaluation of Administrative Requirements

(ii) Stage 2: Evaluation of Compliance with the Qualification Requirements

(iii) Stage 3: Technical Evaluation

(iv) Stage 4: Financial Evaluation

1.2 Clarification from Tenderers

(a) The Engineer may request clarification of any Tender in accordance with the provisions of the Tender Documents (Part 1, Section-I: Instructions to Tenderers, Clause 27).

(b) If clarification is required, the Engineer will send written (Courier/email with PDF attachment) requests to the Authorized Representative for clarification, specifying the deadline for receipt of reply.

(c) Replies to the above requests shall be sent by Tenderer through Courier/e-mail with PDF attachments and the same shall be solely to clarify and/or elaborate the items already included in the submitted Tenders for the purpose of evaluation in accordance with ITT 27.1.

1.3 Tender Forms

(a) Tenderers should note that the information required to be inserted into the Tender Forms shall be comprehensive and detailed. The technical information shall be furnished in line with the requirements of Part 1, Part 2 and Part 3 of the Tender Documents.

(b) All Forms contained in the Tender Documents must be fully and properly completed and all the forms must be returned duly signed by Authorised Representative of the Tenderer, as they will be reviewed exactly as submitted and errors or omissions may count against the Tenderer.

(c) Any Tenderer who is found to have intentionally submitted false or inaccurate statements/information shall be disqualified from the Tendering process.

2. Stages of Evaluation

2.1 Stage 1: Evaluation of Administrative Requirements

A. General

(a) The Stage 1 Evaluation will consist of checking the Tenders to confirm whether they are substantially responsive to the administrative requirements of the Tender Documents.

(b) The following administrative items will be checked:

(i) Whether the Tender submission is in accordance with ITT 11.2;

(ii) Whether the Power of Attorney (POA) for the Tender signatory is in the correct form [Ref. ITT 20.3 and ITT 20.4]. If during technical evaluation stage, POA submitted by the Tenderer is not found in the correct format, Employer will send written (Courier/email with PDF attachment) request to the Authorized Representative for rectification of POA in accordance with format prescribed in Section IV, Tender Forms, specifying the deadline for receipt of Power of Attorney in correct form. If a Tenderer does not provide the Power of Attorney in correct form within the stated date and time set in the Employer's request for correction of Power of Attorney, its Tender is liable to be rejected.

2.2 Stage 2: Evaluation of Compliance with the Qualification Requirements

B. General

Tenders will be reviewed to ascertain whether the Tender complies with all of the minimum requirements as stipulated in the Clause 3. Qualification Criteria.

C. Check Items

The following requirements of the Instruction to Tenderers, Clauses 4, 11 & 17 will be checked to ensure compliance to the requirements of criteria given below:

(a) Eligibility

(i) Nationality: Form ELI-1.1(a), ELI-1.1(b), and Form ELI-1.2
(ii) Conflict Interest: Letter of Tender-Technical Part
(iii) Bank Eligibility: Letter of Tender -Technical Part
(iv) State-owned Enterprise or Institution of the Recipient country: ELI-1.1(a), ELI-1.1(b), and Form ELI-1.2, Letter of Tender -Technical Part
(v) United Nations resolution or Recipient's country law: Letter of Tender-Technical Part

(b) Historical Contract Non-Performance and Litigation

(i) History of Non-Performing Contracts: Form CON-1
(ii) Suspension Based on Execution of Tender- Securing Declaration by the Employer: Letter of Tender-Technical Part
(iii) Pending Litigation: Form CON-1
(iv) Declaration: Environmental, Social, Health, and Safety (ESHS) past performance: Form CON-2

(c) Financial Situation

(i) Financial Situation and Performance: Form FIN-3.3.1
(ii) Average Annual Construction Turnover: Form FIN-3.3.2

(d) Financial Resources

(i) Financial Resources: Form FIN-3.3.3
(ii) Bid Capacity: Form FIN-3.3.4

(e) Experience

(i) General Construction Experience: Form EXP-3.4.1
(ii) Specific Construction and Contract Management Experience: Form EXP-3.4.2(a)
(iii) Specific Construction Experience in Key Activities: Form EXP-3.4.2(b)

3. Qualification Criteria

If the Tenderer fails to comply with any item of Qualification Criteria given below, the Tenderer shall be disqualified.

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
3.1 Eligibility							
3.1.1	**Nationality**	Nationality in accordance with ITT 4.4	Must meet requirement	Must meet requirement	Must meet requirement	Must meet requirement	Forms ELI – 1.1(a). 1.1 (b) and 1.2, with attachments
3.1.2	**Conflict of Interest**	No conflicts of interest in accordance with ITT 4.2	Must meet requirement	Must meet requirement	Must meet requirement	Must meet requirement	Letter of Tender-Technical Part
3.1.3	**Bank Eligibility**	Not having been declared ineligible by the Bank, as described in ITT 4.5.	Must meet requirement	Must meet requirement	Must meet requirement	Must meet requirement	Letter of Tender-Technical Part
3.1.4	**State-owned Enterprise or Institution of the Recipient country**	Meets conditions of ITT 4.6	Must meet requirement	Must meet requirement	Must meet requirement	Must meet requirement	Letter of Tender-Technical Part
3.1.5	**United Nations resolution or Recipient's country law**	Not having been excluded as a result of prohibition in the Recipient's country laws or official regulations against commercial relations with the	Must meet requirement	Must meet requirement	Must meet requirement	Must meet requirement	Letter of Tender-Technical Part

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
		Tenderer's country, or by an act of compliance with UN Security Council resolution, both in accordance with ITT 4.8 and Section V.					
3.1.6	**Share of JV members**	The share of JV members shall not be less than the specified percentage	N/A	100%	30%	34%	Form ELI-1.3
3.2 Historical Contract Non-Performance							
3.2.1	**History of Non-Performing Contracts**	Non-performance of a contract[1] did not occur as a result of contractor default since 1st April 2017 till 28 days prior to deadline of Tender submission.	Must meet requirement	Must meet requirements	Must meet requirement[2]	Must meet requirement	Form CON-1

[1] Nonperformance, as decided by the Employer, shall include all contracts terminated by the Employer where (a) nonperformance was not challenged by the contractor, including through referral to the dispute resolution mechanism under the respective contract, and (b) contracts that were so challenged but fully settled against the Contractor. Nonperformance shall not include contracts where Employer's decision was overruled by the dispute resolution mechanism. Nonperformance must be based on all information on fully settled disputes or litigation, i.e., dispute or litigation that has been resolved in accordance with the dispute resolution mechanism under the respective contract and where all appeal instances available to the Tenderer have been exhausted.

[2] This requirement also applies to contracts executed by the Tenderer as JV member.

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
3.2.2	**Suspension Based on Execution of Tender-Securing Declaration by the Employer**	Not under suspension based on-execution of a Tender/Proposal Securing Declaration pursuant to ITT 4.7 and ITT 19.9	Must meet requirement	Must meet requirement	Must meet requirement	Must meet requirement	Letter of Tender – Technical Part
3.2.3	**Pending Litigation**	Tenderer's financial position and prospective long-term profitability still sound according to criteria established in 3.3.1 (iii) below and assuming that all pending litigation will be resolved against the Tenderer	Must meet requirement	N/A	Must meet requirement	Must meet requirement	Form CON-1
3.2.4	**Litigation History**	Not Applicable					
3.2.5	**Declaration: Environmental, Social, Health, and Safety (ESHS) past performance**	Declare any civil work contracts that have been suspended or terminated and/or performance security called by an employer for reasons related to the non-compliance of any	Must make the declaration	N/A	Must make the declaration.	Must make the declaration	Form CON-2 ESHS Performance Declaration

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
		environmental, or social, or health, or safety requirements or safeguard in the past five years [3] preceding 28 days prior to deadline of Tender submission					
3.3 Financial Situation and Performance							
3.3.1	**Financial Capabilities**	(i) The Tenderer shall demonstrate that it has access to, or has available, liquid assets, unencumbered real assets, lines of credit, and other financial means (independent of any contractual advance payment) sufficient to meet the construction cash flow requirements estimated as **INR *510* million (USD *6.21* million)** for the subject contract **(i.e. C-4).**	Must meet requirement	Must meet requirement	Must meet at least 30% *[Thirty percentage]* of the requirement	Must meet at least 40% *[Forty percentage]* of the requirement	Form FIN-3.3.3 (Sources of Finance for the subject Contract)

[3] The Employer may use this information to seek further information or clarifications in carrying out its due diligence.

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
		(ii) The Tenderer shall also demonstrate, to the satisfaction of the Employer, that it has adequate **Bid capacity** for the works currently in progress and future contract commitments. The **available Bid capacity** should be equal to or more than **INR 12300 million (USD 149.27 million)**. The available Bid capacity will be calculated as per item no. 1 of Form FIN- 3.3.4.	Must meet requirement	Must meet requirement	Must meet at least 30% *[Thirty percentage]* of the requirement	Must meet at least 40% *[Forty percentage]* of the requirement	Form FIN-3.3.2 & Form FIN-3.3.4
		(iii) The Tenderer must demonstrate the current soundness of its financial position and indicate its prospective long-term profitability. a) Average Net-Worth (Total Assets – Total Liabilities)* during the last	Must meet requirement	Must meet requirement	Must meet requirement	Must meet the requirement	Form FIN-3.3.1

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
		three (03) financial years should be **positive** and also the Net-worth during the last financial year should be positive. *Note: Amount corresponding to all pending litigations, considering that these will be resolved against the Tenderer (as per Form CON-1 item 2), shall be subtracted from the average Net Worth calculated above.					
3.3.2	**Average Annual Construction Turnover**	Minimum average annual construction turnover of **INR *4610* million (USD *56.00* million)**, calculated as total certified payments received for contracts in progress and/or completed within the last three financial years divided by three.	Must meet requirement	Must meet requirement	Must meet at least 30% *[Thirty percentage]* of the requirement	Must meet at least 40% *[Forty percentage]* of the requirement	Form FIN-3.3.2

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
3.4 Experience							
3.4.1	**General Construction Experience**	Experience under construction contracts in the role of Prime contractor, JV member or Management Contractor or a sub-contractor starting 1st April 2015 till 28 days prior to deadline of Tender submission.	Must meet requirement	N/A	Must meet requirement	Must meet requirement	Form EXP-3.4.1
3.4.2 (a)	Specific Construction & Contract Management Experience	Participation, as a Prime contractor, Joint venture [4] member or Management Contractor [5]	Must meet requirement	Must meet requirement	Must have the experience of executing at least one "similar work" of value **INR 3690 million**	Must have the experience of executing at least one "similar work" of value **INR 3690 million**	Form EXP-3.4.2(a)

[4] Value of completed work done by a Member in an earlier JV shall be reckoned as per the Note 2 given at the end of Sub-Clause 3.4.2 (a), Section III, EQC for purpose of satisfying his/her experience criteria mentioned in 3.4.2(a).

[5] A management contractor is a firm which takes on the role of contract management as a "general" contractor of sort could do. It does not normally perform directly the work(s) associated with the Contract. Rather, it manages the work of other Contractors/Sub-Contractors while bearing full responsibility for quality, and timely performance of the contract. If the Tenderer or any of the JV/Consortium member submits experience certificate as a Management Contractor, then the documents issued by the Employer (owner of the work) in support of his being appointed as Management Contractor shall only be considered for evaluation and qualification purpose. In case the Tenderer fails to submit such document(s) issued by the Employer (owner of the work), the offer of the Tenderer shall be summarily rejected.

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
		or Sub-Contractor [6] in at least (i) one "similar work"* of value of **INR 7380 million (USD 89.56 million)** or more. OR (ii) two "similar works"* each of value of **INR 4920 million (USD 59.71 million)** or more. OR (iii) three "similar works"* each of value of **INR 3690 million (USD 44.78 million)** or more. The *Works* mentioned in (i) or (ii) or (iii) above must have been successfully			**(USD 44.78 million)** or more that has been successfully ***completed*** **or substantially completed** since 1st April 2015 till 28 days prior to deadline of Tender submission	**(USD 44.78 million)** or more that has been successfully ***completed*** **or substantially completed** since 1st April 2015 till 28 days prior to deadline of Tender submission	

[6] If a tenderer has successfully completed a work as Sub-Contractor, the work experience certificate issued only by the Employer (owner of the work) for such work to Sub-Contractor shall be considered for the purpose of fulfillment of credentials. Tenders submitted without this documentary proof shall be summarily rejected.

For example: Entity **'A'** is the owner of the work and awards a contract for execution of work to Contractor **'X'**. Thereafter, Contractor **'X'** sublets part of the work to Sub-Contractor **'Y'**. In this case, experience certificate of Sub-Contractor **'Y'** issued only by Entity **'A'** shall be considered for the purpose of evaluation of the Tender. Experience certificate issued by Contractor **'X'** to Sub-Contractor **'Y'** shall not be considered and the offer submitted based on such certificate shall be summarily rejected.

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
		completed or substantially completed [7] since 1st April 2015 till 28 days prior to deadline of Tender submission and that are similar to the proposed works. ***"Similar work"** shall be *any infrastructure work for Railway / Metro Rail / RRTS / Road project involving civil works. .*					
3.4.2 (b)	***Specific Construction Experience in Key Activities***	*Participation, as a Prime Contractor, Joint venture member or Management Contractor or Sub-Contractor in:* *(i) one contract involving minimum **3.0 km** of equivalent length[8] of*	*Must meet requirement*	*Must meet requirement*	*Must have the experience of executing at least **1.5 km** of equivalent length of NATM tunnel in infrastructure*	*Must have the experience of executing at least **1.5 km** of equivalent length of NATM tunnel in infrastructure*	*Form EXP-3.4.2 (b)*

[7] Substantial completion shall be based on 80% or more of the original value of works completed under the contract.

[8] **For calculation of equivalent length of NATM tunnel:**

a) In case of Twin Tunnel construction by NATM, each tunnel shall be counted as a separate tunnel for calculation of equivalent length of NATM tunnel

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
		NATM tunnel in infrastructure project for Railway / Metro Rail / RRTS / Road. *OR* *(ii) two contracts involving minimum cumulative equivalent length of **4.0 km** NATM tunnel in infrastructure project for Railway / Metro Rail / RRTS / Road.* *OR* *(iii) three contracts involving minimum cumulative equivalent length of **4.5 km** NATM tunnel in infrastructure project*			*project for Railway/Metro Rail/RRTS/Road in one contract **completed** since 1st April 2015 till 28 days prior to deadline of Tender submission **or in one ongoing contract**.*	*project for Railway/Metro Rail/RRTS/Road in one contract **completed** since 1st April 2015 till 28 days prior to deadline of Tender submission **or in one ongoing contract**.*	

b) Construction of **1** Under Ground station by NATM for Railway/Metro Rail /RRTS/Road projects shall be considered equivalent to construction of 1Km of NATM Tunnel.

c) Length of cross passages between two tunnels or between main tunnel & escape tunnel shall not be considered for calculating equivalent length of tunnel.

d) Experience certificate of "Drill & Blast tunnelling" not involving NATM shall not be considered.

No.	Subject	Requirement	Single Entity	Joint Venture/Consortium (existing or intended)			Submission Requirements
				All Members Combined	Each Member	Lead Member	
		for Railway / Metro Rail / RRTS / Road. *The key activity mentioned in (i) or (ii) or (iii) above should have been executed in contracts* ***completed*** *since 1st April 2015 till 28 days prior to deadline of Tender submission* ***or in ongoing[9] contracts****.*					

[9] *In case of* ***ongoing contracts****, only that length of NATM tunnel shall be considered for evaluation of equivalent length of NATM tunnel for which primary support system and lining have been completed. If lining is not applicable, experience certificate issued by the Employer must clearly state that there is no requirement of lining of tunnel as per the approved design.*

Notes:

1. Exchange Rate for Qualification Criteria

Wherever a Form in Section IV, Tender Forms, requires a Tenderer to state a monetary amount, Tenderers shall indicate the INR equivalent as indicated in the respective form using the rate of exchange determined as follows:

(i) For construction turnover or financial data required for each year – Exchange rate prevailing on the last day of the respective financial year.

(ii) Value of single contract - Exchange rate prevailing on the date of the Contract Award i.e. the date of issue of Letter of Acceptance.

(iii) Exchange rates shall be taken from reference rate published by the Reserve Bank of India (RBI) on its website https://www.rbi.org.in. In case the exchange rate of particular currency on given date is not available on RBI web site, it will be as per the web site https://www.fbil.org.in of Financial Benchmark India Private Limited (FBIL). Any error in determining the exchange rates may be corrected by the Employer. In the case, where a Tenderer is required to convert a monetary amount from a currency other than those currencies for which the RBI/FBIL reference rate is not published, the INR equivalent shall be worked out using the rate of exchange as published by the central bank of the country issuing the said currency. In case the exchange rate of that currency is not directly available in INR on the website of the central bank of the country issuing the said currency then the currency will be first converted to USD as per that web site and then converted from USD to INR as Per RBI or FBIL reference rates.

2. *Value of completed work done by a Member in an earlier JV shall be reckoned only to the extent of the concerned member's share in that JV for purpose of satisfying his/her experience criteria mentioned in 3.4.2(a).*

3. *For past experience of a firm in earlier JV for specified* key *activity in sub clause 3.4.2 (b) credit shall be given for execution of that quantity of the specified* key *activity executed by the firm as part of a JV, duly certified by the Employer. If the Employer's Certificate does not indicate the quantity of specified* key *activity executed by each member, in such a case credit for quantity of specified key activity shall be given as per following provisions in order of priority:*

(i) As per details given in JV agreement forming part of the relevant Contract Agreement.

(ii) If JV agreement does not provide such details, then credit shall be given in

proportion of the percentage share of the firm in that JV mentioned in the Employer's Certificate/ JV Agreement.

4. *In case a JV quoting for the Tender has executed similar work specified in 3.4.2(a) with the same constitution of JV, the requirement specified to be met under Sub-Clause 3.4.2(a) shall be considered to have been met treating the JV as a single entity for this purpose.*
5. *For Sub-Clause 3.3.2, Average Annual Construction Turnover, the Tenderer should submit actual construction turnover figures for the specified financial years. For Evaluation purposes the figures of previous years shall be updated @ 5% per year compounded annually based on Rupee value to bring them to the level of the last Financial Year specified in Sub-Clause 3.3.2. If the figure for turnover in an individual year is in a currency other than INR, then the same shall first be converted to INR based on the exchange rates derived as mentioned in Note 1 above and then the figures in INR shall be updated.*
6. *For Sub-Clause 3.4.2 (a) Specific Construction & Contract Management Experience, the Tenderer should submit actual Value of Work completed/ substantially completed. Value of Work for Evaluation purposes shall be updated @ 5% per year compounded annually based on Rupee value to bring them to the price level of date of deadline for submission of Tenders. Updated value shall be calculated as per formula given below:-*

$A = Bx\ [1.05]^{N/365}$

Where

A = updated value of work on deadline for submission of Tenders.

B = value of work on the date of completion/substantial completion as indicated in the Employer's certificate.

N = Number of days between date of completion and deadline for submission of Tenders.

4. Stage 3: Technical Proposal Evaluation

A. Procedure for Technical Proposal Evaluation

(a) The Stage 3 Evaluation will consist of checking the technical aspects of the Tenders to confirm whether they substantially conform to the requirements of the Tender Documents.

(b) In order to determine whether the Tender substantially conforms to the technical requirements of the Tender Documents, the Technical Proposal shall broadly cover the following items:

S. No.	Technical Evaluation Items	Relevant Forms
1.	Proposed Works Programme and Proposed Design Submission Programme	Form TP-1, Technical Proposal
2.	Proposed Construction Method Statement	Form TP-2, Technical Proposal
3.	Outline Project Management Plan	Form TP-3, Technical Proposal
4.	Outline Quality Assurance and Quality Control Plan	Form TP-4, Technical Proposal
5.	Outline Environment, Social, Health and Safety Plan	Form TP-5, Technical Proposal

The documents mentioned in above Table will be used for the purposes of evaluating and analysing the Tender but will not form part of the Contract unless the same shall have been expressly incorporated into the Contract.

(c) The Technical Proposal will be evaluated to examine the responsiveness and to assess the capability of the Tenderer in executing the proposed work.

B. Technical Proposal

The Tenderer shall be required to amplify, explain and develop the Tenderer's Technical Proposals in substantially greater detail during the Tender evaluation period such that they may be confirmed as complying clearly with the Part 2, Section VII-Employer's Requirements and can be incorporated into the Contract. Technical proposal shall be submitted as per **Annexure-2**: Requirements for Tenderer's Technical Proposals, Section III, EQC. Broad details of various items of Technical Proposal given in above Table are mentioned below:

B1 Proposed Works Programme and Proposed Design Submission Programme:

B1.1 The Tenderer shall submit with his Tender proposed Works Programme which shall indicate how the Tenderer intends to organise and carry out the Works and achieve Stages and

complete the whole of the Works by the appropriate Key Dates. Detailed requirements for the Proposed Works Programme are set out in **Annexure 1** to Section III, EQC.

B1.2 The Proposed Works Programme shall be prepared in terms of weeks from the Date for Commencement of Works.

B1.3 The Proposed Works Programme shall not in any event be construed as a submission of the Works Programme under Clause 8.3 of the GCC.

B1.4 The Tenderer shall submit with his Tender his proposed Design Submission Programme to cover the Design Phase. Such proposed programme shall:

(a) be consistent with the Proposed Works Programme and accord with Appendix 4 of Section VII-9: Appendices to Part 2- Employer's Requirements;
(b) make adequate allowance for periods of time for review by authorities whose approval is necessary;
(c) include a schedule identifying, describing, cross-referencing and explaining the Design Packages and Submissions which the Tenderer intends to submit;
(d) take due account of the design co-ordination interface periods during which the Contractor shall be required to undertake and complete all aspects of design co-ordination with Interfacing Contractors of C-23 and C-5 Packages.

The proposed Design Submission Programme submitted at the time of Tender shall be modified and developed as necessary to incorporate the Employer's requirements in respect of review by the Engineer.

B1.5 The Tenderer's attention is drawn to the requirements of Key Dates to Appendix 2 of Section VII-9 Appendices, Part 2 Employer’s requirements regarding submission of Design Submission Programme.

B2 Proposed Construction Method Statement:

B2.1 The Tenderer shall submit with his Tender, the methods by which the Tenderer intends to construct the Works. The construction methods to be employed will be analysed during the Tender evaluation and their descriptions shall be in sufficient detail to allow a full appreciation of the Tenderer's proposals in relation to all aspects of the Works

B3 Outline Project Management Plan:

In order to ensure satisfactory execution, achievement of Key Dates and timely completion of the Works, the Tenderer shall submit an outline Project Management Plan with his Tender. This Plan, in co-ordination with the Proposed Works Programme shall clearly demonstrate the Tenderer’s proposed management system, methods, procedures, processes, organization, sequences of activities etc., required to meet the Key Dates and the Completion Date. A narrative shall describe the sequence, nature and inter-relationship of the main activities including timing for exchange of information.

The Engineer shall review it and has the right to require necessary amendments to ensure that Key Dates will be met and that requirements for the activities of the Interfacing Contractors, have been catered for.

B4 Outline Quality Assurance and Quality Control Plan:

B4.1 The Contractor shall establish and maintain a Quality Assurance System in accordance with **Appendix 11** of Section VII-9:Appendices, Part 2 Employer's requirements for Design, Construction, procedures and the interfaces between them and other contractors.

This Quality Assurance system shall be applied without prejudice to, or without in any way limiting, any Quality Assurance Systems which the Tenderer already maintains.

B4.2 The Tenderer shall submit as part of his Tender Outline Quality Assurance and Quality Control Plan illustrating the intended means of compliance with **Appendix 11** of Section VII-9: Appendices, Part 2 Employer's requirements and setting out in summary form an adequate basis for the development of the more detailed documents required under Clause 4.9 of GCC. The Outline Quality Assurance and Quality Control Plan shall contain sufficient information to demonstrate clearly the proposed method of achieving the Tenderer's quality objectives with regard to the requirements of the Contract.

B5 Outline Environment, Social, Health and Safety Plan:

B5.1 The Tenderer shall submit as part of its Tender an Outline Environment, Social, Health and Safety Plan which shall contain sufficient information to demonstrate clearly the Tenderer's proposals for achieving effective and efficient Environment, Social, Health and Safety procedures, which shall also include aspects for use of blasting. The Outline Environment, Social, Health and Safety Plan should include an outline of the safety procedures and regulations to be developed and the mechanism by which they will be implemented for ensuring safety as required as per **Appendix 13**, ESHS Manual, Section VII-9: Appendices, Part 2: Employer's Requirements.

C. Evaluation of Technical Proposal

Evaluation of the Tenderer's Technical Proposal will be carried out based on the information furnished in Section IV- Tender Forms, TP-1 to TP-5. It is expected that the Tenderer visits the site and is fully of aware of all the work requirements under this Tender, and then prepares the Technical Proposal.

All Tenders which are found substantially responsive after Stage 3 evaluation will proceed to the next stage.

5. STAGE 4: Financial Evaluation

The activities in this Stage 4 will be in two (2) parts.

A. Evaluation of Compliance and Responsiveness

(a) Under this Stage the following items will be checked:

(i) Whether the Letter of Tender-Financial Part is compliant (i.e. does not include any alteration to the basic terms and does not constitute an alternative offer).

(ii) Whether all Forms and Price Schedules have not been altered and are correctly completed and signed.

B. Detailed Financial Evaluation

(a) After passing the above requirements, the Tender will then proceed for Financial Part evaluation in accordance with ITT 35.

(b) In principle, the lowest evaluated Tender resulting from 'A' above will move to next stage as per ITT "J. Award of Contract", described in ITT Clauses 46 to 50.

ANNEXURE 1

Requirements for Proposed Works Programme

(1) The Proposed Works Programme shall show how the Tenderer proposes to organise and carry out the Design and Construction Works and to achieve Stages and complete the whole of the Works by the given Key Dates.

(2) The Proposed Works Programme or Programmes shall be developed as a critical path network using suitable software. The network must be fully resourced. The Works Programme shall show achievement of all Key Dates and Works Area Access Dates.

(3) The Proposed Works Programme shall take account of the Tenderer's proposed Design Submission Programme and should indicate, as far as possible, dates and periods relating to interfaces with and between others including dates for submission of further documents required by the Contract and periods for their acceptance.

(4) The Proposed Works Programme shall contain sufficient detail to assure the Employer of the feasibility of the plan and approach proposed by the Tenderer.

(5) The Proposed Works Programme shall be accompanied by a narrative statement that shall describe Programme activities, assumptions and logic, and highlight the Tenderer's perception of the major constraints and critical areas of concern in the organisation, construction and completion of the Works. This narrative statement shall also indicate which elements of the Works the Tenderer intends to carry out off-Site with details of the proposed locations of where any such work is to be carried out, the facilities available.

(6) All programmes shall include design, procurement periods, major material, offsite production/ prefabrication, temporary construction and interface with Interfacing Contractors.

ANNEXURE 2

Requirements for Tenderer's Technical Proposals

1. The Tenderer's Technical Proposals shall comply or, subject to reasonable development, be capable of complying with the Employer's Requirements in all respects. The Tenderer's Technical Proposals shall demonstrate such compliance. The Tenderer's Technical Proposals shall establish firmly the intended design and methodology for the Permanent Works.

2. The Tenderer's Technical Proposals shall cover the following:

2.1 Construction of Tunnel (NATM)

(i) Proposed Construction methodology of Tunnel, Portals, permanent ventilation shafts, construction cum utility shaft
(ii) Proposed tunnelling equipment and machinery
(iii) Proposed construction methodology of cross passages

2.2 Construction of Tunnel (Cut & Cover)

(i) Proposed Construction methodology of Tunnel
(ii) Proposed equipment and machinery
(iii) Proposed construction methodology of cross passages

3. The Tenderer's Technical Proposals shall include the following documents:

3.1 Drawings

Drawing shall illustrate:
i) proposed primary support systems for NATM tunnels in rock and soil
ii) Proposed Portals P1 and P2
iii) Proposed Permanent Ventilation shafts and construction cum utility shaft
iv) Proposed secondary lining details
v) Proposed Cross passages

4. The Tender shall be accompanied by documents in amplification of the Tenderer's Technical Proposals, which shall include:

4.1 Technical Notes

Such technical notes or notes on calculations necessary for understanding and explaining the Tenderer's Technical Proposals and proposed arrangements for primary and secondary support system for the tunnel.

4.2 Site Investigation Proposals

Results of any site investigations undertaken by the Tenderer and proposals for site investigations to be undertaken by the Contractor indicating the nature of the investigations, locations and intended purposes with respect to design philosophy

at the time of initial design before start of the work and investigation to be undertaken during execution for validation and design modification depending upon geological conditions encountered during excavation.

Checklist-CL

Checklist of submission of Documents/Forms online, duly filled

(Reference to TDS-ITT 11.2 & 11.3, Section II, Part 1)

A. TECHNICAL PART

S. No.	Requirement of Tender Document	Ref. Clause of Tender documents	Tenderer's Name:	
			Whether information submitted (Yes/No/N.A.)	Ref. Pg No. in the Technical Submittal
1.	Letter of Tender-Technical Part	ITT 11.2 (a) and Section IV		
2.	Technical Part signed by authorized representative of the Tenderer	ITT 20.3		
3.	Tender Security -Online Receipt or Scanned copy of Bank Guarantee	ITT 19.1, ITT 19.3 and Appendix E of Section IV		
4.	Form ELI – 1.1: (a) Tenderer Information Form	ITT 17.1 and Appendix D of Section IV		
5.	Form ELI – 1.1: (b) Tenderer Information Form (JV/Consortium)	ITT 17.1 and Appendix D of Section IV		
6.	Form ELI – 1.2: Tenderer's JV Member Information Form	ITT 17.1 and Appendix D of Section IV		
7.	Form ELI – 1.3: Joint Venture/Consortium Agreement	ITT 17.1 and Appendix D of Section IV		
8.	Form ELI-1.4: Power of Attorney (POA) for Submitting Tender	ITT 20.3 and Appendix D of Section IV		
9.	Board Resolution in case of a Public/Private limited company/LLP	TDS ITT 20.3		
10.	Incorporation Certificate and Memorandum and Articles of Association (MOA & AOA) (in case of Private/Public Limited Company)	Note (iii) (d) of Form ELI 1.4		
11.	Incorporation Certificate and Limited Liability Membership Agreement in case of Limited Liability Membership firms.	Note (iii) (e) of Form ELI 1.4		
12.	Proprietorship Affidavit (in case the Tenderer is Proprietorship Tenderer)	Note (iii) (a) of Form ELI 1.4		

S. No.	Requirement of Tender Document	Ref. Clause of Tender documents	Tenderer's Name:	
			Whether information submitted (Yes/No/N.A.)	Ref. Pg No. in the Technical Submittal
13.	Partnership Deed (in case the Tenderer is Partnership Firm)	Note (iii) (b) of Form ELI 1.4		
14.	Form ELI-1.5: Power of Attorney (POA) for Authorized Signatory of Joint venture (JV) Members	ITT 20.4		
15.	Form ELI-1.6: Power of Attorney to Lead Member and Authorised Representative of Joint venture (JV)	ITT 20.4		
16.	In case of foreign tenderer, the Notarised POA/MOU/JV Agreement is notarised in the country of origin and stamped by India Embassy/ High Commission or Member Countries of Hague convention submitted these documents with "Apostille" stamp	Note (i) of Form ELI 1.4		
17.	Form CON - 1: Historical Contract Non-Performance, Pending Litigation and Litigation History	ITT 17.2 and Appendix D of Section IV		
18.	Form CON - 2: Environmental, Social, Health, and Safety Performance Declaration	ITT 17.2 and Appendix D of Section IV		
19.	Form FIN – 3.3.1: Financial Situation and Performance	ITT 17.2 and Appendix D of Section IV		
20.	Form FIN – 3.3.2: Average Annual Construction Turnover	ITT 17.2 and Appendix D of Section IV		
21.	Form FIN – 3.3.3: Financial Resources	ITT 17.2 and Appendix D of Section IV		
22.	Form FIN - 3.3.4: Bid Capacity	ITT 17.2 and Appendix D of Section IV		
23.	Form EXP – 3.4.1: General Construction Experience	ITT 17.2 and Appendix D of Section IV		
24.	Form EXP – 3.4.2(a): Specific Construction and Contract Management Experience	ITT 17.2 and Appendix D of Section IV		
25.	*Form EXP – 3.4.2(b): Specific Construction Experience in Key Activities*	*ITT 17.2 and Appendix D of Section IV*		

S. No.	Requirement of Tender Document	Ref. Clause of Tender documents	Tenderer's Name:	
			Whether information submitted (Yes/No/N.A.)	Ref. Pg No. in the Technical Submittal
26.	Form TP-1: Proposed Works Programme and proposed Design Submission Programme	ITT 16.1 and Appendix A of Section IV		
27.	Form TP-2: Proposed Construction Method Statement	ITT 16.1 and Appendix A of Section IV		
28.	Form TP-3: Outline Project Management Plan	ITT 16.1 and Appendix A of Section IV		
29.	Form TP-4: Outline Quality Assurance and Quality Plan	ITT 16.1 and Appendix A of Section IV		
30.	Form TP-5: Outline Environment, Social, Health and Safety Plan	ITT 16.1 and Appendix A of Section IV		
31.	Undertaking for compliance to Employer's Requirement & Specification by Tenderer	FORM UT-1 of Section IV		
32.	Undertaking for Downloaded Tender Document	Form UT-2 of Section IV		
33.	In case of Certificate/documents translated in English from Foreign Language, copy of license of licensed translator issued by the competent authority in their country of origin	ITT 10.1 of Section II		

Note:

(i) **The check list is indicative and not exhaustive. The Tenderer must go through the complete tender documents and submit the required documents accordingly.**

(ii) **If any of the above form or criteria is not applicable to the Tenderer, then they can simply indicate N.A. against the relevant column**

(iii) **All Tender Forms contained in the Tender Documents must be fully and properly completed and all the forms must be returned signed by Authorized Representative of the Tenderer.**

B. FINANCIAL PART

The Financial Part is provided in the Tender Documents in the form of MS-EXCEL file and PDF file. The Contract Price for the Works shall be quoted in the MS-EXCEL file provided on the e-procurement portal. The Tenderer shall download the MS-EXCEL file and after quoting their Contract Price, upload the same along with duly signed other PDF documents of Financial Part mentioned in (a) below on e-procurement portal. The quoted Contract Price shall not be offered/quoted elsewhere in the Technical Part submission/ Tender submission. These prices shall include all costs associated with the contract

including GST. The Tenderer shall complete the Financial Part in accordance with the instructions given in the Financial Part.
Following information are required to be submitted by Tenderers in their Financial Part**:**

(a) In PDF File

1. Letter of Tender – Financial Part
2. Appendix A to Financial Part: Schedule of Adjustment Data
   Table A: Foreign Currency (FC)
   Table B: Summery of Payment Currencies
3. Appendix B to Financial Part: Price Schedules
   Contract Price comprises of the following Schedules:

Schedule	Description
A	Lump Sum component of Works
B	Other civil Works
C	Item rate for miscellaneous works

(b) In MS-Excel File

Price Schedule for quoting Price for the Works against each Schedule.

I hereby confirm that:

(i) I have checked the above list with our submittal. I am also aware that if our tender is not containing the above documents, the Employer has the right to reject our tender.

(ii) All the pages of tender submission are properly indexed and numbered.

Seal:
Date:

(Signature of Authorized representative of Tenderer)

Section IV - Tender Forms

Table of Forms

Letter of Tender – Technical Part

INSTRUCTIONS TO TENDERERS: DELETE THIS BOX ONCE YOU HAVE COMPLETED THE DOCUMENT

The Tenderer must prepare this Letter of Tender on stationery with its letterhead clearly showing the Tenderer's complete name and business address.

Note: All italicized text is to help Tenderers in preparing this form.

Date of this Tender submission: [*insert date (as day, month and year) of Tender submission*]

Tender No.: HORC/HRIDC/C-4/2022

To:

Chief Project Manager,
Haryana Rail Infrastructure Development Corporation Limited (HRIDC),
Plot no.143, 5th floor,
Railtel Tower, Sector-44
Gurugram – 122003
Tel: +91 9311478893

We, the undersigned, hereby submit our Tender, in two parts sealed separately, namely: (a) the Technical Part; and (b) the Financial Part.

In submitting our Tender, we declare that:

(a) **No Reservations:** We have examined and have no reservations to the Tender Document, including Addenda issued in accordance with ITT 8;

(b) **Eligibility:** We meet the eligibility requirements and have no conflict of interest in accordance with ITT 4;

(c) **Tender-Securing Declaration:** We have not been suspended nor declared ineligible by the Employer based on execution of a Tender-Securing or Proposal-Securing Declaration in the Employer's Country in accordance with ITT 4.7;

(d) **Conformity:** We offer to execute in conformity with the Tender Document and in accordance with the implementation and completion specified in the construction schedule, the following Works: *[insert a brief description of the Works];*

_____;

(e) **Tender Validity Period**: Our Tender shall be valid for the period specified in TDS 18.1 (as amended, if applicable) from the date fixed for the Tender submission deadline specified in TDS 22.1 (as amended, if applicable), and it shall remain binding upon us and may be accepted at any time before the expiration of that period;

(f) **Performance Security** If our Tender is accepted, we commit to obtain a Performance Security in accordance with the Tender Document;

(g) **One Tender Per Tenderer:** We are not participating, as a Tenderer, either individually or as a Joint Venture member, in more than one Tender in this tendering process, and meet the requirements of ITT 4.3;

(h) **Suspension and Debarment**: We, along with any of our subcontractors, suppliers, consultants, manufacturers, or service providers for any part of the contract, are not subject to, and not controlled by any entity or individual that is subject to, a temporary suspension or a debarment or any ineligibility imposed or recognized by the Bank. Further, we are not ineligible under the Employer's Country laws or official regulations or pursuant to a decision of the United Nations Security Council;

(i) **State-Owned Enterprise or Institution:** [*select the appropriate option and delete the other*] [*We are not a state-owned enterprise or institution*] / [*We are a state-owned enterprise or institution but meet the requirements of ITT 4.6*];

(j) **Binding Contract:** We understand that this Tender, together with your written acceptance thereof included in your Letter of Acceptance, shall constitute a binding contract between us, until a formal contract is prepared and executed;

(k) **Employer Not Bound to Accept**: We understand that you are not bound to accept the lowest evaluated cost Tender, the Most Advantageous Tender or any other Tender that you may receive;

(l) **Prohibited Practice**: We hereby certify that we have taken steps to ensure that no person acting for us or on our behalf engages in any type of Prohibited Practice; and

(m) **Inspection and Audit**: We agree to permit the Bank or its representative to inspect our accounts and records and other documents relating to the tender submission and to have them audited by auditors appointed by the Bank.

(n) We declare and certify that we have not made any misleading or false representation in the forms, statements and attachments in proof of the qualification requirements.

(o) We declare that the information and documents submitted along with the tender by us are correct and we are fully responsible for the correctness of the information and documents, submitted by us.

(p) [*select the appropriate option and delete whichever is not applicable*] [We declare and certify that financial data as per the balance sheets for last three financial years including that for the latest concluded financial year are being submitted] **OR** [We declare and

certify that balance sheet for the latest concluded financial year has not been finalized till date and that is why we are furnishing financial data for last three financial years ignoring the latest concluded financial year.]

Name of the Tenderer*: [*insert complete name of the Tenderer*]

Name of the person duly authorized to sign the Tender on behalf of the Tenderer: **[*insert complete name of person duly authorized to sign the Tender*]

Title of the person signing the Tender: [*insert complete title of the person signing the Tender*]

Signature of the person named above: [*insert signature of person whose name and capacity are shown above*]

Date signed [*insert date of signing*] **day of** [*insert month*], [*insert year*]

*: In the case of the Tender submitted by joint venture/Consortium specify the name of the Joint Venture/Consortium as Tenderer

**: Person signing the Tender shall have the power of attorney given by the Tenderer. The power of attorney shall be attached with the Letter of Tender-Technical Part.

Appendix A to Technical Part: Technical Proposal

[Ref. ITT Sub-Clause 16.1, Clause 4 of Section III, Evaluation and Qualification Criteria (EQC) and Annexure 1 and Annexure2 to Section III, EQC]

1. **Proposed Works Programme and proposed Design Submission Programme**

2. **Proposed Construction Method Statement**

3. **Outline Project Management Plan**

4. **Outline Quality Assurance and Quality Plan**

5. **Outline Environment, Social, Health and Safety Plan**

Form TP-1

Proposed Works Programme and proposed Design Submission Programme

[Ref. Sub-Clause B1 of Clause 4 Stage 3: Technical Proposal Evaluation, Section III, Evaluation and Qualification Criteria (EQC) and Annexure 1 to Section III EQC]

(To be submitted by the Tenderer)

Form TP-2

Proposed Construction Method Statement

[Ref. Sub-Clause B3 of Clause 4 Stage 3: Technical Proposal Evaluation, Section III, Evaluation and Qualification Criteria (EQC) and Annexure 2 to Section III EQC]

(To be submitted by the Tenderer)

Form TP-3

Outline Project Management Plan

[Ref. Sub-Clause B4 of Clause 4 Stage 3: Technical Proposal Evaluation, Section III, Evaluation and Qualification Criteria (EQC)]

(To be submitted by the Tenderer)

Form TP-4

Outline Quality Assurance and Quality Control Plan

[Ref. Sub-Clause B5 of Clause 4 Stage 3: Technical Proposal Evaluation, Section III, Evaluation and Qualification Criteria (EQC)]

(To be submitted by the Tenderer)

Form TP-5

Outline Environment, Social, Health and Safety Plan

[Ref. Sub-Clause B6 of Clause 4 Stage 3: Technical Proposal Evaluation, Section III, Evaluation and Qualification Criteria (EQC]

(To be submitted by the Tenderer)

Appendix B to Technical Part: DELETED

Appendix C to Technical Part: DELETED

Appendix D to Technical Part: Tenderer's Qualification

To establish its qualifications to perform the contract in accordance with Section III, Evaluation and Qualification Criteria the Tenderer shall provide the information requested in the corresponding Information Sheets included hereunder.

Form ELI-1.1(a)

Tenderer Information Form (Single Entity)

Date: _____
Tender No. and title: _____
Page_____ of _____pages

Tenderer's name
Tenderer's actual or intended country of registration: *[indicate country of Constitution]*
Tenderer's actual or intended year of incorporation:
Tenderer's legal address [in country of registration]:
Tenderer's authorized representative information Name: _____ Address: _____ Mobile number: _____ Telephone/Fax numbers: _____ E-mail address: _____
Attached are copies of original documents of ☐ Articles of Incorporation (or equivalent documents of constitution or association), and/or documents of registration of the legal entity named above, in accordance with ITT 4.4 ☐ In case of state-owned enterprise or institution, in accordance with ITT 4.6, documents establishing: • Operation on a commercial basis; • Financial and managerial autonomy; • Day-to-day management not controlled by the government; and • Not under the supervision of the Employer or its procuring agency.

Tenderer's Authorized Representative

Signature: ……..
Date: ……..……..
Company stamp: ……..…..

Form ELI-1.1 (b)

Tenderer Information Form (JV/Consortium)

[Ref. ITT Sub-Clause 17.1]

Date: _____
Tender No. and title: _____
Page_____ of _____pages

Tenderer's JV name
Name of each member of JV/Consortium:
Tenderer's actual or intended country of registration: *[indicate country of Constitution]*
Tenderer's actual or intended year of incorporation:
Tenderer's legal address [in country of registration]:
*Tenderer's authorized representative information Name: _____ Address: _____ Mobile number: _____ Telephone/Fax numbers: _____ E-mail address: _____
Attached are copies of original documents of ☐ In case of intended JV, letter of intent to form JV or JV agreement, in accordance with ITT 4.1

Tenderer's Authorized Representative

Signature: ……..

Date: ……..……..

Company stamp: ……..…..

Note:

1. *Tenderer's Authorized Representative shall be from Lead Member of JV/Consortium.

Form ELI-1.2

Tenderer's JV Member Information Form

[Ref. ITT Sub-Clause 17.1]
(To be completed for each member of Tenderer's JV)

Date: _____
TENDER No. and title: _____
Page _____ of _____ pages

Tenderer's JV name:
JV member's name:
JV member's country of registration:
JV member's year of constitution:
JV member's legal address in country of constitution:
JV member's authorized representative information Name: _____ Address: _____ Mobile: _____ Telephone/Fax numbers: _____ E-mail address: _____
Attached are copies of original documents of ☐ Articles of Incorporation (or equivalent documents of constitution or association), and/or registration documents of the legal entity named above, in accordance with ITT 4.4. ☐ In case of a state-owned enterprise or institution, documents establishing operation on a commercial basis; financial and managerial autonomy; day-to-day management not controlled by the government; and not under the supervision of the Employer or its procuring agency, in accordance with ITT 4.6.

Tenderer's Authorized Representative

Signature: ……..

Date: ……..……..

Company stamp: ……..…..

Form ELI-1.3

Joint Venture/Consortium Agreement

[Ref. ITT Sub-Clause 4.1 and ITT Sub-Clause11.5]

The Members of the Joint Venture/Consortium shall provide Joint Venture/Consortium Agreement for Joint Venture Participation in the name of M/s……of which includes at least the followings: -

(i) M/s …….. having its registered office at …… (hereinafter referred to as ……) acting as the Lead Member of the first part;

and

(ii) M/s ……having its registered office at ……. (hereinafter referred to as `…….') in the capacity of a Joint Member of the other part;

and

(iii) M/s ……having its registered office at ……. (hereinafter referred to as `…….') in the capacity of a Joint Member of the other part.

The expressions of (i) ,…….. (ii) …….. (iii) …… (names of JV/Consortium Members) shall wherever the context admits, mean and include their respective legal representatives, successors-in-interest and assigns and shall collectively be referred to as " the Parties" and individually as " the Party"

WHEREAS:

Haryana Orbital Rail Corporation Ltd. [hereinafter referred to as "Employer"] has invited tenders for …… *"[Insert name of work]……"*

NOW, THEREFORE, THE PARTIES AGREE AS FOLLOWS:

1. The following documents shall be deemed to form and be read and construed as an integral part of this JV agreement.
   i) Specific Procurement Notice, ii) Tender document, iii) Any Addendum/ Corrigendum issued by Haryana Rail Infrastructure Development Corporation Ltd.
   iv) The Tender submitted on our behalf jointly by the Lead Member/ authorised representative.
2. The `Parties' have studied the documents and have agreed to participate in submitting a tender jointly in the name of----------.
3. M/s ……shall be the lead Member of the JV/ Consortium for all intents and purpose and shall represent the Joint Venture/Consortium in its dealing with the Employer. For the purpose of submission of tenders, the parties agree to nominate …….. as the Lead Member duly authorized to sign and submit all documents and subsequent clarifications, if any, to the Employer. However, M/s …… shall not

submit any such tenders, clarifications or commitments before securing the written clearance of the other Member which shall be expeditiously given by M/s……..…….and M/s……. to M/s…….

4. The 'Parties' have resolved that the distribution of share and responsibilities between the JV/Consortium Members is as under:-

(a) Lead Member Name…….and share ……..% ;

(b) Joint Venture /Consortium Member Name…….and share ……..% ;

(c) Joint Venture /Consortium Member Name…….and share ……..% ;

5. JOINT AND SEVERAL RESPONSIBILITIES

The Parties undertake that they shall be jointly and severally liable to the Employer in the discharge of all the obligations and liabilities as per the contract with the Employer and for the performance of contract awarded to their JV/Consortium

6. ASSIGNMENT AND THIRD PARTIES

The parties shall co-operate throughout the entire period of this Joint Venture Agreement on the basis of exclusivity and neither of the Parties shall make arrangement or enter into agreement either directly or indirectly with any other party or group of parties on matters relating to the Project except with prior written consent of the other party and the Employer.

7. EXECUTIVE AUTHORITY

The said Joint Venture/ Consortium through its authorized representative shall receive instructions from the Employer. The management structure for the project shall be prepared by mutual consultations to enable completion of project to quality requirements within permitted cost and time.

8. PROPOSAL SUBMISSION

Each Party shall bear its own cost and expenses for preparation and submission of the tender *and all costs until conclusion of a contract with the Employer for the Project. Common expenses shall be shared by all the parties in the ratio of their actual participation.*

9. INDEMNITY

Each party hereby agrees to indemnify the other party against its respective parts in case of breach/default of the respective party of the contract works of any liabilities sustained by the Joint Venture/ Consortium.

10. For the execution of the respective portions of works, the parties shall make their own arrangements to bring the required finance, plants and equipment, materials, manpower and other resources.

11. DOCUMENTS & CONFIDENTIALITY

Each Party shall maintain in confidence and not use for any purpose related to the Project all commercial and technical information received or generated in the course of preparation and submission of the tender.

12. ARBITRATION

Any dispute, controversy or claim arising out of or relating to this Joint Venture agreement shall be settled in the first instance amicably between the parties. If an amicable settlement cannot be reached as above, it will be settled by arbitration in accordance with the Indian Arbitration and Conciliation Act 1996 or any amendments thereof. The venue of the arbitration shall be _____.

13. **VALIDITY**

This Joint Venture agreement shall remain in force till the occurrence of the earliest of any of the following, unless by mutual consent, the Parties agree in writing to extend the validity for a further period.

a. The Tender submitted by the Joint Venture/ Consortium is declared unsuccessful, or
b. Cancellation/ shelving of the Project by the Employer for any reasons prior to award of work
c. Execution of detailed JV /Consortium agreement by the parties, setting out detailed terms after award of work by the Employer.

14. This Joint Venture agreement is drawn in ….. number of copies with equal legal strength and status. One copy is held by M/s …… and the other by M/s. ..... and M/s. ..... and a copy submitted with the tender.

15. This Joint Venture agreement shall be construed under the laws of India.

16. NOTICES BETWEEN JV/CONSORTIUM MEMBERS

Notices shall be given in writing by fax confirmed by registered mail or commercial courier to the following fax numbers and addresses:

Lead Member.	Other Member	Other Member
……..	……	……
……	……	……
(Name & Address)	(Name & Address)	(Name & Address)

IN WITNESS WHEREOF THE PARTIES, have executed this MOU the day, month and year first before written

M/s……	M/s……	M/s……
……..……	……	……
(Seal)	(Seal)	(Seal)

Witness

1……..(Name & Address)

2…….. (Name & Address)
3……. (Name & Address)

Form ELI-1.4

[Ref. ITT Sub-Clause 20.3]

Power of Attorney (POA) for Submitting Tender

(For Single Entity/Sole Tenderer only)

(*To be executed on non-judicial stamp paper of the appropriate value in accordance with relevant stamp Act. The stamp paper to be in the name of the company who is issuing the Power of Attorney*)

Know all men by these presents, we…..…….. (name and address of the registered office) do hereby constitute, appoint and authorise Mr/Ms…….. (name and residential address) who is presently employed with us and holding the position of ……..as our attorney, to do in our name and on our behalf, all such acts, deeds and things necessary in connection with or incidental to our tender for the work of "**C-4:** Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;
(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;
(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;
(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00",

including signing and submission of all documents and providing information/ responses to Haryana Rail Infrastructure Development Corporation Ltd (HRIDC), representing us in all matters before HRIDC, and generally dealing with HRIDC in all matters in connection with our tender for the said project.

We hereby agree to ratify all acts, deeds and things lawfully done by our said attorney pursuant to this Power of Attorney and that all acts, deeds and things done by our aforesaid attorney shall and shall always be deemed to have been done by us.

……. (Signature)
(Name, Title and address) of the **Person Accepting the POA.**

……. (Signature)
(Name, Title and address) of the **Person issuing the POA**

Notes:

i. The tenderer should submit the notarised Power of Attorney. In case of Foreign Members, Power of Attorney(s) and Board Resolution confirming authority on the persons issuing the Power of Attorney for such actions shall be submitted duly notarized by the notary public of country of origin and should be either stamped by Indian Embassy/High Commission or Member Countries of Hague convention may submit these document with "Apostille" stamp. Also, in case the documents are in foreign language the translation of the same shall be authenticated by Embassy/High Commission.

ii. The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executant(s) and when it is so required the same should be under common seal affixed in accordance with the required procedure.

iii. The tenderer should submit following additional document in support of the POA as case to case basis:

a) Proprietorship Affidavit in case of Proprietary Tenderer.
b) Partnership Deed in case of Partnership Firms.
c) Board Resolution in case of a Public/Private limited company/LLP.
d) Incorporation Certificate and Memorandum & Article of Association in case of a Public/Private limited company.
e) Incorporation Certificate and Limited Liability Membership Agreement in case of Limited Liability Membership firms.

Form ELI-1.5

Power of Attorney (POA) for Authorized Signatory of Joint Venture (JV)/ Consortium Members

[Ref. ITT Sub-Clause 20.4]

(To be submitted by Tenderer's each JV member)

POWER OF ATTORNEY*

(*To be executed on non-judicial stamp paper of the appropriate value in accordance with relevant stamp Act. The stamp paper to be in the name of the company who is issuing the Power of Attorney*)

Know all men by these presents, we…..…….. do hereby constitute, appoint and authorise Mr/Ms. …….. who is presently employed with us and holding the position of ……..as our attorney, to do in our name and on our behalf, all such acts, deeds and things necessary in connection with or incidental to our tender for the work of "**C-4:** Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680.

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00", including signing and submission of all documents, withdrawal, substitution and modification of tender and providing information/ responses to Haryana Rail Infrastructure Development Corporation Ltd, representing us in all matters, dealing with Haryana Rail Infrastructure Development Corporation Ltd. in all matters in connection with our tender for the said project.

We hereby agree to ratify all acts, deeds and things lawfully done by our said attorney pursuant to this Power of Attorney and that all acts, deeds and things done by our aforesaid attorney shall and shall always be deemed to have been done by us.

Dated this the …… day of ……. 20..

(Signature of authorised Signatory in token of **Acceptance of POA**

……

(Signature and Name in Block letters of Signatory)

Seal of Company

Witness

Witness 1:	Witness 2:
Name:	Name:
Address:	Address:
Occupation:	Occupation:

**Notes:*

i) To be executed by all the Members individually, in case of a Joint Venture/Consortium.

ii) The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executant(s) and when it is so required the same should be under common seal affixed in accordance with the required procedure.

Form ELI-1.6

Power of Attorney to Lead Member and Authorized Representative of Joint Venture (JV)/ Consortium

[Ref. ITT Sub-Clause 20.4]

(To be executed on non-judicial stamp paper of the appropriate value in accordance with relevant stamp Act. The stamp paper to be in the name of the company who is issuing the Power of Attorney)

POWER OF ATTORNEY[1]

Whereas Haryana Rail Infrastructure Development Corporation Ltd. has invited Tenders for the work of ……

Whereas, the Members of the Joint Venture/Consortium comprising

1. M/s. …,
2. M/s. ……,

and

3. M/s. ……,

are interested in submission of tender for the work of "**C-4:** Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00" in accordance with the terms and conditions contained in the tender documents.

Whereas, it is necessary for the Members of the Joint Venture to designate one of them as the Lead Member as the authorized representative, with all necessary power and authority to do, for and on behalf of the Joint Venture/ Consortium, all acts, deeds and things as may be necessary in connection with the Joint Venture's tender for the project.

NOW THIS POWER OF ATTORNEY WITNESSETH THAT:

We, M/s. …… (Lead Member). M/s_____ and M/s_____ hereby designate M/s. ……, being one of the Members of the Joint Venture, as the Lead Member of the Joint Venture and designate Mr/Ms. _____ being authorized representative of the Joint Venture, to do on behalf of the Joint Venture, all or any of the acts, deeds or things necessary or incidental to the Joint Venture's tender for the contract, including submission of tender, withdrawal, substitution and modification of tender, participating in conferences, responding to queries, submission of information/ documents and generally to represent the Joint Venture in all its dealings with the Employer or any other Government Agency or any person, in connection with the contract for the said work until culmination of the process of tendering till the contract agreement is entered into with the Haryana Orbital Rail Corporation Limited and thereafter till the expiry of the contract agreement.

We hereby agree to ratify all acts, deeds and things lawfully done by Lead Member, our said attorney, pursuant to this power of attorney and that all acts deeds and things done by our aforesaid attorney shall and shall always be deemed to have been done by us/ Joint Venture.

Dated this the …… Day of …….. 20..…….

(Signature)	(Signature)	(Signature)
……	……	……

(Name in Block letters of all Executants with Seal of Company)

……. (Signature)

(Name, Title and address) of the **Person Accepting the POA**

Witness 1:	Witness 2:
Name:	Name:
Address:	Address:
Occupation:	Occupation:

Notes:

1. To be executed by all the Authorized POA holders of each Members of the JV/Consortium.
2. The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executant(s) and

when it is so required the same should be under common seal affixed in accordance with the required procedure.

3. Authorized Representative of Tenderer's JV shall be from Lead Member of JV/Consortium.

Form CON-1

Historical Contract Non-Performance, Pending Litigation and Litigation History

[Ref. ITT Sub-Clause 17.2 and Section III, Evaluation and Qualification Criteria, Sub-Clause 3.2.1 and Sub-Clause 3.2.3]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium , each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____

JV Member's Name_____

Page _____of _____pages

1. Non-Performed Contracts in accordance with Section III, Evaluation and Qualification Criteria			
Description			YES/NO
(i) Whether Contract(s) Non-Performance occurred as a result of Contractor's default since 1st April 2017 specified in Section III, Evaluation and Qualification Criteria, requirement 3.2.1			
(ii) If answer to (i) above is YES, then following details to be submitted:			
Year	**Non-performed portion of contract**	**Contract Identification**	**Total Contract Amount (current value, currency, exchange rate and INR equivalent)**
[insert year]	*[insert amount and percentage]*	Contract Identification: *[indicate complete contract name/ number, and any other identification]* Name of Employer: *[insert full name]* Address of Employer: *[insert street/city/country]* Reason(s) for nonperformance: *[indicate main reason(s)]*	*[insert amount]*

2. Pending Litigation, in accordance with Section III, Evaluation and Qualification Criteria	
Description	YES/NO
(i) Whether any litigation is still pending against the Contractor in accordance with Section III, Evaluation and Qualification Criteria, Sub-Clause 3.2.3.	
(ii) If answer to (i) above is YES, then following details to be submitted:	

Year of dispute	Amount in dispute (currency)	Contract Identification	Total Contract Amount (currency), INR Equivalent (exchange rate)
		Contract Identification: _____ Name of Employer: _____ Address of Employer: _____ Matter in dispute: _____ Party who initiated the dispute: ____ Status of dispute: _____	
		Contract Identification: Name of Employer: Address of Employer: Matter in dispute: Party who initiated the dispute: Status of dispute:	

3.	Litigation History in accordance with Section III, Evaluation and Qualification Criteria **(Not Applicable)**

Tenderer's Authorized Representative

Signature: ……..
Date: ……..
Company stamp: ……..

Chartered Accountant/Company Auditor/Statutory Auditor

Certified that the information furnished above is correct as per the audited balance sheets of the entity.

Signature: ……..
Name: ……..
Position: ……..
Date: ……

Form CON-2

Environmental, Social, Health, and Safety Performance Declaration

[Ref. ITT Sub-Clause 17.2 and Section III, Evaluation and Qualification Criteria, Sub-Clause 3.2.5]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium, each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____

JV Member's Name_____

Page _____of _____pages

<table>
<tr><td colspan="4">Environmental, Social, Health, and Safety Performance Declaration in accordance with Sub-Clause 3.2.5, Section III, Qualification Criteria and Requirements</td></tr>
<tr><td colspan="3">Description</td><td>YES/NO</td></tr>
<tr><td colspan="3">(i) Declaration of suspension or termination of contract:
Whether contract(s) has/have been suspended or terminated and/or Performance Security called by an employer(s) for reasons related to Environmental, Social, Health, or Safety (ESHS) performance since the date specified in Section III, Qualification Criteria, and Requirements, Sub-Clause 3.2.5.</td><td></td></tr>
<tr><td colspan="4">(ii) If answer to (i) above is YES, then following details to be submitted:</td></tr>
<tr><td colspan="4">a. Details of Contract(s) suspended/terminated by an employer(s) for reasons related to ESHS performance</td></tr>
<tr><td>Year</td><td>Suspended or terminated portion of contract</td><td>Contract Identification</td><td>Total Contract Amount (current value, currency, exchange rate and INR equivalent)</td></tr>
<tr><td>[insert year]</td><td>[insert amount and percentage]</td><td>Contract Identification: [indicate complete contract name/ number, and any other identification]
Name of Employer: [insert full name]
Address of Employer: [insert street/city/country]
Reason(s) for suspension or termination: [indicate main reason(s)]</td><td>[insert amount]</td></tr>
</table>

[insert year]	*[insert amount and percentage]*	Contract Identification: *[indicate complete contract name/ number, and any other identification]* Name of Employer: *[insert full name]* Address of Employer: *[insert street/city/country]* Reason(s) for suspension or termination: *[indicate main reason(s)]*	*[insert amount]*
...	...	*[list all applicable contracts]*	...
b. **Details of Contract(s) in which Performance Security called by an employer(s) for reasons related to ESHS performance**			
Year		Contract Identification	Total Contract Amount (current value, currency, exchange rate and INR equivalent)
[insert year]		Contract Identification: *[indicate complete contract name/ number, and any other identification]* Name of Employer: *[insert full name]* Address of Employer: *[insert street/city/country]* Reason(s) for calling of performance security: *[indicate main reason(s)]*	*[insert amount]*

Tenderer's Authorized Representative

Signature: ……..
Date: ……..
Company stamp: ……..

Form FIN-3.3.1:

Financial Situation and Performance

[Ref. ITT Sub-Clause 17.2 and Section III, Evaluation and Qualification Criteria, Sub-Clause 3.3.1 (iii)]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium, each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____

JV Member's Name: _____
Page _____of _____pages

Financial data *(All amounts in Millions)*

Type of Financial information in (currency)	**Historic information for last three Financial Years, (amount in currency, currency, exchange rate*, INR equivalent)**		
	Year 1: 2019-20	**Year 2:2020-21**	**Year 3:2021-22**
	Statement of Financial Position (Information from Balance Sheet)		
Total Assets (TA)			
Total Liabilities (TL)			
Total Equity/Net Worth (NW) = TA-TL			
Current Assets (CA)			
Current Liabilities (CL)			
Working Capital (WC)			
Total Revenue (TR)			
Profits Before Taxes (PBT)			

*Refer to Notes: Exchange Rate for Qualification Criteria, Section III, EQC.

Notes:

(i) In case, the Financial Year is the same as the Calendar Year, the financial data for the year 2019, 2020 and 2021 shall be furnished.

(ii) The Tenderer is not required to submit any document as documentary evidence along with the Tender Documents. All information furnished in this form shall be certified by a Chartered Accountant/Company Auditor/Statutory Auditor.

(iii) The Form duly certified by a Chartered Accountant/Company Auditor/Statutory Auditor shall also be signed by Tenderer's Authorized representative.

(iv) The above documents shall reflect the financial situation of the legal entity or entities comprising the Tenderer and not the Tenderer's parent companies, subsidiaries, or affiliates.

(v) In the event that the audited accounts for the latest concluded Financial Year are not available, the Tenderer shall furnish information pertaining to the last three financial years after ignoring the latest concluded financial year. In case, the Tenderer submits audited financial information for the last four or more years, only the figures for the latest three years shall be considered for evaluation.

(vi) In case audited balance sheet of the last financial year is not available with the Tenderer, he will declare the same vide item (p) prescribed in the Letter of Tender-Technical Part.

(vii) ***If the value of Net Worth is not submitted for any of the last three years, the Tender shall be considered non-responsive and shall be summarily rejected.***

Tenderer's Authorized Representative

Signature: ……..

Date: ……..……..

Company stamp: ……..…..

Chartered Accountant/Company Auditor/Statutory Auditor

Certified that the information furnished above is correct as per the audited balance sheets of the entity.

Signature: ……..

Name:

Position:

Date:

Company:

Company stamp:

Membership No:

Address:

Contact No:

Email ID:

Form FIN-3.3.2:

Average Annual Construction Turnover

[Ref. ITT Sub-Clause 17.2, Section III, Evaluation and Qualification Criteria, Sub-Clause 3.3.1 (ii) and Sub-Clause 3.3.2]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium, each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____

JV Member's Name: _____
Page _____of _____pages

(All amounts in Millions)

Annual Turnover Data for the Last Three (03) Financial Years (Construction Only)			
Year	**Amount Currency**	***Exchange Rate**	**INR Equivalent**
2019-20	*[insert amount and indicate currency]*		
2020-21			
2021-22			
Average Annual Construction Turnover for last 3 financial years			

* See Section III, Evaluation and Qualification Criteria, Sub-Clause 3.3.2.

Notes:

(i) In case, the Financial Year is the same as the Calendar Year, the turnover for the year 2019, 2020 and 2021 shall be furnished.

(ii) The Average Annual Construction Turnover shall be calculated by adding the turnover amount of last three financial years divided by three.

(iii) The Tenderer is not required to submit any document as documentary evidence along with the Tender Documents. All information furnished in this form shall be certified by a Chartered Accountant/Company Auditor/Statutory Auditor.

(iv) The Form duly certified by a Chartered Accountant/Company Auditor/Statutory Auditor shall also be signed by Tenderer's Authorized representative.

(v) The above documents shall reflect the financial situation of the legal entity or entities comprising the Tenderer and not the Tenderer's parent companies, subsidiaries, or affiliates.

(vi) In the event that the audited accounts for the latest concluded Financial Year are not available, the Tenderer shall furnish information pertaining to the last three financial years after ignoring the latest concluded financial year. In case, the Tenderer submits audited financial information for the last four or more years, only the figures for the latest three years shall be considered for evaluation.

(vii) In case audited balance sheet of the last financial year is not available with the Tenderer, he will declare the same vide item (p) prescribed in the Letter of Tender-Technical Part.

(viii) If the value of Annual construction Turnover is not submitted for any of the last three years prescribed in Financial Data, the Tender shall be evaluated by considering "NIL" Turnover for that year(s).

Tenderer's Authorized Representative

Signature: ……..

Date: ……..……..

Company stamp: ……..…..

Chartered Accountant/Company Auditor/Statutory Auditor

Certified that the information furnished above is correct as per the audited balance sheets of the entity.

Signature: ……..

Name:

Position:

Date:

Company:

Company stamp:

Membership No:

Address:

Contact No:

Email ID:

Form FIN-3.3.3:

Sources of Finance for the Subject Contract

[Ref. ITT Sub-Clause 17.2 and Section III, Evaluation and Qualification Criteria, Sub-Clause 3.3.1 (i)]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium, each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____

JV Member's Name: _____
Page _____of _____pages

Tenderer should specify proposed sources of financing, such as liquid assets, unencumbered real assets, lines of credit, and other financial means, net of current contract commitments, available to meet the total construction cash flow demands of the subject contract **i.e. Package C-4.**

(*All amounts in Millions*)

No.	Source of financing	Amount (INR equivalent)
1		
2		
3		
	Total Sources of Finance for the subject Contract	

(i) The Tenderer is not required to submit any document as documentary evidence along with the Tender Documents. All information furnished in this Form shall be certified by a Chartered Accountant/Company Auditor/Statutory Auditor.

(ii) The Form duly certified by a Chartered Accountant/Company Auditor/Statutory Auditor shall also be signed by Tenderer's Authorized representative.

(iii) The above documents shall reflect the financial situation of the legal entity or entities comprising the Tenderer and not the Tenderer's parent companies, subsidiaries, or affiliates.

Tenderer's Authorized Representative

Signature: ……..

Date: ……..……..

Company stamp: ……..…..

Chartered Accountant/Company Auditor/Statutory Auditor

Certified that the information furnished above is correct.

Signature: ……..

Name:

Position:

Date:

Company:

Company stamp:

Membership No:

Address:

Contact No:

Email ID:

Form FIN-3.3.4:

Bid Capacity

[Ref. ITT Sub-Clause 17.2, Section III, Evaluation and Qualification Criteria, Sub-Clause 3.3.1 (ii]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium, each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____
JV Member's Name_____
Page _____of _____pages

1.0 Bid Capacity:

The available bid capacity shall be calculated as under:
Available Bid Capacity = [A x N x 2] – 0.33xNxB
Where,

A = Maximum value of construction works executed and payment received in any one of the previous three financial years, taking into account the completed as well as works in progress.

N= Number of years prescribed for completion of work for which Tender has been invited **(i.e. *4* years)**.

B = Existing commitments and balance amount of ongoing works with tenderer and also the works which are awarded to tenderer but yet not started upto the date of inviting the Tender.

Note:

(a) The Tenderer(s) shall furnish the details of :

(i) Maximum value of construction works executed and payment received in any one of the previous three financial years for calculating **'A'**, and

(ii) Existing commitments and balance amount of ongoing works with tenderer and also the works which are awarded to tenderer but yet not started upto the date of inviting the Tender for calculating **'B'**. The details shall be submitted in the prescribed proforma given under **2.0 below.** In case of no works in hand, a 'NIL' statement should be furnished.

The submitted details for (i) and (ii) above should be duly verified by Chartered Accountant.

(b) In case if a tenderer is JV, the Tenderer(s) must furnish the details of:

(i) Maximum value of construction works executed and payment received in any one of the previous three financial years by each member of JV for calculating **'A'**, and

(ii) Existing commitments and balance amount of ongoing works with each member of JV either in individual capacity or as a member of other JV and also the works which are awarded to each member of JV either in individual capacity or as a member of other JV but yet not started upto the date of inviting the Tender for calculating **'B'**. The details shall be submitted by each member of JV in the prescribed proforma given under **2.0 below.** In case of no works in hand, a 'NIL' statement should be furnished.

The submitted details for (i) and (ii) above should be duly verified by Chartered Accountant.

(c) Value of a completed work/work in progress/work awarded but yet not started for a Member in an earlier JV/Consortium shall be reckoned only to the extent of the concerned member's share in that JV/Consortium for the purpose of satisfying his/her compliance to the above mentioned bid capacity in the tender under consideration.

(d) For assessing the combined Bid capacity of JV/Consortium, the arithmetic sum of individual "Bid Capacity" of all the members shall be taken.

(e) In case, the Tenderer/s failed to submit the above statement along with offer, their/his offer shall be considered as incomplete and will be rejected **summarily**.

(f) The Available Bid Capacity of Tenderer shall be assessed based on the details submitted by the tenderer. In case, the available bid capacity is less than that prescribed in Sub-Clause 3.3.1 (ii), Section III, EQC , then the offer shall not be considered even if the Tenderer has been found eligible in other eligibility criteria/tender requirement**.**

2.0 Tenderer should provide information on their current commitments on all contract that have been awarded, or for which a letter of intent or acceptance has been received, or for contracts approaching completion, but for which an unqualified, full completion certificate is yet to be issued.

Current Contract Commitments /Works in Progress

(All amounts in INR)

S. No.	Name and Brief particulars of contract (Clearly indicate the part of the work assigned to the applicant)	Contract No. & Date	Name of client with telephone number	Contract Value in INR Equivalent (Give only the value of work assigned to the applicant)	Stipulated Period of completion	Value of balance work yet to be done in INR equivalent upto the date of inviting the Tender
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Total value of balance work yet to be done in INR equivalent upto the date of inviting the Tender						**B=**

Notes:

(i) Where a work is undertaken by a JV/Consortium, only that portion of the contract which is undertaken by the concerned applicant/member should be indicated and the remaining done by the other members of the JV/Consortium be excluded.

(ii) The Tenderer is not required to submit any document as documentary evidence along with the Tender Documents. ***All information furnished in this Form shall be certified by a Chartered Accountant/Company Auditor/Statutory Auditor.***

(iii) The above documents shall reflect the financial situation of the legal entity or entities comprising the Tenderer and not the Tenderer's parent companies, subsidiaries, or affiliates.

"Certified that current commitments on all the contracts that have been awarded or for which a letter of intent or acceptance has been received or for the works in progress or the works approaching completion, value of outstanding work has been indicated in the above table correctly. It is further certified that if later on the Employer discovers that information provided in the table is incorrect then the Employer will treat our Tender invalid and it will be liable for rejection"

3.0 Calculation of Available Bid Capacity

Description	**Value**
A= Maximum value of construction works executed and payment received in any one of the previous three financial years, taking into account the completed as well as works in progress **as per Form FIN 3.3.2** (in INR Equivalent)	
N= Number of years prescribed for completion of work for which Tender has been invited (in years)	***4***
B= Existing commitments and balance amount of ongoing works with tenderer and also the works which are awarded to tenderer but yet not started upto the date of inviting the Tender (in INR Equivalent)	
Bid Capacity (in INR Equivalent) = [A x N x 2] – 0.33xNxB	

Tenderer's Authorized Representative

Signature: ……..

Date: ……..……..

Company stamp: ……..…..

Chartered Accountant/Company Auditor/Statutory Auditor

Certified that the information furnished above is correct.

Signature: ……..

Name:

Position:

Date:

Company:

Company stamp:

Membership No:

Address:

Contact No:

Email ID:

Form EXP-3.4.1

General Construction Experience

[Ref. ITT Sub-Clause 17.2 and Section III, Evaluation and Qualification Criteria, Sub-Clause 3.4.1]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium, each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____

JV Member's Name_____
Page _____of _____pages

Details of Works executed under construction contracts in the role of Prime Contractor or a JV member *or "Management Contractor* or a Sub-Contractor, starting 1st April 2015 till 28 days prior to deadline of Tender submission.

Starting Year	Ending Year	Contract Identification	Role of Tenderer [insert "Prime Contractor" or "JV member " or "Management Contractor" or "Sub-Contractor"]
		Contract name: _____ Brief Description of the Works performed by the Tenderer: _____ Amount of contract: _____ Name of Employer: _____ Address: _____	
		Contract name: _____ Brief Description of the Works performed by the Tenderer: _____ Amount of contract: _____ Name of Employer: _____ Address: _____	

		Contract name: _____ Brief Description of the Works performed by the Tenderer: _____ Amount of contract: _____ Name of Employer: _____ Address: _____	

Tenderer's Authorized Representative

Signature: ……..

Date: ……..

Company stamp: ……..

Form EXP-3.4.2(a)

Specific Construction and Contract Management Experience

[Ref. ITT Sub-Clause 17.2 and Section III, Evaluation and Qualification Criteria, Sub-Clause 3.4.2 (a)]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium, each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____

JV Member's Name_____
Page _____of _____pages

Similar Contract No.	*Information*		
Contract Identification			
Award date			
Completion date			
Role in Contract as Prime Contractor or Member in JV or Management Contractor or Sub-Contractor	*[insert the role in Contract]*		
Total Contract Amount	*[insert Contract amount(s) and currency(ies)]*		INR [insert *exchange rate and total Contract amount in INR equivalent]
If member in a JV or sub-contractor, specify participation in total Contract amount	*[insert Percentage participation]*	*[insert amount(s) and currency) of participation]*	*INR [insert exchange rate(i) and amount of participation in INR equivalent]*
Employer's Name:			
Address: Telephone/fax number E-mail:			
Description of the similarity in accordance with Sub-Clause 3.4.2(a) of Section III:			
1. Amount (INR)	*[insert the Contract amount in INR]*		

2. *Infrastructure work for Railway / Metro Rail / RRTS / Road project involving civil works.*	*[insert type of Infrastructure work involving civil works]*

**Refer to Notes: Exchange Rate for Qualification Criteria, Section III, EQC.*

Tenderer's Authorized Representative

Signature: ……..

Date: ……..

Company stamp: ……..

Notes:

(i) Value of completed work done by a Member in an earlier JV shall be reckoned as per the Note 2 given at the end of Sub-Clause 3.4.2(b), Section III, EQC for the purpose of satisfying his/her experience criteria mentioned in 3.4.2(a).

(ii) The Tenderer shall submit copy of certificates issued by the Employer (owner of the work) as documentary proof clearly indicating the similarity of the work as per Sub-Clause 3.4.2 (a), actual completion cost, actual completion date. Tender submitted without this documentary proof shall not be evaluated.

(iii) In case Tenderer submits work experience certificate issued by other than Govt. / Public Sector undertakings, the Tenderer shall also submit along with work experience certificate, the relevant copy of work order, bill of quantities, bill wise details of payment received duly certified by Chartered Accountant, TDS certificates for all payments received and copy of final/last bill paid by company in support of above work experience certificate.

(iv) If a tenderer has successfully completed a work as Sub-Contractor, the work experience certificate issued for such work to Sub-Contractor by the Employer (owner of the work) shall only be considered for the purpose of fulfillment of credentials. Tender submitted without this documentary proof shall be summarily rejected.

Form EXP-3.4.2(b)

Specific Construction Experience in Key Activities in Completed/Ongoing contracts

[Ref. ITT Sub-Clause 17.2 and Section III, Evaluation and Qualification Criteria, Sub-Clause 3.4.2 (b)]

[The following table shall be filled in for the Tenderer or in case of JV/Consortium, each member of a Joint Venture/Consortium]

Tender No.: HORC/HRIDC/C-4 /2022

Tenderer's Name: _____

JV Member's Name_____
Page _____of _____pages

1. Key Activity: Execution of equivalent length of NATM tunnel in infrastructure work for Railway / Metro Rail / RRTS / Road project

	Information	
Contract Identification		
Award date		
Completion date / ongoing contracts		
Role in Contract as Prime Contractor or Member in JV or Management Contractor or Sub-Contractor	*[insert the role in Contract]*	
Total Contract Amount	*[insert Contract amount(s) and currency(ies)]*	*INR [insert *exchange rate and total Contract amount in INR equivalent]*
Employer's Name:		
Address: *Telephone/fax number* *E-mail:*		
Description of the key activity in accordance with Sub-Clause 3.4.2 (b) of Section III:		
(iv) Length of NATM Tunnel executed (km) in infrastructure work for Railway / Metro Rail / RRTS / Road project (A)		

	Information
(v) No. of UG Station executed by NATM in infrastructure work for Railway / Metro Rail / RRTS / Road project (B)	
Equivalent length of NATM Tunnel (km) executed in infrastructure work for Railway / Metro Rail / RRTS / Road project, (C) = (A+B)	
In case the qualifying contract has been executed as JV/Consortium member:	
a) Specify the percentage share of the participating Tenderer / JV member in the qualifying contract, (D)	
b) Actual equivalent length of NATM Tunnel (km) executed by the participating Tenderer / JV member in infrastructure work for Railway / Metro Rail / RRTS / Road project, (E) = (C) x (D)	

Notes:

(i) ***For calculation of equivalent length of NATM tunnel:***

a) In case of Twin Tunnel construction by NATM, each tunnel shall be counted as a separate tunnel for calculation of equivalent length of NATM tunnel

b) Construction of **1** Under Ground station by NATM for Railway/Metro Rail /RRTS/Road projects shall be considered equivalent to construction of 1Km of NATM Tunnel.

c) Length of cross passages between two tunnels or between main tunnel & escape tunnel shall not be considered for calculating equivalent length of tunnel.

d) Experience certificate of "Drill & Blast tunnelling" not involving NATM shall not be considered

e) In case of **ongoing contracts**, only that length of NATM tunnel shall be considered for evaluation of equivalent length of NATM tunnel for which primary support system and lining have been completed. If lining is not applicable, experience certificate issued by the Employer must clearly state that there is no requirement of lining of tunnel as per the approved design.

(ii) For past experience of a firm in earlier JV for specified key activity in Sub-Clause 3.4.2 (b) credit shall be given for execution of that quantity of the specified key activity executed by the firm as per the Note 3 under Sub-Clause 3.4.2 (b).

(iii) The Tenderer shall submit copy of certificates issued by the Employer (owner of the work) as documentary proof clearly indicating the description of the key activity as per Sub-Clause 3.4.2 (b), actual completed quantity and actual completion date. Tender submitted without this documentary proof shall not be evaluated.

(iv) In case Tenderer submits work experience certificate issued by other than Govt. / Public Sector undertakings, the Tenderer shall also submit along with work experience certificate, the relevant copy of work order, bill of quantities, bill wise details of payment received duly certified by Chartered Accountant, TDS certificates for all payments received and copy of final/last bill paid by company in support of above work experience certificate.

(v) If a tenderer has successfully completed a work as Sub-Contractor, the work experience certificate issued for such work to Sub-Contractor by the Employer (owner of the work) shall only be considered for the purpose of fulfillment of credentials. Tender submitted without this documentary proof shall be summarily rejected.

Appendix E to Technical Part: Tender Security

The amount for Tender Security in INR can be paid online by eligible Tenderers on e-procurement Portal of Government of Haryana.

OR

Tender Security can be submitted in the form of unconditional and irrevocable Bank Guarantee in INR or USD from the banks specified in Sub-Clause ITT 19.3, Section II- TDS using the Tender Security Form given below:

Tender Security
Form of Demand Guarantee

Beneficiary:

Chief Project Manager,
Haryana Rail Infrastructure Development Corporation Limited,
Plot No 143, 5th Floor, Railtel Tower,
Sector-44, Gurugram, Haryana-122003

Tender No: HORC/HRIDC/C-4/2022

Date: _____*[Insert date of issue]*

TENDER SECURITY GUARANTEE No.: _____

Guarantor: *[Insert name and address of place of issue, unless indicated in the letterhead]*

We have been informed that _____ (hereinafter called "the Applicant") has submitted or will submit to the Beneficiary its Tender (hereinafter called "the Tender") for the execution of **"C-4:** Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00" under Tender No. HORC/HRIDC/C-4/2022.

Furthermore, we understand that, according to the Beneficiary's conditions, Tenders must be supported by a Tender guarantee.

At the request of the Applicant, we, as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of _____ (_____) upon receipt by us of the Beneficiary's complying demand, supported by the Beneficiary's statement, whether in the demand itself or a separate signed document accompanying or identifying the demand, stating that either the Applicant:

(a) has withdrawn its Tender during the period of Tender validity set forth in the Applicant's Letter of Tender ("the Tender Validity Period"), or any extension thereto provided by the Applicant; or

(b) having been notified of the acceptance of its Tender by the Beneficiary during the Tender Validity Period or any extension thereto provided by the Applicant, (i) has failed to execute the contract agreement, or (ii) has failed to furnish the Performance Security in accordance with the Instructions to Tenderers ("ITT") of the Beneficiary's Tender Document.

This guarantee will expire: (a) if the Applicant is the successful Tenderer, upon our receipt of copies of the contract agreement signed by the Applicant and the Performance Security issued to the Beneficiary in relation to such contract agreement; or (b) if the Applicant is not the successful Tenderer, upon the earlier of (i) our receipt of a copy of the Beneficiary's notification to the Applicant of the results of the Tendering process; or (ii) twenty-eight days after the end of the Tender Validity Period.

Consequently, any demand for payment under this guarantee must be received by us at the office indicated above on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758.

_____

[signature(s)]

Form of Tender-Securing Declaration

DELETED

FORM UT-1

Undertaking for compliance to Employer's Requirements & Specification by Tenderer

1. We understand that our Technical Proposal are for assessment of eligibility requirements and the same have no bearing on our Financial Part. We undertake that the work will be executed as per provision of tender specifications/ drawings/ design basis report despite contrary provisions, if any, in our submission and nothing extra will be claimed on this account.

2. We hereby confirm that we will comply all the design requirement and codal provisions as specified in Tender documents and also confirm that due to any change in design/construction /methodology during the execution of work, nothing extra shall be claimed by us.

3. We understand that some of the parameters have been assumed or taken from Geo-Technical report for design purpose. The Geo-Technical report is for general information only. We hereby confirm that all the design/ methodologies shall be based on the detailed soil investigation to be carried out by us after award of work for which nothing extra shall be claimed by us.

We hereby undertake that in case of any deviation in Technical Proposal with respect to the Tender documents & Tender drawings, the conditions as mentioned in the Tender documents shall prevail.

Signature of authorized signatory of Tenderer with Seal

Form UT-2

Undertaking for Downloaded Tender Document

I/We hereby declare that, I/we have downloaded the Tender documents/addendum/corrigendum/ clarifications along with the set of enclosures hosted on e-procurement portal as mentioned in tender document. I/We verified the content of the document from the website and there is no addition, no deletion or no alteration to the content of the tender document. In case of any discrepancy noticed at any stage i.e. evaluation of tenders, execution of work or final payment of the contract, the master copy of Tender Documents available with HRIDC shall be final and binding upon me/us.

Signature of Authorized Signatory of Tenderer with Seal

Letter of Tender – Financial Part

INSTRUCTIONS TO TENDERERS: DELETE THIS BOX ONCE YOU HAVE COMPLETED THE DOCUMENT

The Tenderer must prepare this Letter of Tender on stationery with its letterhead clearly showing the Tenderer's complete name and business address.

Note: All italicized text is to help Tenderers in preparing this form.

Date of this Tender submission: [*insert date (as day, month and year) of Tender submission*]
Tender No.: [*insert tender reference number*]
Alternative No.: [*insert reference number if this is a Tender for an alternative*]

To: **[*insert complete name of Employer*]**

We, the undersigned, hereby submit the second part of our Tender, the Tender Price and Price Schedule. This accompanies the Letter of Tender – Technical Part.

In submitting our Tender, we declare that:

(a) **Tender Validity Period**: Our Tender shall be valid for the period specified in TDS 18.1 (as amended, if applicable) from the date fixed for the Tender submission deadline specified in TDS 22.1 (as amended, if applicable), and it shall remain binding upon us and may be accepted at any time before the expiration of that period;

(b) ***Tender Price:** The total price of our Tender including Provisional Sum is: [*insert the total price of the Tender in words and figures in INR*];

(c) **Commissions, Gratuities, Fees:** We have paid, or will pay the following commissions, gratuities, or fees with respect to the Tendering process or execution of the Contract: *[insert complete name of each Recipient, its full address, the reason for which each commission or gratuity was paid and the amount and currency of each such commission or gratuity]*

Name of Recipient	Address	Reason	Amount

(If none has been paid or is to be paid, indicate "none.")

Name of the Tenderer: **[*insert complete name of the Tenderer*]

Name of the person duly authorized to sign the Tender on behalf of the Tenderer: ***[*insert complete name of person duly authorized to sign the Tender*]

Title of the person signing the Tender: [*insert complete title of the person signing the Tender*]

Signature of the person named above: [*insert signature of person whose name and capacity are shown above*]

Date signed [*insert date of signing*] **day of** [*insert month*], [*insert year*]

* The total price of Tender including Provisional Sums quoted in this Letter of Tender-Financial Part shall be same as given in Worksheet BOQ3 (Price Schedule –Summary Sheet) of MS-Excel File which includes cost of Schedule 'A" plus Schedule 'B' plus Schedule 'C' plus Provisional Sum.

**In the case of the Tender submitted by Joint Venture/Consortium specify the name of the Joint Venture/Consortium as Tenderer

*** Person signing the Tender shall have the Power of Attorney given by the Tenderer. The power of attorney shall be attached with the Letter of Tender-Technical Part.

Appendix A to Financial Part: Schedule of Adjustment Data

1. Price adjustment

1.1 The amounts payable to the Contractor for Works shall be adjusted in accordance with the provisions of this Clause 1.0, Sub-Clause 13.7 of GCC and Sub-Clause 13.7, Specific Provision, Part B, Section IX-PCC.

1.2 The Contract Price shall be adjusted for increase or decrease in rates and prices of labour, materials, fuel and lubricants, equipment, Machinery, Plant and other Materials or inputs in accordance with the principles, procedures and formulae specified below:

a) Base month for the purpose of Price Adjustment shall be the month in which the Tender is opened for Civil & BLT Works and General Electrical Services Works. The 1st Quarter will start from Base month;

b) For Schedule-A, Price adjustment shall be applied on completion of the specified stage of the respective item of work.

c) Adjustment for each item of work/stage shall be made separately;

d) The following expressions and meanings are assigned to the value of the work done for Civil works:

EW = Value of work done for the completion of a stage under the Cost Centre 'CE' of Price Schedule 'A';

BR = Value of work done for the completion of a stage under the Cost Centre 'CB' of Price Schedule 'A';

TUNL = Value of work done for the completion of a stage under the Cost Centre 'CTU' of Price Schedule 'A';

BLT = Value of work done for the completion of a stage under the under the Cost Centre 'CBT' of Price Schedule 'A';

RW = Value of work done for the completion of a stage under the Cost Centre 'RW' of Price Schedule 'A';

SCHB = Value of work done under Price Schedule 'B';

MISC = Value of work done under Price Schedule 'C';

e) Price adjustment for change in costs of civil works shall be paid in accordance with the following formula:

i) VEW= 0.85 EW x [PLB x (LBi – LBo)/LBo + PF x (Fi –Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

ii) VBR = 0.85 BR x [PLB x (LBi – LBo)/LBo + PC x (Ci – Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

iii) VTUNL = 0.85 TUNL x [PLB x (LBi – LBo)/LBo + PC x (Ci –Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi– MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo + PXLP x(XLPi – XLPo)/XLPo];

iv) VBLT = 0.85 BLT x [PLB x (LBi – LBo)/LBo + PC x (Ci –Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi– MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

v) VRW = 0.85 RW x [PLB x (LBi – LBo)/LBo + PC x (Ci – Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

i) VSCHB = 0.85 RW x [PLB x (LBi – LBo)/LBo + PC x (Ci – Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

ii) VMISC= 0.85 MISC x [PLB x (LBi – LBo)/LBo + PF x (Fi –Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

Where

VEW = Increase or decrease in the cost under the Cost Centre ‘CE’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VBR = Increase or decrease in the cost of Cost Centre ‘CB’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VTUNL = Increase or decrease in the cost under the Cost Centre ‘CTU’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VBLT = Increase or decrease in the cost under the Cost Centre ‘CBLT’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VRW = Increase or decrease in the cost under the Cost Centre ‘RW’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VSCHB = Increase or decrease in the cost of work done under Price Schedule ‘B’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VMISC = Increase or decrease in the cost of work done under Price Schedule ‘C’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

PC, PF, PLB, PMACH, POTH, PS and PXLP are the percentages of cement, fuel and lubricants, labour, Plant Machinery and tools, other materials, steel/ steel components (including structural steel) and explosives, respectively for the relevant item as specified in sub-paragraph (f);

Co = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for sub-group Cement, Lime & Plaster for the Base Month;

Ci = The WPI for sub-group Cement, Lime & Plaster for the average price index of the 3 months of the quarter under consideration;

Fo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for group Fuel & Power for the Base Month;

Fi = The WPI for group Fuel & Power for the average price index of the 3 months of the quarter under consideration

LBo = The consumer price index for industrial workers – All India, published by Labour Bureau, Ministry of Labour, Government of India, (hereinafter called "CPI") for the Base Month;

LBi = The CPI for industrial workers – All India for the average price index of the 3 months of the quarter under consideration;

MACHo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for category- k "Manufacturing of Machinery for Mining, quarrying and construction' under (R) Manufacturing of Machinery and Equipment for the Base Month;

MACHi = The WPI for category- k "Manufacturing of Machinery for Mining, quarrying and construction' under (R) Manufacturing of Machinery and Equipment for the average price index of the 3 months of the quarter under consideration;

OTHo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for all commodities for the Base Month;

OTHi = The WPI for all commodities for the average price index of the 3 months of the quarter under consideration;

So = Average Rate of RINL for Rebar 8 mm (coil) as published for Ludhiana Branch on their website for the Base Month;

Si = Average rate of RINL for Rebar 8 mm (coil) as published for Ludhiana Branch on their website for the 3 months of the quarter under consideration;

If only one rate is published for the 3 months of the quarter under consideration, the published rate for that quarter shall be considered for the quarter under consideration.

If no rate is published by RINL for Rebar 8mm (coil) for the 3 months of the quarter under consideration, the value of Si and So will be taken as under:

"So": Wholesale Price Index for 'MS Bright Bars' individual commodity of group item (d) Mild Steel- Long products under (N) MANUFACTURE OF BASIC METALS, published by Office of Economic Adviser, Government of India, Ministry of Commerce & Industry Department of Industrial Policy & Promotion (DIIP) for the Base Month;

"Si": Average Wholesale Price Index for 'MS Bright Bars' individual commodity of group item (d) Mild Steel- Long products under (N) MANUFACTURE OF BASIC METAL, published by Office of Economic Adviser, Government of India, Ministry of Commerce & Industry Department of Industrial Policy & Promotion (DIIP) for the 3 months of the quarter under consideration;

XLPo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for explosives for the Base Month; and

XLPi = The WPI for explosives for the average price index of the 3 months of the quarter under consideration.

f) The following percentages shall govern the price adjustment of the Contract Price for costs of civil works:

Component	EW (Cost Centre CE of Price Schedule 'A')	BR & RW (Cost Centre CB and Cost Centre CRW of Price Schedule 'A')	TUNL (Cost Centre CTU of Price Schedule 'A')	BLT (Cost Centre CBT of Price Schedule 'A')	SCHB (Price Schedule 'B')	MISC (Price Schedule 'C')
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Cement (PC)	-	20%	20%	20%	20%	-
Fuel and lubricants (PF)	30%	20%	15%	20%	20%	30%
Labour (PLB)	20%	10%	10%	10%	10%	20%
Machinery and Plants (PMACH)	40%	15%	10%	15%	15%	40%

Component	EW (Cost Centre CE of Price Schedule 'A')	BR & RW (Cost Centre CB and Cost Centre CRW of Price Schedule 'A')	TUNL (Cost Centre CTU of Price Schedule 'A')	BLT (Cost Centre CBT of Price Schedule 'A')	SCHB (Price Schedule 'B')	MISC (Price Schedule 'C')
Other Materials (POTH)	10%	10%	10%	10%	10%	10%
Steel(PS)	-	25%	30%	25%	25%	-
Explosives (PXLP)	-	-	05%	-	-	-
Total	100%	100%	100%		100%	100%

g) The following expressions and meanings are assigned to the value of the work done for Various General Electrical Services works:

i) **ELEGWK** = Value of work done for the completion of a stage under Cost Center 'E1- General Electrical Services works of Price Schedule 'A';

ii) **INVELECTRICAL** = Value of work done for the completion of a stage under Cost Center 'E2'- Inventory/Spare Items' of Price Schedule 'A';

Note: - No price adjustment shall be paid against Sub-Cost Center- E3. (Maintenance and Manning of Electrical system).

h) Price adjustment for changes in cost for various General Electrical Services works shall be paid in accordance with the following formula:

i) **VELEGWK** = 0.85 ELEGWK x [PLB x (LBi – LBo)/LBo + POTH x (OTHi – OTHo)/OTHo]

ii) **VINVELECTRICAL** = 0.85 INVELECTRICAL x [POTH x (OTHi – OTHo)/OTHo];

Where: -

VELEGWK = Increase or decrease in the cost under cost center 'E1' of Price Schedule 'A' of General Electrical Services works with complete accessories during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (i);

VINVELECTRICAL = Increase or decrease in the cost under cost Centre 'E2' of Price Schedule 'A' of Inventory/Spare item during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (i);

PLB and POTH and PELEX are the percentages of Labor and, All Other Commodities respectively for the relevant item as specified in sub-paragraph (i);

LBo = The consumer price index for industrial workers – All India, published by Labour Bureau, Ministry of Labour, Government of India, (hereinafter called "CPI") for the Base month;

LBi = The CPI for industrial workers – All India for the average price index of the 3 months of the quarter under consideration

OTHo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for "All commodities" for the Base month;

OTHi = The WPI for all commodities for the average price index of the 3 months of the quarter under consideration;

i) The following percentages shall govern the price adjustment of the Contract Price for Various General Electrical Services works:

(i) For Electrical works, & Inventory /Spare Item:

Component	General Electrical Services Works except commissioning for the Division (E1 – E1.1, E1.2, & E1.3)	Inventory/Spare Item (E2)	Commissioning of Electrical system with complete accessories (E1.4)
Labour (PLB)	20%	-	100%
Electronics (PELEX)	-	-	-
PVC Insulated Cable (PIC)	-	-	-
Fibre Cable (POFC)	-	-	-

All other commodities (POTH)	80 %	100.00%	-
Total	100.00%	100.00%	100.00 %

Table A. Foreign Currency (FC)

Not applicable as Tenderer's are required to quote rates and prices only in INR.

Table B. Summary of Payment Currencies

For ……. [insert name of Works]

Name of Payment Currency	A Amount of Currency	B Rate of Exchange (local currency per unit of foreign)	C Local Currency Equivalent C = A x B	D Percentage of Net Tender Price (NTP) 100xC / NTP
For Schedule 'A'				
Local currency (INR)		**1.00**		
USD ($)				
EUR (€)				
JPY (¥)				
Schedule 'B'		**1.00**		
Schedule 'C'		**1.00**		
Net Tender Price				**100.00**
Provisional Sums Expressed in Local Currency (INR) in million	100,000,000.00	**1.00**	100,000,000.00	**Not Applicable**
TOTAL TENDER PRICE (including Provisional Sum)				

Note: *The Tenderer is required to propose and submit the schedules given in tables above as part of the Tender. The rates of exchange shall be the reference rate twenty-eight (28) days prior to the deadline for submission of Tenders published by the Reserve Bank of India (RBI) on its website https://www.rbi.org.in. In case the exchange rate of particular currency on given date is not available on RBI web site, it will be as per the web site https://www.fbil.org.in of Financial Benchmark India Private Limited (FBIL).*

Appendix B to Financial Part: Price Schedules

1 Preamble

1.1. The Price Schedules shall be read in conjunction with the Instructions to Tenderers, the General Conditions, the Particular Conditions and the Employer's Requirements *{General, Functional (Civil and BLT), Design (Civil and BLT), Construction (Civil and BLT), Outline Design Specifications (ODS)- Civil and BLT, Outline Construction Specifications (OCS)-Civil and BLT, General Electrical Services, Tender drawings and documents and Appendices}* and the Addenda (if any).

1.2. **Schedule 'A'** comprises scope of work to be executed under lump sum contract as detailed in Part 2- Employers' Requirements of Tender Document. *Cost of Schedule 'A' also includes cost of tree cutting for entire package C-4 as per Sub-Clause 10.14 of Appendix 10, Section VII-9: Appendices, Part 2 -Employer's Requirements of Tender Documents. The Tenderer has to quote a single lump sum amount against Schedule 'A'.* Payment to the Contractor will be made in accordance with payment stages/Milestones defined for each Cost Centre detailed in Clause 5.0 below unless otherwise specified in the Contract.

1.3. **Schedule 'B' -** Other civil works:

Schedule 'B' comprises of percentage rate for "Other civil works"**.** The work has to be carried out as per the description of items given in Schedule 'B' and directions of the Engineer. *Cost of design and drawings of all the temporary works, temporary road diversion is deemed to be included in the rates quoted for the relevant item of Schedule 'B' unless otherwise specified in the Contract.* The Tenderer has to quote the percentage Excess (+) or Less (-) over the total Estimated amount of Schedule 'B' *(which is shown as "Estimated Rate" against Schedule 'B' in BOQ2 of MS excel file on e- procurement portal)*. The payment against this Schedule 'B' will be made on the basis of quantities executed, measured and certified. Under this Schedule, the Contractor is required to carry out other civil works, which are not covered in Schedule 'A', as per site requirements and as per the direction of the Engineer.

1.4. **Schedule 'C'** comprises "Item rates for miscellaneous works". Under this Schedule, the Contractor has to undertake items or works not covered in Schedule 'A' or Schedule 'B'. Execution of items under this Schedule shall be carried out only after specific instructions of the Engineer. This Schedule consists of items for Civil works. The work has to be carried out as per Schedule of items given in this Schedule 'C'. This Schedule contains only Rate and Unit of items of the works. The basis of payment will be the actual quantities of work ordered and carried out, as measured by the Contractor and verified by the Engineer and valued at the rates and prices quoted in the Price Schedules. The Tenderer has to quote the percentage (%) Excess (+) or Less (-) over the *total Estimated Cost of Schedule 'C' (which is shown as "Estimated Rate" against Schedule 'C' in BOQ2 of MS excel file on e procurement portal)* Schedule 'C' for items to be executed against this head.

1.5. The Schedules may not generally give a full description of the works to be performed and the plant or equipment to be supplied under each item. Tenderers shall be deemed to have read the Employer's Requirements and the other sections of the Tender Documents and reviewed the Drawings to ascertain the full scope of the requirements included in each item prior to filling the rates and prices.

1.6. The price quoted in the Price Schedules for Schedule 'A'. Schedule 'B' and Schedule 'C' are for complete and finished items of the work in all respects. The Price quoted in the Price Schedules shall, except in so far as it is otherwise provided under the Contract, shall include all design, include all necessary survey work, plants , tools, machinery, Contractor's equipment, labour, compliance of labour laws, supervision, materials, transportation, handling, loading & unloading, storage, sampling, testing, fuel, oil, consumables, electric power, water, all leads & lifts, dewatering, all temporary works including temporary accesses, staging, form works and false works, stacking, provision and maintenance of all temporary works area, construction of temporary store and buildings, fencing, barricading, lighting, drainage arrangements, erection & maintenance of inspection facilities above and below ground such as brick, concrete and steel etc., reinstatement, remedy of any defects during the Defects Notification Period, safety measures for workmen and road users, preparation of design and drawings pertaining to permanent and temporary works, & *temporary diversion works, temporary road widening,* traffic diversion works, mobilisation and demobilisation, establishment and overhead charges, labour camps, insurance cost for labour and works, contractor's profit, all taxes including Goods and Service Tax (GST), insurance, royalties, duties, cess, octroi, other levies and other charges together with all general risks, liabilities and obligations set out or implied in the Contract.

The price and rates quoted by Tenderer shall be deemed to have included GST at the rate of 18% as notified by 47th GST Council on 29th June 2022 ***and Item 18.5 of Circular No. 177/09/2022-TRU dated 03rd August 2022 issued by Ministry of Finance, Government of India.***

1.7. The whole cost of complying with the provisions of the Contract shall be included in the items provided in the Price Schedules, and where no items are provided, the cost shall be deemed to be distributed among the rates and prices entered for the related items of the Work.

1.8. To the extent acceptable to the Employer for the purpose of making payments or partial payments, valuing variations or evaluating claims, or for such other purposes as the Engineer may reasonably require, the Contractor may provide the Engineer with a breakdown of any composite or lump sum items included in the Schedules.

1.9. The Provisional Sums included and so designated in the Price Schedules shall be expended in whole or in part at the direction and discretion of the Engineer. The Provisional Sum shall be used to cover the Employer's share of the DAAB members' fees and expenses, in accordance with Clause 21. No prior instruction of the Engineer shall be required with respect to the work of the DAAB in accordance with Sub-Clause 13.4 of Part B-Specific Provisions - Particular

Conditions of Contract. The Contractor shall submit the DAAB members' invoices and satisfactory evidence of having paid 100% of such invoices as part of the substantiation of those statements submitted under Sub-Clause 14.3. in accordance with Sub-Clauses 13.4 of the General Conditions.

1.10. The prices shall be quoted against Schedule 'A', Schedule 'B' and Schedule 'C' in the Price Schedule (Excel Workbook) uploaded on the e-Procurement portal.

1.11. The prices quoted shall be comprehensive and must include for complying in all respects with the Price Schedules, Instruction to Tenderers, the General Conditions, the Particular Conditions, Employer's Requirements, Specifications and Drawings and for all matters and things necessary for the proper construction, completion, and making good of any defect in part or of the whole of the Works.

1.12. No claims for additional payment shall be allowed for any error or misunderstanding by the Contractor of the work involved.

1.13. The rates quoted by the Tenderer are for design and construction of the Works as per approved Alignment Plan and Longitudinal Section and approved GADs of bridges as per the Scope of the Works.

2 Variations in Price Schedule 'A', Schedule 'B' and Schedule 'C'

2.1 Variations in Price Schedules shall be dealt in accordance with Sub Clause 13.3.1 of Part B-Specific Provisions, Section IX- Particular Conditions of Contract.

2.2 The through Chainages mentioned in the Scope of the Works/Tender Drawings can undergo some minor corrections, without any impact on the overall length/Scope of the Works.

3 Measurement and Payment

3.1 The measurement shall be made as per Price Schedules i.e. Schedule 'A'. Schedule 'B' and Schedule 'C' and other relevant provisions of the Contract such as Employer's Requirements and the Drawings.

3.2 If during execution of the Contract, it is decided by the Employer/Engineer that one or more items of Work/Milestone of a Cost Centre in a particular Price Schedule is not required to be executed, the proportionate amount against that particular Item of Work/Milestones shall not be paid. The Engineer's decision in this regard shall be final.

3.3 The Payment shall be made as per Clause 14 [Contract Price and Payment] of the General Conditions and Particular Conditions.

3.4 The Employer shall make interim payments to the Contractor in accordance with the provisions of Sub-Clause 14.6 [Issue of Interim Payment Certificates] of the General Conditions and Particular Conditions, as certified by the Engineer on the basis of the progress achieved for the items of works/stages/Milestones of the works.

3.5 The Contractor shall base its claim for interim payment in accordance with Sub-Clause 14.3 [Application for Interim Payment] of the General Conditions and Particular Conditions for each stage for various items of work on the basis of actual progress of work executed (i.e. Milestones achieved) till the end of the month for which the payment is claimed in relation to the Contractor's total executed quantity, supported with documents and updated programme in accordance with the Employer's Requirements.

3.6 The Employer may carry out necessary tests, either directly or through an independent agency, of the Works done by the Contractor for which payment has been accepted and certified by the Engineer. The payment shall depend upon the outcome of such tests.

3.7 Format for the Contractor's application for payment shall be agreed between the Engineer and the Contractor.

3.8 All necessary supplementary details to support progress claims, including all certified Request for Inspection in hard bound copy, shall be included with application for payment. Sketches, drawings, approvals, calculations, test reports etc. shall accompany an application for payment to be substantiated and certified by the Engineer and submitted to the Employer.

3.9 Even if no work is executed during the month, or the Contractor does not choose to issue an application for payment, a 'NIL' application shall be submitted.

3.10 For the purposes of payment, the Contractor shall submit to the Engineer a detailed Price Schedule indicating a further breakdown for each stage of payment contained in the Price Schedules within forty-two (42) days after the receipt of the Letter of Acceptance. Such cost breakdowns shall be subject to approval of the Engineer who shall review and evaluate with comments and/or issue approval within twenty-eight (28) days of receipt of same. The Contractor shall resubmit the cost breakdown structure corresponding to the Engineer's comments for review, if required.

3.11 The Engineer is not obliged to issue an Interim Payment Certificate until such breakdown structure of payment schedule has been submitted and accepted by the Engineer.

4 Methodology for Claiming Payment

4.1 The Contractor shall prepare his monthly application for payment in the agreed format in two hard copies and one soft copy. This shall be accompanied by supplementary details in accordance with Sub-Clause 14.3 [Application for Interim Payment Certificates] of the General Conditions. All hard copies shall bear the original signatures of the Contractor's Representative and be submitted to the Engineer.

4.2 If these are found in order, in accordance with Sub-Clause 14.6 [Issue of Interim Payment Certificates] of the General Conditions, then the Engineer shall forward two certified copies of the application along with certified supplementary details to the Employer, with his recommendation for payment; otherwise, all documents shall be returned to the Contractor for rectification and resubmission.

5 Schedules

5.1 Schedule "A'- Breakup of Lump Sum cost of Works under various Sub-Heads shall be as follows:

Sub-Head	Description	Percentage of the quoted lump sum cost of Schedule 'A'	No. of Cost Centres	Total Cost of each Sub-Head
1	**2**	**3**	**4**	**5**
C	Civil & BLT works	96%	6	C= 0.96xLS*
E	General Electrical Services works	4%	3	E=0.04xLS

*LS = Total lump sum *accepted* cost of Works for Schedule 'A'

5.2 Apportionment of Contract Price for payments under various Cost Centre for Sub-Head 'C'- Civil & BLT Works

Cost Centre	Description of Cost Centre	Percentage of Cost Centre 'C'	Total Cost of Cost Centre	Total Cost of Sub-Head 'C'
1	2	3	4	5
CG	General	2.00%	CG= 0.02x 'C'	96% of SCH 'A'
CE	Earthwork & blanketing	1.2%	CE=0.012x 'C'	
CB	Bridges	1.44%	CB=0.0144x 'C'	
CTU	Tunnel & Shafts	90.84%	CTU=0.9084x 'C'	
CBT	Ballastless Track	4.52%	CBT=0.0452x 'C'	
	Total	100%		

Note: Value of 'C' shall be as defined in Sub-Clause 5.1 above.

The percentage figures as filled in column (3) by the Employer for the apportionment of the Contract Price for completion of the Works corresponding to the various Sub-Heads and Cost Centres are fixed and payment will be released for different Cost centre as per above percentage break-up of Contract Price.

5.3 Stages of Payment i.e. Milestones of Cost Centre 'CG'- General

Cost Centre			'CG'- General	
Weightage of Cost Centre 'CG', (Y)-			2%	
Sub Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
CG1- General	CG.1	GT investigation	GT investigations and submission & approval of GIR.	20%
CG2- Design	CG.2.1		Submission and approval of preliminary and final design and Good for Construction (GFC) drawings of portals, tunnels, permanent ventilation shafts & construction cum utility shaft.	30%

Cost Centre			'CG'- General	
Weightage of Cost Centre 'CG', (Y)-			**2%**	
Sub Cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No.	**Description**		
1	2	3	4	5
	CG.2.2		Submission and approval of GAD, final design and Good for Construction (GFC) drawings of bridges and embankment	10%
	CG.2.3		Submission and approval of preliminary and final design and Good for Construction (GFC) drawings of Ballastless track	20%
CG.3- "As Built" Drawings & Documents	CG.3.1	As Built Drawings	Submission of "As Built" Drawings	10%
	CG.3.2	As Built Documents	Submission of "As Built" Documents	10%
			Total	**100%**

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CG.1 will be = 0.96x*LS*xXxY=0.96x *LS*x0.20 x 0.02.
2. Adjustment to Contract Price pursuant to GCC 13.7 shall **NOT** be applicable to the payments of Works executed under this Cost Centre.
3. Payment will be made on Completion of each Milestones as per weightage given in this Cost Centre

5.4 Stages of Payment i.e. Milestones of Cost Centre 'CE'- Earthwork and Blanketing

Cost Centre			**'CE'- Earthwork and Blanketing**	
Weightage of Cost Centre 'CE', (Y)-			**1.2%**	
Sub-Cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No.	**Description**		
1	2	3	4	5
CE.1- Earthwork	CE.1.1	Earthwork in formation from Ch 12000 to 12500 for double main line track.		
	CE1.1.1		Earthwork in embankment / cutting including compaction.	3.4%
	CE1.1.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE1.1.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.2	Earthwork in formation from Ch 12500 to 13000 for double main line track.		
	CE1.2.1		Earthwork in embankment / cutting including compaction.	3.4%
	CE1.2.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE1.2.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.3	Earthwork in formation from Ch 13000 to 13500 for double main line track.		
	CE1.3.1		Earthwork in embankment / cutting including compaction.	3.4%
	CE1.3.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE1.3.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.4	Earthwork in formation from Ch 13500 to 14000 for double main line track.		
	CE.1.4.1		Earthwork in embankment / cutting including compaction.	3.9%
	CE.1.4.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE.1.4.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.5	Earthwork in formation from Ch 14000 to 14500 for double main line track.		
	CE.1.5.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.5.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE.1.5.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.6	Earthwork in formation from Ch 14500 to 15000 for double main line track.		
	CE.1.6.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.6.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE.1.6.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.7	Earthwork in formation from Ch 15000 to 15500 for double main line track.		
	CE.1.7.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.7.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.3%
	CE.1.7.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.8	Earthwork in formation from Ch 15500 to 16000 for double main line track.		
	CE.1.8.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.8.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.3%
	CE.1.8.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.9	Earthwork in formation from Ch 16000 to 16500 for double main line track.		
	CE.1.9.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.9.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.3%
	CE.1.9.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.10	Earthwork in formation from Ch 16500 to 17000 for double main line track.		
	CE.1.10.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.10.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.3%
	CE.1.10.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.11	Earthwork in formation from Ch 17000 to 17500 for double main line track.		
	CE.1.11.1		Earthwork in embankment / cutting including compaction.	5.0%
	CE.1.11.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.4%
	CE.1.11.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.12	Earthwork in formation from Ch 17500 to 18000 for double main line track.		
	CE.1.12.1		Earthwork in embankment / cutting including compaction.	5.0%
	CE.1.12.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.4%
	CE.1.12.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.13	Earthwork in formation from Ch. 29580 to 29680	On completion of earthwork in cutting including *providing vegetative cover including coir netting (where specified)* and drainage arrangement complete in all respect.	4.9%
CE.2- Blanketing	**CE.2.1**	Blanketing from Ch 12000 to 12500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.2	Blanketing from Ch 12500 to 13000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.3	Blanketing from Ch 13000 to 13500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.4	Blanketing from Ch 13500 to 14000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.5	Blanketing from Ch 14000 to 14500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.6	Blanketing from Ch 14500 to 15000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
	CE.2.7	Blanketing from Ch 15000 to 15500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.8	Blanketing from Ch 15500 to 16000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.9	Blanketing from Ch 16000 to 16500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.10	Blanketing from Ch 16500 to 17000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.11	Blanketing in formation from Ch 17000 to 17500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.12	Blanketing from Ch 17500 to 18000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
			Total	**100%**

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CE.1.1.1 will be = 0.96x*LS*xXxY=0.96x *LS*x0.034 x 0.012.

2. Adjustment to Contract Price pursuant to GCC 13.7 shall be applicable to the payments of Works executed under this Cost Centre / Price Schedule.
3. Payment will be made on Completion of each Milestones as per weightage given in this schedule.

5.5 Stages of Payment i.e. Milestones of Cost Centre 'CB'- for Bridges

Cost Centre			'CB'- Bridges	
Weightage of Cost Centre 'CB', (Y)-			1.44%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
CB.1- Minor Bridges	CB1.1	Construction of minor bridge No. 47, 48 & 49 between ch 12000 to 12500 for main line track.	On completion of *bridgeworks in all respects*	22.4%
	CB1.2	Construction of minor bridge No. 50 between ch 12500 to 13000 for main line track.	On completion of *bridgeworks in all respects*	5.6 %
	CB1.3	Construction of minor bridge No. 51 between ch 13000 to 13500 for main line track.	On completion of *bridgeworks in all respects*	6.3 %
	CB1.4	Construction of minor bridge No. 52 between ch 13500 to 14000 for main line track.	On completion of *bridgeworks in all respects*	4.4 %
	CB1.5	Construction of minor bridge No. Nil between ch 14000 to14500 for main line track.	-	0%
	CB1.6	Construction of minor bridge No. 54 & 55 between ch 14500 to 15000 for main line track.	On completion of *bridgeworks in all respects*	21.7%
	CB1.7	Construction of minor bridge No. 56 between ch 15000 to15500 for main line track.	On completion of *bridgeworks in all respects*	5.8%
	CB1.8	Construction of minor bridge No. 57 between ch 15500 to16000 for main line track.	On completion of *bridgeworks in all respects*	14.8%
	CB1.9	Construction of minor bridge No. Nil between ch 16000 to16500 for main line track.	-	0%
	CB1.10	Construction of minor bridge No. Nil between ch	-	0%

Cost Centre			'CB'- Bridges	
Weightage of Cost Centre 'CB', (Y)-			1.44%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
		16500 to17000 for main line track.		
	CB1.11	Construction of minor bridge No. Nil between ch 17000 to17500 for main line track.	-	0%
	CB1.12	Construction of minor bridge No. Nil between ch 17500 to18000 for main line track.	-	0%
CB.2- Major Bridges	CB.2.1	Foundation	On completion of the foundation work including pile caps/ well caps and foundations for wing and return walls and testing.	4.0%
	CB.2.2	Substructure	On Completion of Abutment/Piers including Abutment/Pier Cap without bearings.	
	CB.2.2.1		Pier/Abutment	3%
	CB.2.2.2		Pier/Abutment cap	0.5%
	CB.2.2.3		Completion of the wing walls, return walls in all respects	2.5%
	CB.2.3	Superstructure	On completion of superstructure *including launching in position*.	5.0%
	CB.2.4		On completion of balance works as per drawing like- protection works including Toe wall, Pitching, inspection platform at each pier & abutment *including* access ladder, inspection steps, Bridge plaque, Bridge board, painting of HFL, *Height gauge & drainage arrangements in*	4%

Cost Centre			'CB'- Bridges	
Weightage of Cost Centre 'CB', (Y)-			1.44%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			RUBs and testing on completion, if any, complete in all respect and fit for use.	
			Total	**100%**

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CB1.1 will be = 0.96x*LS*xXxY=0.96x *LS*x0.224 x 0.0144.

2. Adjustment to Contract Price pursuant to GCC 13.7 shall be applicable to the payments of Works executed under this Cost Centre / Price Schedule.

3. Payment will be made on Completion of each Milestones as per weightage given in this schedule.

4. CB2-Major Bridges:
   (ii) For the purpose of stage payment/Milestones, cost of a bridge shall be taken in proportion to its linear length measured along the alignment to the total linear length of all major bridges.
   (iii) Payment of each stage/Milestones for a bridge will be made on completion of the relevant stage as per the weightage given in this schedule in proportion to the cost of the bridge.

5. Stages CB.2.1 to CB.2.2 will further be subdivided into the number of piers + 2 abutments, as applicable as per approved drawing by the Engineer, and Milestones for completed work for each pier and abutment shall be made as per the requirement of the stages stated above.

6. For PSC slabs payment against sub cost centre 2.3 shall be released as per following schedule-

(i) On casting of PSC slabs: 50%

(ii) On prestressing: 20%

(iii) On completion in all respect: 30%

7. *The cost of Milestones included cost of all temporary work and temporary diversion of road wherever required for all bridges included in Schedule 'A', Section VII-2, Employer's Requirements.*

5.6 Stages of Payment i.e. Milestones of Cost Centre 'CTU'- Tunnel & Shafts

Cost Centre			'CTU'- Tunnel	
Weightage of Cost Centre 'CTU', (Y)-			90.84	
Sub-cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
CTU.1– Permanent ventilation Shafts and Construction cum utility shaft	CTU1.1	Completion of excavation for construction of permanent ventilation shafts and Construction cum utility shaft		
	CTU1.1.1		Construction of Permanent Ventilation Shaft No. 1 at Chainage 26080	0.8%
	CTU1.1.2		Construction of Permanent Ventilation Shaft No. 2 at Chainage 26080	0.8%
	CTU1.1.3		Construction of Permanent Ventilation Shaft No. 3 at Chainage 27680	0.8%
	CTU1.1.4		Construction of Permanent Ventilation Shaft No. 4 at Chainage 27680	0.8%
	CTU1.1.5		Construction of Construction cum Utility Shaft at Chainage 26950	0.8%
CTU.2- NATM Drive	CTU2.1	On completion of first round of the Excavation by NATM from		
	CTU2.1.1		Face F1	0.5%
	CTU2.1.2		Face F2	0.5%
	CTU2.1.3		Face F3	0.5%
	CTU2.1.4		Face F4	0.5%
	CTU2.1.5		Face F5	0.5%
	CTU2.1.6		Face F6	0.5%

Cost Centre			**'CTU'- Tunnel**	
Weightage of Cost Centre 'CTU', (Y)-			**90.84**	
Sub-cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No.	**Description**		
1	2	3	4	5
	CTU2.1.7		Face F7	0.5%
	CTU2.1.8		Face F8	0.5%
	CTU2.1.9		Face F9	0.5%
	CTU2.1.10		Face F10	0.5%
	CTU2.1.11		Face F11	0.5%
	CTU2.1.12		Face F12	0.5%
	CTU2.1.13		Face F13	0.5%
	CTU2.1.14		Face F14	0.5%
CTU.3	CTU.3.1	NATM Main Drive of both tunnels from chainage *24850 (Up line) & 24853 (Dn line) t*o 26067.5m	On Completion of NATM Main Drive (On account payment will be made on proportionate basis based on actual work progress in m divided by Total length of NATM drive)	11%
	CTU.3.2	NATM Main Drive of both tunnels from chainage 26092.5m to 27667.5m and from chainage 27692.5m to 28480m	On Completion of NATM Main Drive (On account payment will be made on proportionate basis based on actual work progress in m including Benching divided by Total length of NATM drive)	37.4%
CTU.4-Secondary Lining	CTU4.1	Secondary lining in both tunnels in NATM portion	On completion of Secondary Lining (on account payment will be made on proportionate basis based on actual progress of work in meter divided by total length of NATM tunnel)	14%
CTU.5-Cut & Cover Tunnel	CTU 5.1	Excavation of Cut & Cover Tunnel	Excavation for Cut & Cover tunnel (On account payment will be made on proportionate basis based on actual progress of work in sqm on Plan divided by Total area in sqm on Plan)	4.6%

Cost Centre			'CTU'- Tunnel	
Weightage of Cost Centre 'CTU', (Y)-			90.84	
Sub-cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
	CTU 5.2	Cut & Cover Tunnel Structures	Completion of Cut & Cover Tunnel Structures including waterproofing, backfill & drainage arrangement (on account payment will be made on proportionate basis based on actual work progress in sqm on Plan divided by Total area in sqm on Plan)	10%
CTU5-Cross Passage	CTU5.1	Cross Passage	Construction of Cross Passages	3.0%
CTU6-Miscellaneous works	CTU6.1	Miscellaneous	Construction of Portal P2, Footpath, Drainage, Restoration of the Areas etc. complete in all respect.	9.0%
			Total	**100%**

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CTU1.1.1will be = 0.96x*LS*xXxY=0.96x *LS*x0.008 x 0.9084.
2. Adjustment to Contract Price pursuant to GCC 13.7 shall be applicable to the payments of Works executed under this Cost Centre / Price Schedule.
3. *Inc case of any addition / reduction in the length of tunnel due to change in the location of Portal P-1, payment/deduction shall be made @ INR 9.60 lacs per metre addition/reduction in the length of tunnel.*

5.7 Stages of Payment i.e. Milestones of Cost Centre 'CBT'- Ballastless Track

Cost Centre			'CBT'- Ballastless Track	
Weightage of Cost Centre 'CBT', (Y)-			4.52%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
CBT.1	CBT1.1	Supply of Fastening system	On supply of Track fitting/fastening system complete	15%
	CBT1.2	Construction of ballastless track	Construction of ballastless track (On account payment will be made on proportionate basis based on actual work progress in meter divided by total length of ballastless track)	65%
	CBT1.3	Misc. works	On completion of all balance works as per drawings like welding into LWR, destressing, drainage, supply of spare fittings/ fastenings for BLT etc. complete.	10%
	CBT1.3	Maintenance	Maintenance of ballastless track for one year after start of traffic (to be paid monthly on pro rata basis based on satisfactory performance certificate by the Engineer.)	10%
			Total	100%

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CBT1.1 will be = 0.96x*LS*xXxY=0.96x *LS*x0.15 x 0.0452.
2. Adjustment to Contract Price pursuant to GCC 13.7 shall be applicable to the payments of Works executed under this Cost Centre / Price Schedule.

6 Apportionment of the Contract Price for Schedule 'A' under various Cost Centre for Sub-Head 'E'-General Electrical Services works

Cost Centre	Description of Cost Centre	Percentage of Cost Centre	Total Cost of Cost Centre	Total Cost of Sub-Head "E"
1	**2**	**3**	**4**	
E1	General Electrical Services works	94.36%	E1=0.9436 x 'E'	4% of Schedule 'A"
E2	*Contract* Spare*s, Tools & Tackles and Measuring Instruments*	4.83%	E2=0.0483 x 'E'	
E3	Maintenance and Manning of electrical system for one year	0.81%	E3=0.0081x 'E'	
	Total	**100%**		

6.1 Stages of Payment i.e. Milestones of cost center E1. – General Electrical Services works

Cost center			E1. – General Electrical Services works	
Weightage of Cost Centre 'E1', (Y)			94.36 %	
Sub Cost Centre	Item of Work		Milestone	Weightage (X)
	No	Description		
1	2	3	4	5
E1.1	E1.1.1	Drawing and Design	Preparation and Submission of Drawing and Design for General Electrical Services works, Plan, Specifications, Load calculations, Reports and Drawing of civil structure/building for sub-stations etc. required for commissioning of Electrical System.	5.00%
E1.2	E1.2.1	Supply of Electrical Equipment and associated materials	Supply of equipment and associated material for the Electrical system and material for construction of civil structure/building for sub- stations. i. Major Electrical item like – 11 kVA GIC Panel, Transformers, DG sets, All types of cables, Cable Tray, LT Panels, all types of LED fittings and its associated items.	60.00%
E1.3	E1.3.1	Installation & Erection of Electrical Equipment	Delivery to Site from , Installation and Site Testing of all equipments for Electrical system (includes pre-installation tests and post installation tests). i. Construction of building for sub-stations. ii. Installation of all Electrical equipment iii. Installation of all required sensors and Earthing system.	20.00%
E1.4	E.1.4.1	Testing and Commissioning	System Acceptance Tests (SAT) and Integrated Commissioning and Charging of Total Electrical system	15.00%
			Total	**100%**

Note:

1 The value of each Milestone will be 4% of total Lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example, *the value of Milestone* E1.1.1 will be = *0.04xLSxXxY* = 0.04 x*LSx* 0.05x 0.9436.

2 Adjustment to Contract Price Shall Not be applicable E1.1 to the payments of Works executed under Cost Centre 'E1'.

3 Payment will be made on completion of each Milestones as per weightage given in this Cost Centre.

4 Payment against the Sub Cost Centre E1.2 shall be made for quantities as per the approved Design, on receipt of Material at contractor's depot, production of inspection certificates & other documents and against BG of equivalent amount.

5 Payment against each Sub Cost Centre shall be made only on completion of work under Sub Cost Centre.

6.2 Stages of Payment i.e. Milestones of cost center E2 – *Contract Spares, Tools & Tackles and Measuring Instruments*

Cost center			**E2 – Contract Spares, *Tools & Tackles and Measuring Instruments***	
Weightage of Cost Centre 'E2', (Y)			**4.83%**	
Sub Cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No	**Description**		
1	**2**	**3**	**4**	**5**
E2.1	E2.1.1	*Contract Spares, Tools & Tackles and Measuring Instruments etc..*	Supply of *Contract Spares, Tools & Tackles and Measuring Instruments etc.*	100%
			Total	**100%**

Note:

1. The value of each Milestone will be 4% of total Lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example, *the value of Milestone* E2.1.1 will be = *0.04xLSxXxY* = 0.04 x 1x 0.0483.
2. Adjustment to Contract Price shall be applicable to the payments of Works executed under Cost Centre 'E2'.
3. Payment will be made on completion of each Milestones as per weightage given in this Cost Centre.

6.3 Stages of Payment i.e., Milestones of Cost Centre E3 – Maintenance and Manning of Electrical system *for one year*

Cost center			**E3 – Maintenance and Manning of Electrical system *for one year***	
Weightage of Cost Centre 'E3', (Y)			**0.81%**	
Sub Cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No	**Description**		
1	**2**	**3**	**4**	**5**
E3.1	E3.1.1	Maintenance and Manning of *Electrical system* for one year	Maintenance and Manning of Electrical system *for one year*	100.00%

Note:

1. The value of each Milestone will be 4% of total Lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example, *the value of Milestone* E3.1 will be = *0.04xLSxXxY* = 0.04 x *LS x* 1x 0.0081.

2. Adjustment to Contract Price shall be applicable to the payments of Works executed under Cost Centre 'E3'.

3.Payment will be made on completion of each Milestones as per weightage given in this Cost Centre.

7 Schedule 'B': Other civil works

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
Schedule B1:- NWR-USSOR 2019 BASED ITEMS							
1	011010	Earthwork in cutting (classified) in formation, trolley refuges, side drains, level crossing approaches, platforms, catch water drains, diversion of nallah & finishing to required dimension and slopes to obtain a neat appearance to standard profile inclusive of all labour, machine & materials and removing & leading all cut spoils either to make spoil dumps beyond 10m from cutting edge or for filling in embankment with leads within 2 km on either side of cutting edge, lifts, ascent, descent, loading, unloading, all taxes / royalty, clearance of site and all incidental charges, bailing & pumping out water, if required, etc. complete as per directions of the Engineer in-Charge. The work is to be executed as per latest / updated edition of "Guidelines for Earthwork in Railway Projects" issued by RDSO, Lucknow. Cut trees shall be property of Railways and to be deposited in the railway godown unless specified otherwise in the Special Conditions of Contract. {Note - (i) All usable earth arising from cut spoils shall be led into bank formation and Unusable spoils shall be dumped / stacked (ii) All hard rock /and boulders not fit for					

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		filling will be stacked by the contractor and will be property of the HRIDC.}					
1a	011012	Soft rock not requiring blasting in all conditions	2000	Cum	347.68	389.85	**779,700.00**
1b	011013	In hard rock requiring blasting with explosives and blasting/drilling equipment Including all incidental work in all conditions. Rate includes cost of all explosive material.	45000	Cum	545.17	611.28	**27,507,600.00**
1c	011014	In rock and very hard rock with hammer / chisel / pavement breaker etc. where blasting is not permitted due to special circumstances and if specifically ordered in writing including drilling and all incidental work in all conditions	5000	Cum	1,225.22	1,373.80	**6,869,000.00**
2	022010	Earthwork in excavation by mechanical means (Hydraulic Excavator)/Manual Means for foundations and floors of the bridges, retaining walls etc. including setting out, dressing of sides, ramming of bottom, getting out the excavated material, back filling in layers with approved material and consolidation of the layers by ramming and watering etc. including all lift, disposal of surplus soil upto a lead of 300m, all types of shoring and strutting with all labour and material complete as per drawing and technical specification as directed by Engineer. **Note**: This item will be used for excavation work in					

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		connection with other miscellaneous works also like side drains, foundation for OHE masts and other miscellaneous structures in connection with Gauge Conversion, Doubling, New lines.					
2a	022011	All kinds of soils	6000	Cum	195.57	219.29	**1,315,740.00**
3	022040	Providing and laying in position machine batched, machine mixed and machine vibrated Design Mix Cement Concrete of specified grade **(M-20** Cast in-Situ) using 20mm graded crushed stone aggregate and coarse sand of approved quality in RCC raft foundation & Pile cap including finishing, using Admixtures in approved proportions (as per IS:9103), to modify workability & other properties without impairing strength and durability complete as per specifications and direction of the Engineer in charge. Payment for cement, reinforcement and shuttering shall be paid extra. **Note**-Cement concrete in drainage and other miscellaneous works shall be paid under this item.	1,737	Cum	2,840.33	3,184.77	**5,531,945.49**
4	022070	Providing and fixing Weep Holes in Abutments, RCC Box, Wing walls and Return walls etc., of new bridges with 110mm dia UPVC pipe (IS :13592) Type A ISI marked with all contractor's men,	1,500	Rmt	242.28	282.93	**424,395.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		material, transportation, all taxes as per specifications and as directed by Engineer-in-Charge.					
5	023010	Earth work in OPEN excavation in foundation of bridges, for placing of well curbs of all shapes and designs in all kinds of soil including taking out the excavated soil, levelling, ramming of bottom of excavation and trimming of sides, returning the soil in layers, consolidation, disposal of surplus soil within a lead of 300m, including all lift, dewatering, shoring and strutting complete as per technical specification and as directed by Engineer in charge. (compaction of surplus soil when led to the bank will be paid as per relevant item separately)	300	Cum	293.36	328.94	**98,682.00**
6	023030	Supplying, Fabrication, assembly, erection & placing in position the cutting edge of well curb with structural steel including MS sheet/Plates of specified thickness for pier/abutment complete as per approved plans and as per direction of Engineering In charge including all operations like cutting, bending, straightening, drilling holes, bolting, riveting, welding, threading, jointing of steel sections including outer and inner places liners and skin plates, stiffeners, hooks, bottle nuts, bond rods etc. as per design including all ascent, descents, leads, lifts, handing, re-handling, all other obstructions	9	MT	96,774.58	108,510.24	**976,592.16**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		whatsoever, diverting channels, pumping / bailing out of water wherever required including cost of steel such as flats, sheets, angles, steel bars etc. with all labour and material as a complete job					
7	023040	Dry/Wet Sinking of Circular Wells (Other than pneumatic method) in all types of strata except hard rock requiring ballasting, including bailing and pumping out water, removal of excavated soil with all labour and material required for sinking as per drawing and direction of the Engineer in charge, disposal of surplus soil in the adjoining bank/embankment (compaction to be paid separately under the relevant item).					
7a	023041	From initial level of cutting edge & upto 3m depth	777	Cum	183.34	205.57	**159,769.00**
7b	023042	Above 3m to 10m depth	1,813	Cum	294.64	330.37	**599,092.96**
7c	023043	Above 10m to 15m depth	1,295	Cum	410.28	460.03	**595,876.86**
7d	023044	Above 15m to 20m depth	1,295	Cum	563.53	631.87	**818,461.21**
7e	023045	Above 20m to 25m depth	1,295	Cum	809.02	907.13	**1,175,005.49**
7f	023045	Above 25m to 30m depth	648	Cum	1,249.18	1,400.67	**907,213.96**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
8	023090	Providing and laying in position machine batched, machine mixed and machine vibrated Design Mix Cement Concrete of specified grade (Cast in-Situ) using 20mm graded crushed stone aggregate and coarse sand of approved quality in the following elements of well including finishing, using Admixtures in approved proportions (as per IS:9103), to modify workability & other properties without impairing strength and durability complete as per drawings and technical specifications as directed by Engineer. Payment for cement, reinforcement and shuttering shall be made extra.					
8a	023091	In well Curb	249	Cum	3,124.37	3,503.26	**871,260.76**
8b	023092	In Steining of wells	3,338	Cum	3,124.37	3,503.26	**11,694,932.86**
8c	023093	In Bottom plug for wells including arrangements for placing concrete under water with tremie or bottom opening skips.	432	Cum	3,124.37	3,503.26	**1,512,707.67**
8d	023095	In Intermediate/Top plug with internal shuttering	259	Cum	2,982.35	3,344.01	**866,432.99**
8e	023096	In Well cap and corbel, if provided	412	Cum	2,982.35	3,344.01	**1,378,735.32**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
9	023100	Supplying and filling ordinary sand in between bottom plug and top plug in wells including all lead lift handling, re-handling, as a complete job. Sand should be simultaneously filled with water for three days to achieve full compaction so that further chances of shrinkage due to voids are eliminated					
9a	023102	Using sand from other than River bed (This item is to be operated if suitable sand is not available in River Bed for filling	3,173	Cum	2,031.30	2,277.63	**7,227,831.04**
10	025020	Providing and applying two coats of coal tar or bitumen confirming to IS:3117– latest version on the top and sides of RCC box/slabs @ 1.70 kg/sqm after cleaning the surface with all labour and materials complete job as directed by the Engineer	3,150	Sqm	155.67	174.55	**549,832.50**
11	025030	centering and shuttering including strutting, propping etc. and removal of form for :					
11a	025031	All types of bridge sub-structures, e.g. pier, abutment, wing wall, retaining wall, RCC box type foundations, Abutment cap, Pier Cap, Inspection Platform & Pedestal over Pier cap, Fender wall, Diaphragm wall etc. upto 5m above ground level	16,500	Sqm	671.94	753.42	**12,431,430.00**
11b	025032	All types of bridge super-structures, e.g. slabs, I-girders, T-girders, Box girders etc. upto 5m above ground level	3,200	Sqm	874.49	980.54	**3,137,728.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
11c	025033	Extra for additional height over item no. 025031 & 025032 wherever required with adequate bracing, propping etc. over initial height of 5 metres for every additional height of 1 metre or part thereof	2,600	Sqm	110.17	123.53	**321,178.00**
12	025060	Supply and using Cement at Worksite					
12a	025062	Ordinary Portland Cement 53 grade	335	MT	7,398.80	8,623.08	**2,888,731.80**
12b	025063	Pozzolana Portland Cement	2060	MT	6,905.10	8,047.69	**16,578,241.40**
13	025070	Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete					
13a	025072	Thermo-Mechanically Treated bars of grade Fe-500D or more.	1,576,620	Kg	78.01	87.70	**138,269,574.00**
14	031020	Providing and laying in position machine batched, machine mixed and machine vibrated Design Mix Cement Concrete of specified grade using 20mm graded crushed stone aggregate and coarse sand of approved quality for the Precast Prestressed (Post tensioned) concrete girder/Box (spans upto 30.5m) in contactor's casting yard, including finishing, using Admixtures in approved proportions (as per IS:9103), to modify workability & other properties without impairing strength and durability, complete as per drawings, specifications and direction of the	290	Cum	2,840.33	3,184.77	**923,583.30**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		Engineer. Payment for Shuttering, Cement, reinforcement, HTS cables, anchorage cones, stressing of cables and grouting of the ducts will be done extra. Launching of girder/slab in position is not included in this item.					
14a	031021	Deduct from 0310220 for casting of Slab in place of Girder/Box	290	Cum	42.48	47.63	**-13,812.70**
15	031040	Providing, fabricating & fixing in position to exact design profiles, prestressing H.T.S. cables of all classification made from Low Relaxation strands conforming to IS:14268– latest version in Prestressed (Post tensioned) Concrete girders/slabs etc. including supplying, cutting, making into cables with necessary spacers, colour coding, protecting with water soluble oil at all time, anchoring of cables, supplying and placing spiral corrugated type galvanized metal steel ducts sheathing made up of Cold Rolled Cold Annealed (CRCA) mild steel conforming to IS:513 of required diameter/ thickness, vent pipe, placing, bending, routing, fixing, stressing & grouting of cable ducts with cement grout, Anchorage sets in required number with provision for future prestressing if any including all lead and lift with contractor's own materials, labour, equipments etc. complete as per drawings & specifications. Rate also includes	13	MT	179,099.63	232,655.79	**3,024,525.27**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		covering anchorage pads with epoxy mortar of approved quality to avoid corrosion. Cement for grouting to be paid separately. Payment shall be made in terms of weight of HTS cables as per drawing.					
16	031140	Providing and fixing in position GI Drainage Spouts of required length with Grating in RCC slab and filling bitumen along kerb as shown in drawing with contractor's pipes, bitumen, tools, equipment, lead, lifts etc. complete as per specifications and as directed by Engineer in-charge					
16a	031142	100mm dia. Drainage Spouts	120	Metre	1,202.50	1,348.32	**161,798.40**
17	041330	Launching & fixing in specified Bridge location all types of Steel Plate girders / PSC girders / Slabs including loading/unloading and transport to the site of launching with a lead of five kilometres & lifting to any height as per site requirement, provision of approaches for leading, cleaning of bed block and minor repairs to bed block with epoxy if required, as directed by Engineer in charge with all labour, tools and plant, equipment etc., complete					
17a	041331	PSC girders / slabs	910	MT	6,346.14	7,115.72	**6,475,305.20**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
18	041390	Supplying fabricating and erecting welded and/or bolted and/or riveted steel work in built up sections, trusses and framed work, staging, racks etc.for Steel Structures other than bridge girders, using RSJ, tees, angles and channels/flats, plates, gussets, round or square bars, cleats, bolts etc., with contractors own steel including cutting, bending, straightening, drilling, riveting, hoisting, fixing, erecting, welding, bolting etc., with Providing stiffeners wherever required as per approved drawing including applying a priming coat of a approved steel primer with all contractor's materials, labour, tools & plants, lead & lift including crossing of tracks if required etc., complete as per specification and as directed by Engineer-in-charge.	70	MT	86,019.71	122,227.99	**8,555,959.30**
19	051170	Providing and laying of filter media consisting of granular materials of GW, GP, SW groups as per IS:1498 (latest) in required profile behind boulder filling of abutments, wing walls / return walls etc. above bed level with all labour and material complete job as per drawing and technical specification of RDSO Guidelines.	8,500	Cum	2,658.72	2,587.70	**21,995,450.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
20	052230	Providing cast in situ bridge number plaques as per Railway drawing in cement concrete 1:2:4 mix using 20mm hard stone aggregate embedded in 30mm notch in Bridge parapet coping duly engraving the letter and figures and an arrow indicating the direction of flow and finishing the top exposed surface with cement mortar 1:3, painting letters and figures with two coats of black enamel paint on two coats of white background with all labour, tools, cement, paint etc. with all leads and lifts.	5	Each	801.69	898.91	**4,494.55**
21	052240	Providing cast in-situ plaques for bridge foundations details of size 45cmx45cmx5cm in cement concrete 1:2:4 mix using 20mm hard stone aggregate embedded in 30mm deep notch over abutment & piers, engraving the letters & figures with CM 1:3 and finished smooth including painting letters and figures with 2 coats of black enamel and plaque with white enamel with all labour, tools, cement, paint, curing etc. as a complete job.	10	Each	1,049.88	1,177.20	**11,772.00**
Schedule B2:- DSR-2021 BASED ITEMS							
22	10.16	Steel work in built up tubular (round, square or rectangular hollow tubes etc.) trusses etc., including cutting, hoisting, fixing in position and applying a priming coat of approved steel primer, including					

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		welding and bolted with special shaped washers etc. complete.					
22a	10.16.2	Hot finished seamless type tubes	2,000	Kg	168.95	183.55	**367,100.00**
23	10.28	Providing and fixing stainless steel (Grade 304) railing made of Hollow tubes, channels, plates etc., including welding, grinding, buffing, polishing and making curvature (wherever required) and fitting the same with necessary stainless steel nuts and bolts complete, i/c fixing the railing with necessary accessories & stainless steel dash fasteners , stainless steel bolts etc., of required size, on the top of the floor or the side of waist slab with suitable arrangement as per approval of Engineer-in-charge, (for payment purpose only weight of stainless steel members shall be considered excluding fixing accessories such as nuts, bolts, fasteners etc.).	800	Kg	612.25	665.14	**532,112.00**
24	16.30.2	Providing and applying tack coat using hot straight run bitumen of grade VG - 10, including heating the bitumen, spraying the bitumen with mechanically operated spray unit fitted on bitumen boiler, cleaning and preparing the existing road surface as per specifications On bituminous surface @ 0.50 Kg / sqm	4,252	Sqm	36.60	39.76	**169,059.52**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
25	16.33.2	2.5 cm premix carpet surfacing with 2.25 cum and 1.12 cum of stone chippings of 13.2 mm and 11.2 mm size respectively per 100 sqm and 52 kg and 56 kg of hot bitumen per cum of stone chippings of 13.2 mm and 11.2 mm size respectively, including a tack coat with hot straight run bitumen, including consolidation with road roller of 6 to 9 tonne capacity etc. complete (tack coat to be paid for separately). With paving Asphalt grade VG - 30 with no solvent	4,125	Sqm	254.80	276.81	**1,141,841.25**
26	16.40	Providing and laying seal coat of premixed fine aggregate (passing 2.36 mm and retained on 180 micron sieve) with bitumen using 128 kg of bitumen of grade VG - 10 bitumen per cum of fine aggregate and 0.60 cum of fine aggregate per 100 sqm of road surface, including rolling and finishing with road roller all complete	4,125	Sqm	79.85	86.75	**357,843.75**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
27	16.55.1	Providing and laying bituminous macadam using crushed stone aggregates of specified grading premixed with bituminous binder, transported to site by tippers, laid over a previously prepared surface with paver finisher equiped with electronic sensor to the required grade, level and alignment and rolling with smooth wheeled, vibratory and tandem rollers as per specifications to achieve the desired compaction and density, complete as per specifications and directions of Engineer-in-Charge.50 to 100 mm average compacted thickness with bitumen of grade VG-30 @ 3.50% (percentage by weight of total mix) prepared in Batch Type Hot Mix Plant of 100-120 TPH capacity.	1,200	Cum	7,756.40	8,426.50	**10,111,800.00**
28	16.69	Providing and laying at or near ground level factory made kerb stone of M-25 grade cement concrete in position to the required line, level and curvature, jointed with cement mortar 1:3 (1 cement: 3 coarse sand), including making joints with or without grooves (thickness of joints except at sharp curve shall not to more than 5mm), including making drainage opening wherever required complete etc. as per direction of Engineer-in-charge (length of finished kerb edging shall be measured for payment). (Precast C.C. kerb stone shall be approved by Engineer-in-charge).	20	Cum	8,613.55	9,357.71	**187,154.20**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
29	16.75	Providing and laying C.C. pavement of mix M-25 with ready mixed concrete from batching plant. The ready mixed concrete shall be laid and finished with screed board vibrator , vacuum dewatering process and finally finished by floating, brooming with wire brush etc. complete as per specifications and directions of Engineer-in-charge. (Note:- Cement content considered in this item is @ 330 kg/cum. Excess/less cement used as per design mix is payable/ recoverable separately).	220	Cum	8,277.55	8,992.68	**1,978,389.60**
30	16.78.2	Construction of granular sub-base by providing close graded Material conforming to specifications, mixing in a mechanical mix plant at OMC, carriage of mixed material by tippers to work site, for all leads & lifts, spreading in uniform layers of specified thickness with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per specifications and directions of Engineer-in-Charge. With material conforming to Grade-II (size range 53 mm to 0.075 mm) CBR Value-25	600	Cum	2,775.65	3,015.45	**1,809,270.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
31	16.79	Providing, laying, spreading and compacting graded stone aggregate (size range 53 mm to 0.075 mm) to wet mix macadam (WMM) specification including premixing the material with water at OMC in for all leads & lifts, laying in uniform layers with mechanical paver finisher in sub- base / base course on well prepared surface and compacting with vibratory roller of 8 to 10 tonne capacity to achieve the desired density, complete as per specifications and directions of Engineer-in-Charge	550	Cum	2,803.65	3,045.87	**1,675,228.50**
32	16.91	Providing and laying factory made chamfered edge Cement Concrete paver blocks in footpath, parks, lawns, drive ways or light traffic parking etc, of required strength, thickness & size/ shape, made by table vibratory method using PU mould, laid in required colour & pattern over 50mm thick compacted bed of sand, compacting and proper embedding/laying of inter locking paver blocks into the sand bedding layer through vibratory compaction by using plate vibrator, filling the joints with sand and cutting of paver blocks as per required size and pattern, finishing and sweeping extra sand. complete all as per direction of Engineer-in-Charge.					
32a	16.91.1	60 mm thick C.C. paver block of M-30 grade with approved color design and pattern.	450	SQM	932.35	1,012.90	**455,805.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
33		Items included in Delhi Schedule of Rate-(Horticulture & Landscaping) 2020		LS			**1,060,000.00**
Schedule B3:- NS BASED ITEMS							
34	NS-1	Earthwork in filling with contractor's own earth of approved quality from borrow areas including all lead all lead, lift, ascent, descent, royalty, taxes, cess, compensation, crossing of nallahs /stream and other obstructions including mechanical compaction in layers with watering to 95% of MDD (as per IS 2720 part 8), handling, re-handling, dressing to the final profile with all labour, material, tools, plant, machinery and equipment, taxes, cess etc. as a complete job in accordance with the specification and drawings.	2,000	Cum	271.46	287.75	**575,500.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
35	NS-2	Supplying and laying in position **M-35 RCC** as per approved design mix with admixtures and manufactured in fully automatic batching plant and transported to site of work in transit mixer for all lifts & leads, having continuous agitated mixer, pumping concrete from transit mixer to site of laying, compacting, finishing & curing, with all labour, material, tools, plants, machinery and equipment, taxes, cess etc., as a complete job ,but excluding supplying & fixing form work (centring & shuttering),in accordance with the specification and drawings.Note – (i) Cost of cement is included in the above item.(ii) Cost of Reinforcement steel is not included in the above item and will be paid separately under item no.8(I) (USSOR item No. 025072)(iii) Cost of supplying & fixing form work (centring & shuttering) is not included in the above item (except pile cap & open foundation) and will be paid separately under relevant item no. 6(i),(ii),(iii) (USSOR item No. 025030)					
35a	NS-2A	In Pile caps, open foundation & RCC Box/Sub way, well steining, well cap	4,935	Cum	7,776.37	8,242.95	**40,678,958.25**
35b	NS-2B	In Piers, abutments, box	960	Cum	8,098.18	8,584.07	**8,240,707.20**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
35c	NS-2C	Abutment cap & Pier Cap, pedestals, approach slab, Deck slab	460	Cum	8,421.36	8,926.64	**4,106,254.40**
35d	NS-2D	Retaining walls, wing walls, return walls, drop walls, curtain walls, toe walls etc. of all heights	700	Cum	7,888.74	8,362.06	**5,853,442.00**
36	NS-3	Providing Boulder Backing behind wing wall, return wall, retaining wall with hand packed boulders & cobbles not less than 15cm in any direction & not less than 15kg (except smaller boulders required for filling voids) including all lead, lift, labour & other incidental charges as complete work in all respect. Cost of boulder/cobbles is included in this item.	1,900	Cum	1,475.82	1,564.37	**2,972,303.00**
37	NS-4	Providing and fixing of 75mm dia PVC pipe for weep holes in abutments, Wing Wall, Return Wall, Face wall, retaining wall etc. at suitable intervals as directed by the Engineer-in-charge.	1,000	Rmt	231.00	244.86	**244,860.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
38	NS-5	Casting, supplying and installation of Pre-cast cement concrete blocks of size 25X25 X20cm. or of required size as directed by the Engineer for protective works at bridges & banks like pitching, toe wall, flooring, drains etc. using M20 design concrete mix with 20mm aggregate size including Contractor's shuttering, leading to bridge site from casting depot, including dressing and levelling of surface, providing gravel backing, laying & jointing blocks with cement mortar 1:3 with Contractor's labour and as directed by Engineer-in-charge (All labour and materials including cement by Contractor). Note: i) Payment for gravel backing will be paid under item no. NS-6 of this Bill. ii) 60% Payment shall be made after casting of pre-cast concrete blocks and bringing at work site. The balance 40% will be made on completion of laying and finishing. iii) Measurement is based on quantity calculation of blocks used only (no of blocks x volume of one block).	1,400	Cum	7,731.14	8,195.01	**11,473,014.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
39	NS-6	Supplying and laying of 150mm thick well graded stones aggregate/gravel as base layer over the slopes of embankment with manual dressing with water compaction including the cost of supply of all material, labour, lead, lift, tools, plants, crossing of tracks etc. complete as per approved drawings and technical specifications.	1,080	Cum	2,139.90	2,268.29	**2,449,753.20**
40	NS- 7	Supply & installation of precoated galvanized iron profile sheets (size, shape and pitch of corrugation as approved by Engineer-in-charge) 0.50mm +/- 5% total coated thickness (TCT) thick Zinc coating 120gsm as per IS:277 in 240mpa steel grade, 5-7microns epoxy primer on both side of the sheet and polyester top coat 15-18 microns. Sheet should have protective guard film of 25 microns minimum to avoid scratches while transportation and should be supplied in single length upto 12 metre or as desired by Engineer-in-charge. The sheet shall be fixed using self drilling / self tapping screws of size (5.5 x 55mm) with EPDM seal or with polymer coated J or L hooks, bolts and nuts 8mm diameter with bitumen and G.I. limpet washers or with G.I. limpet washers filled with white lead complete upto any pitch in horizontal/vertical or curved surfaces excluding the cost of purlins, rafters and trusses and including cutting to size and shape wherever required.	100	Sqm	756.52	801.91	**80,191.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
41	NS-8	Ø25 SN Bolts (Cement grouted): Supply, drilling, installation and grouting of SN type rockbolts of the specified length, Yield strength ≥500 MPa (slopes, tunnel support & face bolts) as per approved drawings and Specifications or as directed by Engineer, with contractors men, material, consumables, plants, equipments, machineries, including all lead & lifts loading , unloading etc required for the complete job.	4,500	Rmt	430.25	456.07	**2,052,315.00**
42	NS-9	Wire Mesh: Supply, cutting, placing and fixing into position with appropriate anchors of 150x150x6 mm or 100x100x4 mm welded wire fabric of Fy=480 MPa as reinforcement in primary lining & inner lining with contractors men, material, cost of pins, hooks, consumables , tools & plants, equipments, machineries, including all lead & lifts, loading , unloading, handling complete job .	11	MT	77408	82,052.48	**902,577.28**
43	NS-10	M30 Shotcrete : Shotcreting with wiremesh/fibers as per design Primary lining :Shotcrete for primary (outer) lining of Tunnel or Niches, grade M30, including face sealing shotcrete, temporary invert, filling of cavities, widening of top heading footing in tunnel and slope stabilization and in open excavation etc. Note: The Dry shotcrete shall also be payable under this item.	250	Cum	10269	10,885.14	**2,721,285.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
44	NS-11	Supply of structural steel for steel ribs of various sections confirming IS 2062 of Grade-A from approved manufacturers at various sites including all transportation and freight charges and all taxes, duties etc. with contractors men, material, tools & plants, equipments, machineries, testing, all lead & lifts, loading , unloading , etc complete	4	MT	77968.38	82,646.48	**330,585.92**
45	NS-12	Steel Ribs: Fabrication and erection in position permanent tunnel steel ribs including of variable geometry and or member size as per design/assembly, using structural steel Grade A, Yield stress ≥250MPa with all accessories such as bolt/nuts, washers, plates, tie rods etc., including cutting, drilling, cold bending, welding, threading, leveling, aligning and fixing in position of all rods, gusset/ wall plates, pre-stressing by blocking against rock-surface etc. as per approved drawings and Specifications or as directed by Engineer with contractor's men, material, consumables, tools and plants, equipments, machineries, including all lead and lift, loading, unloading. Rate to cover supports & scaffoldings required during the course of erection etc. complete.Note: Payment for supply of structural steel shall be paid as per approved drawing	1	MT	9944	10,540.64	**10,540.64**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		(excluding all wastages) separately as per item NS-11.					
46	NS-13	Lattice Girders: Fabrication and erection of lattice girders using high strength reinforcing steel Fe-500D with all accessories such as bolt/nuts, washers, plates, tie rods etc, including all lead, lift, wastage, storing, drilling holes, fixing in phases etc. and installation of accessories for joining the Lattice girder segments and fixing into place as per approved drawings and Specifications or as directed by Engineer. The rate shall include costs of all materials except as noted below, labour, equipment, welding, etc for the complete job including additional cost for enlargement of top heading footing. (Payment for supply of reinforcement steel (excluding all wastages) will be made separately as per item NS-11)	3	MT	9944	10,540.64	**31,621.92**
47	NS-14	Providing, fabricating & laying of colour coated galvalume (Proflex system roofing)material for self supported roofing system, material shall be of following specification, BMT 0.90mm to 1.00mm,APT 0.95mm tolerance +/- 0.02mm thick ,Width 605 mm or as decided by railway (Tolerance +/- 2mm),including supplying, loading ,transporting, uploading & stacking at site ,fabricating and laying with all contractors tools, plants, machineries	100	Sqm	2370.98	2,513.24	**251,324.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		materials and fixtures labours including all lead and lift and laps/wastage if any etc. complete. The colour of sheet will be decided by Engineer. The rate is also inclusive of designing of roofing system, proof checking and providing execution drawing. Fabrication and installation of self supported roofing.					
						Total Amount of Schedule 'B'	**389,447,602.42**

8 Schedule 'C': Item rate for miscellaneous woks

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
DSR-21 Items						
1	DSR-21 19.35	Providing and laying Non Pressure NP-3 class (Medium duty) R.C.C. pipes including collars/spigot jointed with stiff mixture of cement mortar in the proportion of 1:2 (1 cement : 2 fine sand) including testing of joints etc. complete.				
I	19.35.1	450mm dia. RCC pipes	Metre	2385.5	8.64%	**2,591.61**
II	19.35.2	600 mm dia RCC pipes.	Metre	3051.55	8.64%	**3,315.20**
2	DSR-21 19.6	Providing and laying non-pressure NP2 class (light duty) R.C.C. pipes with collars jointed with stiff mixture of cement mortar in the proportion of 1:2 (1 cement : 2 fine sand) including testing of joints etc. complete :				
I	19.6.1	100 mm dia. R.C.C. pipe	Metre	447.25	8.64%	**485.89**
II	19.6.2	150 mm dia. R.C.C. pipe	Metre	493.1	8.64%	**535.70**

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
III	19.6.3	250 mm dia. R.C.C. pipe	Metre	811	8.64%	**881.07**
3	DSR-2021 16.90	Providing and laying tactile tile (for vision impaired persons as per standards) of size 300x300x9.8mm having with water absorption less than 0.5% and conforming to IS:15622 of approved make in all colours and shades in for outdoor floors such as footpath, court yard, multi modals location etc., laid on 20mm thick base of cement mortar 1:4 (1 cement : 4 coarse sand) in all shapes & patterns including grouting the joints with white cement mixed with matching pigments etc. complete as per direction of Engineer-in-Charge.	Sqm	1719	8.64%	**1,867.52**
4	DSR-21 11.26	Kota stone slab flooring over 20 mm (average) thick base laid over and jointed with grey cement slurry mixed with pigment to match the shade of the slab, including rubbing and polishing complete with base of cement mortar 1: 4 (1 cement : 4 coarse sand) Cost of cement is included in this item.				
I	11.26.1	25 mm thick	Sqm	1706.6	8.64%	**1,854.05**

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
USSOR-2019(NWR) Items						
5	USSOR-2019(NWR) 031110	Load testing of one or more spans of bridge as selected by the Engineer as per approved load test procedure following relevant IS/IRC/Railway codes with contractor's labour, deflection measuring instruments, loading materials, recoding and analyzing the load testing results including all lead & lift, etc. complete as required. The rates are all inclusive and will be paid after load test is finished and girder is cleared of the kentledges/loading material etc. The load shall be 1.25 times the stipulated design load.				
I	031111	For Span design load upto 100 MT	Each	85662.09	12.13%	**96,052.90**
II	031112	Extra for every increase 1 MT or part thereof in the span design load capacity upto 800 MT	MT	845.81	12.13%	**948.41**

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
6	021010	Exploratory drilling of boreholes down to required depth, drilling of 150mm dia. boreholes in all type of soils except hard rock & large boulders (boulder core more than 30cm) including refilling, reinstating surface and disposing off surplus material including use of mechanical rigs with power operated winches as well as percussion/chiselling tool for advancing through occasional seams of hard strata to be employed, where necessary in Dry area.				
I	021011	0m to 10m	Metre	1,213.51	12.13%	**1,360.71**
II	021012	10m to 20m	Metre	1,296.46	12.13%	**1,453.73**
III	021013	20m to 30m	Metre	1,431.59	12.13%	**1,605.24**
IV	021014	30m to 40m	Metre	1,554.68	12.13%	**1,743.26**
7	*021050*	*Drilling of NX size borehole (75mm dia.) in all types of hard rock and collection of rock core samples from boreholes and preserving in boxes*				
I	*021051*	*0m to 10m*	*Metre*	*3,189.64*	*12.13%*	***3,576.54***
II	*021052*	*10m to 20m*	*Metre*	*3,418.43*	*12.13%*	***3,833.09***
III	*021053*	*20m to 30m*	*Metre*	*3,775.66*	*12.13%*	***4,233.65***

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
8	*021060*	*Conducting in-situ full size Plate Load Test (PLT) at selected location as per IS:1888 including making loading arrangements & casting of RCC/cast in-situ concrete footing as per codal provisions including excavation and refilling of trial pit*				
I	*021062*	*Plate size 45cm x 45cm*	*Each*	*27,754.18*	*12.13%*	***31,120.76***
II	*021063*	*Plate size 60cm x 60cm*	*Each*	*31,000.02*	*12.13%*	***34,760.32***
9	*021080*	*Conducting SCPT for soil as per IS:4968*	*Each*	*47,313.49*	*12.13%*	***53,052.62***
10	*021090*	*Conducting DCPT for soil as per IS:4968*	*Each*	*37,394.02*	*12.13%*	***41,929.91***
11	*021110*	*Taking out 100mm dia. & 450mm long undisturbed samples of soil from bore holes, including provision of air tight containers for packing and, labelling incl. transporting the samples to laboratory. Piston sampler shall be used for extracting undisturbed samples where necessary. Samples shall be collected as per IS:2720.*	*Each*	*152.52*	*12.13%*	***171.02***
12	*021120*	*Taking out 100mm dia. & 450mm long disturbed samples of soil from bore holes, including provision of air tight containers for packing, labelling and transporting the samples to laboratory. Samples shall be collected as per IS:2720.*	*Each*	*164.57*	*12.13%*	***184.53***

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
13	*021130*	*Conducting standard penetration test as per IS:2131 at approximate1.5m intervals in bore holes, as directed by the Engineer in charge*	*Each*	*852.27*	*12.13%*	***955.65***
14	*021150*	*Conducting laboratory Tests on collected soil samples as per relevant IS code*				
I	*021151*	*Moisture Content/Dry Density*	*Each*	*287.66*	*12.13%*	***322.55***
II	*021152*	*Atterberg Limits*	*Each*	*586.02*	*12.13%*	***657.10***
III	*021153*	*Specific Gravity*	*Each*	*631.51*	*12.13%*	***708.11***
IV	*021154*	*Grain size analysis including Hydrometer analysis*	*Each*	*731.85*	*12.13%*	***820.62***
V	*021155*	*Direct Shear Test*	*Each*	*2,140.70*	*12.13%*	***2,400.37***
VI	*021156*	*Natural Density*	*Each*	*709.11*	*12.13%*	***795.13***
VII	*021157*	*Consolidation Test*	*Each*	*6,886.37*	*12.13%*	***7,721.69***
VIII	*021158*	*Unconfined Compression Test*	*Each*	*2,006.91*	*12.13%*	***2,250.35***
IX	*021159*	*Tri-axial Test*	*Each*	*2,408.29*	*12.13%*	***2,700.42***
NS Items						
15	*NS-1*	*Boring 1200 mm diameter piles using Hydraulic Rig in all kinds of strata including boulder studded soil, underground structure like channel, sewer manholes, old foundation or any other obstruction, irrespective of sub-soil water level in all conditions whether dry or under water, shoe and temporary casing pipe, if*	*Rmt*	*10,232.00*	*6.00%*	*10,845.92*

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
		required, with contractor plant, machinery & equipment for pile boring, use of bentonite slurry including all operations, cleaning of bore holes, supplying and laying in-situ with tremie pipe M-35 RCC in piles as per approved design mix with admixtures and manufactured in fully automatic batching plant and transported to site of work in transit mixer for all lifts & leads, having continuous agitated mixer, pumping concrete from transit mixer to site of laying including supplying & fixing form work (centering & shuttering), compacting, finishing, curing, chipping off pile top to remove laitance concrete above cut off level, removal and disposal of surplus excavated earth/debris/muck outside ROW including all lead, lift, ascends, descends, loading, unloading handling, re-handling, crossing of stream, nallahs, railway track, level crossing etc. with all labour, material, tools, plants, machinery and equipment, taxes, cess etc. as a complete job in accordance with the Specification and the Drawings. *Note –* *i. Cost of cement is included in the above item.*				

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
		ii. Cost of Reinforcement steel is not included in the above item and will be paid separately under relevant item of Schedule-B. *iii. Cost of temporary casing pipe is included in the above item. However, cost of permanent casing pipe is not included in this item and shall be paid separately under item, if required and approved by the Engineer.*				

Total Estimated cost of Schedule 'C'- INR 2.00 Crore (INR 20 million).

Price Schedule

(Please refer Price Schedule uploaded on e-procurement portal)

Validate Print Help BoQ

Tender Inviting Authority: Haryana Rail Infrastructure Development Corporation Limited

Name of Work: C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:
(i)Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km 24.850 to km 29.580;
(ii)Design & Installation of Ballastless Track (excluding supply of rails) from km 24.843 to km 29.680;
(iii)Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commis... T/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km 24.843 to km 29.680;
(iv)Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.

Contract No: HORC/HRIDC/C-4/2022

Name of the Bidder/ Bidding Firm / Company :					

PRICE SCHED...

(This BOQ template must not be modified/replaced by the bidder and the same should be uplo... the relevent columns, else the bidder is liable to be rejected for this tender.
Bidders are allowed to enter... s and Values only)

NUMBER #	TEXT #	TEXT #	#	NUMBER #	TEXT #
Sl. No.	Item Description	U...	RATE In ...gures To be entered by the Bidder in Rs. P	TOTAL AMOUNT With Taxes Rs. P Rs. P	TOTAL AMOUNT In Words
1.01	Schedule A: Lumpsum component of ...	Lump Sum		0.00	INR Zero Only
Total in Figures				0.00	INR Zero Only
Quoted Rate in Words					INR Zero Only

SAMPLE Price Schedule

Tenderer is only required to fill the information in the boxes highlighted with cyan colour in Price Schedule (Excel sheet)

Price Schedule Contd.

(Please refer Price Schedule uploaded on e-procurement portal

Validate Print Help e BoQ

Tender Inviting Authority: Haryana Rail Infrastructure Development Corporation Limited

C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:
(i)Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km 24.850 to km 29.580;
(ii)Design & Installation of Ballastless Track (excluding supply of rails) from km 24.843 to km 29.680;
(iii)Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 1 er and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system, etc. from km 24.843 to km 29.680;
(iv)Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.

Contract No: HORC/HRIDC/C-4/2022

Name of the Bidder/ Bidding Firm / Company :	

PRICE SCHEDU

(This BOQ template must not be modified/replaced by the bidder and the same should be uploaded af revent columns, else the bidder is liable to be rejected for this tender. Bidders are allowed to enter the Bi values only)

SAMPLE Price Schedule

NUMBER #	TEXT #	NUMBER		TEXT	NUMBER #	TEXT #
Sl. No.	Item Description	Estimated Rat in	AGE (%) to be ntered by the Bidder	Select Excess or less	TOTAL AMOUNT With Taxes Rs. P Rs. P	TOTAL AMOUNT In Words
1.01	Schedule B: Other Civil Works	38,94,47,602.42		SELECT	0.00	INR Zero Only
1.02	Schedule C: Item rate for Works	2,00,00,000.00		SELECT	0.00	INR Zero Only
Total in Figures					0.00	INR Zero Only
Quoted Rate in Words		INR Zero Only				

**Tenderer is only required to fill the information in the boxes highlighted with cyan colour in Price Schedule (Excel sheet)*

Price Schedule Contd.

(Please refer Price Schedule uploaded on e-procurement portal

Validate Print Help

Tender Inviting Authority: Haryana Rail Infrastructure Development Corporation Limited

C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:
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(iv)Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.

Contract No: HORC/HRIDC/C-4/2022

Name of the Bidder/ Bidding Firm / Company :			

PRICE SCHEDULE-SUMMARY SHEET

(This BOQ template must not be modified/replaced by the bidder and the same should be uploaded after filling the relev... ...ise the bidder is liable to be rejected for this tender. Bidders are allowed to enter the Bidder Name and Val...

NUMBER #	TEXT #	NUMBER #	TEXT #
Sl. No.	Item Description	TOTAL AMOUNT With Taxes Rs. P Rs. P	TOT...
1.01	Schedule-A: Lumpsum component of Works	0.00	INR Zero Only
1.02	Schedule-B: Other Civil Works	0.00	INR Zero Only
1.03	Schedule-C: Item rate for miscellaneous ...	0.00	INR Zero Only
1.04	Provisional Sums	10,00,00,000.00	INR Ten Crore Only
Total in Figures		10,00,00,000.00	INR Ten Crore Only
Quoted Rate in Words		INR Ten Crore Only	

SAMPLE Price Schedule

**Tenderer is only required to fill the information in the boxes highlighted with cyan colour in Price Schedule (Excel sheet)*

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Section V - Eligible Countries

Eligibility for the Provision of Goods, Works and Non-Consulting Services in Bank-Financed Procurement

In reference to ITT 4.8 and 5.1, for the information of the Tenderers, at the present time, firms, goods and services from the following countries are excluded from this Tendering process:

Under ITT 4.8 (a) and 5.1: ***None***

Under ITT 4.8 (b) and 5.1: ***None***

Section VI - Prohibited Practices

1. The Bank requires that the Recipient (and all other beneficiaries of the Bank financing), as well as tenderers, suppliers, contractors, concessionaires and consultants under Bank-financed contracts for the Project, observe the highest standard of transparency and integrity during the procurement, execution and implementation of such contracts.

2. Definitions. In pursuance of this policy, the Bank defines the terms set forth below as Prohibited Practices:

   (a) "**coercive practice**" means impairing or harming, or threatening to impair or harm, directly or indirectly, any party or the property of a party to influence improperly the actions of a party;
   (b) "**collusive practice**" means an arrangement between two or more parties designed to achieve an improper purpose, including to influence improperly the actions of another party;
   (c) "**corrupt practice**" means the offering, giving, receiving or soliciting, directly or indirectly, of anything of value to influence improperly the actions of another party;
   (d) "**fraudulent practice**" means any act or omission, including a misrepresentation, that knowingly or recklessly misleads, or attempts to mislead, a party to obtain a financial or other benefit or to avoid an obligation.
   (e) "**misuse of resources**" means improper use of the Bank's resources, carried out either intentionally or through reckless disregard;
   (f) "**obstructive practice**" means any of the following practices: (i) deliberately destroying, falsifying, altering or concealing of evidence material to a Bank investigation; (ii) making false statements to investigators in order to materially impede a Bank investigation into allegations of a Prohibited Practice; (iii) failing to comply with requests to provide information, documents or records in connection with a Bank investigation; (iv) threatening, harassing or intimidating any party to prevent it from disclosing its knowledge of matters relevant to a Bank investigation or from pursuing the investigation; or (v) materially impeding the exercise of the Bank's contractual rights of audit or inspection or access to information; and
   (g) "**theft**" means the misappropriation of property belonging to another party.

3. Any occurrence, or suspected occurrence, of a Prohibited Practice in the procurement, award, or implementation of a Bank-financed contract is dealt with in accordance with the provisions of the Bank's Policy on Prohibited Practices. Suppliers, contractors, service providers and consultants selected pursuant to the provisions of Section II and concessionaires selected

pursuant to paragraph 14.3 of the Bank's Procurement Instructions for Recipients, as well as the Recipient shall fully cooperate with the Bank (or a cofinancier undertaking an investigation pursuant to paragraph 6.1 of the Bank's Procurement Instructions for Recipients) in any investigation into an alleged Prohibited Practice to be carried out pursuant to the Policy on Prohibited Practices, and permit the Bank or its representative (including such co-financier) to inspect such of their accounts and records as may be relevant for such investigation and to have such records and accounts audited by the auditors appointed by the Bank.

4. Provisions to this effect are included in the Legal Agreements and the procurement contracts with such entities.

5. If the Project is financed by a sovereign-backed loan, the Bank (or, where relevant, a co-financier having undertaken an investigation pursuant to paragraph 6.1 of the Bank's Procurement Instructions for Recipients):

   (a) may take any of the following additional actions in connection with a Prohibited Practice under the Project:

      (i) reject a proposal for award if it determines that the tenderer recommended for award, or any of its personnel, or its agents, or its sub-consultants, subcontractors, service providers, suppliers or their employees, has, directly or indirectly, engaged in a prohibited practice in competing for the contract in question; and

      (ii) cancel the undisbursed portion of the loan allocated to a contract (and require reimbursement of the disbursed portion of the loan allocated to the contract) if it determines at any time that representatives of the Recipient or of a recipient of any part of the proceeds of the loan engaged in a prohibited practice during the procurement, administration or implementation of the contract in question; and

   (b) requires that a clause be included in tender documents and in contracts financed by the Bank loan, requiring tenderers, suppliers and contractors, and their subcontractors, agents, personnel, consultants, service providers, or suppliers, to permit the Bank (and a co-financier undertaking an investigation pursuant to paragraph 6.1 of the Bank's Procurement Instructions for Recipients) to inspect all accounts, records, and other documents relating to the submission of tenders and contract performance, and to have them audited by auditors appointed by the Bank.

Final Tender Document for Works

(Two-Envelope Tendering Process Without Prequalification)

Procurement of:

C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580.

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA , Tunnel lighting system etc. from km *24.843* to km 29.680.

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from Ch. km 12.00 to Ch. km 18.00.

Summary

Specific Procurement Notice (SPN)

PART 1 – TENDERING PROCEDURES

Section I - Instructions to Tenderers (ITT)

Section II - Tender Data Sheet (TDS)
Section III - Evaluation and Qualification Criteria
Section IV - Tender Forms
Section V - Eligible Countries
Section VI - Prohibited Practices

PART 2 – EMPLOYERS' REQUIREMENTS

Section VII – Employer's Requirements

PART 3 – CONDITIONS OF CONTRACT AND CONTRACT FORMS

Section VIII - General Conditions of Contract (GCC)
Section IX - Particular Conditions of Contract (PCC)
Section X - Contract Forms

PART 2 – Employer's Requirements

Summary Table

Section VII: Employer's Requirements

Section VII-1: GENERAL

EMPLOYER'S REQUIREMENTS - GENERAL

1 Project Profile and Background.

1.1 General

State of Haryana is strategically located bordering the National capital of Delhi. NCT, Delhi shares three fourth of its border with Haryana alone and remaining with Uttar Pradesh. The development of Haryana region, bordering Delhi is very important for balanced growth of NCR as it acts as buffer zone against rampant migration and other support infrastructure. At present on account of growth of Metro network in Delhi & NCR, there is radial movement of commuters to and from, Delhi being in centre. This "Hub and Spoke" traffic planning has resulted in rapid growth of Noida, Greater Noida, Faridabad and Gurugram. However, for hub and spoke concept to sustain it is necessary to link the ends of spoke by ring connectivity. There will be natural demand for commuter movement within these towns like Gurugram, Faridabad, Ballabhgarh, Palwal, Sohna, Manesar etc. Peripheral roads have been commissioned recently, linking these towns around Delhi but Rail link provides economical, sustainable, eco-friendly and bulk freight transport option. The peripheral Rail link will also help in growth of other cities within the same distance from Delhi like Sonipat, Panipat, and Rohtak. Western DFC originating from Dadri station is passing through Asaoti Station on Delhi- Mathura route, providing connectivity to Haryana Orbital Rail Corridor (HORC). This will also help in easing the pressure on the transport network of Delhi as some of the commuter traffic moving on the radials will get shifted to HORC. Apart from passenger traffic, substantial amount of freight traffic, which is entering the Delhi area of rail network but is not meant to be consumed in Delhi, will also get diverted via this corridor. Apart from this, there are major goods sheds in the heart of Delhi causing endless avoidable traffic jams. The goods sheds in west Delhi are Azadpur, Shakurbasti, Dayabasti, Sabzi Mandi which are located on prime commercial land and are black spots of the urban planning. Previously moving out commercial activity to other states had interstate taxation issues but now with GST in place, there is no reason of not shifting these activities to the peripheral region. In any case, if freight traffic movement through Delhi is restricted, then these goods sheds or alternatives will be serviced via the proposed HORC. Haryana Orbital Rail Corridor (HORC) from Palwal to Sonipat Via Sohna, Manesar, Kharkhoda and Harsana Kalan is to be constructed as an Electrified (1X25kV AC-50Hz) double line track, capable of operating at a maximum train speed of 160 kmph.

1.2 Forest and Environmental Clearance

It is mentioned that for railway projects no prior environmental clearance is required as per Environment Impact Assessment (EIA) Notification, 2006. Further, the Forest (Conservation) Act, 1980 is not applicable to the Project in terms of Ministry of Environment, Forest and Climate Change (MoEFCC's) OM No.11-37/2016 FC dated 10.03.2022. However, certain part of the Project falls in specified area of Aravalli range. The clearance for specified area of Aravalli range is under process and is likely to be obtained before the award of contract.

2. DEFINITIONS AND INTERPRETATIONS

In addition to the words and expressions defined in the General Conditions of Contract, further following words and expressions shall have the meaning assigned to them except where the context otherwise requires:

- "**Availability**" shall mean the probability that an item will be in a state to perform a required function under given conditions at a given instant or over a given time interval assuming that the required external resources are provided.

- **"As-Built Drawings"** means those drawings produced by the Contractor and endorsed by its true records of construction of the Permanent Works and which have been given a consent from the Engineer.

- **"As-Built Documents"** mean the set of drawings and documents which are a true record of the construction of the Permanent Works prepared by the Contractor.

- **"CAD Standards"** means requirements for CAD, as specified in the Appendix 9 of Employer's Requirements.

- **"Charted Utilities"** mean identified Utilities listed in Employer's Requirements-Tender Drawings and Documents, which may be affected by the execution of the Works under the Contract.

- **"Cold Joint"** means a joint or discontinuity formed when a concrete surface hardens before the next batch is placed against it, characterised by poor bond unless necessary procedures are observed.

- **"Combined Services Drawings" (CSD):** means drawings showing the locations, layouts and sizes of all services including those of other contractors co-ordinated so as to eliminate all clashes.

- **"Construction Phase":** has the meaning identified in the Employer's Requirements - General.

- **"Construction Reference Drawings":** means those drawings referred in the Employer's Requirements - Design in respect of which a Notice has been issued.

- **"Construction Reference Drawings Submission":** means the submission of Construction Reference Drawings representing elements of the Permanent Works and for which the Contractor seeks a Notice.

- **"Contract Spares"** means any Spare Parts recommended by the Contractor for the operation and maintenance of the Permanent Works following the Taking Over of the Works.

- **"Contractor's Project Plan"** means the plan to provide a clear overview of the Contractor's organisation, management systems and the methods to be used for the execution and completion of the Works

- **"Controlled Blasting"** means a method of blasting which is aimed at reducing vibration and noise due to blasting.

- **"Construction/Installation and/or Manufacture Documents"** means the document which contain all drawings, calculations, computer software, samples, patterns, models, operation / maintenance manuals and other information to be submitted by the Contractor and approved by the Engineer.

- **"Consumables"** means those parts that are not repairable and usually have a relatively short life span.

- **"Critical Path Method"** means a schedule network analysis technique used to determine the amount of scheduling flexibility (the amount of float) on various logical network paths in the project schedule network, and to determine the minimum total project duration.

- **"Definitive Design Submission":** means the submission of documents which comprise the whole or parts of the proposed Definitive Design and for which the Contractor seeks a Notice.

- **"Design Criteria":** means the criteria defined in Employer's Requirements-Design and Outline Design Specifications.

- **"Design Manual":** means the manual to be prepared and submitted by The Contractor as part of the Definitive Design and as described in the Employer's Requirements - Design.

- **"DN Line"** means the down line of the HORC double line track route from Sonipat to Palwal.

- "**Final Design":** has the meaning identified in the Employer's Requirements – Design.

- **"Fixed Structure Gauge":** means the profile related to the designed normal co-ordinated axis of the track into which no part of any structures or fixed equipment may penetrate.

- **"Good For Construction Drawings (GFC)":** Construction Reference Drawings or Working Drawings which have received Notice from the Engineer, shall be endorsed as "Good For Construction Drawings" and will be issued to the Site. Execution of work shall be carried out only as per drawings which have been endorsed as GFC.

- **"Interface Management Plan"** means the plan for all interface issues that may arise during the design, construction, testing and commissioning of the Works, in consultation with the Interfacing Contractors/ Interfacing Parties and the Engineer.

- **"Isolation"** means isolating and earthing of the electrical equipment, by disconnection of the respective section from all incoming sources of electricity supply and also outgoing connections.

- **"Independent Laboratory"** means a laboratory, submitted by the Contractor to the Engineer for approval, that is free from outside control and not subject to direct or indirect influence or authority of the Employer, the Engineer, or the Contractor

- **"Inspection and Test Plan"** means a document that states inspection and testing requirements and actions provisioned for the Works, related process, Plant, or Materials. It is used to control, check, monitor and record; testing procedures that are required for quality assurance and to achieve the agreed quality requirements for the Works.

- **"Installation Tests"** means the tests to be performed to verify the conformity of completion of an installation/assembly to the design documents approved by the Engineer prior to the start of Commissioning, and they must be successfully completed before the Tests on Completion.

- **"Interface Coordinator"** means the person who has the responsibility, and authority with substantial experience to resolve interface matters to the satisfaction of the Engineer and provide the necessary support team for the Interface Management System as specified in Appendix 5

- **"Interfacing Contractor"** means the Contractor engaged by the Employer or other agencies having an interface issue with the Contractor for the Works.

- **"Interfacing Parties"** comprises the interfacing contractors / consultants / service providers, who are engaged in part of the works, relevant authorities and public utility agency.

- **"Interface Table"** means the table that describes the relationships between the Contractor and Interfacing Contractors / Interfacing Parties and their roles and responsibilities is a key document.

- **"Kick-Off Meeting"** means the meeting held by the Engineer to formally notify all parties concerned under the Contract that the project has commenced and to ensure that every party has a common understanding of their role from the Commencement Date up until issuance of the Performance Certificate.

- **"Maintainability"** means a characteristic expressed as the probability that an item will be retained in or restored to a specified condition within a given period, when the maintenance is performed in accordance with prescribed procedures and resources.

- **"Maintenance Manuals"** means the manuals providing detailed instructions for the maintenance of infrastructure and maintenance facilities.

- **"Method Statement"** means a document that states the way a particular work, task, or process along with various associated aspects such as quality, safety, environment protection, time and resources; are planned to be directly controlled by the Contractor or its Subcontractor.

- **"Monthly Progress Meeting"** means the meeting specified under Appendix 7 of the Employer's Requirements.

- **"Monthly Progress Report"** means the report that the Contractor shall prepare and submit to the Engineer.

- **"Nonconformity Report"** means a report documenting non-fulfilment of a requirement, with objective evidence, the location and time of occurrence or detection, and provision for its proper resolution by the concerned responsible.

- **"Notice":** means a Notice of No Objection.

- **"Notice of Objection"** means a category of Engineer's response, issued by the Engineer to the Contractor.

- **"Not Reviewed"** means a category of Engineer's response, issued by the Engineer to the Contractor.

- **"On-Site Laboratory"** means Contractor's own laboratory submitted by the Contractor to the Engineer for approval as specified in Appendix 12 of the Employer's Requirements.

- **"Operation and Maintenance Manuals (O&M Manuals)"** means the manual that will be indicating the provisions which are required for maintenance of various assets created under the Contract by the Employer under their operation phase.

- **"Priority Section"** means the section from Km 49.7 to Km 55.6 of HORC Main line and connectivity line from Manesar station on HORC and Patli station on Delhi-Rewari section of Indian Railway Network.

- **"Programme Analysis Report"** means the report submitted to the Engineer that shall, in narrative format, describe the basis and assumptions used to develop each programme.

- **"Project"** means the project named as "Haryana Orbital Rail Corridor (HORC)".

- **"Project Management Plan"** refers to the plan that will be established by the Contractor for the management of activities related to design, procurement, manufacture, execution/construction, delivery, installation, testing and commissioning.

- **"Project Management Information System"** means a document, information and communication technology system (platform) that is to be implemented by the Contractor so that the management of information between the Contractor, the Employer and the Engineer is efficient, reliable, and secure.

- **"Preliminary Design":** means the submission of documents which comprise the initial stage of the design phase.

- **"Indian Railway"** means the rail tracks of the Indian Railway and any ancillary areas of Indian Railway such as the depots, sidings, stations, terminus, traction power stations, etc.

- "**Request for Inspection"** means the form used to give notice by the Contractor to the Engineer.

- **"Railway Representative"** means a person, or persons, nominated by the Employer / Engineer to liaise with the Contractor and the Engineer on matters affecting the operation of Indian Railway.

- **"Restriction"** means speed restriction, which is a limitation of the normal permitted speed of rail traffic over a specified length of the Railway.

- **"Tender Drawings and Documents"** means the drawings and documents prepared by the Employer for reference purposes only and included in the Tender Documents.

- **"Reliability"** means the probability that an item/equipment/system can perform a required function under given conditions for a given time interval.

- **"Routine Test"** means the test which is required to perform or undergo on each Plant, Contractor's Equipment and Materials during or after manufacture to ascertain that it complies with specified criteria.

- **"Right of Way"** means the land area of the Project, either acquired by the Employer or for which the Employer has the permission of the Stakeholder to construct the embankment & bridges, etc. over their area.

- **"Environmental, Social, Health and Safety Management Plan"** means the plan in accordance with the requirements of Appendix 13 of the Employer's Requirements.

- "**Safety**" freedom from unacceptable risk of harm.

- "**Safety Integrity Level**" One of a number of defined discrete levels for specifying the safety integrity requirements of the safety functions to be allocated to the safety related systems. Safety Integrity Level with the highest figure has the highest level of safety integrity.

- **"Safety-Critical"** means failure of the system, sub-system or equipment that directly leads to a situation with the potential to cause harm, injury, damage to property, plant or equipment, damage to the environment, or economic loss.

- **"Smooth Blasting"** means a type of controlled blasting which achieves minimum rock damage and a smooth surface. This is achieved by drilling a line of closely spaced parallel holes along the excavation surface with a suitable burden/spacing ratio, loading all the holes lightly with an appropriate amount of explosive and detonating all these charges simultaneously after the detonation of main production blast.

- **"Software Related Items"** comprises (but not limited to) erasable programmable read only memory (EPROM), digital versatile disc (DVD), other related items which are the most updated items used in relation to the Works, and those to be supplied by Subcontractors of any tiers

- **"Site Offices"** means Site Office for Employer's/Engineer's Personnel constructed by the Contractor.

- **"Spare Parts"** means those parts which are generally repairable and have normally a service life of several years.

- **"Specification":** has the meaning identified in the Employer's Requirements - General.

- **"Sub-system"** Each system comprises of sub systems. Signalling System comprise sub systems of Electronic Interlocking System, Train Detection System, Point Operation System, Absolute Block Working with BPAC, Power Supply System etc. Telecommunication System comprise sub systems of Optical Fiber Communication System, Quad cable system, Data Networking System, Telephone System, Emergency Communication System, VHF Communication System, Master Clock System, Integrated train platform announcement and display system and 48 volt DC Battery Backup System etc.

- **"Temporary Benchmarks (TBM)"** means the benchmarks provided by the Employer, used to locate & confirm the Right of Way (ROW) and its co-ordinates including levels.

- **"Three Months Rolling Programme"** means the programme which the Contractor shall prepare and update monthly as per Appendix 6 of the Employer's Requirements.

- **"Three Weeks Rolling Programme"** means the programme which the Contractor shall prepare and update weekly per Appendix 6 of the Employer's Requirements.

- **"Time Bar Chart",** known as "Gantt Chart" too is a type of bar chart which illustrates a project schedule. i.e. the start and finish dates of the activities and summary elements of a project

- **"Uncharted Utilities"** mean Utilities other than Charted Utilities which are identified during a survey conducted by the Contractor or encountered during excavation/ other works.

- **"UP Line"** means the up line of the HORC double line track route from Palwal to Sonipat.

- **"Utilities"** means the electricity, lighting, traffic control, telephone and/or communication cables, gas, water, sewage and drainage pipes, including all associated protection, supports, ancillary structures, fittings and equipment.

- **"Working Drawing"** means additional drawings developed by the Contractor as necessary to supplement the Construction Reference Drawings and to specify additional details and procedures for construction of the Works, such as shop drawings, fabrication drawings, erection drawings, Temporary Works drawings, bar bending schedules, bar reference drawings, embankment/cutting cross sections. All such drawings shall comply with the requirements of the Contract.

- **"Works Programme"** means the time-scaled and resource-loaded critical path network, updated from time to time in accordance with the General Conditions of Contract and Employer's Requirements, depicting activities, durations, sequences and interrelationships that represent the Contractor's work plan, work breakdown, schedule structure for constructing and completing the Works, distributed over the Time for Completion of the Contract.

- **Abbreviations**

AC	**:**	**Alternating Current**
ACB	**:**	**Air Circuit Breaker**
AIIB	**:**	**Asian Infrastructure Investment Bank**
ALARP	**:**	**As Low As Reasonably Practicable**
ASLI	**:**	**Automatic Safe Load Indicator**
BG	**:**	**Broad Gauge**
BIS	**:**	**Bureau Of Indian Standards**
BLT	**:**	**Ballastless Track**
BOCW	**:**	**Building Or Other Construction Work**
BS	**:**	**British Standards**
CAD	**:**	**Computer Aided Design**
CCTV	**:**	**Closed Circuit Television**
CD	**:**	**Compact Disc**
CIF	**:**	**Cost, Insurance And Freight**
CIP	**:**	**Co-Ordinated Installation Plan**
CP	**:**	**Contract Package**
CPCB	**:**	**Centre Pollution Control Board**
CPM	**:**	**Critical Path Method**

CRS	**:**	**Commissioner Of Railway Safety**
CSD	**:**	**Combined Service Drawings**
CTC	**:**	**Centralized Traffic Control**
CV	**:**	**Curriculum Vitae**
D&B	**:**	**Drill And Blast**
DB	**:**	**Decibel**
DB	**:**	**Distribution Box**
DC	**:**	**Direct Current**
DCN	**:**	**Design Change Notice**
DDF	**:**	**Digital Distribution Frame**
DFC	**:**	**Dedicated Freight Corridor**
DFCCIL	**:**	**Dedicated Freight Corridor Corporation of India Limited**
DG	**:**	**Diesel Generator**
DGPS	**:**	**Differential Global Positioning System**
DIN	**:**	**Deutsche Industrial Norms**
DL	**:**	**Double Line**
DNP	**:**	**Defects Notification Period**
DP	**:**	**Detection Point**
DPI	**:**	**Dots Per Inch**
DPR	**:**	**Daily Progress Report**
DSS	**:**	**Distribution Substation**
DT	**:**	**Down Time**
DTN	**:**	**Data Transmission Network**
DVD	**:**	**Digital Versatile Disc**
DVT	**:**	**Design Verification Table**
E&M	**:**	**Electrical & Mechanical**
EIA	**:**	**Environmental Impact Assessment**

ELCB	**:**	**Earth Leakage Circuit Breaker**
EMC	**:**	**Electro Magnetic Compatibility**
EMI	**:**	**Electro Magnetic Interference**
EPROM	**:**	**Erasable Programmable Read Only Memory**
ERP	**:**	**Enterprise Resource Planning**
ESHS	**:**	**Environmental, Social, Health and Safety**
FAT	**:**	**Factory Acceptance Test(S)**
FCN	**:**	**Field Change Notice**
FFL	**:**	**Finished Floor Level**
FL	**:**	**Formation Level**
FMECA	**:**	**Failure Modes Effect and Criticality Analysis**
FRACAS	**:**	**Failure Report and Corrective Action System**
FTA	**:**	**Fault Tree Analysis**
GAD	**:**	**General Arrangement Drawing**
GCC	**:**	**General Conditions Of Contract**
GE	**:**	**Geotechnical Engineering**
GFL	**:**	**Ground Floor Level**
GIS	**:**	**Geographical Information System**
GL	**:**	**Ground Level**
GNSS	**:**	**Global Navigation Satellite System**
GOI	**:**	**Government Of India**
GPR	**:**	**Ground Penetrating Radar**
GPS	**:**	**Global Positioning System**
GRC	**:**	**Grievance Redress Committee**
GRM	**:**	**Grievance Redress Mechanism**
GS	**:**	**General Specifications**

GSM-R	**:**	**Global System For Mobile Communication - Railway**
HDPE	**:**	**High Density Polyethylene**
HFL	**:**	**Highest Flood Level**
HORC	**:**	**Haryana Orbital Rail Corridor**
HP/BHP	**:**	**Horse Power / Brake Horse Power**
HT	**:**	**High Tension**
HTML	**:**	**Hyper Text Markup Language**
HV	**:**	**High Voltage**
HVAC	**:**	**Heating, Ventilation And Air Conditioning**
Hz	**:**	**Hertz**
IC	**:**	**Integrated Circuit**
ICD	**:**	**Interface Co-Ordination Document**
ID	**:**	**Identification**
IEC	**:**	**International Electro – Technical Commission**
IHA	**:**	**Interface Hazard Analysis**
IISWBM	**:**	**Indian Institute Of Social Welfare & Business Management**
IMD	**:**	**Integrated Maintenance Depot**
IMP	**:**	**Interface Management Plan**
INR	**:**	**Indian Rupee**
IP	**:**	**Point Of Intersection**
IPS	**:**	**Integrated Power Supply**
IR	**:**	**Indian Railways**
IRC	**:**	**Indian Road Congress**
IRJ	**:**	**Insulated Rail Joints**
IRS	**:**	**Indian Railway Standards**
IRSEM	**:**	**Indian Railway Signal Engineering Manual**

IS	**:**	**Indian Standards**
ISO	**:**	**International Organization For Standardization**
IT	**:**	**Information Technology**
ITP	**:**	**Inspection And Test Plan**
ITT	**:**	**Instruction To Tenderers**
KM / KM	**:**	**Kilo meter**
kV	**:**	**Kilo Volt**
LAN	**:**	**Local Area Network**
LCD	**:**	**Liquid Crystal Display**
LCX	**:**	**Leaky Coaxial Cable**
LED	**:**	**Light Emitting Diode**
LRU	**:**	**Line Replaceable Units**
LT	**:**	**Low Tension**
LV	**:**	**Low Voltage**
LWL	**:**	**Lowest Water Level**
MC	**:**	**Municipal Corporation**
MCB/LV	**:**	**Miniature Circuit Breaker / Low Voltage**
MCCB	**:**	**Moulded Case Circuit Breaker**
MCIL	**:**	**Maintainability Critical Items List**
MDR	**:**	**Major District Roads**
MMI	**:**	**Man Machine Interface**
MOR	**:**	**Ministry Of Railway**
MPR	**:**	**Monthly Progress Report**
MQR	**:**	**Monthly Quality Report**
MS	**:**	**Method Statement**
MSDS	**:**	**Material Safety Data Sheet**
MSL	**:**	**Mean Sea Level**

MTBF	**:**	**Mean Time Between Failure**
MTBSAF	**:**	**Mean Time Between Service Affecting Failure**
MTTR	**:**	**Mean Time To Repair**
MTTR	**:**	**Mean Time To Restore**
NABL	**:**	**National Accreditation Board For Testing And Calibration Laboratories**
NATM	**:**	**New Austrian Tunnelling Method**
NCR	**:**	**Nonconformity Report**
NFPA	**:**	**National Fire Protection Association**
NGO	**:**	**Non-Governmental Organization**
NH	**:**	**National Highway**
NHAI	**:**	**National Highway Authority Of India**
NOC	**:**	**No Objection Certificate**
NONO	**:**	**Notice Of No Objection**
NONOC	**:**	**Notice Of No Objection With Comments**
NOO	**:**	**Notice Of Objection**
NR	**:**	**Not Reviewed**
O&M	**:**	**Operation And Maintenance**
O&SHA	**:**	**Operating And Support Hazard Analysis**
OCS	**:**	**Overhead Catenary System**
ODBC	**:**	**Open Data Base Connectivity**
ODF	**:**	**Optical Equipment Manufacturer**
ODR	**:**	**Other District Roads**
OEM	**:**	**Original Equipment Manufacturer**
OFC	**:**	**Optical Fibre Cable**
OHE	**:**	**Over Head Electrification**
OHSAS	**:**	**Occupational Health And Safety Assessment Series**

OHTL	**:**	**Over Head Transmission Lines**
OPM	**:**	**Other Preventive Measures**
PCC	**:**	**Particular Conditions Of Contract**
PDF	**:**	**Portable Document Format**
PHA	**:**	**Preliminary Hazard Analysis**
PMIS	**:**	**Project Management Information System**
PPE	**:**	**Personal Protective Equipment**
PR	**:**	**Public Relation**
PS	**:**	**Particular Specifications**
PVC	**:**	**Polyvinyl Chloride**
PWD	**:**	**Public Works Department**
QA	**:**	**Quality Assurance**
RAMS	**:**	**Reliability, Availability, Maintainability And Safety**
RAP	**:**	**Resettlement Action Plan**
RBD	**:**	**Reliability Block Diagram**
RC	**:**	**Reinforced Concrete**
RCC	**:**	**Reinforced Cement Concrete**
RCIL	**:**	**Reliability Critical Item List**
RDSO	**:**	**Research Designs And Standards Organization**
RDT	**:**	**Reliability Demonstration Testing**
RFI	**:**	**Request For Inspection**
RFO	**:**	**Rail Fly Over**
RINL	**:**	**Rashtriya Ispat Nigam Limited**
RL	**:**	***Reduced* Level**
ROB	**:**	**Road Over Bridge**
ROCS	**:**	**Rigid Overhead Conductor System**

ROM	**:**	**Read Only Memory**
ROW	**:**	**Right Of Way**
RUB	**:**	**Road Under Bridge**
S&T	**:**	**Signalling And Telecommunication**
SAIL	**:**	**Steel Authority Of India Limited**
SAT	**:**	**System Acceptance Test(S)**
SCADA	**:**	**Supervisory Control And Data Acquisition**
SCC	**:**	**Sectional Control Centre**
SCIL	**:**	**Safety Critical Items List**
SER	**:**	**Signalling Equipment Room**
SH	**:**	**State Highway**
SI	**:**	**International System Of Units**
SIL	**:**	**Safety Integrity Level**
SL	**:**	**Single Line**
SM	**:**	**Station Master**
SOD	**:**	**Schedule Of Dimensions**
SP	**:**	**Sectioning Post**
SRR	**:**	**Submission Review Request**
SRS	**:**	**System Requirement Specifications**
SSHA	**:**	**Subsystem Hazard Analysis**
SSP	**:**	**Sub-Sectioning Post**
SWR	**:**	**Station Working Rules**
TCAS	**:**	**Train Collision Avoidance System**
TCP	**:**	**Traffic Control Plan**
TER	**:**	**Telecommunication Equipment Room**
TMS	**:**	**Train Management System**
TOT	**:**	**Transfer Of Technology**

TSS	**:**	**Traction Substation**
UG	**:**	**Under Ground**
UPS	**:**	**Uninterrupted Power Supply**
USB	**:**	**Universal Serial Bus**
UTM	**:**	**Universal Transverse Mercator**
VDU	**:**	**Video Display Unit**
VHF	**:**	**Very High Frequency**
VN	**:**	**Variation Notice**
WGS84	**:**	**World Geodetic System 84**
WHO	**:**	**World Health Organization**
WQMP	**:**	**Works Quality Management Plan**
XLPE	**:**	**Cross Linked Polyethylene**

3 RELEVANT DOCUMENTS

The Design Criteria shall be read in conjunction with the General Conditions of Contract (GCC), the Particular Conditions of Contract (PCC), the Employer's Requirements, the drawings and any other document forming part of the Contract.

Notwithstanding the precedence specified above the Contractor shall always immediately seek advice from the Engineer in the event of conflicts between Specifications.

In case of conflict in Design Criteria in various Sub-Sections of Section VII, Employer's Requirements the order of precedence shall be as follows:

CIVIL &BLT

i. Outline Design Specifications (ODS)-Civil & BLT
ii. Outline Construction Specification (OCS)-Civil & BLT
iii. Tender Drawings
iv. Functional, Design, Construction, General
v. Appendices
vi. Indian and other International Standards referenced herein.
vii. Indian and other International Standards.

ELECTRICAL

i. General Electrical Services
ii. General Specifications
iii. Tender Drawings

iv. General

v. Appendices

All relevant RDSO Standards/drawings required by the Contractor for performance of its obligations under the Contract shall be obtained by the Contractor at their own cost from the office of RDSO. RDSO drawings can also be purchased online from RDSO website.

4 PHASES (DESIGN AND CONSTRUCTION)

a) The Contractor shall execute the Works in two phases, the Design Phase and the Construction Phase.

b) The Design Phase shall commence upon the date of Letter of Acceptance (LOA). This phase shall include the preparation and submission of:

i. the Preliminary Design,

ii. the Definitive Design;

iii. the Construction Reference Drawings.

iv. The Design Phase will be complete upon the issue of a Notice in respect of the comprehensive and complete Construction Reference Drawings Submission for the whole of the Permanent Works.

c) The requirements for the Preliminary Design, Definitive Design and Construction Reference Drawings are stated in Clause 2 of the Employer's Requirements -Design.

d) The Construction Phase for the whole or a part of the Permanent Works shall commence immediately upon the issue of a Notice by the Engineer/Employer in respect of the relevant Construction Reference Drawings Submission. Such Notice may be issued by the Engineer in respect of a Construction Reference Drawing Submission covering a major and distinctive part of the Permanent Works. However, construction shall not be commenced until the appropriate Working Drawings have been endorsed:

i. by the Contractor as "Good for Construction"; and

ii. by the Engineer that he has no objections to the drawing.

The Construction Phase shall include the completion and submission of the Final Design and the preparation and submission of the As Built Drawings and other records as specified.

e) Notwithstanding Clause 4 b (iv) above, for those elements identified under Sub-Clause 2.5 of the Employer's Requirements - Design, the Construction Phase may commence immediately upon the issue of the Notice in respect of the Definitive Design Submission in respect of each such element subject to availability of the site in accordance with agreed programme.

f) The Contractor shall furnish Contractor's Warranty in the format approved by the Employer given in Section X – Contract Forms.

5. SPECIFICATIONS

In accordance with the provisions of these Employer's Requirements (Section VII-1 to Section VII-9), the Contract Specification contained in the Contract shall be developed during the design stage and submitted as part of the Definitive Design Submission. When the Specification has received a Notice of No Objection from the Engineer it shall become the Particular Specifications and shall take precedence over the other Specifications for

construction purposes.

6. SPECIFICATIONS IN METRIC AND IMPERIAL UNITS

a) The Contract shall utilise the SI system of units. Codes and Standards in imperial units shall not be used unless the Engineer has given his consent.

b) Conversion between metric units and imperial units shall be in accordance with the relevant Indian Standards.

7. WORKS PROGRAMME

a) The Key Dates are defined in Appendix 2 to these Employer's Requirements.

b) The Contractor shall prepare and submit its Works Programme and three-month rolling programmes and the detailed requirements contained in Appendix 6 to these Employer's Requirements.

c) In compiling its Works Programme and in all subsequent updating and reporting, the Contractor shall make provision for the time required for co-ordinating and completing the design, testing, commissioning and integrated testing of the Works, including, inter alia, design co-ordination periods during which the Contractor shall co-ordinate its design with those of Interfacing Contractors, the review procedures, determining and complying with the requirements of all Government Departments and all others whose consent, permissions, authority or licence is required prior to the execution of any work.

d) The Works Programme shall take full account of the Design Submission Programme.

8. MONITORING OF PROGRESS

a) Project Monitoring shall be done by Integrated Project Monitoring Software (IPMS). The contractor has to prepare Primavera P6 schedule as per the Programme Requirements provided in Appendix 6.

b) The Contractor shall submit to the Engineer three copies (along with an additional copy in digital format) of a Monthly Progress Report (MPR), as described in Appendix 7 to these Employer's Requirements, describing the progress and current status of the Works. The MPR shall address the matters set out in the Works Programme.

c) The MPR shall be submitted by the end of each calendar month. It shall account for all works actually performed in the current month.

d) The MPR shall be divided into two sections. The first section shall cover progress and current status relating to design and the second section shall cover progress and current status relating to construction.

e) A monthly meeting to monitor & review the progress of the project shall be convened by the Engineer. Contractor's site Representative & Designer Representative of Contractor and site representative of all Interfacing Contractors shall also attend the meeting. The Employer may also be present in the meeting.

f) The Engineer or Employer may also conduct progress review meetings and Interface meetings on weekly /bi-weekly intervals depending upon the requirements or urgency of works. In these review meetings Engineer may call Contractor's Supplier/Sub-Contractor/Designer etc. as per the requirements.

9. QUALITY ASSURANCE

The Contractor shall establish and maintain a Quality Assurance System in accordance with Appendix 11 to these Employer's Requirements for design and construction procedures and

the interfaces between them. This Quality Assurance system shall be applied without prejudice to, or without in any way limiting, any Quality Assurance Systems that the Contractor already maintains.

10 SOFTWARE SUPPORT

10.1 GENERAL

a) The Contractor shall provide full support to the Engineer for all computer programs provided by the Contractor under the Contract.

b) The Contractor shall submit a software support plan at least 90 days before commencement of software installation. This plan shall require the Contractor to provide all changes, bug fixes, updates, modifications, amendments, and new versions of the program as required by the Engineer.

c) The Contractor shall provide all tools, equipment, manuals and training necessary for the Employer / Engineer to maintain and re-configure all the software provided under the Contract.

d) The Contractor shall submit all new versions to the Engineer for review at least 2 weeks prior to their installation. New Versions of any program shall not result in any non-conformance with the Specification or degrade the operation of the System. The Contractor shall:

   i. Ensure that all new versions are fully tested and validated on the simulation and development system prior to installation.

   ii. Ensure that all new versions are fully tested and commissioned once installed on the Site.

   iii. Deliver to the Employer/Engineer any new version, together with the updated Operation and Maintenance Manuals.

e) The Engineer shall not be obliged to use any new version and that shall not relieve the Contractor of any of its obligations. Any effect upon the performance or operation of the computer-controlled system that may be caused by a new version shall be brought to the Engineer attention including updating the files to suit new version.

10.2 IMPLEMENTATION OF SOFTWARE BASED BILLING & PROJECT MANAGEMENT SYSTEMS

The contractor shall perform all billing processes through the software-based billing system as and when introduced by HORC *free of cost*. The Contractor shall also introduce appropriate Project Management Systems during the project execution phase.

10.3 ERROR CORRECTION

a) When a fault is discovered within delivered software or documentation, the Contractor shall take necessary steps to rectify errors or faults at the earliest.

b) The Contractor shall provide written details as to the nature of the proposed correction to the Engineer.

c) The Contractor shall notify the Employer promptly of any fixes or patches that are available to correct or patch faults.

d) The Contractor shall detail any effect such fixes or patches are expected to have, upon

the applications.

10.4 TRAINING

The Contractor shall provide training for the Employer's/Engineer's staff to enable the Employer/Engineer to make proper use of any software and its new versions. In case Contractor fails or unable to provide training, the Engineer may ask for proposal.

11. CO-ORDINATION WITH INTERFACTING CONTRACTORS

11.1 General

a) The Contractor is responsible for detailed co-ordination of his design and construction activities with Interfacing Contractors. Such co-ordination responsibilities of the Contractor shall include the following:

i. To provide all information reasonably required by the Interfacing Contractors in a timely and professional manner to allow them to proceed with their design or construction activities, and specifically to meet their contractual obligations.

ii. To ensure that the Contractor's requirements are provided to all other Interfacing Contractors before the cut-off dates to be identified in the Interface Management Plan (IMP).

iii. To obtain from the Interfacing Contractors information reasonably required to enable the Contractor to meet the design submission dates as identified in Appendix 2.

iv. Where the execution of the work of the Interfacing Contractors depends upon the site management or information to be given by the Contractor, the Contractor shall provide to such Interfacing Contractors the services or correct and accurate information required to enable them to meet their own programme or construct their work.

v. To attend regular co-ordination meetings convened by the Engineer with the Interfacing Contractors. The Contractor shall conduct separate meetings with the Interfacing Contractors as necessary to clarify particular aspects of the interfacing requirements of the Works. The party who convenes the meeting shall prepare minutes recording all matters discussed and agreed at the meeting.

vi. To ensure that copies of all correspondence, drawings, meeting minutes, programmes, etc. relating to the Contractor's co-ordination with the Interfacing Contractors are issued to all concerned parties and the Engineer no later than two (2) calendar days from the date of such correspondence and meetings.

b) The Contractor, shall in carrying out his co-ordination responsibilities, raise in good time and provide sufficient information for the Engineer to decide on any disagreement between the Contractor and the Interfacing Contractors as to the extent of services or information required to pass between them. If such disagreement cannot be resolved by the Contractor despite having taken all reasonable efforts, then the decision of the Engineer shall be final and binding on the Contractor.

c) Where an Interfacing Contract is yet to be awarded the Contractor shall proceed with the co-ordination activities with the Engineer until such time when the Interfacing

Contractor is available. The Contractor shall provide the Interfacing Contractor with all information necessary to enable the Interfacing Contractor to follow-on and proceed with their co-ordination.

d) The cut-off dates to be identified in the IMP are the latest dates. Any claim of additional costs by the Interfacing Contractors as a result of the Contractor's failure in adhering to these dates shall be borne by the Contractor. The Contractor shall note that the information exchange is an iterative process requiring the exchange and update of information at the earliest opportunity and shall be carried out on a regular and progressive basis so that the process is completed for each design stage by the cut-off dates.

e) The Contractor shall co-ordinate with the Engineer on all matters relating to works that may affect the Operation & Maintenance of the already operational Section corridor of the of Employer in general. Such work shall be subject to the rules and regulations imposed by the Employer.

11.2 Design & Construction Interface

a) The dates shown in Employer's Requirements Appendix 2 are critical to the timely completion of the project. The Contractor shall commence design interface with the Interfacing Contractors as soon as he has been notified by the Engineer that such Interfacing Contract has been awarded. In the case of utility agencies and other statutory boards, interface shall commence as soon as it is practicable. Where no design interface date has been established whether because the Interfacing Contractor(s) have not been identified or for whatever reason, the Contractor shall liase with such Interfacing Contractor/s as soon as they have been awarded.

b) The Contractor shall immediately upon award of the Contract gather all necessary information and develop his design to a level where meaningful interaction can take place as soon as the Interfacing Contracts are available. The Contractor shall submit together with each of his Design Submissions a joint statement from the Contractor and the relevant Interfacing Contractor confirming that design co-ordination has been completed and that they have jointly reviewed the appropriate document to ensure that a consistent design is being presented.

c) The design interface is an iterative process requiring regular exchange and update of interfacing information. The Contractor shall ensure that the information he requires from the Interfacing Contractors is made known at the outset of each design interface and vice versa so that the information can be provided in time for the Contractor and the Interfacing Contractors to complete their design to meet their various design submission stages.

11.3 Construction Interface

a) Construction interface will be necessary throughout the duration of the Works commencing from the time the Contractor mobilises to the Site to the completion of the Works. Construction interface will overlap design interface, involving cast-in and buried items such as pipes for electrical and mechanical services, supports, brackets, plinths, ducts, service buildings, openings, cableways, trenches etc. that are to be incorporated at the early stage of the construction up to provision of attendance during the testing and commissioning stage.

b) The Contractor shall ensure that there is no interference with the Works of the

Interfacing Contractors and shall maintain close co-ordination with them to ensure that his work progresses in a smooth and orderly manner. The Contractor shall carry out and complete the Works, or any part thereof, in such order as may be agreed by the Engineer or in such revised order as may be requested by the Engineer from time to time. The Contractor shall, unless otherwise provided, be liable for and shall indemnify the Employer against all costs, charges, expenses and the like resulting from failure of the Contractor to co-ordinate the Works as specified.

12. SURVEY AND SITE INVESTIGATIONS

a) The datum used for the Contract shall be Mean Sea Level Datum

b) The Contractor shall carry out all further site investigations (such as detailed utility identification, detailed geo technical investigation etc.) necessary for the design of the Permanent Works and to enable the determination of the methods of construction and the nature, extent and design of the Temporary Works.

c) The Contractor shall carry out geotechnical investigation using conventional method of boreholes and geo-physical methods for the entire alignment.

13. CLIMATIC CONDITIONS

a) The entire section of HORC with connecting IR Station is situated in the state of Haryana. During summer months the temperature can be as high as 45°C with a high level of humidity, nights can be relatively cool with temperatures dipping to 30°C. Torrential rains and high humidity accompany the monsoon in late June to early September. In the winter months temperatures can vary from a high of 21°C during day to a low of 2°C during night.

b) The information given above is only indicative. The contractor shall obtain detailed climatic data in respect of minimum & maximum temperatures, rain, relative humidity, sunshine, and wind velocity/pressure etc. from "India Meteorological Department publications" and the same shall be taken into account by the Contractor when designing any part of the Permanent Works. The Contractor shall ensure that due allowance is made for more severe local conditions when Permanent Works are required to operate, for example, with restricted ventilation that may lead to higher local ambient temperatures, and any other factors that may affect the operating environment in any way.

c) Unless specific figures are provided elsewhere, the Permanent Works will generally be required to function at its rated value with the values of ambient temperature and relative humidity appropriate to the location of the equipment within the classifications shown in Table given below. Certain parts of the Permanent Works may need to be rated for more or less onerous conditions as required by the PS.

d) The Contractor's attention is drawn to the more severe environmental conditions that may exist during the construction/installation period and shall take adequate measures to protect the Permanent works against any deleterious effects of such conditions during the time between installation and final completion of the project. Also, Air throughout the project will contain considerable moisture content, hence the permanent works shall be tropicalized and vermin proof.

14. PROJECT MANAGEMENT INFORMATION SYSTEM (PMIS)

The Contractor shall use PMIS developed by the Employer. All documents generated by the Contractor should be transmitted to the Engineer by electronic means (and vice versa) and that all documents generated by either party will be electronically captured at the point

of origin and can be reproduced later, electronically and in hard copy.

15. CONTRACTOR'S PROJECT ORGANISATION

a) The Contractor shall have a competent team of Managers, Engineers, Technical staff etc. so as to complete the work satisfactory as per various requirements of the Contract.

b) The designations of the various project organisations team members shall be got approved by the Engineer before adoption so as to avoid any duplication of the designations with those of the Employer or the Engineer.

16. CONTRACTOR'S CERTIFICATE

The Contractor shall provide his registration details for GST Registration, EPF registration, ESI registration, Statutory Certificate, Certificate as per ESHS Manual etc. as required for the execution and completion of the Works.

17. DELETED

18. MAINTENANCE REPORT

i. The Maintenance Report shall be submitted as part of the Definitive Design and shall include full details of the long term inspection and maintenance operations for each major component of tunnels and drainage.

ii. The Contractor shall provide inspection and maintenance manuals for the civil and electrical services.

iii. For each area an inspection checklist shall be supplied giving inspection frequency, items to be inspected, criteria for acceptance, criteria for remedial works and details of the remedial works, including proposed materials and method statements. The recommended regular maintenance regime of each area shall also be given including cleaning methods and frequency for different surfaces; removal of leakage borne salts from concrete surfaces; cleaning of drainage channels, sumps and pipes; repainting of metallic items;

iv. All instruments necessary to carry out the inspections and monitoring that are identified in the report shall be provided by the Contractor within the lump sum tender price.

Section VII: Employer's Requirements
Section VII-2: Functional (Civil & BLT)

EMPLOYER'S REQUIREMENTS –FUNCTIONAL (CIVIL & BLT)

OBJECTIVE

The objective of the Contract is the design, construction completion, testing and commissioning of the permanent works by the Contractor (including without limitation, the design, installation and removal of the Temporary Works) and the rectification of defects appearing in Permanent Works in the manner and to the standards and within the time stipulated by the Contract. In full recognition of this objective, and with full acceptance of the obligations, liabilities and risks which may be involved, the Contractor shall undertake the execution of the Works.

1 GENERAL

1.1 *The Works to be executed under Package C-4 is for design and construction of civil works and General electrical services work as per Employer's Requirements on 'Design Build' basis. All information available with the Employer has been furnished in Section VII-8, Tender Drawings and Documents, Part 2, Employer's Requirements. The Works are to be designed by the Contractor. Any other site data and information required for design of the Works shall be collected (through tests or otherwise), arranged, produced by the Contractor at his own cost. No claim from the Contractor whatsoever shall be entertained on the ground of certain information not being furnished in the Contract.* The design and performance of the Permanent Works shall comply with the specific core requirements contained in these Employer's Requirements – Functional (Civil &BLT).

1.2 The design of the Permanent Works shall be developed in accordance with these Employer's Requirements – Functional (Civil & BLT) and other requirements of the Contract.

1.3 The Permanent Works shall be designed and constructed to the highest standards available using proven up-to-date good Engineering practices. Construction shall be carried out employing the procedures established by the Contractor as per approved Quality Assurance and Quality Control plan and Environmental, Social, Health and Safety (ESHS) Plan.

1.4 The Contractor shall be responsible for obtaining all necessary approvals from the relevant Public/Government/Local/Statutory or any agencies in the design and construction of the Works.

1.5 Employer's Requirements- Functional (Civil & BLT) shall be read in conjunction with Employer's Requirements-Design, Construction, Outline Design Specification (ODS)-Civil & BLT, Outline Construction Specifications (OCS)-Civil & BLT and other requirements of the Contract. *The price quoted by the Contractor shall be deemed to have included cost of Works as per Part 2-Employer's Requirements (General, Functional (Civil and BLT) , Design (Civil), Construction (Civil) , Outline Design Specifications (ODS)- Civil and BLT , Outline Construction Specifications (OCS)-Civil and BLT , General Electrical Services , Tender drawings and Documents and Appendices).*

2 SCOPE OF THE WORKS

2.1 Scope under Lumpsum Price Schedule 'A'

HORC project crosses Aravalli Range between Sohna and Dhulawat stations through a tunnel to be constructed in C-4 Package from Ch.*24850* m to Ch.29580 m. The tunnelling is required to be done in rock as well as in soil. It involves tunnelling by NATM method and Cut and Cover method. Two separate tunnels are to be constructed - one for Up line and one for Down line. The tunnel is to be provided with Ballastless track (BLT). NATM work is required to be carried out from fourteen faces as shown in Tender drawings. The tunnel has got four permanent ventilation shafts and one construction cum utility shaft. Tentative location of the shafts and area of land which will be made available to the Contractor for working is shown in Tender drawings. The soil excavated from the tunnel will be used for construction of embankment from Ch. 12000 m to Ch. 18000 m. Bridges *as per list given in Annexure F-1 and Annexure F-2* are also involved in formation from Ch. 12000 m to Ch. 18000 m .

The through Chainages mentioned in the Scope of the Works/Tender drawings can undergo some minor corrections, without any impact on the overall length/Scope of the Works. The Scope of the Works for C-4 Package will be, but not limited to, as follows:

2.1.1 Design and Construction of Twin Tunnel

a) *Design and construction of Cut & Cover Tunnels from Ch. 28480 m to Ch. 29580 m including drainage arrangements for catering to surface run off from open cutting of about 1340 m length as shown in Tender drawings.*

b) Design and construction of NATM twin Tunnels from Ch. *24850 m for UP line and Ch. 24853 m for DN line* to Ch. 28480 m in all types of strata (rock and soil) *including drainage arrangements for catering to surface run off from open cutting as shown in Tender drawings*.

c) Design and construction of four (02x02) Nos. of permanent ventilation shafts and other associated structures *including roofing system and stairs as specified in Section VII-5: Outline Design Specifications (ODS)-Civil & BLT*, *Section VII-6: Outline Construction Specifications (OCS)-Civil & BLT, DBR and* Tender drawings.

d) Design and construction of one (01) No. construction cum utility shaft *and other associated structures including roofing system and stairs as specified in Section VII-5: Outline Design Specifications (ODS)-Civil & BLT, Section VII-6: Outline Construction Specifications (OCS)-Civil & BLT, DBR and as shown in Tender drawings*. Cross passage between two tunnels at the location of construction *cum utility* shaft *shall be provided* to accommodate electrical installations *as shown in Tender drawings*.

e) Design and construction of cross passages at an interval of approximately 350m including fire stop doors at both ends as shown in the Tender drawings.

f) Design and construction of *Portal P-2 for both UP & DN lines including drainage arrangement at the interface of Portal P2 and Cut & Cover tunnel for catering to surface runoff from the cutting.*

g) Design of Portal P-1 for both UP & DN lines including slope stability of rock, boulder fall and protection arrangements.

h) Design of *drainage system at Palwal end approach of Portal P-1 for both UP & DN lines for disposal of storm water coming out of the tunnel and from adjoining open area and integrating the drainage system with the drainage scheme of DFC.*

i) *Design of Abutment A-2 for proposed HORC viaduct for both UP & DN lines including bearing pedestal and seismic restrainers near Portal P-1 as shown in Tender drawings. Construction of Abutment A-2 for both UP & DN lines of viaduct including bearing pedestal and seismic restrainers shall be paid under Schedule 'B'.*

Note-

1. Excavated earth/rock from tunnelling/cutting shall be property of the Contractor. Royalty for using the excavated earth/rock for construction of the Works shall be borne by the Contractor. Surplus excavated earth/rock from tunnel shall be disposed off by the Contractor at his own cost.

2. *The Contractor shall take adequate protection measures for safety of DFC viaduct and ensure its safety during construction (especially during blasting operations and rock cutting) near proposed Portal-P. The Contractor shall ensure that there is no damage caused to DFC viaduct. In case of any damage to DFC viaduct due to failure of the Contractor, the Contractor shall have to repair/restore the viaduct to its original condition at his own cost to the satisfaction of DFC. The Contractor shall ensure that there is no obstruction to operation of DFC track failing which the Contractor shall be responsible for payment of loss/damages caused to DFC on this account. The decision of DFC regarding extent of loss/damages shall be final and binding on the Contractor.*

2.1.2 Design and Construction of Ballastless Track

Design and construction of ballastless track including transition from ballastless track to ballasted track at each end *of tunnel,* and derailment guard *from Ch. 24843m for UP line and Ch. 24847m for DN line to Ch. 29680 m*. The work also includes supply of spare *track fittings* and maintenance of ballastless track for a period of one year after start of traffic.

2.1.3 Design and construction of railway formation *in embankment including protection works*

a) The Contractor shall design and construct railway formation in embankment for 32.5 t axle load as per RDSO Specifications "Comprehensive Guidelines and specifications for Railway Formation- Specification No. RDSO/2020/GE: IRS-0004, Sept 2020" (primarily using excavated material from tunnelling/cutting) from Ch.12000 m to Ch. 18000 m and from abutment A-2 *(Ch. 24843.548 m of Up line and Ch. 24847.154m*

for DN line) of *proposed HORC* viaduct to *Ch. 24850m for UP line and Ch. 24853m for DN line* for double track of Main line as shown in Tender drawings and *shall include earthwork in filling, subgrade, prepared subgrade and blanketing including mechanical compaction*. The Contractor shall arrange borrow areas for earthwork (required in addition to earth obtained from cutting/tunnelling) in embankment at his own cost.

Excavated earth/rock from cutting/tunnelling shall be utilised for formation in embankment/structures in C-4 Package. Royalty for using the excavated earth/rock for construction of the Works shall be borne by the Contractor. Surplus/unsuitable excavated earth/rock shall be disposed off by the Contractor at his own cost.

b) The Contractor shall design and construct precast RCC longitudinal drains on berms of embankments to collect surface runoff from the slope. Precast RCC chute drains shall be provided at approximately every 50 m for collecting water from drains on berms and discharging it safely away from toe of embankments as shown in Tender drawings. RCC collecting chambers shall be provided at the junction of longitudinal berm drains and precast RCC chute drains.

c) The slopes of embankment shall be protected by vegetative cover comprising perennial turf forming grass in accordance with Section VII- 6 Outline Construction Specifications (OCS)-Civil & BLT. On embankments higher than 4 m vegetative cover shall be provided over coir netting as per IS:15869, IS:15872 and IRC: 56.

d) After Taking Over the Works, the Contractor shall maintain slopes of embankment, sumps, pre-cast RCC drains on berms, precast RCC chutes drains and vegetative cover for a period of one (01) year and shall make good any loss/damage to slopes of embankment, sumps, pre-cast RCC drains on berms, precast RCC chute drains and vegetative cover due to rain cuts, pedestrian movement or any other reason.

2.1.4 Design and construction of cutting in the approach of Portal P-2 *including protection works*

a) Design and construction of cutting *from Portal P-2 to Ch. Km 29.680* or equal to transition length required between BLT and ballasted track in open cutting, whichever is more.
b) Design and construction of side drains and catch water drains on both sides *of cutting* along with two (02) sumps i.e. one (01) No. on outer side of each track at the junction of *Portal P-2* and cutting.
c) *The Contractor shall design and construct precast RCC longitudinal drains on berms of cuttings to collect surface runoff from the slope. Precast RCC chute drains shall be provided at approximately every 50 m for collecting water from drains on berms and discharging it safely into side drains of cuttings as shown in Tender drawings. RCC collecting chambers shall be provided at the junction of longitudinal berm drains and precast RCC chute drains.*
d) *The slopes of cutting shall be protected by vegetative cover comprising perennial turf forming grass in accordance with Section VII- 6 Outline Construction Specifications (OCS)-Civil & BLT. On cuttings deeper than 4 m*

vegetative cover shall be provided over coir netting as per IS:15869, IS:15872 and IRC: 56.

e) After Taking Over the Works, the Contractor shall maintain slopes of cutting, sumps, pre-cast RCC drains on berms, side drains, catchwater drains, precast RCC chute drains and vegetative cover for a period of one (01) year and shall make good any loss/damage to slopes of cutting including sumps, pre-cast RCC drains on berms, side drains, catchwater drains, precast RCC chute drains and vegetative cover due to rain cuts, pedestrian movement or any other reason.

f) Inspection steps shall be provided on both sides of cutting for escape of passengers in case of emergency as shown in Tender drawings.

2.1.5 Design and construction of minor bridges

*The Contractor shall design and construct minor bridges (RUBs, canal and waterway bridges) including protection works on bridge approaches and height gauges at all RUBs as per Employer's Requirements. List of minor bridges is given in **Annexure-F-1**. Approach road on both sides of RUBs shall be designed and constructed by the Contractor upto ROW of HORC for full clear width of RUB. Design and construction of permanent diversion at RUBs shall be carried out by the Contractor as shown in the Tender drawings.*

2.1.6 Design and construction of major bridge

*The Contractor shall design and construct major bridges (RUBs, canal and waterway bridges) including protection works on bridge approaches and height gauges at all RUBs as per Employer's Requirements. List of major bridges is given in **Annexure- F-2**. Approach road on both sides of RUBs shall be designed and constructed by the Contractor upto ROW of HORC for full clear width of RUB. Design and construction of permanent diversion at RUBs shall be carried out by the Contractor as shown in the Tender drawings.*

2.1.7 Design and construction of RCC hume pipe (NP-4) of 450 mm dia/precast RCC box (500mm x 500mm, clear opening) in the embankment from Ch. 12000 m to Ch. 18000 m at approximately 500m interval for crossing utilities in future.

2.1.8 Design of bridges *including protection works* as given in **Annexure-F-3**. *Construction of* these bridge shall be paid under Schedule 'B'.

2.1.9 All temporary Works associated with construction of the Works, including construction and maintenance of site office(s) *and Resting accommodation* for Engineer's/Employer's staff complete in all respects as per the details given in the Employer's Requirement (Appendix 10 of Section VII-9: Appendices) to the satisfaction of the Engineer for the duration of the Contract.

2.1.10 *The Contractor shall provide and maintain during progress of works barricading around the work area where vehicular or pedestrian traffic passes with all safety measures as shown in Tender drawings. The excavations near habitations/public movement areas and all works*

along the roads shall be provided with proper caution signs and marked with red lights, reflectors at night to avoid accidents near public places to ensure safety of public.

2.1.11 *Traffic management along the work site including construction works required in connection with traffic management like road works, footpaths, drains and other services etc. and repair and maintenance of these construction works during construction period. Any road widening / diversion along with associated drainage system required to facilitate the movement of traffic and their repair & maintenance shall also be carried out by the Contractor. It also includes reinstatement of land/structure/roads/services etc. to original condition wherever road diversion has been made outside original road including reconstruction of structure demolished for traffic management. Materials and other specification related to traffic control devices shall conform to IRC standards.*

2.1.12 *Reinstatement/Restoration of roads and services with new material of similar specification as per codal requirement after completion of work for the area disturbed by the Contractor during construction activities. However, reinstatement of roads and its drainage system will be as per current standards being used by the roads/service owning agency for similar roads. Proper survey to be done before dismantling of any of the above services along with extensive photographs, videos & sample of these services by the Contractor & get it verified by the representative of Engineer so as to ascertain the extent of these existing services and its specification.*

2.1.13 *If protection works and drainage arrangements of DFC viaduct near portal P1 are required to be dismantled or get damaged during execution of the Works, the same shall be reinstated in original condition by the Contractor at his cost.*

2.1.14 Surveying, instrumentation and monitoring for settlement of buildings, structures, transmission towers and risk analysis, settlement prediction, preventive and corrective actions as per Section VII-5: Outline Design Specifications (ODS)-Civil &BLT.

2.1.15 All interfacing works with the Interfacing Contractors as defined in the Appendix 5 of the Contract.

2.1.16 The Contractor shall be responsible for obtaining approval of drawings of *bridges and* structures by all relevant authorities through the Employer, if required.

2.1.17 For details of scope of "General Electrical Services" under lumpsum component of the Works refer Section VII-7: General Electrical Services, Part 2 -Employer's Requirements.

2.1.18 *There is possibility of some of the items not getting mentioned in the above list of works. Tenderers are requested to go through the Tender drawings also in details as the works listed in Clause 2.1 above as well as indicated in the Tender drawings would be considered inclusive in the scope of work under lump sum quoted price except the items mentioned in*

Sub-Clause 2.2, 2.3 and 2.4 below unless specified otherwise in the Contract. Engineer's decision shall be final in this regard in case of dispute.

2.1.19 The work content against the lump sum component of the work shall also include, but not limited to, the following:

a) Site clearance and dismantling of obstructions etc., before commencement of work as specified or as directed by the Engineer;

b) True and proper setting out and layout of the Works, benchmarks and provision of all necessary labour, instruments and appliances in connection therewith as specified or as directed by the Engineer;

c) All aspects of quality assurance, including testing of materials as per the approved inspection and test plan and other components of the work, as specified or as directed by the Engineer;

d) Day to day cleaning of worksite throughout the execution period;

e) *Maintenance of the completed Works during the period as specified or as directed by the Engineer*

f) Submission of completion (i.e., 'As-Built') drawings 06 (Six) sets in A-1 size and all other related documents as specified including scanned and AutoCAD copy with soft copies in both formats of all As-built drawings & documents.

g) Preparing Definitive Design, Construction Reference drawings, Good For Construction(GFC) drawings and working drawings for various components of the works and obtaining approval in respect thereof from the Engineer, inclusive of incorporation of all modifications, alterations, changes, etc. that may be required to be carried out as directed by the Engineer;

h) Compliance of requirements of Environmental, Social, Health and Safety (ESHS) Manual as per Appendix 13 of Employer's Requirements, Section VII-9

i) Results of sub-surface investigations conducted at project site are enclosed with the Tender documents. This information about the soil and sub-soil water conditions is being made available to the Contractor in good faith and the Contractor shall have to obtain the details of sub soil parameters independently. No claim whatsoever on account of any discrepancy/variation in soil parameters, sub soil water conditions and change in geology that may be actually encountered at the time of execution of the work and those given in these Tender Documents shall be admissible to the Contractor under any circumstances.

2.1.20 ASSOCIATED WORKS

Works to be performed shall also include all general works, preparatory works for the construction and works of any kind necessary for the design and satisfactory construction, completion and maintenance of the

works to the intent and meaning of the drawings adopted and Outline Construction Specifications , to best Engineering standards and orders that may be issued by the Engineer from time to time, compliance with all Conditions of Contract, supply of all materials, apparatus, plants, equipment, tools, fuel, water, strutting, timbering, transport, offices, stores, workshop, staff, labour and the provision of proper and sufficient protective works, diversion, temporary fencing, lighting and watching required for the safety of the public and protection of works on adjoining land; first-aid equipment, sanitary accommodation for the staff and workmen, effecting and maintenance of all insurances, the payment of all wages, salaries, fees, royalties, duties or the other charges arising out of the execution of works and the regular clearance of rubbish, clearing up, leaving the site perfect and tidy on completion.

2.1.21 CONTRACTOR'S FACILITIES & SITE OFFICE

Land as shown in Section VII-8: Tender drawings and documents, Part 2-Employer's Requirements will be made available by the Employer which can be utilised by the Contractor for Contractor's facilities and site office (excluding labour camps) with the approval of the Engineer. Any land required beyond the above area will have to be arranged by the Contractor at his own cost. This land shall be made good for such offsite activities as needed by the Contractor at no extra cost to the Employer. The land shall be cleared from debris, all structures made by the contractor including, RCC footings and rafts etc. and reinstated to the line, level and to the same conditions as existed before the work started before handing over back to the Employer within 91 days after Taking over Certificate. The final bill shall be released to the contractor after all structures from the Contractor facility and site office are removed & clearance of site. The cost of setting up of all the above mentioned facilities & the office and reinstatement of site is included in lump sum price in Schedule 'A'.

2.2 Scope under BOQ Schedule 'B'

Under this Schedule, the Contractor is required to carry out works which are not covered in Schedule 'A'. Broadly following works shall be carried out under this Schedule 'B':

a) Construction of Portal P-1 for both UP and DN lines including protection arrangements (rock cutting, rock bolting, shotcreting etc.).

b) Construction of drainage system at Palwal end approach of Portal P-1 of UP and DN lines for disposal of storm water coming out of the tunnel and from adjoining open area and integrating the drainage system with the drainage scheme of DFC.

c) *Construction of Abutment A-2 of proposed HORC viaduct for both UP and DN lines including bearing pedestal and seismic restrainers near Portal P-1.*

d) Construction of bridges as per list given in **Annexure-F-3**.

e) Any other item as directed by the Engineer related to the Works.

2.3 Scope under Schedule 'C' (Item Rate for miscellaneous works)

Under this Schedule, the Contractor is required to carry out works which are not covered in Schedule 'A' or Schedule 'B'.

a) Diversion of all uncharted utilities, if required, as per approved plan.

b) Any other activity as directed by the Engineer

2.4 REFERENCE TO THE STANDARD CODES OF PRACTICE

2.4.1 All Standards, Outline Construction Specifications (OCS)-Civil & BLT, Technical Specifications and Codes of Practice referred to shall be latest editions including all applicable official amendments and revisions. The Contractor shall make available at site all relevant Indian Standard Codes of practice, IRS, IS, IRC, UIC, as applicable.

2.4.2 Wherever Indian Standards do not cover some particular aspects of design/ construction, relevant International Standards will be referred to. The Contractor shall make available at site such standard codes of practice.

2.4.3 In case of discrepancy among Standard codes of practice and Section VII-6: Outline Construction Specifications (OCS)-Civil &BLT, the order of precedence shall be as given below:

a) Outline Design Specifications-Civil &BLT
b) Outline Construction Specifications-Civil &BLT
c) Standard Codes of Practice.
   In case of discrepancy among Standard Codes of Practice, the order of precedence will be
   (i) IRS,
   (ii) IS,
   (iii) IRC,
   (iv) other International codes
d) Indian Railway Unified Standard Specifications,
e) CPWD specifications,
f) NBC 2016,
g) MORTH Specification for Road & Bridges,

2.5 DIMENSIONS

As regards errors, omissions and discrepancies in Specifications and Drawings, relevant clause of Particular Specification will apply. The levels, measurements and other information concerning the existing site as shown on the conceptual / layout drawings are believed to be correct, but the Contractor should verify them for himself and also examine the nature of the ground as no claim or allowance whatsoever shall be entertained on account of any errors or omissions in the levels or strata turning out different from what is shown on the drawings**.**

2.6 INSPECTION

The Employer may appoint an independent agency to ensure the quality checking of design, supply, fabrication, erection and construction of all works under Scope of the Works. *The payment to the independent agency shall be made by the Employer separately.* The Contractor shall ensure complete co-operation with the agency to perform their work satisfactorily. In addition, the Employer also reserves right to undertake quality check and inspection directly by itself.

2.7 ALIGNMENT OF TRACKS (TUNNEL, CUTTING & EMBANKMENT)

2.7.1 The alignment shall be as shown in the Tender drawings. The alignment has been developed by the Employer to meet operational and technical criteria. The Contractor is not required to evaluate the alignment for compliance with these criteria, but shall review it with respect to his own design and construction proposals and shall also satisfy himself that it suits to the available land width and there is no conflict with any existing and planned structures which are to be preserved.

2.7.2 The Contractor is permitted to propose *minor* deviations in alignment to suit his construction proposals, but he must demonstrate that any such deviations do not reduce the technical and operational performance. The Contractor needs to verify the contract boundaries while proposing any change in vertical and/or horizontal alignment but such deviations shall require prior approval of the Employer subject to following conditions: -

a) There is no extra cost to the Employer

b) Changes proposed are essentially required to suit the contractor's specific design

c) There is no change at the contract boundaries or if there is any, the same is agreed by the Contractor of the adjoining section without any extra cost to the Employer.

2.7.3 *The ground levels shown in Conceptual Alignment Plan & L-Section tender drawings are based on preliminary survey. Detailed survey will have to be carried out by the Contractor for confirming and preparation of final Alignment Plan & L-Section. No cost implication shall be considered for any variation in the ground levels with respect to ground levels shown in conceptual Alignment Plan & L-Section tender drawings.*

2.8 CLEARANCES

2.8.1 The Permanent Works shall not infringe the Fixed Structure Gauge in tunnels as shown in *Tender* drawings and Indian Railway Schedule of Dimensions (IR SOD) at other places. Extra clearance shall be provided on curved alignment as per IR SOD.

2.8.2 The Permanent Works shall provide for the installation of operating equipment for the railway without infringement of the Fixed Structure Gauge and IR SOD.

2.9 DURABILITY AND MAINTENANCE

2.9.1 The Permanent Works shall be designed and constructed such that, if maintained reasonably and in accordance with the Contractor's statement of maintainability contained in the Contract, they shall endure in a serviceable condition throughout their minimum lives as

described under Sub-Clause 2.3 of the Section VII-5: Outline Design Specifications (ODS)-Civil & BLT and in above mentioned paragraphs.

The Permanent Works shall be designed and constructed so as to minimise the cost of maintenance whilst not compromising the performance characteristics and ride quality of the railway.

2.10 OPERATIONAL REQUIREMENTS

2.10.1 The Permanent Works shall be designed to permit the railway to operate satisfactorily at a maximum design speed of 160 kmph where applicable.

2.10.2 During construction the Contractor shall be responsible for providing and maintaining adequate flood protection to the works.

2.11 ENVIRONMENTAL CONSIDERATIONS

All provisions and conditions contained in the Environmental, Social, Health and Safety (ESHS) Manual as per Appendix 13 of Section VII-9: Appendices, Part 2, Employer's Requirements shall be strictly complied with.

2.12 FUNCTIONAL REQUIREMENTS REGARDING INTERFACE WITH CONCERNED AUTHORITIES

Requests for temporary power supplies for the construction of the works must be submitted by the Contractor to the concerned authorities. Alternatively separate power supplies may be arranged by the Contractor subject to compliance with all necessary statutory requirements, especially pollution control.

2.13 TRAFFIC MANAGEMENT

The Contractor shall carry out the Works so as to minimise disruption to road and pedestrian traffic. The Contractor shall prepare his traffic management plan based on his proposed construction methodology in co-ordination with Engineer and in conjunction with the concerned road authority as per Appendix 10. He shall comply strictly with the approved plan during construction of his plan.

2.14 CRS INSPECTION

The Contractor shall note that the Commissioner for Railway Safety (CRS) will inspect the Works from time to time for the purpose of determining whether the HORC Project complies in terms of operational and infrastructural safety in accordance with the Laws of India. The contractor shall note that CRS approval is mandatory for commissioning the system. Notwithstanding other provisions of the Contract, the Contractor shall ensure that the Works comply with the requirements of CRS. The Contractor shall make all necessary arrangements

for assisting CRS in carrying out his inspection duties and also comply with his instructions regarding rectifying any defects and making good any deficiencies. Contractor shall prepare and make available all drawings, documents, sketches, photographs etc. as required for submission of application for inspection of CRS as instructed by the Engineer.

2.15 STANDARDS

2.15.1 Equipment, materials and systems shall be designed, manufactured and tested in accordance with the latest issue of National and/or International codes and standards. The Contractor shall submit copies to the Engineer of all codes and standards used for the work.

2.15.2 Reference to standards or to materials and equipment of a particular manufacturer shall be regarded as followed by the words "or equivalent". The Contractor may propose alternative standard materials, or equipment that shall be equal to or better than those specified. If the Contractor for any reason proposes alternatives to or deviations from the specified standards, or desires to use materials or equipment not covered by the specified standards, the Contractor shall apply for the consent of the Engineer. The Contractor shall state the exact nature of the change, the reason for making the change and relevant specifications of the materials and equipment in the English language. The decision of the Engineer in the matter of quality will be final.

ANNEXURE-F-1

LIST OF MINOR BRIDGES UNDER SCHEDULE-A

S.NO.	Br. No.	*Chainage (M)	Type of Crossing	Type of Bridge	SPAN No. x L (in m) x H (in m)
1.	47	12208.018	Balancing Culvert	RCC Box	1x2.00x2.00
2.	48	*12298.962*	Drain+ *Road*	2 Cell RCC Box	*1x4.0x5.0+ 1x5.0x5.0*
3.	49	12341.836	Balancing Culvert	RCC Pipe	1x1.8
4.	50	12645.715	Balancing Culvert	RCC Box	1x2.00x2.00
5.	51	13114.998	Canal	RCC Box	1x3.00x3.00
6.	52	13903.112	*Balancing Culvert*	RCC Box	1x3.00x3.00
7.	54	14601.627	Canal	RCC Box	1x3.00x3.00
8.	55	14756.727	Road	RCC Box	1x5.00x5.00
9.	56	*15100.163*	Balancing Culvert	RCC Box	1x2.00x2.00
10.	57	15944	Road	RCC Box	1x5.00x5.00

*Main line Chainages start from Prithala station of HORC.

ANNEXURE-F-2

LIST OF MAJOR BRIDGES UNDER SCHEDULE-A

S.NO.	Br. No.	*Chainage (M)	Type of Crossing	Type of Bridge	SPAN No. x L (in m) H (in m)
1.	62	17500	Road	PSC U-Slab	1x12.20

*Main line Chainages start from Prithala station of HORC.

ANNEXURE-F-3

LIST OF BRIDGES UNDER SCHEDULE-B

S.NO.	Br. No.	*Chainage (M)	Type of Crossing	Type of Bridge	SPAN No. x L (in m) H (in m)
1.	53	14472.112	Stream	Composite Girder	2x24.40**
2.	58	16127	Canal	PSC U-Slab+ RCC box abutments	*1x5x5.4*+1x12.20 + 1x5.00x*5.4*
3.	59	16727	Road	PSC U-Slab	2x12.20
4.	60	16827	Road	RCC Box	2x7.00x5.60
5.	61	16917	Canal	PSC U-Slab + *RCC box Abutments*	*1x5x5.4*+ 1x12.20 +*1x5x5.4*

*Main line Chainages start from Prithala station of HORC.
**Fabrication & erection of composite steel superstructure is not in the scope of work.

ANNEXURE-F-4

APPROXIMATE LOCATIONS OF RETAINING WALL

Deleted

Section VII: Employer's Requirements

Section VII-3: Design (Civil and BLT)

EMPLOYER'S REQUIREMENTS – DESIGN (CIVIL and BLT)

1. INTRODUCTION

1.1 The Employer's Requirements - Design, specifies the procedural requirements for the preparation of the design of the Permanent Works. These requirements are subdivided into: **Design Phase**, **Construction Phase** and **General Application**.

1.2 In addition to the express requirements herein, the Contractor shall, whenever the Engineer so requests, provide information and participate in discussions that relate to design matters.

1.3 The Contractor shall engage the Designer who shall undertake and prepare the design of the Permanent Works and Temporary Works. The Contractor shall place his core design team at Gurugram.

1.4 The Contractor shall ensure that the Designer shall be associated during construction of NATM tunnel at least throughout the NATM Main Drive and shall review the primary support adequacy as the excavation proceeds and propose any change in primary support system requirement due to encountered geology for the approval of Engineer including the interpretations of monitoring Data.

1.5 The Contractor shall submit his Quality Assurance Plan as required in Appendix 11, Section VII-9: Appendices, Part 2- Employer's Requirements for the design required by the Contract.

1.6 The Design and Construction Standards shall be in conformity with the requirements of "Rules for Opening of a Railway or a Section of a Railway for Public Carriage of Passengers" and to the satisfaction of the Commissioner of Railway Safety whose sanction is mandatory for commissioning of the System.

1.7 The Contractor shall submit the design of NATM tunnel, Cut & Cover tunnel, BLT, Permanent Ventilation Shafts and Portals *etc. to the Engineer for approval*. *In addition, the designs can be got checked from the third party appointed by the Employer. The cost of third party checking shall be borne by the Employer.*

2. REQUIREMENTS DURING DESIGN PHASE

2.1 The principal requirements of the Design Phase are the production of the Preliminary Design and General Arrangement Drawings, the Definitive Design and the Construction Reference Drawings. It should be clearly understood that the Tenderer's technical proposal submitted along-with his tender including any modifications to the same during negotiations stage shall only form the basis for further design development into the preliminary and Definitive design, subject to the same conforming to the Outline Design Specifications.

2.2 Preliminary Design

The Preliminary Design shall define the main structural elements. In addition, General arrangement drawing, general construction methods and documentation needed to develop the Definitive Design shall be submitted.

2.3 Definitive Design -Tunnel

2.3.1 The Definitive Design shall accord with and incorporate the Preliminary design and shall be the design developed to the stage at which all elements of the primary support of the tunnel, final lining and structures are fully defined and specified and in particular:

(a) Calculation and analysis duly incorporating the expected geological variations are complete for primary support system required for NATM tunnel, final lining and temporary support system for any other works;

(b) all element of primary support for NATM tunnel are delineated;

(c) all main and all other significant elements are delineated;

(d) all field and laboratory tests are carried out to a reasonable extent to evaluate geological conditions and geotechnical parameters required for design of NATM tunnel and other associated works;

(e) all tests and trials for the performance of NATM tunnels, primary support system elements such as rock bolts/dowels, shotcrete creep tests, etc. and selection of materials and equipment required for installation of primary support system and final lining of tunnel;

(f) shall take full account of effect on the permanent works of the proposed excavation schemes and primary support system used herein on the final lining to be installed and commissioned for NATM tunnel;

(g) shall take full account of the effect on the Permanent Works of the proposed methods of construction and of the Temporary Works.

(h) Interface Management Plan (IMP).

2.3.2 During the preparation of the Definitive Design, the Contractor shall complete all surveys investigations, Geological investigation and related field and laboratory test and shall submit Geotechnical interpretative report for the full alignment. The Geotechnical interpretative report shall clearly include all parameters (elastic and strength parameters) required for analysis and design of primary and secondary support system for the tunnel.

2.4 Definitive Design -Bridges, BLT and other civil structures

2.4.1 Definitive Design shall be the design developed to the stage at which all elements of the structures are fully defined and specified and in particular:

a) Calculation and analysis are complete;

b) All main and all other significant elements are delineated;

c) All tests and trials and all selection of materials and equipment are complete;

d) Shall take full account of the effect on the Permanent Works of the proposed methods of construction and of the Temporary Works.

e) Interface Management Plan (IMP).

2.4.2 During the preparation of the Definitive Design, the Contractor shall complete all surveys investigations and testing necessary to complete the design of the Permanent Works.

2.5 The Contractor shall sub-divide the proposed Definitive Design into Design Packages to be submitted in advance of the Definitive Design Submission and to be identified in the Design Submission Programme. The Design Packages are to relate to the significant and clearly identifiable parts of the proposed Definitive Design and shall address the design requirements as described herein. The Design Packages shall facilitate the review and understanding of the Definitive Design as a whole and shall be produced and submitted in an orderly, sequential and progressive manner.

2.6 Separate Definitive Design Submissions may be prepared for those major elements to be procured by sub-contract and which sub-contracts include design. Where such work is to be procured by the Contractor on the basis of outline design, design briefs and performance specifications, such documents may be submitted as Definitive Design Submissions.

2.7 Upon issue of the Notice in respect of the Definitive Design Submission, the Contractor shall complete the design in all respects and produce the Construction Reference Drawings, the purpose of which is to illustrate all kinds of primary support system suiting to geological variations expected to be encountered along the alignment and in case of geological conditions encountered or not envisages one of the situation, the proposal shall be submitted to the Engineer for approval and immediate requirement of support shall be carried out at least with the consent of the Engineer and detailed scheme with supporting calculations shall be submitted for the approval of the Engineer. For the Permanent Works construction reference drawings shall be submitted complete in all respect for the purpose they are intended.

2.8 Construction Reference Drawings shall fully detail for the construction of the elements covered by the Definitive Design and shall show in full the works to be constructed.

3. REQUIREMENTS DURING CONSTRUCTION PHASE

3.1 The selection of the support system on the basis of geological conditions encountered during excavation

3.2 The review of adequacy of primary support on the basis of geological conditions variations encountered with respect to expected geological conditions assumed at Definitive Design Stage

3.3 Performance/adequacy of the primary support system elements for NATM tunnel by conducting pull-out test on support elements such as rock bolts/dowels, creep test of shotcrete.

3.4 The response of tunnel after installation of primary support in terms of inward movements and loading on the support elements evaluated on the basis of instrumented data gathered from load cells, strain gauges, etc. for shotcrete as well as rock bolts/dowels.

3.5 The principal requirements relating to design during the Construction Phase are the production of Working Drawings, the preparation of technical submissions as required under the Contract, the compilation of the Final Design and the production of the "As-Built" Drawings.

3.6 Working Drawings shall be prepared as required under the Contract. They shall be endorsed by the Contractor as being in accordance with the Construction Reference Drawings.

3.7 The Contractor shall endorse the submissions required under the Contract that "all effects of the design comprising the submission on the design of adjacent or other parts of the works have been fully taken into account in the design of these parts"

3.8 At least 3 months but not more than 6 months prior to the anticipated date of substantial completion of the Works, the Contractor shall submit the Final Design to the Engineer.

3.9 The Final Design is the design of the Permanent Works embodied in:

a) the latest revisions of the documents comprised in the Definitive Design, taking account of comments in the schedules appended to Notices of No Objection
b) the latest revisions of the Construction Reference Drawings;
c) the calculations (see Clause 11 below); and
d) co-ordinated interfaces and such other documents as may be submitted by the Contractor at the request of the Engineer to illustrate and describe the Permanent Works and for which a Notice has been issued.

3.10 The Contractor shall maintain all records necessary for the preparation of the As-Built Drawings. Upon completion of the Works or at such time as agreed to or required by the Engineer, the Contractor shall prepare drawings which, subject to the Engineer's agreement, shall become the As-Built Drawings. All such drawings shall

be endorsed by the Contractor as true records of the construction of the Permanent Works and of all temporary works that are to remain on the site. The Contractor shall also show the locations of utilities exposed, and retained as directed.

4. DESIGN INTERFACES WITH INTERFACING CONTRACTS

The Contractor shall co-ordinate all design and installation work with the various Interfacing Contractors as described in Appendix 5, Section VII-9: Appendices, Part 2- Employer's Requirements.

5. DESIGN SUBMISSIONS

5.1 Preliminary Design Submission

The preliminary design shall provide initial design documents for review and shall be sufficiently detailed to show the element of the design main and documents required for preparation of the definitive design. It shall also include:

(a) the quality assurance plan for design

(b) review of the outline design criteria

(c) the submission of design manuals

(d) the submission of proposed software

(e) the proposed geological/ geotechnical investigations/ test

(f) the preliminary onsite testing recommendation for bridges and other civil structures

(g) outline of proposed design philosophy (NATM)

(h) Equipment likely to be used for excavation and installation of support system including shotcrete

(i) the preliminary equipment layouts and details

(j) the preliminary off site testing recommendation

(k) the submission of specifications proposed for NATM, BLT, Bridges and other civil works

(l) the identification of design codes and standards

(m) the CAD procedures

(n) preliminary section of the NATM tunnel shape and size.

(o) outline primary support system for NATM tunnel in soil or rock or partially in rock and partially in soil

(p) an alignment review

(q) the preliminary construction methodology for NATM tunnel, Cut & Cover tunnel, portals and permanent ventilation shafts, BLT, Bridges and other civil works

(r) the design submission programme (update)

(s) the utility diversion plan

(t) proposed site surveys and other field surveys

(u) the preliminary ground treatment proposal

(v) The preliminary reinstatement drawings.

(w) GAD of bridges

5.2 Definitive Design Submission

5.2.1 General

The Definitive Design Submission shall be a coherent and complete set of documents properly consolidated and indexed and shall fully describe the proposed Definitive Design. In particular, and where appropriate, it shall define:

a) the dimensions of all major features, primary and secondary support system for NATM tunnel, structural elements and members;

b) the details of the portals and primary support system at permanent ventilation shafts *and Construction cum Utility Shaft*;

c) all materials including rock bolts/dowels, pipe roofing, lattice girder and shotcrete;

d) Submission of GIR

e) expected loading on the primary and secondary support system depending upon geological conditions & overburden, deformations inside the tunnel and surface settlements;

f) potential forces and movements due to excavation on the primary support system and final lining of the NATM tunnel,

g) potential forces and movements due to all possible loadings and actions, and their accommodation;

h) all second order effects;

i) the layout and typical details of reinforcement in structural concrete members including tunnel lining;

j) the locations and nature of all relevant joints and connections and details thereof;

k) standard details;

l) location, geometry and setting-out of all main elements and features;

m) provisions and proposals for construction interfacing with the Interfacing Contractors;

n) construction sequences and shuttering arrangements for tunnel lining;

o) utilities to be diverted /supported;

p) proposed methods of predicting the ground movements due to work and adjacent to the excavations;

q) Erection/launching scheme of bridge girders/slabs.

r) predictions of effect on structures due to ground movements and the proposed protective measures to limit the effects to a degree not exceeding the limit as defined under the Outline Design Specifications (Design Criteria);

s) Traffic or other civic service affected;

t) Prediction of lowering of water table and its effect on the works; and

u) Cross Passages.

v) Design of formation including slope stability analysis from Ch. 12000m to Ch. 18000m and Ch. 29580m to Ch. 29680m.

w) Design of retaining wall, if required.

5.2.2 Drawings

The Definitive Design Submission shall include drawings that shall illustrate the proposed Definitive Design and in particular shall include, without limitation:

a) General Arrangements;
b) Layouts and details of structural elements for BLT, bridges and other civil works

c) Expected geological conditions along the alignment;

d) Support arrangement and construction methodology for portals, and permanent ventilation shafts,

e) Excavations sequence and details of the support system and their sequencing for the tunnel in all kind of expected geological strata;

f) Detail of the portals and permanent ventilation shafts *and Construction cum Utility Shaft*;

g) Associated support arrangements;

h) Earthwork in formation and cutting including slope protection;

i) Structural and surface drainage;

j) Access roads and temporary road works;

k) Bridge works

l) Existing and proposed utilities;

m) Road works and works related to traffic management including decking.

n) Embedded items

o) Excavation Machines and Back-up Equipment

p) Cross passages

q) formation from Ch. 12000 m to Ch. 18000 m and Ch. 29580 m to Ch. 29680 m

r) Retaining wall, if required.

5.2.3 *Contract Specification*

The Specification included in Outline Design Specification and Outline Construction Specifications shall be amplified so as to specify comprehensively the design and construction of the Permanent Works.

5.2.4 Design Manual

The Design Manual shall incorporate all design requirements, standards, codes, loading cases, permissible movements and deflections, excavations scheme, characteristics of primary and secondary support system including shotcrete, limit states, design stresses and strains, material properties and all other documents or matters which are relevant to and govern the design. The Design Manual shall refer to all materials, codes and standards used, making clear their specific applications. The Design Manual of tunnel shall specifically state methodology of design of excavation of tunnel, adequacy of the primary and secondary support system of the tunnel including excavation scheme, Permanent Works as a comprehensive reference text and efficient working document

5.2.5 Interface Report on Interfacing Contractors

This will include the following:

(i) Details of the design and construction of the Works adjacent to other contracts.

5.2.6 Testing and Commissioning Report: Details of proposals for testing and commissioning procedures for all relevant elements and equipment contained in the Permanent Works.

5.2.7 Supporting Documents

The Definitive Design Submission shall be accompanied by the following documents, which will be considered by the Engineer in his review of the Definitive Design Submission. Where relevant or required, these documents shall be accompanied by a design note stating clearly how information has been used in the design of the Permanent Works.

5.2.8 Geotechnical Interpretative Report

A report including site investigation results and covering the geotechnical interpretation of site investigation work including that undertaken by the Contractor in sufficient detail to confirm and justify parameters used in the tunnel foundation and geotechnical designs. The report shall include the full logs and descriptions of confirmatory boreholes drilled by the Contractor.

5.2.9 Survey Report

A report on all survey work undertaken by the Contractor, including checks on mapping, survey stations, co-ordinates and setting-out. Updated topographical and survey drawings shall also be included.

5.2.10 Utilities Report

A report giving details of arrangements and working methods in respect of the existing utilities, including protection measures, diversions, reinstatements and programme allowances.

5.2.11 Temporary Works Design Report

A report which provides sufficient information on the design of the Temporary Works to allow the Engineer to assess their effects on the Permanent Works and to enable these to be taken into account in the review of the Definitive Design.

5.2.12 Primary Support Design Report for NATM

A comprehensive report which provides sufficient details for primary support design including calculations as well as for final tunnel lining shall be furnished. The primary support system shall be designed for various geological conditions expected to be encountered during excavation.

5.2.13 Construction / Installation Analysis Report

A report containing a stage-by-stage construction/installation sequence for all structures/equipment.

5.2.14 Construction Method Statement

A report which provides sufficient information on primary and secondary support system including elements of support system and list of the equipment proposed to be used and for other works, the methods of construction and Contractor's Equipment to allow the Engineer to assess their effects on the Permanent Works and to enable these to be taken into account in the review of the Definitive Design.

5.2.15 Project Schedule Review

(i) The Contractor shall, prior to submitting the Definitive Design Submission, review the Project Schedule against the current version of the Design Submission

Programme.

(ii) In the event that the Contractor considers that there are any discrepancies or inconsistencies between the Design Submission Programme and the Project Schedule, the Contractor shall submit with the Definitive Design Submission its proposed revisions to the Project Schedule such that the discrepancies or inconsistencies are removed.

(iii) The Contractor shall provide details of submissions of the proposed Working Drawings and their anticipated timing during the Construction Phase and shall identify information required from or actions to be undertaken by the Employer or others which are necessary to permit the completion of the design of the Permanent Works and the Working Drawings. Desired Dates for the receipt required by the Contractor of such information or for the completion of such actions shall be included with appropriate justification.

5.2.16 Report on the Use of Works Areas

A report updating the proposals from those contained in the Contractor's Technical Proposals for the use of Works Areas and their reinstatement, detailing the tunnel accesses and accesses facilities.

5.2.17 Notices on Definitive Design Submission

The Contractor may make Definitive Design Submissions and seek separate Notices in respect of:

a) The temporary works for bridges, permanent construction shaft and portals of the underground works.

b) All works related to the lengths or sequence of excavation scheme for tunnel which will be excavated from one location together with any intervening works.

c) Major elements as identified under Sub-Clause 2.7 above.

The issue of such separate Notices under above mentioned points shall be conditional upon the Contractor having demonstrated, to the satisfaction of the Engineer, that the effect of each structure on other structures, utilities, etc., has been fully accommodated in the design.

6 DESIGN SUBMISSIONS – CONSTRUCTION REFERENCE DRAWINGS SUBMISSIONS

6.1 The Construction Reference Drawings shall be derived directly from the Definitive Design and shall detail and illustrate in full the Permanent Works. The Construction Reference Drawings shall form part of the Working Drawings to be used for construction purposes.

6.2 Prior to any Construction Reference Drawings Submission, the Contractor shall prepare a full list of Construction Reference Drawings in order to demonstrate, to the

satisfaction of the Engineer, that such Construction Reference Drawings will be sufficient in extent to cover the construction of the whole of the Permanent Works.

6.3 Unless otherwise required by the Engineer, the Construction Reference Drawings need not include bar bending schedules, bar reference drawings, fabrication or shop drawings as well as other schedules or erection drawings which are to be provided by the Contractor during the Construction Phase.

6.4 The latest Construction Reference Drawing for which Notice has been issued by the Engineer shall be drawn on a tracing film duly signed by the Designer and the Contractor and shall be submitted to the Engineer for his approval. The Engineer will issue Notice in respect of such drawings, endorse them and return to the Contractor. The Contractor shall endorse such drawings as "Good For Construction (GFC)" and shall issue them to the Site for execution of the works.

7 DESIGN SUBMISSIONS – CONSTRUCTION PHASE

7.1 The Contractor shall prepare proposed Working Drawings such as site sketches, bar bending schedules, bar reference drawings, fabrication and shop drawings, construction erection sequences and the like. All such drawings shall be based on Construction Reference Drawings and shall comply with the requirements of the Contract. Working Drawings shall be submitted to the Engineer for his approval.

7.2 If the Working Drawings are considered in order, the Engineer shall issue Notice in respect of such drawings, endorse them and return to the Contractor. On the endorsement by the Engineer, the original will forthwith be returned to the Contractor as the Working Drawings. The Contractor shall endorse such drawings as "Good For Construction (GFC)" and shall issue them to the Site for execution of the works.

7.3 The contractor shall finalize details of the excavation scheme and installation sequence of primary support system and submit such finalized details to the Engineer for review. The proposed excavation scheme and primary support system requirement and installation sequence shall not adversely affect the final lining.

7.4 The Contractor shall finalise details of the proposed method of construction and submit such finalised details to the Engineer for review. The proposed method shall have no adverse effects on the partially completed Permanent Works and shall ensure the Works are statically and, if appropriate, aerodynamically stable.

7.5 The Contractor shall undertake and submit a stage by stage construction sequence and the effect of any Temporary Works and the Contractor's Equipment on the Permanent Works. This analysis shall be in sufficient detail to demonstrate that the Contractor's proposals are safe and have no adverse effects upon any parts of the Permanent Works.

7.6 As-Built Drawings, endorsed by the Contractor shall be submitted to the Engineer for agreement in accordance with Clause 5.5 of the GCC and in electronic format using a commercially available CAD program.

8 DESIGN SUBMISSIONS - REVIEW PROCEDURES

8.1 Submissions of Design Data shall be made and reviewed by the Engineer. The form and detail of the review shall be as determined by the Engineer and will not release or remove the contractor's responsibility for the design under the contract.

8.2 The issue of a Notice shall be without prejudice to the issue of any future Notices.

8.3 The Contractor shall, prior to the submission of the Design Data, obtain all required

and/or statutory approvals that relate to that submission including, where appropriate, the approval of the Concerned Government Authorities and utility undertakings, and demonstrate that all required approvals have been obtained.

8.4 All submissions shall be accompanied by two original copies of a `Design Certificate' as set out in Attachment D1 hereto and signed by the Contractor and the Designer.

9 DESIGN SUBMISSION PROGRAMME

9.1 The Contractor shall prepare the Design Submission Programme which is to set out fully the Contractor's anticipated programme for the preparation, submission and review of the Design Packages, the Definitive Design Submission and the Construction Reference Drawings Submissions and for the issue of Notices in relation thereto.

9.2 The Design Submission Programme shall:

(a) be consistent with and its principal features integrated into the Works Programme, and show all relevant Key Dates;

(b) identify dates and subjects by which the Engineer's decisions should be made;

(c) make adequate allowance for periods of time for review by the Engineer and other review bodies;

(d) make adequate allowance for the design and development of specialist works;

(e) include a schedule identifying, describing, cross-referencing and explaining the Design Packages into which the Contractor intends to divide the Definitive Design and Construction Reference Drawings; and

(f) indicate the Design Interface and Co-ordination periods for the Concessionaire and each Designated Contractor.

9.3 Deleted

10 PROGRAMME FOR SUBMISSIONS DURING THE CONSTRUCTION PHASE

In accordance with Clause 4 of the Employer's Requirements - General, the Contractor shall identify submissions required during the Construction Phase.

11 CALCULATIONS

11.1 Unless otherwise required by the Engineer, calculations relevant to the Definitive Design and Construction Reference Drawings shall be submitted for review with the respective Design Packages or Submissions. The Engineer may require the submission of applicable software including in house software programmes/worksheets developed by the Contractor, computer input and programme logic for its review prior to the acceptance of the computer output.

11.2 The Contractor shall prepare and submit a comprehensive set of calculations for the Definitive Design in a form acceptable to the Engineer. If the design of the Permanent Works be revised thereafter and such revision renders the calculations as submitted obsolete or inaccurate, the Contractor shall prepare and submit the revised calculations

11.3 Similarly, the Contractor shall submit such further calculations as have been prepared in connection with the Construction Reference Drawings. Calculations to be included as part of the submission herein shall comprise the up- to-date calculations in respect of the Definitive Design, the Construction Reference Drawings and such further calculations which the Contractor has prepared during the production of Working Drawings.

11.4 The Contractor shall submit all calculations necessary to support proposals relating to the construction methods.

12 DOCUMENTS REQUIREMENTS

12.1 Drawings shall be prepared generally to A1 size, but to ISO AO size where appropriate. Appendix 7 of Section VII-9: Appendices, Part 2 -Employer's Requirements defines the Drawings and CAD Standards required for drawing preparation and submittal.

12.2 The Contractor shall submit 3 copies of his design and/or drawings for review by the Engineer. After receipt of "No Objection" from the Engineer, the Contractor shall submit 6 copies of design and/or drawing for the use of the Engineer.

12.3 The submission of drawings may be by CAD Media files and Appendix 9 specifies drawing Submission requirements for CAD Media files.

12.4 The contractor to provide *one* licensed working software copy being used by its DDC to Employer/Engineer's design department maintained for the entire contract period.

13 Detail Design Consultant (DDC) for Ballastless Track (BLT) System

13.1 Upon award of the Contract, the Contractor shall engage Detail Design Consultant for design of BLT. The Contractor shall submit details of DDC proposed to be engaged for Design of Ballastless track system for the approval of the Engineer. DDC shall be engaged within twelve months of the Commencement Date.

13.2 DDC shall have the experience of design of BLT of at least 10 Km length having satisfactory working performance under mixed traffic conditions with at least 22 tonne axle load and at an operational speed of at least 130 kmph for at least 5 years since the date of its operation as on date of opening of the Tender.

13.3 DDC shall submit experience certificate for design of ballastless track system issued by the user railway administration. The certificate shall specifically indicate that the designer has designed ballastless track system (including fastening system) of at least 10 Km length. The certificate shall clearly state that ballastless track system is having satisfactory working performance under mixed traffic conditions with at least 22T axle load and at an operational speed of at least 130Kmph. The certificate shall state the date of start of operation on ballastless track system and the duration for which ballastless track system has been in continuous operation.

In case the user railway administration is from foreign country and the certificate is issued in language other than English, the supporting documents shall be translated into English. The translation of the certificate shall be either stamped by Embassy/High Commission of India or Partner Countries of Hague convention may submit these documents with "Apostille" stamp. The experience certificate issued by

foreign user railway administration in English shall also be either stamped by Embassy/High Commission of India or submitted with "Apostille" stamp.

Note:

The qualifications of DDC given above are based on Railway Boards letter No. 2016/39/CE-III/BR/BLT dated 06.02.2018. If the criteria given in Railway Boards letter is modified by Railway Board / concerned government authority / RDSO, the same will be followed. However, the modified criteria will not be stricter than the criteria given above.

13.4 DDC proposed to be engaged shall submit details containing, but not limited to, the name of line in which the system is in use for minimum 5 years, details of user railway administration such as name of the Railway administration and its contact person, address, telephone number, E-mail id etc.

13.5 The Contractor shall submit test report of the proposed fastening system from a reputed independent institute/laboratory. The test report shall be accompanied with the drawing of the fastening system including its components which have been tested and reported upon. The Contractor shall propose the same fastening system for which test report has been submitted. The testing shall be done for Cat 'E' as specified in *EN-13481* Pt-1:2012 & EN-13401 Pt-5:*2017* for 60Kg UIC rail section. The Contractor shall also submit a statement showing compliance or otherwise, in juxtaposition to each Clause and Sub-Clause as specified in EN-13481 Pt-1:2012 & *EN-13481* Pt-5:*2017*.

The above Specifications are based on Railway Boards letter No. 2016/39/CE-III/BR/BLT dated 06.02.2018. If the Specifications given in Railway Boards letter are modified by Railway Board / concerned government authority / RDSO, the same will be followed. The Contractor shall design and construct the BLT system as per the modified Specifications without any additional cost to the Employer.

13.6 The Contractor shall submit detailed design and drawings of ballastless track for main line including fastening system, derailment prevention arrangement, arrangement for provision of ducts for signal/telecommunication/electrical in longitudinal and transverse direction, transition system, drainage system with construction procedure & maintenance /repair procedure, QAP etc. to the Engineer for approval.

13.7 The Contractor shall indemnify HORCL and HRIDC against any claims from any other party in connection with the intellectual property rights of the drawings and design/fastening system/ballastless track system or any other documents submitted by the Contractor or any other patent rights.

14 Detailed Design Consultant (DDC) for Tunnel by NATM

14.1 Upon award of the Contract, the Contractor shall engage Detail Design Consultant (DDC) for design of tunnel. DDC must have experience of design of minimum 2.0 km length of tunnel by New Austrian Tunnelling Method (NATM) in a single contract during the last seven years. The Contractor shall submit details DDC proposed to be engaged to the Engineer for approval.

ATTACHMENT D 1

DESIGN CERTIFICATE

This Design Certificate refers to design submission no. ....., which comprises of Definitive Design submission / Construction Reference Drawings submission, working drawing submission scheduled in the attached transmittal, in respect of:

(Description of Permanent Works to which the submission refers)

DESIGNER'S STATEMENT:

We certify that:

a) the outline designs, design briefs and performance specifications of those elements of the Permanent works as illustrated and described in the documents scheduled in the attached transmittal, complies with the Outline Design Specifications and other contract provisions.

b) an in-house check has been undertaken and completed in accordance to approved Quality Assurance Plan (QAP) to confirm the completeness, adequacy and validity of the design of the Permanent Works as illustrated and described in the documents scheduled in the attached transmittal.

c) all necessary and required approval relating to the design of the Permanent Works, as illustrated and described in the documents listed in the attached transmittal, have been obtained.

d) all effects of the design comprising the submission on the design of adjacent or other parts of the works have been fully taken into account in the design of those parts.

Signed by Designer's Authorised Representative

Name : .....

Position : .....

Date : .....

CONTRACTOR'S CERTIFICATE:

The Certifies that all design has been performed utilizing the skill and care to be expected of a professionally qualified and competent designer, experienced in work of similar nature and scope. This further certifies that all works relating to the preparation, review, checking and certification of design has been verified by us and the design proposed by the designer has been accepted by us.

Signed by Contractor's authorised representative

Name : .....

Position : .....

Date : .....

Note 1

The Contractor shall insert one of the following, as applicable:

(i) the Contractor's Technical Proposals

(ii) the Contractor's Technical Proposals and Design Packages Nos. ..... for which a Notice of No Objection has been issued.

(iii) Design Packages Nos. ..…... for which a Notice of No Objection has been issued if such Design Packages develop and amplify the Contractor's Technical Proposals.

(iv) The Definitive Design

SAMPLE DESIGN/DRAWING TEMPLATE

(a) 'Design Quality Assurance' by designer & contractor:

DESIGN QUALITY ASSURANCE			
The responsibility of control, check and verification of accuracy, correctness, completeness, integration and full compliance of contract provisions in respect of design analysis and drawings rests with the design consultants and the contractor.			
By Designer			**By Contractor**
Sig. :	Sig. :	Sig. :	Sig. :
Date. :	Date. :	Date. :	Date. :
Name :	Name :	Name :	Name :
Designed by	Checked by	Approved by	Accepted By

(b) <u>Notice of 'No Objection' from the Engineer:</u>

Notice of 'No Objections' from the Engineer			
Notice of "No Objections" from the Engineer is being accorded for design Principles. However, the overall responsibility for the detailing and design accuracy lies with Design and Build Contractor.			
	REMARKS		
Design Engineer (GC/HORC)	Reviewed		
Senior Design Expert (GC/HORC)	Reviewed		
Chief Design Expert (GC/HORC)	Reviewed		
DPD (GC/HORC)	Reviewed & comments as marked on drawing		

<u>Section C</u>

[Contractor to attach copies of necessary and required approvals]

MINIMUM REQUIREMENT OF THE DDC'S ORGANIZATIONAL STRUCTURE

The DDC shall submit an Organisation Chart together with clear description of the responsibilities of each member within the overall works programme.

Sr.NO	Designation	Numbers	Experience
1	Team Leader	01	Graduate degree in Civil Engineering having experience not less than 15 years and would have handled minimum 02 projects involving design of tunnel by NATM as Team Leader.
2	Tunnel Design Expert (NATM)	02	Graduate degree in Civil Engineering *with total experience of 12 years* and minimum *6* years of relevant *experience in design of NATM tunnel.*
3	Tunnel Design Expert (Cut & Cover)	02	Graduate degree in Civil Engineering *with total experience of 12 years* and minimum *6* years of relevant experience in design of Cut & Cover tunnel.
4	Bridge Design Expert	01	Graduate degree in Civil Engineering *with total experience of 10 years* and minimum *5* years of relevant *experience in design of railway bridge involving deep foundation*

NOTE:

1. *The CVs of concerned personnel shall be submitted to the Engineer for approval. No person mentioned in table above shall be deployed in the project without Engineer's approval.*

2. *Relaxation in qualification / experience can be given by the Engineer in exceptional cases where candidates have got high level of professional competency. Decision of the Engineer in such cases shall be final and binding.*

3. The requirement given above is minimum. The Contractor shall be required to supplement the above mentioned design team as per requirement of the Works so as to adhere to the timelines given in Appendix-2- Contract Key Dates and Completion Date, Section VII-9: Appendices, Part 2- Employer's Requirements under the Contract.

Section VII: Employer's Requirements

Section VII-4: Construction (Civil and BLT)

Contents

EMPLOYER'S REQUIREMENTS – CONSTRUCTION (CIVIL & BLT)

1. CONTRACTOR'S SUPERINTENDENCE

The Contractor shall submit a Staff Organization Plan in accordance with the Attachment C-1

This plan shall be updated and resubmitted whenever there are changes to the staff. The plan shall show the management structure and state clearly the duties, responsibilities and authority of each staff member.

The contractor's representative and his associates/supervisors shall have experience and qualification appropriate to the type and magnitude of the Works as per Attachment C-2. Full details shall be submitted of the qualifications and experience of all proposed staff to the Engineer for his approval.

2. CHECKING OF THE CONTRACTOR'S DESIGN OF TUNNEL EXCAVATION AND TEMPORARY WORKS

i. The Contractor shall, prior to commencing the Excavation of the tunnel shall submit certificate to the Engineer certifying that excavation schemes, adequacy of primary support system and its installation sequence are sufficient on the basis of geological and geotechnical information's gathered/derived (from field and laboratory testing) for the most probable geological conditions, However, the adequacy of the support system shall be checked on the basis of geological conditions encountered during excavations and on the basis of instrumented data.

ii. For works other the NATM tunnel, the Contractor shall submit the certificates that the Temporary Works have been properly and safely designed and checked and that the Contractor has checked the effect of the Temporary Works on the Permanent Works and has found this to be satisfactory.

3. CARE OF THE WORKS

(i) Unless otherwise permitted by the Engineer all work shall be carried out in dry conditions.

(ii) The Works, including materials for use in the Works, shall be protected from damage due to water. Water on the Site and water entering the Site shall be promptly removed by temporary drainage or pumping systems or by other methods capable of keeping the Works free of water. Silt and debris shall be removed by traps before the water is discharged and shall be disposed of at a

location or locations to which the Engineer has given his consent.

(iii) The discharge points of the temporary systems shall be as per the consent of the Engineer. The Contractor shall make all arrangements with and obtain the necessary approval from the relevant authorities for discharging water to drains, watercourses, etc. The relevant work shall not be commenced until the approved arrangements for disposal of the water have been implemented.

(iv) The methods used for keeping the Works free from water shall be such that settlement of, or damage to, new and existing structures do not occur.

(v) Measures shall be taken to prevent flotation of new and existing structures.

(vi) Inward movement in the NATM tunnel shall be monitored by using 3-D laser targets at an appropriate locations approved by the Engineer the results shall be reviewed by the designer on regular basis and submitted to the Engineer with the comments and interpretation. If results are beyond permissible limits the remedial measures shall be adopted immediately with consent of the Engineer.

(vii) The results for load cells, strain gauges etc shall be reviewed by the designer and interpreted in acceptable form and submitted to the Engineer on regular basis with the comments and recommendation of the designer.

4. Protection of the Works from Weather

(i) Work shall not be carried out in weather conditions that may adversely affect the Works unless proper protection is provided to the satisfaction of the Engineer.

(ii) Permanent Works, including materials for such Works, shall be protected from exposures of weather conditions that may adversely affect such Permanent Works or materials.

(iii) During construction of the Works storm restraint systems shall be provided where appropriate. These systems shall ensure the security of the partially completed and on going stages of construction and in all weather conditions. Such storm restraint systems shall be installed as soon as practicable and shall be compatible with the right of way, or other access around or through- out the Site.

(iv) The Contractor shall, at all times programme and order progress of the work and

make all protective arrangements such that the Works can be made safe in the event of storms.

(v) The finished works shall be protected from any damage that could arise from any activities on the adjacent site/ works.

4.1 Utilities

Please refer to Appendix 10 of Section VII-9: Appendices, Part 2- Employer's Requirements of this document

5. TESTING

5.1 General

The Contractor shall provide and perform all forms of testing procedures applicable to the NATM Works and various elements of the primary support and shall conduct all necessary laboratory and site acceptance tests.

All testing procedures shall be submitted at least thirty (30) days prior to conducting any Test. The Testing procedures shall show unambiguously the extent of testing covered by each submission, the method of testing, the Acceptance Criteria, the relevant drawing (or modification) status and the location.

The testing Procedures shall be submitted, as required, by the Contractor during the duration of the contract to reflect changes in primary support system or the identification of additional support requirement.

The Engineer shall have the facilities for monitoring all tests and have access to all testing records.

All costs associated with the Testing shall be borne by the Contractor, unless otherwise specified, including the services of any specialised personnel or independent assessors.

All testing equipment shall carry an appropriate and valid calibration labels.

5.2 Batches, Samples and Specimens

A batch of material is a specified quantity of the material that satisfies the specified conditions.

If one of the specified conditions is that the material is delivered to the Site at the same time, then material delivered to the Site over a period of a few days may be considered as part of the same batch if in the opinion of the Engineer there is sufficient proof that the other specified conditions applying to the batch apply to all of the material delivered over the period.A sample is a specified quantity of material that is taken from a batch for testing and which consists of a specified amount, or a specified number of pieces or units, of the material.A specimen is the portion of a sample that is to be tested.

5.3 Samples for Testing

Samples shall be of sufficient size and in accordance with relevant Standards to carry out all specified tests.

Samples taken on the Site shall be selected by, and taken in the presence of, the Engineer and shall be suitably marked for their identification. An identification marking system should be evolved at the start of works in consultation with the Engineer.

Samples shall be protected, handled and stored in such a manner that they are not damaged or contaminated and such that the properties of the sample do not change.

Samples shall be delivered by the Contractor, under the supervision of the Engineer, to the specified place of testing. Samples on which non-destructive tests have been carried out shall be collected from the place of testing after testing and delivered to the Site or other locations instructed by the Engineer.

Samples which have been tested may be incorporated in the Permanent Works provided that:

(i) the sample complies with the specified requirements;

(ii) the sample is not damaged; and

(iii) the sample is not required to be retained under any other provision of the Contract.

Additional samples shall be provided for testing if in the opinion of the Engineer:

(i) material previously tested no longer complies with the specified requirements; or

(ii) material has been handled or stored in such a manner that it may not comply with the specified requirements.

5.4 Testing

The Contractor shall be responsible for all on-site and off-site testing and for all in-situ testing. All appropriate laboratory tests shall be carried out in the Contractor's laboratory, unless otherwise permitted or required by the Engineer. Where the laboratory is not appropriately equipped and/or staffed for some tests, or if agreed to by the Engineer, tests may be carried out in other laboratories provided that:

(i) they are accredited for the relevant work at least NABL approved to a standard acceptable to the Engineer ; and
(ii) particulars of the proposed laboratory are submitted to the Engineer for his consent shall be at least NABL approved.

In-situ tests shall be done in the presence of the Engineer.

Equipment, apparatus and materials for in-situ tests and laboratory compliance tests carried out by the Contractor shall be provided by the Contractor. The equipment and apparatus shall be maintained by the Contractor and shall be calibrated before the testing starts and at regular intervals as permitted by the Engineer. The equipment, apparatus and materials for in-the situ tests shall be removed by the Contractor as soon as practicable after the testing is complete.

The Contractor shall be entitled in all cases to attend the testing carried out in the Employer's or other laboratories, to inspect the calibration certificates of the testing machines and to undertake the testing on counterpart samples. Testing of such samples shall be undertaken in laboratories complying with Sub-section 4.12.4(i) above and particulars of the laboratory proposed shall be submitted to the Engineer for consent prior to the testing.

Attendance on tests, including that by the Engineer, Contractor and Designer, shall be as laid down in the Quality Assurance procedures.

5.5 Compliance of Batch

The results of tests on samples or specimens shall be considered to represent the whole batch from which the sample was taken.

A batch shall be considered as complying with the specified requirements for a material if the results of specific tests for of the specified properties comply with the specified requirements

for the properties.

If additional tests are permitted or required by the Engineer but separate compliance criteria for the additional tests are not stated in the Contract, the Engineer shall determine if the batch complies with the specified requirements for the material on the basis of the results of all tests, including the additional tests, for every property.

5.6 Records of Tests

Records of in-situ tests and laboratory compliance tests carried out by the Contractor shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within seven (7) days, or such other time stated in the Contract or in the Quality Assurance Programme, after completion of each test. In addition to any other requirements, the report shall contain the following details:

(a) material or part of the Works tested;

(b) location of the batch from which the samples were taken or location of the part of the Works;

(c) place of testing;

(d) date and time of tests;

(e) weather conditions in the case of in-situ tests;

(f) technical personnel supervising or carrying out the tests;

(g) size and description of samples and specimens;

(h) method of sampling;

(i) properties tested;

(j) method of testing;

(k) readings and measurements taken during the tests;

(l) test results, including any calculations and graphs;

(m) specified acceptance criteria; and

(n) other details stated in the Contract.

Reports of tests shall be signed by the site agent or his assistant, or by another representative authorised by the Contractor.

If requested, records of tests carried out by the Employer's staff or by the Engineer shall be given to the Contractor.

5.7 Test for Shotcrete Operators

Shotcrete operators are to be tested for their performance by performing an in-situ test for spraying of shotcrete in a desired manner. Successful operators should be issued a competency certificate and record for all such competent operators shall be maintained. Shotcreting for the NATM tunnelling work should be done only by operators having competency certificate.

6. MATERIALS

Materials and goods for inclusion in the Permanent Works shall be new unless the Engineer has consented otherwise. Preference shall be given to local materials where available. Approved Manufacturers/Suppliers of few important items have been given in Section VII-8: Tender drawings and documents of this document. These materials shall be procured only from approved manufacturers/Suppliers.

Certificates of tests by manufacturers which are to be submitted to the Engineer shall be current and shall relate to the batch of material delivered to the Site. Certified true copies of certificates may be submitted if the original certificates could not be obtained from the manufacturer.

Parts of materials which are to be assembled on the Site shall be marked to identify the different parts.

Materials which are specified by means of trade or proprietary names may be substituted by materials from a different manufacturer which has received the consent of the Engineer provided that the materials are of the same or better quality and comply with the specified requirements.

Samples of materials submitted to the Engineer for information or consent shall be kept on the Site and shall not be returned to the Contractor or used in the Permanent Works unless permitted by the Engineer. The samples shall be used as a mean of comparison which the Engineer shall use to determine the quality of the materials subsequently delivered. Materials delivered to the Site for use in the Permanent Works shall be of the same or better quality as the samples which have received consent.

7. TAKING OVER OF WORKS / SECTIONS

7.1 Inspection

a) General

Within seven (7) days of receipt of the Contractor's written application for a Taking-Over Certificate, pursuant to Sub-Clause 10.1 of the General Conditions of Contract, the Engineer, in the company of the Contractor, will inspect the Works or Section covered by the application, as per the requirements described in this Sub-Clause. During the joint inspection, the Works or Section will be examined and relevant documentation will be reviewed. The Engineer will prepare a written list of outstanding items, if any, to be completed or corrected before issuance of the Taking-Over Certificate and a separate written list of items to be completed or corrected during the remainder of the Contract or the Defects Notification Period. The list shall include an agreed date of correction for each deficiency.

The Contractor shall also obtain written confirmation from all applicable Interfacing Contractors that all interfacing matters have been concluded.

If there are no outstanding items to be completed or corrected before the Taking Over of the Works or a Section, the Contractor shall submit to the Engineer all guarantees, warranties, final certifications or similar documents or both as are required under the Contract.

b) Static Inspection

The inspection listed in the following table shall be conducted by the Engineer, in coordination with Interfacing Contractors as necessary.

The Contractor shall prepare and submit for review and approval by the Engineer a Static Inspection Plan detailing and explaining how the Contractor will plan, perform and document all tests and inspections that shall be conducted to verify and validate the Works. The Static Inspection Plan shall consist of a narrative description supported by graphics, diagrams and tabulations as required.

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
Earthwork	Formation width	At every 100m on straight line, at every 20m on curved line, at each terminal point of structures	✓		✓

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
	Cross section	Drawings at every 100m on straight line, at every 20m on curved line, at each terminal point of structures.	✓		✓
	Retaining wall	List of location of retaining walls	✓	✓	
	Construction	Soil test records, compaction records, CBR & deformation modulus (Ev_2) records, construction photos	✓		
	Blanketing layer	Blanket material test records, compaction test records, CBR & deformation modulus (Ev2) test records.	✓		
		Thickness	✓		✓
	Structures Crossing	List of structures crossing the Railway (earth cover, overhead clearance, etc.)	✓		✓
	Drainage system	Drainage works at embankment/cutting, drainage diagram	✓		✓
Bridges	Formation width	At each bridge	✓		✓
	Construction	Quality records of aggregate used, reinforcement, cement	✓		

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
		concrete quality control data, measurement records of cast-in-situ piles/ open foundation etc.			
	Repairing of structures	Records of repaired parts of structures	✓	✓	
	Rebar cover	Records of measurement of rebar cover	✓		
	Clearance under girder/slab	Above roads/rail	✓		✓
	Abutment/pier structures/RCC box etc.	All Structural drawings	✓	✓	
	Concrete strength	Schmidt hammer tests	✓		✓
	List of bridges	List of bridges	✓	✓	
	PSC slab/girder	Test record of prestressing cable, anchorage system & prestressing record.	✓		
	Pile load test	Pile load test parameters	NA		
	Steel Girder	Material test record, fabrication, welding & trial assembly records, dead load camber	NA		
	Bearings	Acceptance test record	NA		

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
	Track on OWG	Track parameters at every sleeper location	NA		
	Load test	Load test parameters of superstructure (PSC girder/slab)	✓		✓
		Load test parameters of skew RCC box	✓		
Tunnel	*Construction*	*Quality control record, Instrumentation data*	✓		
	Profile	*Tunnel profile at every 10 m interval, at each cross passage & portal*		✓	✓
Ballast less Track	*Construction*	*Quality control record, acceptance test record of fastening system*	✓		
	Track Parameters	*Track parameters at every sleeper*		✓	✓
	Toe Load	*Toe Load at every sleeper*			✓
Station	Platform length, width	At every 10m on straight line, at every 5m on curved line, control points of curve	NA		
	Clearance of isolated and continuous structures on platform as per SOD	All structures			

Structure	Inspection Item		Inspection Method		
			Confirmation of "As-Built" Records	Visual Inspection	Measurement Test Check
	Staircase and pavement	Results of stair width measurement			
	Drainage of platform & yard	Section & slope at every 20m			
	Safety fence, etc.	List of facilities (clearance from platform end to fixed/movable fence, etc.)			
Protective facilities	Abutment/ Pier protection	Drawings	✓	✓	
	Slope protection works	List, location and Drawings of slope protection works	✓	✓	

After Static Inspection of the Works as mentioned above the Contractor shall submit the Inspection Report in the agreed format in four (4) signed copies to the Engineer for review and approval.

7.2 Remedial Action and Re-inspection

Within twenty-eight (28) days of receipt of a written application for a Taking-Over Certificate,the Engineer shall proceed in accordance with Sub-Clause 10.1 of the General Conditions of Contract.

7.3 Taking Over Certificate

If the Engineer does not issue a Taking-Over Certificate, but gives instructions in accordance with sub-paragraph (ii) of Sub-Clause 10.1 of the General Conditions of Contract, the Contractor shall, when he considers the work specified by the Engineer completed, give written notice to the Engineer and the Contractor.

The Contractor shall submit documents required by Commissioner of Railway Safety (CRS) and shall accompany him during his inspection along with necessary records.

8. Sub-Contractor for Construction of Ballast less Track System

8.1 Upon award of the Contract, the Contractor shall engage Sub-Contractor for Construction of ballastless Track System. The Contractor shall submit details of Sub-Contractor proposed to be engaged for Construction of ballast less Track System for the approval of the Engineer.

8.2 Sub-Contractor to be engaged shall have the experience of Construction of ballast less track system for a minimum length of 2.0 km in a single contract during last seven years from the last date of submission of Tender.

8.3 Sub-Contractor to be engaged shall submit experience certificate for construction of ballast less track system issued by the user railway administration.

In case the user railway administration is from foreign country and the certificate is issued in language other than English, the supporting documents shall be translated into English *language. The translation of Certificates / documents in foreign language shall be done by the licensed translator. The Contractor must submit copy of license issued by the competent authority in their country of origin.*

8.4 Proposed Sub-Contractor shall submit details containing, but not limited to the name of line in which the system is in use for minimum 5 years, details of user railway administration such as name of the Railway administration and its contact person, address, telephone number, E-mail id etc.

8.5 Upon approval of the Sub-Contractor, the Contractor is required to enter into legally enforceable agreement with the Sub-Contractor within 60 days of approval of designer and submit a copy of the agreement to the Engineer. The agreement must specify the specific role and responsibility of the Sub-Contractor.

8.6 No construction of BLT shall be started unless agreement with the Sub-Contractor is submitted to the Engineer.

ATTACHMENT - C-1

MINIMUM ORGANISATION STRUCTURE REQUIRED

The figures indicated in Table 1 below are the minimum number of Project-Personnel required which are to be deployed as per the minimum level of supervision. The qualification/experience of such Project personnel is given under Attachment-C-2

TABLE-1 LIST OF MINIMUM ORGANISATION STRUCTURE REQUIRED

S. No.	Designation of Project Personnel	Minimum no. of Project-Personnel required	Penalty for Non-deployment per week or part thereof per person
1.	Contractor's Representative/ Project Manager	1	Rs1,00, 000/-
2.	Senior Tunnel Expert (NATM)	4	Rs40,000/- for first 3 months and Rs. 80,000/- thereafter
3.	Tunnel Expert (NATM)	4	
4.	Ballast less Track Expert	1	-
5.	Planning Engineer	1	Rs40,000/- for first 3 months and Rs. 80,000/- thereafter
6.	Senior Quality Assurance/Quality Control Expert	2	Rs40,000/- for first 3 months and Rs. 80,000/- thereafter
7.	Quality Assurance/Quality Control Expert	2	
8.	Health & Safety Expert	4	Rs40,000/- for first 3 months and Rs. 80,000/- thereafter
9.	Surveyor	5	-
10.	Tunnel Expert (Cut & Cover)	2	Rs40,000/- for first 3 months and Rs. 80,000/- thereafter
11.	Bridge Expert	1	-
12.	Procurement Manager	1	-
13.	Senior Geologist	1	Rs40,000/- for first 3 months and Rs. 80,000/- thereafter
14.	Geologist	*2*	-

S. No.	Designation of Project Personnel	Minimum no. of Project-Personnel required	Penalty for Non-deployment per week or part thereof per person
15.	Environmental Expert	1	-
16.	Senior Geotechnical Engineer	1	Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter
17.	Geotechnical Engineer	*2*	
18.	Blast Expert	1	
19.	Civil Engineer (Concrete Expert)	4	
20.	*Senior Electrical Engineer*	*1*	*Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter*
21.	*Electrical Engineer*	*2*	
22.	*Senior Mechanical Engineer*	*1*	*Rs 40,000/- for first 3 months and Rs. 80,000/- thereafter*
23.	*Mechanical Engineer*	*2*	

NOTES:-

i. The Contractor shall deploy resources as per the above-mentioned table. The Contractor shall also confirm to deploy manpower over and above the minimum numbers indicated above, if the work so requires.

ii. The performance of project personnel deployed will be evaluated periodically by the Engineer during the contract period. In case the performance of any of the project personnel is not satisfactory, the Contractor shall replace them with good personnel immediately as per directions of the Engineer.

iii. The personnel at Sr.No.1, must be deployed by Commencement Date. Personnel at Sr. No. 2, 5, 6, 8, 10, 13, 16, 20, & 22 in the above table must be deployed within 30 days of Commencement Date. Non adherence to these provisions shall attract penalty as indicated in the table above.

iv. All *minimum* resources *indicated in the table above may* not be *required to be* mobilized simultaneously for entire duration of the contract. The Contractor shall mobilize the resources as per the deployment programme approved by the Engineer.

v. In case of non-deployment of project personnel, the penalty shall be imposed as indicated above and deducted from Contractor's running / final bills. The decision of the Engineer in this regard shall be final and binding.

vi. The Contractor shall be required to supplement the above mentioned resources per requirement of the Works so as to adhere to the timelines given in Appendix-2- Contract Key Dates and Completion Date, Section VII-9: Appendices, Part 2- Employer's Requirements under the Contract.

ATTACHMENT C-2

MINIMUM QUALIFICATION & EXPERIENCE OF PROJECT PERSONNEL

S. No.	DESIGNATION	QUALIFICATION	EXPERIENCELEVEL
1.	Contractor's Representative/ Project Manager	Graduate in Civil Engineering	Minimum total experience of 15 years out of which, minimum 5 years as In-charge in tunnel projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways.
2.	Senior Tunnel Expert (NATM)	Graduate/Diploma in Civil Engineering	Minimum total experience of 10/12 years out of which minimum 05/08 years in relevant field in tunnel projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways
3.	Tunnel Expert (NATM)	Graduate/Diploma in Civil Engineering	Minimum total experience of 8/10 years out of which minimum 03/05 years in relevant field in tunnel projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways
4.	Ballastless Track Expert	Graduate/Diploma in Civil Engineering	Minimum total experience of 8/10 years out of which minimum 02/04 years in relevant field in ballastless track projects of Railway/ DFC/ Metro/ RRTS
5.	Planning Engineer	Graduate in Civil Engineering with certification Primavera software	Minimum total experience of 10 years out of which minimum 05 years in planning of Infrastructure projects.
6.	Senior Quality Assurance (QA) /Quality control (QC) Expert	Graduate/Diploma in Civil Engineering	Minimum total experience of 10/12 years out of which minimum 05/07 Yrs. In QA (Field) and at least one year as In-Charge in Infrastructure Project
7.	Quality Assurance (QA) /Quality control (QC) Expert	Graduate/Diploma in Civil Engineering	Minimum total experience of 08/10 years out of which minimum 03/05Yrs. in QA (Field) in Infrastructure Project
8.	Health & Safety Expert	Graduate/Diploma in Engineering/Science with one year full time Diploma in Industrial safety or equivalent	Minimum total experience of 06/08 years with relevant experience of 3 years in Infrastructure projects.

S. No.	DESIGNATION	QUALIFICATION	EXPERIENCELEVEL
9.	Surveyor	Diploma in Civil Engineering / ITI	Minimum total Experience of 05/08 Years in Survey Work for linear Infrastructure project
10.	Tunnel Expert (Cut & Cover)	Graduate/Diploma in Civil Engineering	Minimum total experience of 8/10 years out of which minimum 03/05 years in relevant field in tunnel projects of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways
11.	Bridge Expert	Graduate/Diploma in Civil Engineering	Minimum total experience of 08/10 years out of which minimum 03/05 years in relevant field in infrastructure projects involving bridges of Railway/ DFC/ Metro/ RRTS/ Highway /Expressways
12.	Procurement Manager	Graduate in Engineering / Diploma in procurement	Minimum total experience of 05/08 years in procurement in Infrastructure Project.
13.	Senior Geologist	Master's degree in Geology	Minimum total experience of 10 years out of which minimum 05 years in tunnel projects.
14.	Geologist	Master's degree in Geology	Minimum total experience of 05 years out of which minimum 03 years in tunnel projects.
15.	Environmental Expert	Graduate in Environmental Engineering/ Master's degree in Environmental Engineering/Environmental Science or equivalent	Minimum total experience of 06 years out of which 3 years of experience of working on environmental aspects in Infrastructure projects.
16.	*Senior Geotechnical Engineer*	*Graduate in Civil Engineering*	*Minimum total experience of 10 years out of which minimum 05 years in infrastructure projects.*
17.	*Geotechnical Engineer*	*Graduate/Diploma in Civil Engineering*	*Minimum total experience of 05/07 years out of which minimum 03/05 years in infrastructure projects.*
18.	Blast Expert	Graduate/Diploma in Engineering	Minimum Experience of 05/07 years in blasting
19.	Civil Engineer (Concrete Expert)	Graduate in Civil Engineering	Minimum total experience of 05 years out of which minimum 03 years in relevant field in Infrastructure projects.
20.	*Senior Electrical Engineer*	*Graduate in Electrical Engineering*	*Minimum total experience of 10 years out of which minimum 05 years in Electrical and E&M works (Experience in tunnel projects will be preferred)*

S. No.	DESIGNATION	QUALIFICATION	EXPERIENCELEVEL
21.	*Electrical Engineer*	*Graduate/Diploma in Electrical Engineering*	*Minimum total experience of 05/07 years out of which minimum 03/05 years in Electrical and E&M works (Experience in tunnel projects will be preferred)*
22.	*Senior Mechanical Engineer*	*Graduate in Mechanical Engineering*	*Minimum total experience of 10 years out of which minimum 05 years in infrastructure projects.*
23.	*Mechanical Engineer*	*Graduate/Diploma in Mechanical Engineering*	*Minimum total experience of 05 years out of which minimum 03 years in Infrastructure projects.*

Notes:

1. The CVs of concerned personnel shall be submitted to the Engineer for approval. No person mentioned in table above shall be deployed in the project without Engineer's approval.

2. Relaxation in qualification / experience can be given by the Engineer in exceptional cases where candidates have got high level of professional competency. Decision of the Engineer in such cases shall be final and binding.

ATTACHMENT C-3

MINIMUM RESOURCES REQUIRED FOR THE PROJECT- PLANT & EQUIPMENT

The figures indicated below are the minimum number of equipment required.

S. No.	Types of Equipment Required for the Work	Minimum No. of Unit of Equipment Required for the Work
1.	Double Boomer	*03*
2.	Robotic Shotcrete Machine	07
3.	Concrete Batching Plant (each 60 cum/hr)	02
4.	Excavator (75 cum/hr)	07
5.	Grader	02
6.	Dozer (150 Cum/hr)	02
7.	Vibratory Roller (10 T)	02
8.	Pugmil/Crusher(200MT/hr)	01
9.	Concrete Boom Placer	02
10.	Stationary Concrete Pumps (36 cum/hr)	04
11.	Transit mixers	10
12.	Survey Instruments (Total Station)	*04*
13.	Lab Testing equipment-fully equipped for site tests.	As per Appendix 12 of Section VII-9: Appendices, Part 2- Employer's Requirements
14.	Digital Level (Leica, Sokia)	04
15.	Tunnel lining gantry of minimum length 15 m	04
16.	*Loader (2 cum)*	*05*
17.	*Dumper (18 cum)*	*16*
18.	*Scissor platform (1ton)*	*03*
19.	*Diesel tanker (dispenser)*	*02*

S. No.	Types of Equipment Required for the Work	Minimum No. of Unit of Equipment Required for the Work
20.	*Water tanker*	*02*
21.	*D G set (630kva)*	*06*
22.	*Blower fans (75Kw)*	*06*
23.	*JCB*	*02*
24.	*Grouting pumps (MAI & Uni pumps)*	*04*
25.	*Water pumps (10 HP)*	*04*
26.	*Tunnel profiler (Trimbel, S7/S9/S12, Leica TS16/MS60)*	*02*

Note:

All plants and equipment need not be mobilized simultaneously. Plants and equipment as required as per the progress of the work shall be brought at site in advance as directed by the Engineer.

Section VII: Employer's Requirements

Section VII-6: Outline Design Specifications (ODS)-Civil and BLT

Contents

CHAPTER 1

INTRODUCTION

This part lays down the specifications/criteria for design of civil structures i.e. tunnels (NATM and Cut & Cover), permanent ventilation shafts, *construction cum utility shaft* ballastless track, bridges, *embankments and other civil structures.*

The broad parameters covered in these specifications are listed below:

1. Material Parameters (Concrete, Reinforcement steel & Structural Steel etc.)
2. Design Parameters
3. Loadings
4. Load Combinations
5. Allowable stresses
6. Design Methodology
7. List of Design Codes and Standards

CHAPTER 2

OUTLINE DESIGN SPECIFICATION -GENERAL

CHAPTER 2

OUTLINE DESIGN SPECIFICATIONS- GENERAL

2.1 General

The structures to be designed in C-4 Package are mentioned in the Employer's Requirements, Section VII-2, Functional (Civil and BLT), Sub-Clause 2, Scope of Works.

The design works include the preparation and approval of GADs/architectural drawings, Definitive Design and Construction Design for structures as per the Employer's Requirements, Section VII-3, Design (Civil and BLT).

Initially GADs of bridges shall be prepared by the Contractor after carrying out detailed topographical survey and will be based on conceptual GAD and preliminary design. These GADs will be sent to the Site for checking feasibility of construction by Engineers Representative and Contractors Representative. The initial GADs shall be modified incorporating remarks of construction feasibility and submitted to the Engineer along with the preliminary design calculations. After approval of the Engineer, GADs shall be submitted to the stakeholders for approval, if any. Getting approval of GAD from the concerned stakeholders is the responsibility of the Contractor. The Contractor shall address all the queries of the stakeholders. However, the Employer will assist the Contractor in obtaining approval from the concerned stakeholders. the Contractor shall attend any meeting/presentation/joint site visit with stakeholders, as per the requirement, for the approval of GADs. After approval of the stakeholders, the GAD shall be finally approved by the Employer.

2.2 Employer's Inputs

The Employer shall furnish following documents to the Contractor: -

a) *Conceptual* Plan and L-section of the main line

b) Conceptual GAD of bridges

c) Conceptual layout plan for tunnel

d) *Preliminary* Geotechnical Interpretive Report (GIR) for tunnel

e) Design Basis Report (DBR) for tunnel

f) *Preliminary* Geo-technical investigation reports for tunnel and bridges

2.3 Design Life

The design life of a structure is that period for which it shall be designed to fulfill its intended function.

The Contractor is required to submit a report demonstrating the approach in design, construction and selection of material so as to achieve the design life as specified.

The design life of tunnel and bridges shall be as follows:

a) Tunnels works

The design life of all tunnel structures *including, portals, permanent ventilation shafts and construction cum utility shaft* shall be 120 years.

b) Bridges

The design life of bridges shall be 100 years.

c) *Deleted*

d) Other Civil Structures

The design life of Other Civil Structures shall conform to relevant codal provisions.

2.4 Schedule of Dimensions, Fixed Structure Gauge (FSG) and Clearances

Tunnel, bridges and other structures shall be designed to cater for movement of double stack containers. FSG for tunnel shall be as shown in Employer's Requirements, Section VII-8, Tender drawings and documents and clearances shall be as per IR Schedule of Dimensions for Broad Gauge.

2.5 Rock and Soil Parameters

Geotechnical investigation reports shared with the Tender Documents are indicative in nature and the Contractor shall carry out independent detailed GT investigations as per codal provisions. However, if there is a wide variation (>15%) in the design rock/soil parameters compared to the parameters as per GT report of nearest bore hole given in the Tender Documents, the same shall be brought to the knowledge of the Engineer and a confirmatory (repeat) bore hole shall be done to ascertain design soil parameters.

2.6 Liquefaction of soil

Liquefaction of soil shall be considered as per IS 1893-Part-1. The design ground water table shall be used for liquefaction potential calculation. The moment magnitude Mw to be taken in design shall be 7.0. The factor of safety shall be more than 1.0 to ascertain that the strata is not liquefiable.

2.6.1 Design Ground Water Table

Base value of ground water table shall be considered as the highest level of the following:

(a) Data published by Central Ground Water Board (CGWB),

(b) Ground water table reported in Geotechnical report provided in Tender Documents,

(c) Ground water table encountered by the Contractor during GT investigation.

The design ground water table shall be taken as minimum 3.0m higher than the base value of ground water table as given above.

2.7 Differential Settlement in continuous structures

Differential Settlement between two adjacent bridge piers shall not be more than-

a) 12mm for Long Term Settlement;

b) 6mm for Short Term Settlement

2.8 General Design Requirements

2.8.1 The Project entails construction of BG double-track electrified railway lines capable of handling "25t loading -2008" double stack containers for a maximum speed of 100 kmph. The design speed for passenger train shall be 160 kmph. The Project is a feeder route to DFC also. The embankment and cutting shall be designed for "DFC loading (32.5t axle load)". Bridge substructure shall be designed for "DFC loading (32.5t axle load)"and superstructure shall be designed for "25t loading – 2008" unless specified otherwise in the Contract.

2.8.2 All levels shall be quoted in meters correct to three decimal places and shall be to Mean Sea Level (MSL) Datum India. The rail level on a track shall refer to the top of the inner rail of the UP Line i.e. line going from New Prithala to Sonipat.

2.8.3 The Contractor shall comply with the provisions of IR Schedule of Dimensions, with regard to the clearance over the existing IR network.

2.8.4 Horizontal and vertical alignment has been given in the *Conceptual Plan and Longitudinal Section* Drawings. Proposed Right of Way (ROW) has also been marked on *these* Drawings. The Contractor *shall* check the feasibility of alignment at site and may propose *minor modifications*, if required.

2.8.5 All structures shall be designed and detailed to withstand earthquake forces for Seismic Zone IV.

2.8.6 Exposure conditions shall be considered as 'moderate' for design of all type of structures/bridges. *However, in case of waterway bridges carrying sewage/waste water, the exposure condition shall be considered "Severe" .*

2.8.7 Minimum grade of reinforcement steel shall be Fe 500D conforming to IS 1786.

2.8.8 Data like bridge length, size, barrel length, type of crossing, highest flood level (HFL), total waterway and indicative span configuration etc. in respect of the proposed road/ waterway bridges has been shown in the conceptual GAD of the bridges. *The bridge opening (horizontal and vertical) shall not be less than the indicated in the Conceptual GADs.*

2.8.9 Backfill on approaches of Minor Bridge shall be placed in accordance with IRS Substructure Code. Approaches of Major Bridges (i.e. bridges having span equal to or more than 12.2m) shall be provided transition system as per RDSO report GE:R-50 as shown in Sketch No. GC-HRIDC-SK-GEN-019.

2.8.10 In case of pile foundation, bored cast in-situ concrete piles of diameter 1.2m shall be *designed.*

2.8.11 Inspection platform all-round the abutment caps/pier caps shall be *designed* along with access ladder.

2.8.12 Trolley *refuges* on bridges shall be *designed* as per provisions of IRSOD/IRPWM.

2.8.13 In case, the bridge is at a location where the Right of Way is restricted, special type of abutment / pier / return wall / wing wall shall be designed subject to approval of the Engineer.

2.8.14 *The* embankment on approaches of bridges shall be *protected* by CC blocks of suitable sizes, over consolidated gravel bed of minimum thickness of 150 mm, encased in cast in-situ RCC grid frames of suitable cross section having opening size of approximately 1.75m x 1.75m, for a length of 30m on both sides for major bridges and 15m on both sides for RCC boxes. Toe wall shall be *designed* at the end of *embankment* slope as shown in Tender drawings.

2.8.15 Inspection steps (1m wide) on either side of formation shall be *designed* with CC of M20 grade at all bridges.

2.8.16 Adequate provision shall be made for inspection and replacement of bearings without major disruption to railway operations or any activity underneath the bridge.

2.8.17 Necessary provisions for OHE mast *(2 x 25 kV)* shall be kept on bridges.

2.8.18 *Deleted*.

2.8.19 Precast CC coping shall be provided over the return wall *&* wing wall *of bridges* with minimum thickness of 75mm at the edge and 100mm at the centre. It shall project 75mm beyond the wall thickness on either side.

2.8.20 NP-4 pipe of 450mm diameter, conforming to IS 458 *in embankments* shall be designed *for* fill heights upto 5m *including ballast cushion*. In embankments having fill heights more than 5m, precast RCC box of 500mmx500mm clear size shall be designed for the purpose of future utilities. RCC pipe shall be designed for appropriate installation conditions as per IS-783, according to the fill height.

2.8.21 Compensated Ruling Gradient for the section is 1 in 150.

OUTLINE DESIGN SPECIFICATIONS – TUNNEL (Ch. 3 to Ch. 11)

CHAPTER 3

ALIGNMENT, CROSS SECTION AND LOADING REQUIREMENTS FOR TUNNEL

3.1 GENERAL

The Outline Design Criteria hereto provide minimum standards that are to govern the design of NATM tunnel, Cut & Cover tunnel, Permanent Ventilation Shafts, *construction cum utility shaft,* portals and other Permanent Works. The Outline Design Criteria shall be read in conjunction with DBR and Outline Construction Specifications (Civil and BLT) where appropriate.

Wherever in contract documents any term provides for consent, concurrence, no-objection or agreement of the Employer or the Engineer, the same shall mean and denote consent concurrence or agreement in writing (even if not so expressly stated).

3.2 CODES AND STANDARDS

The design and construction of the Permanent Works shall comply with codes of practice and standards prevalent at the time of submission of Tender Documents. Regulations made and requirements issued by the Indian Government and by relevant utility authorities shall be followed and specified.

Alternative or additional codes, standards and specifications proposed by the Contractor shall be internationally recognized codes including Austrian Standards for NATM shall be equivalent to or better than, Indian Standards issued by the Bureau of Indian Standards or any other Indian professional bodies or organizations, subject to being, in the opinion of the Engineer, suitable for incorporation into the Specifications.

Subject to the requirement of this specification and other control documents all design work will comply with the appropriate current standards issued by the Bureau of Indian Standards (BIS), or subject to approval by the authority, an appropriate current standard from a reputable institution may be used. All standards shall be that including Amendments and Addenda, current at the date of tender.

3.3 HORIZONTAL AND VERTICAL ALIGNMENT OF TUNNEL

The horizontal and vertical alignments of the HORC Project are given in the Tender drawings as listed in Employer's Requirements, Section VII-8, Tender drawings and documents.

The Contractor shall design the tunnel works to these alignments. However, subject to the provisions of the Contract, *minor* changes to the given alignments may be permitted to suit the specific characteristics of his design as per Sub-Clause 2.7 of Employer's Requirements – Functional(Civil and BLT), at no extra cost to the Employer subject to prior approval of the Employer. While fixing the design alignment of tunnel, due consideration for lateral and vertical clearances as per IRSOD on curves shall be given.

3.4 TUNNEL CROSS SECTION

The cross section of tunnel shall be determined in accordance with *Design Basis Report* (DBR) *provided under List of Documents, Section VII-8: Tender Drawings and Documents, Part 2 -Employer's Requirements*. The cross section of the tunnel shall ensure provision of space for associated structures and equipment required for operation and maintenance of the tunnel.

3.5 CROSS SECTION OF PERMANENT VENTILATION SHAFTS AND CONSTRUCTION CUM UTILITY SHAFT

3.5.1 The cross section of permanent ventilation shaft has been shown as rectangular in Tender drawings. The Contractor may modify the cross section to any other shape provided clear opening along the length of the tunnel is not less than 25 m and clear opening perpendicular to the track is not less than 12 m. The cross section of construction cum utility shaft can be decided by the Contractor depending upon construction requirement for introduction of four nos. of working faces for both tunnels.

3.6 LOADING REQUIREMENTS

3.6.1 General

The loads for design of tunnel shall broadly be taken as given in the DBR in Employer's Requirements, Section VII-8, Tender drawings and documents unless stated otherwise in the Contract.

3.6.2 Design Loads and Loading Combinations

Each component of the structure shall be designed/checked for all possible combinations of loads indicated in DBR of tunnel in Employer's Requirements, Section VII-8, Tender drawings and documents but not limited to these only.

CHAPTER 4
GEOLOGICAL AND GEOTECHINICAL INVESTIGATIONS AND FIELD TRIALS

CHAPTER 4

GEOLOGICAL AND GEOTECHINICAL INVESTIGATIONS AND FIELD TRIALS

4.1 GENERAL

4.1.1 The Contractor shall be responsible for determining for his design purposes the Geology and the Geotechnical parameters of the sub-surface strata along the route. Geotechnical Investigations have been carried out by the Employer and the Preliminary Geotechnical Investigations Reports are given in Employer's Requirements, Section VII-8, Tender drawings and documents for information only. *The Contractor shall confirm geotechnical parameters independently through confirmatory boreholes. Additional boreholes, wherever required for design, shall also be carried out at his own cost. Minimum depth of confirmatory / additional boreholes below tunnel invert level shall be 1.5 times the excavation width /depth of the tunnel whichever is more.*

4.1.2 *If the Contractor intends to carry out additional ground investigation from the surface, beyond the limits of the worksite, he shall make his own arrangements with land owners and occupiers for the necessary access. He shall not assume that such access will necessarily be granted, although the Engineer will provide assistance where it appears that this would be beneficial.*

4.2 FIELD TRIALS FOR PRIMARY SUPPORT SYSTEM

The Contractor shall carry out intensive field testing in order to evaluate the geological conditions expected to be encountered during tunnel excavation and to evaluate the design parameters required for design of the NATM tunnel. The trial may be made to the primary support system such as rock bolts/dowels, shotcrete, forepoling and pipe roofing in order to evaluate their performance in different geological conditions to the extent possible prior to the design of works so that more appropriate designs for different geological conditions can be established before the execution of work. Otherwise, such tests may be recommended at a suitable frequency in different geological conditions and change in geological conditions during excavation and design of primary support system shall be reviewed on the basis of the interpretation of the results obtained from instrumented data.

CHAPTER 5

DESIGN OF CUT & COVER TWIN TUNNEL, PERMANENT VENTILATION SHAFTS AND CONSTRUCTION CUM UTILITY SHAFT

CHAPTER 5

DESIGN OF CUT & COVER TWIN TUNNEL, PERMANENT VENTILATION SHAFTS AND CONSTRUCTION CUM UTILITY SHAFT

5.1 GENERAL PRINCIPLES

5.1.1 The Contractor shall use design methods for the analysis of *Cut & Cover tunnel*, permanent ventilation shafts *and construction cum utility shaft* that take into account, but not limited to:

a. the method of construction, including temporary works;

b. the ground/structure interaction, including the effects of temporary works;

c. ground pressure redistribution and bending moment redistribution;

d. short and long term heave and settlement;

e. Groundwater loading, backfill and other imposed loading, if any.

For the purposes of assessing ground pressures the shafts shall be considered as effectively a rigid box structure subject to earth pressure at rest.

Temporary Ground Support shall be designed in accordance with the requirements of Chapter 6.

5.1.2 *Preliminary Geotechnical investigation reports given in Section VII-8: Tender Drawings and Documents are indicative in nature. The Contractor shall confirm geotechnical parameters independently through confirmatory boreholes. Additional boreholes, wherever required for design, shall also be carried out at his own cost.*

5.1.3 If the Contractor intends to carry out additional ground investigation from the surface, beyond the limits of the worksite, he shall make his own arrangements with landowners and occupiers for the necessary access. He shall not assume that such access will necessarily be granted, although the Engineer will provide assistance where it appears that this would be beneficial.

5.1.4 The design life required shall be obtained by the use of durable materials, corrosion protection, resistance to or avoidance of wear etc.

5.2 DESIGN PRINCIPLES

The design method for construction of the cut and cover tunnels/ shafts shall take into account at least:

a) the geology along the length and depth of the *Cut & Cover tunnel/shafts;*

b) the hydrology and the permeabilities of the strata encountered along the length of the *Cut & Cover tunnel/shafts*.

c) the magnitude of settlement which could be expected. In this context the

location of the works in relation to existing structures shall be considered.

d) the depth of construction required;

e) any particular difficulties that special plant *& machinery* might meet with in respect of access, clearances and working space;

f) the noise levels produced;

g) the methods by which the completed structure shall be secured against flotation;

h) the method of waterproofing the completed structure:

i) Slope instability.

5.3 EXCAVATION WITHOUT SUPPORT SYSTEM (OPEN EXCAVATION) FOR CUT & COVER TUNNEL

The open excavation shall be carried out in the area, where, there are no structures/ utilities/other establishment in the influence Zone of the excavation and does not involve extra tree cuttings. The detailed excavation scheme along with complete details of the scheme shall be submitted for prior approval of the Engineer.

5.4 FLOTATION

Minimum depth of overburden on underground structures should not be less than 2 metres in general. The Contractor shall check the cut and cover tunnels for the possibility of flotation due to differential water pressure and shall design the structure such that adequate factors of safety against flotation are provided as set out below.
A load factor of 0.90 shall be applied to the self weight of the structure, including the first stage only of the track concrete. A load factor of 1.0 shall be applied to the weight of backfill material over the structure.
The overall factor of safety against flotation shall not be less than 1.05 and 1.10 for any construction stage and after the completion of the Permanent Works respectively.
Suitable measures to counteract flotation forces for the Permanent Works shall be incorporated in the Contractor's design. The measure(s) chosen shall suit the particular conditions and the method of construction:

a) Toeing-in of the base slab into the surrounding ground;

b) increasing the dead weight of the structure by: thickening of structural members;

c) providing an extra thickness of concrete beneath the base slab tied into the structural base slab;

It will not normally be acceptable to modify the vertical alignment of the tunnels solely to counteract flotation forces. The use of ground anchors as a permanent measure to counteract flotation forces will not be permitted.

Where the base slab is toed-in to the surrounding ground a partial safety factor of 2.0 shall be

applied to the shear resistance of the ground above the toe and the adhesion factor shall not apply. The value of the weight of ground above the toe shall be calculated as for the backfill material.

The value of the weight of any additional thickness of concrete shall take account of the increased volume of water displaced.

The Contractor shall ensure that his method and sequence of construction is such that an adequate resistance to uplift is maintained at all times, and shall put forward his proposal to this effect.

5.5 CRACKING OF CONCRETE

Anti-crack reinforcement shall be provided in all walls and slabs more than 250 mm thick to distribute cracking arising from shrinkage, early thermal and temperature effects.

Minimum reinforcement on each face in each direction shall be at least 0.125% of the concrete cross-sectional area for grades 415 and above.

In addition, spacing between the bars should not be greater than 150 mm.

Generally, pairing of bars and more than one layer of bars is not preferred for such structures. It is preferred that smaller diameter bars in any direction are placed at closer intervals to prevent early thermal and shrinkage cracks.

5.6 THERMAL CRACKING

Walls and slabs of underground structures are usually thick. Therefore, adequate consideration shall be given to the risk of early thermal cracking and shrinkage effects. Suitable property enhancers/blending material conforming to relevant codes shall be used by the weight of cement in such a manner that it shall replace the cement quantity for the same grade of concrete to reduce the risk of early thermal cracks. This concrete shall serve as a measure to reduce the thickness of walls & slab to minimise the risk of thermal cracks. The designer shall ensure that any requirements considered appropriate such as cement chemistry and curing methods are properly addressed.

5.7 CORNER DETAILS

Particular attention shall be paid to the corner joints of large structural members. External wall/slab junctions shall be provided with crack control steel and transverse ties. Radius of bend of main tension bars shall be increased to cater for the high bearing stresses within the bend.

5.8 CONSTRUCTION JOINTS

The design and detailing shall be such that the number of construction joints will be as few as practicable and shall minimise leakage.

5.9 BASE STABILITY

The Contractor shall include in design adequate precautions against base heave in the clayey silts during construction. The stability of the bottom of the excavation shall be checked in accordance with an acceptable method of analysis. A surcharge of 20 kN/m^2 shall be allowed for, applied at ground level to the ground surrounding the excavation.
The Contractor shall show in his calculations the contribution made to the base stability of the excavation by his proposed method of construction and shall state the factor(s) of safety used in the design. The factor(s) of safety shall relate to the method of construction and to the particular location of the Works and shall be subject to the consent of The Engineer.The Contractor shall check the stability of the completed structure against failure due to base heave under the structure.

5.10 WATERPROOFING

The grade of concrete, treatment of construction joints, areas of slab pours and external protection shall be chosen such that the required standard of waterproofing can be achieved and maintained. Materials for expansion joints, caulking etc. shall have acceptable fire performance for use on an underground railway line.

1. *Waterproofing of cut & cover tunnel shall be carried out by a manufacturer having minimum 10 years of experience in manufacturing waterproofing product of the type specified, able to provide test report showing compliance with the specifications, and able to provide on -site technical representation to advise on installation.*

2. *The installation shall be carried out either by the manufacturer or his approved applicator having experience of minimum 05 years in application of waterproofing products in underground structures. The waterproofing shall be carried out by manufacturer's applicators strictly in accordance with the recommendation of the manufacturer.*

3. *All components and elements, which are required to make the structures watertight, shall be demonstratable and proven to work together. There shall be a single source of responsibility and performance of the material and products. Specifically, material and water stops shall be manufactured out of virgin raw material and only form the same formulation of raw material. The manufacturer shall confirm full, demonstratable and proven compatibility of the entire waterproofing system in writing. The waterproofing system provided shall be installed without damage and protected against construction operations. The contractor shall carry out a trial application of the waterproofing and submit the report containing the details and method statement to obtain approval from the Engineer.*

4. *The waterproofing shall be provided on outside side of vertical walls and top slab.*

5. *Waterproofing scheme*

   i. Outside of vertical walls and top slab shall be provided with spray applied liquid coating of minimum thickness 2.0 mm as per IS 16471 (Type A).

   ii. Construction joints in vertical walls shall be provided with PVC water stops as per IS 16471 (Type B).

   iii. Use of waterproofing admixture to the concrete of slabs and walls of Cut & Cover tunnel

6. *Spray applied liquid coating on external side of vertical walls and top slab*

   i. System and properties of materials
   Fully bonded spray-applied liquid polymer two component, solvent free, hybrid polyurea polyurethane/ polyurea/ polyurethane applied elastomeric seamless membrane of minimum 2 mm Dry Film Thickness (DFT) shall be used. DFT shall be achieved in minimum 2 coats (of two different contrasting colors), over and above one coat of a solvent free two component epoxy primer which shall be compatible with the liquid polymer and from the same manufacturer. No sand broadcast layer is permitted in the system. The system must be such that it is thixotropic, can be applied by airless spray; as well as the same product shall be capable of being applied manually only for local detailing and patch repairs (maximum area 1 m2). The product shall be applied in accordance with the manufacturer's instructions.

   ii. The waterproofing membrane shall have following minimum properties:
   a. Tensile strength> 15MPa as per ASTM D 412.
   b. % Elongation>300% as per ASTM D 412.
   c. Bond strength on concrete > 2 MPa as per ASTM D 7234.
   d. Minimum crack bridging capability of over 2.0 mm.
   e. Specific Gravity of 1.15 (+/-10%)

iii. Codes and Standards for reference:

ASTM D 412	*Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension*
ASTM D 7234	*Standard Test Methods for Pull-off Adhesion Strength of Coating on concrete Using portable Pull – off Adhesin Testers.*

iv Inspection

The thickness of spray applied liquid coating waterproofing membrane shall be checked for every 20 m^2 area of water proofing. The thickness at the point of checking shall not be less than 2 mm.

7. Construction joints in vertical walls

i. The contractor shall construct his concrete works so as to minimize the likelihood of water penetration.

ii. Before placing new concrete against concrete that has already hardened, the face of the old concrete shall be treated in accordance with manufacturer's recommendation.

iii. Inside rendering shall not be accepted as a method of making joints watertight.

iv. Water stops shall be of PVC strips. The water stops shall be installed so that they are securely held in their correct positions whilst the concrete is being placed. No holes shall be made through any water stop except were provided for by the manufacturer. Water stops shall be provided as per manufacturer recommendations. The contractor shall submit the method statement for providing water stops to the Engineer for approval.

8. Use of waterproofing admixtures in concrete of slabs and vertical walls of subway

Waterproofing admixtures shall be used in conjunction with other waterproofing components supplied by the same manufacturer, for example, water stops, achieve watertight structures.

9. Surface preparation

Waterproofing work shall commence only after obtaining approval from the Engineer. Application of waterproofing system shall only commence upon the completion of curing of concrete. All cracks on the exposed concrete surfaces of external structural members shall be effectively sealed before applying any waterproofing system. The Contractor shall ensure that surfaces to which waterproofing is to be applied, shall be clean, dust-free and dry and shall be prepared fully in accordance with the manufacturer's recommendation. The waterproofing shall be carried out by the manufacturer's applicators strictly in accordance with the recommendations of the manufacturer and with accepted best practice in the trade.

5.11 Material parameters, loads & loading combinations, concrete cover and crack width shall be taken as per Design Basis Report given in Employer's Requirements, Section VII-8, Tender drawings and documents.

CHAPTER 6

TEMPORARY GROUND SUPPORT SYSTEM & OTHER REQUIREMENTS FOR EXCAVATION TO CUT & COVER TWIN TUNNEL, PERMANENT VENTILATION SHAFTS AND CONSTRUCTION CUM UTILITY SHAFT

CHAPTER 6

TEMPORARY GROUND SUPPORT SYSTEM & OTHER REQUIREMENTS FOR EXCAVATION TO CUT & COVER TWIN TUNNEL, PERMANENT VENTILATION SHAFTS AND CONSTRUCTION CUM UTILITY SHAFT

6.1 TEMPORARY GROUND SUPPORT SYSTEM

Excavation will be required in soil as well as in rock or partially in rock and partially in soil for Cut & Cover tunnel and shafts. The design of temporary ground support system for Cut & Cover tunnel and shafts shall take into account all prevailing factors, loading and circumstances to ensure safety of temporary ground support system till permanent structures are constructed.

6.2 DESIGN OF TEMPORARY WORKS

Temporary works shall in general be designed in accordance with the same design standards as the permanent works. However, the design may take into account the limited duration over which the temporary works are expected to function. The calculations and drawings shall make clear where provision for limited life has been taken into account, particularly where this may have a substantial influence on the stability of the temporary works.

The design of temporary works shall take account of all the applied external forces and imposed structural deformations, and, additionally for underground works, the effects of removal of load from the ground and the movement of the ground independent of the load.

CHAPTER 7

DESIGN OF PRIMARY SUPPORT SYSTEM FOR NATM MAIN DRIVE AND PORTALS

CHAPTER 7

DESIGN OF PRIMARY SUPPORT SYSTEM FOR NATM MAIN DRIVE AND PORTALS

7.1 GENERAL

7.1.1 *Preliminary Geotechnical investigation reports given in Section VII-8: Tender Drawings and Documents are indicative in nature. The Contractor shall confirm geotechnical parameters independently through confirmatory boreholes. Additional boreholes, wherever required for design, shall also be carried out at his own cost.*

7.1.2 ***Deleted***

7.1.3 If the Contractor intends to carry out additional ground investigation from the surface, beyond the limits of the worksite, he shall make his own arrangements with land owners and occupiers for the necessary access. He shall not assume that such access will necessarily be granted, although the Engineer will provide assistance where it appears that this would be beneficial.

7.2 DESIGN PRINCIPLES

The design method for construction of the NATM main drive and final lining of NATM tunnel shall take into account at least:

a) the expected geological conditions along the length and depth of the tunnel alignment;

b) the hydrology and the permeabilities of the strata encountered along tunnel alignment;

c) the depth of construction required;

d) any particular difficulties that special plant might meet with in respect of access, clearances and working space;

e) the noise levels produced;

f) control over heave, swell, piping and instability of the base of construction;

g) the methods by which the completed permanent ventilation shafts shall be secured against flotation;

h) the method of water proofing the completed structure;

i) expected performance of the proposed support system for NATM main drive

j) support system requirements for various expected geological conditions

k) type of construction equipment proposed for the NATM main drive

l) sequence of primary supports installations

7.2.1 NATM Main Drive in Soil

NATM tunnel shall be constructed in soil portion *approximately* from CH 26000 m to CH 28880 m. The excavation sequences for heading, benching and invert shall be designed in such a manner that the deformations inside the tunnel shall be limited to the design deformations considered in fixing the excavation profile. The design calculations for the support system shall be carried out with standard software available in the market, e.g. FLAC, PLAXIS, RS2 etc. The design submitted for the same shall also indicate for adjustment for support system requirement with respect to the instrumented data gathered during execution.

7.2.2 NATM Main Drive Partially in Alluvium and partially in Rock

In such a situation the primary support system shall be designed keeping in view of the requirements indicated in Sub-section 7.2.1 above with due consideration in the modelling for these geological variations and interfaces in between soil and rock.

7.2.3 NATM Main Drive in Rock

In rocky strata it is expected on the basis of observations made for the outcrops around the work site that the strata will be highly fractured. Special precaution shall be taken in the design for excavation sequence and support system in order to avoid collapse of the ground in any case. Due to highly fractured rock the analysis shall be carried out for excavation sequence and support system requirements and their installation sequences. The adequacy of the support system shall be ensured by means of detailed analysis and design of the construction sequences and installation of primary support systems and proposing the adjustment for these support systems after reviewing the instrumented data during excavation.

7.3 DESIGN OF NATM MAIN DRIVE

7.3.1 General

The Contractor shall prepare and submit to the Engineer for his consent a detailed design including calculations schedules and drawings for primary support system requirements and sequences of installations vis-à-vis excavations sequences for all kind of geological variations expected to be encountered along the tunnel alignment. The design of NATM main drive shall be carried out in accordance with provisions of DBR.

7.3.2 Method Statement

The Contractor shall prepare a method statement giving the full details of materials, plant and operations involved in the excavation and installation of primary support system for

NATM main drive. This shall be incorporated into the design submission for consent and shall include details of:

a) Sequences of excavations;

b) The method of producing the shotcrete

c) The method of application of shotcrete

d) The method of placement of seal coat of shotcrete to the excavation;

e) Method of installations of rock bolt/dowel

f) Method of installation of lattice girder

g) Method of installation of shotcrete lining of required thickness

h) Method of installation of fore poling / pipe roofing

i) The methods of monitoring tunnel convergence and checking the stability of tunnel;

j) The methods of monitoring and checking the stability of neighbouring properties, highways, utilities and other underground structures;

k) Emergency procedures to be implemented in the event that monitoring indicates instability of tunnel excavation.

7.3.3 Ground Movements

The design of temporary ground-support works shall limit ground movement around the site and thereby avoid damage to adjacent structures and properties, roads, utilities, and footpaths.

During the Preliminary Design phase, all existing structures that may be influenced by construction of the works shall be investigated to establish allowable settlement criteria for each structure or group of structures. Establishment of an appropriate zone of influence shall be accepted as 50m either side of the tunnel centre-line or the base of the excavation plus a spread of 45° to the horizontal in areas where structures are located whichever is more. *However, 765 kV EHT transmission tower located at chainage 28265 m which is adjacent to up line tunnel shall be protected by appropriately designed sheet piling/soldier piling/micro piling. The design shall be got approved by the utility owner.*

The design of all ground-support walls shall limit settlement in the adjacent structures or ground to 25 mm maximum.

The design shall also include provisions to limit angular distortions in adjacent structures to 1:500 maximum. Angular distortion to sensitive structures may be limited to maximum 1:2000 depending upon nature and type of structures.

The above limits/provisions are upper limits. However, this may have to be restricted

further if required to avoid damage to the adjacent structure or causing discomfort to the occupants.

These requirements are in addition to any other requirements imposed by applicable government agencies and the Employer.

7.3.4 Limiting Construction-Induced Vibrations at Existing Adjacent Structures

In the design, the effects of construction-related vibrations shall be considered. Unless otherwise accepted by the applicable government agencies and the Employer, peak particle velocities at existing adjacent structures shall not exceed the values in the Table below:

Table 7.1: Peak Particle Velocities in mm/sec (Maximum Allowable) at Existing Adjacent Structures

Most structures in "good" condition	25
Most structures in "fair" condition	12
Most structures in "poor" condition	5
Water-supply structures	5
Heritage structures/bridge structures	5

Above limits are maximum permissible. However, this may have to restricted further if required to avoid damage to the adjacent structure or causing discomfort to the occupants. Methods of reducing vibration, such as limiting explosive charge per delay or operating pile-driving equipment at lower energy levels, may be required. The use of expansive agents or mechanical excavation methods shall be required in place of blasting at certain critical locations. In addition working hours for such equipment causing vibrations may have to restricted, keeping the convenience and comfort of the occupants in mind.

7.4 `DESIGN OF *Secondary* LINING

7.4.1 General

The Contractor shall prepare and submit to The Engineer for his consent a detailed design including calculations schedules and drawings for *secondary* lining for all kind of geological variations expected to be encountered along the tunnel alignment. Design of lining shall be carried out in accordance with provisions of DBR.

7.4.2 Cracking of Concrete

Anti-crack reinforcement shall be provided in all walls and slabs more than 250 mm thick to distribute cracking arising from shrinkage, early thermal and temperature effects. Reinforcement on each face in each direction should be at least 0.125% of the concrete cross-sectional area for grades *Fe 500D* and above. In addition, spacing between the bars should not be greater than 150 mm.

Generally, pairing of bars and more than one layer of bars is not preferred for such structures. It is preferred that smaller diameter bars in any direction are placed at closer intervals to prevent early thermal and shrinkage cracks.

7.4.3 Thermal Cracking

Walls and slabs of underground structures are usually thick. Therefore, adequate consideration shall be given to the risk of early thermal cracking and shrinkage effects. Suitable property enhancers/blending material conforming to relevant codes shall be used by the weight of cement in such a manner that it shall replace the cement quantity for the same grade of concrete to reduce the risk of early thermal cracks. This concrete shall serve as a measure to reduce the thickness of walls & slab to minimise the risk of thermal cracks. The designer shall ensure that any requirements considered appropriate such as cement chemistry and curing methods are properly addressed.

7.4.4 Construction Joints

The design and detailing shall be such that the number of construction joints will be as few as practicable and shall minimise leakage.

7.4.5 Waterproofing

Ground water Leakage rates shall not exceed a general value of 0.1 litres/sqm/day. For any 10metre length of tunnel, the leakage rate shall not exceed 0.2 litres/sqm/day

The grade of concrete, treatment of construction joints, areas of pours and external membranes shall be chosen such that the required standard of waterproofing can be achieved and maintained without using waterproofing membrane.

7.4.6 Cross Passages

Design of cross passages shall be carried out on the lines of NATM main drive.
The locations of cross passages shall be chosen to avoid critical sections of the alignment where their construction could have an adverse effect on adjacent structures.

The openings into the running tunnels shall have a minimum width of 3.5 m and a minimum height of 3.5 m. Throughout the cross passage minimum headroom of 3.5 m

shall be maintained over a width of 3.5 m.

The cross passage floor screed shall be laid to fall and drain into the running tunnel drainage system. Floor level shall correspond with the level of the tunnel escape route.

A concrete bulkhead with the provisions of fitting steel door and frame shall be provided to isolate the cross passage from each running tunnel. The door along with frame shall be provided and fitted (fixed) by the Contractor. The door shall be self-latching and have a fire resistance of 2 hours minimum and shall be capable of withstanding the maximum differential pressures on either side created by the passage of trains. Maximum force to open shall not exceed 150N. Any mechanism needed to operate the door must be demonstrated to be of adequate reliability.

7.4.7 Design of Portals

Portals P1 and P2 shall be designed in accordance with provisions of DBR.

CHAPTER 8

INSTRUMENTATION AND MONITORING IN NATM TUNNEL

CHAPTER 8

INSTRUMENTATION AND MONITORING IN NATM TUNNEL

8.1 GENERAL

The Contractor shall submit a complete comprehensive instrumentation scheme with the Preliminary Design to achieve the following:-

i. Safety during and after the construction by providing early warning of any excessive and undue ground movement inside the tunnel.

ii. To provide deformations and loading data for the verification of initial design of the primary and secondary support.

iii. To provide early information about tunnel behaviour in order to optimize excavation and support activities during construction and to recognize in time the requirements for remedial measures (Observational Approach)

The instruments shall be designed to meet the basic and minimum standards indicated in the specifications for designing, furnishing, installing, maintaining and removing instrumentation systems for the detection of ground movements, settlements and displacements, performance of tunnel ground support, measurement of loads, stress and strain in structural elements for the support of excavations. Associated field surveying work, development, processing and visualization of data shall also be carried out. Contractor shall be responsible for the supply and installation of the instrumentation, monitoring which includes taking of readings and the presentation of the results in a report form as per specifications and as directed by the Engineer.

8.2 SUBMISSIONS

8.2.1 General

All technical submissions are subject to the approval of the Engineer.

8.2.2 Method Statement for instrumentation

The Contractor shall submit together with Method Statement along with specifications, how he intends to run the specified monitoring system. The Method Statement shall include but not necessarily be limited to, the following:

(i) Proposed programme and procedures for obtaining and installing instruments and for performing the works. Quality Assurance Plan including various tests for quality control shall be submitted.

(ii) Site organisation and a plan for his personnel deployment (no of crews and person

per crew) and how he intends to perform the specified work. The program shall consider the following conditions and time frame for excavation activities:

(iii) Tunnel excavation works will be day and night 7 days a week.

(iv) Instrument and material information shall consist of complete instrument description and specification; calibration test results and certificates of compliance; replacements, spares, maintenance requirements and suppliers details.

(v) Details of the system, which shall be used for data collection and data transfer to a computer unit and/or recording unit. This is related to all monitoring devices, which are equipped with remote reading facilities.

(vi) Type and presentation of output to be produced by the Contractor.

(vii) Detailed procedures applied during acceptance tests, function testing and calibrations for all monitoring equipment.

(viii) Proforma Sheets as applicable.

8.2.3 Working drawings, records and procedures

(i) Working drawings and complete installation procedures including checks and calibrations.

(ii) Principal features of the work to establish and reference instrumentation locations.

(iii) Established elevation of each cased deep benchmark and the initial elevation of each settlement reference point.

(iv) Working drawing or in report form showing the following:

(a) Installation procedure used for the installation of each instrument. Include date of installation.

(b) As built configuration of each instrument including depths, lengths, elevations, station, offset and other dimensions of key elements of each installed instrument.

(c) Verification of records that instruments meet specified tolerances.

(v) Daily logs and survey notes:

(a) Keep logs and survey notes stating all instrument readings and observations made about events regarding temperature, weather, soil and groundwater conditions on the Site, and all other information required to properly interpret the data.

(b) The notes and logs shall include at least the following additional information:

(i) Temperature.

(ii) Water ingress.

(iii) List of instrument observations performed.

(iv) Date and time of observations.

(v) Coordinates of locations.

(vi) Names of the operators.

(vii) Types and serial numbers of measuring devices used.

(viii) Construction loading or other activities in the vicinity of instrumentation.

(ix) Duration and cause of interruptions or delays to progress.

(x) Any cracks in or damage to any structures, or other events.

8.3 Deleted

8.4 Deleted

CHAPTER 9

MONITORING SECTIONS AND MONITORING DEVICES FOR NATM TUNNELS

CHAPTER 9

MONITORING SECTIONS AND MONITORING DEVICES FOR NATM TUNNELS

9.1 GENERAL

In principle, the various monitoring devices shall be installed in monitoring sections. Monitoring sections can be subdivided according to the instrumentation installed. For this project, the following types of instrumented sections shall be applied:

Table 9.1: Definition of Monitoring Sections

Monitoring Section Type	Monitoring Devices Surface	Monitoring Devices Underground
Standard (Type A)	Precise Leveling (only for Open Excavations near portal)	Absolute Displacement Monitoring
Main (Type B)	Extensometers (only in soft ground sections with shallow overburden)	For Tunnels: Absolute Displacement Monitoring, Extensometers, Pressure Cells, Shotcrete Strain Meters For Shafts: Absolute displacement monitoring and shotcrete strain meters
Special	To be defined according to requirements	

Standard Monitoring Sections (Type A) consist only of targets for absolute displacement monitoring underground. They shall be installed at regular intervals in the tunnels (approximately every 10 meters). For the excavations near portals surface markers at suitable distances shall be installed and precise leveling carried out.

In "Main" Monitoring Sections (Type B) additionally the monitoring devices given in the table above shall be installed. They shall allow additionally an assessment of the loading of the primary support and of ground movements outside the excavation for design verification purposes. At present it is envisaged to install these sections at approximately 150m to 200m distance. This distance may be changed as per site conditions.
Special monitoring instruments shall be installed for special purposes and may contain rock bolt strain meters and rock bolt load cells.

9.2 PRECISION LEVELING

Precision Leveling shall be performed at the surface for control of the slopes near the portal. All settlement points shall be installed at construction activities or to allow for reliable zero readings without any influence of construction activities.
It has to be guaranteed that the settlement pins are properly connected to the ground and their movement is not restricted or hindered by application of any structural elements to the location.

All precise leveling points shall be sufficiently protected against any damage due to traffic, vehicles, etc.

9.3 3D ABSOLUTE DISPLACEMENT MONITORING

Monitoring of absolute displacements improved rapidly with improvements in electronic surveying instruments and computer software. With absolute displacement monitoring it is possible to determine 3D-coordinates of defined targets (reflectors) fixed to the tunnel wall. This information is used to track the target movements in space and allows a realistic assessment of the deformation behavior of the tunnel.

It is obvious that the layout of monitoring stations respectively their spacing between each other is depending on the geological conditions.

In general, the following scheme shall be applied:

Table 9.2: Installation Scheme of Targets for 3D – Absolute Displacement Monitoring

Structure	No. of Targets in Cross Section	Longitudinal Spacing	
		Good Ground Condition	Poor Ground Condition
Main Tunnel	7 (5 in top heading, 2 at bench)	10 ~ 20 m	5 m

Additional targets and displacement monitoring sections (type A) might be required in special areas such as intersections and niches. However, the installation of these sections shall be decided by the Geotechnical Engineer on site during execution of the works.

9.4 EXTENSOMETERS

Extensometers are used for determination of ground movements outside of the excavated structure. They allow an assessment of the development of strains in the surrounding ground and stabilization of movements around an excavation.

Extensometers shall be multiple rod type with anchors connected to the ground by grouting

at predefined positions.

Extensometers installed shall be sufficiently protected against any damages by construction or equipment.

Structure	No. of Targets in Cross Section	Longitudinal Spacing
Main Tunnel	3 Nos. 3 points MPBX	50m

9.5 SHOTCRETE STRAIN MEASUREMENTS

Shotcrete strain meters are used for determination of the stress development in the shotcrete lining by measuring strains. They are always installed pair wise to allow a determination of sectional forces such as normal thrust and bending moments.

Based on the measured strains stresses in the shotcrete lining are calculated by utilization of a nonlinear material law. As several input parameters are required for this material law long term creep tests on young shotcrete shall be performed, allowing a determination of the required material parameters.

Shotcrete strain meters shall be temperature compensated to compensate for temperature increase of the shotcrete during the hardening process. Shotcrete strain gauges shall be installed at following sections:

Structure	No. of Targets in Cross Section	Longitudinal Spacing
Main Tunnel	7 Nos.	100m

9.6 PRESSURE CELLS

9.6.1 Radial Pressure Cells

With radial pressure cells the development of ground pressure acting on the primary support structure (shotcrete lining) is measured. To get reliable results the following requirements shall be met:

1. Large size pressure cells, as a larger area of the cell gives more reliable results (larger area of influence)
2. Possibility of Rerouting; caused by thermal effects a shrinkage gap develops between the cell and the shotcrete lining, which has to be closed to provide accurate

cell readings.

Therefore, pressure cells shall be of size 300 x 300 mm. Readings shall be taken remote controlled with electrical transducers.

9.6.2 Tangential Pressure Cells

Tangential Pressure cells are used for determination of the shotcrete lining stress. They shall only be installed in areas of special interest such as intersections. They shall have a dimension of 100 × 200 mm. Readings shall be remote controlled with electrical transducers.

9.6.3 Following scheme shall be followed:

Structure	No. of Targets in Cross Section	Longitudinal Spacing
Main Tunnel	7 Nos.	100m

9.7 ROCK BOLT AXIAL FORCE METER "MEASURING ANCHOR"

Measuring Anchors are used to determine the load development along the anchor. This will provide information how load increases from the anchor tip to the anchor plate. Measuring anchors shall be installed together with rock bolt load cell and extensometers. These shall be installed at least at 3 locations.

9.8 ROCK BOLT LOAD CELL (CENTER HOLE TYPE)

The load cell (accuracy 0.5% and of 250 kN capacity) is installed at the anchor plate, It gives information on the maximum anchor load and the degree of utilization of the anchor. These shall be provided at least at 3 locations.

Structure	No. of Targets in Cross Section
Main Tunnel	5 Nos. center hole load cells

9.9 SWITCH BOX

2 Nos. of switch boxes shall be provided at every 50 m.

CHAPTER 10

EVALUATION AND INTERPRETATION OF MONITORING RESULTS

CHAPTER 10

EVALUATION AND INTERPRETATION OF MONITORING RESULTS

10.1 GENERAL PROCEDURE

In general, the data handling and information flow of monitoring results shall be as follows:

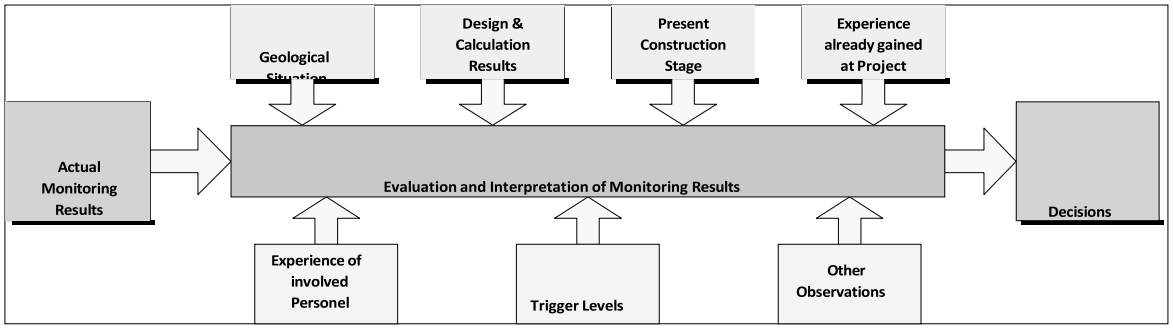


Fig. 10.1: Input Parameters for Evaluation and Interpretation of Monitoring Results

This will provide information how load increases from the anchor tip to the anchorplate. Measuring devices shall be installed together with rock bolt load cell and extensometers.

Upon completion of daily monitoring activities and preprocessing of monitoring raw data a preliminary evaluation of the monitoring results by a plausibility check shall be performed. Only after the results have to be found reasonable and eventual errors have been excluded and corrected, an update of the database shall be performed. Plausibility checking shall be performed by the monitoring contractor together with the DDC Instrumentation /Survey Engineer.

When the database has been updated with the actual monitoring results, Data are provided to Engineer with evaluation and interpretation of the results. To guarantee a quick decision with regard to support requirements and working procedures the database must be updated with the daily, measurements each afternoon as directed by the Engineer.

If the monitoring results are outside of the range of expected behavior the Contractor has to make immediately required decisions and notify the Engineer.

10.2 METHODS OF DATA EVALUATION AND INTERPRETATION

10.2.1 General

According to their geomechanical relevance, the main monitoring parameters for tunneling are as follows:

Table 10.1: Parameters and their Geomechanical Relevance of 3D-Monitoring Results

Parameter	Geomechanical Relevance
Trend of Time Histories	
Time - Displacement Diagram	Useful for assessment of time dependent components of displacement and stabilization of construction steps
Distribution of Cross Section Displacemen t Vectors in	Reflects the effects of geological structures subparallel to the tunnel axis
Influence Lines (General)	Reflects the geomechanical conditions of the ground along the tunnel and the effect of individual excavation steps on the already excavated section
Trend Lines	Useful for determination ground o f changes in indicator for conditions and critical as developments
Development of longitudinal Displacements close to the excavation face	Indicates changes in ground stiffness ahead of the face
Trend of advancing displacements due to bench excavation	Reflects the influence on individual bench excavation steps on the already excavated tunnel sections
Development of differential settlements between crown and top heading footings	Reflects the bearing behavior of the primary lining and the quality of the primary lining foundations

10.2.2 Time – Displacement Diagrams, Magnitude of Displacements

Time-Displacement diagrams show the development of the displacement of one point versus time. Time-displacement diagrams can be generated for all three components

of the displacement vector (vertical, horizontal and longitudinal displacement). Construction phases (top heading, bench, and invert) are usually shown on the same diagram to allow for an easy correlation between displacement behavior and construction activities.

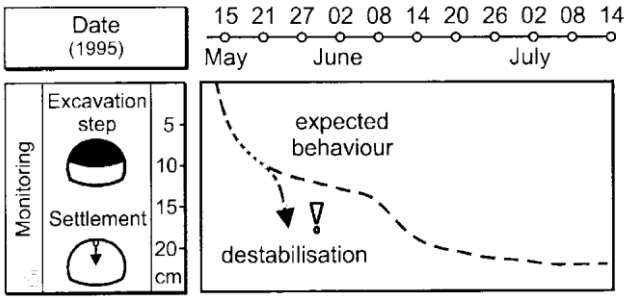


Fig. 10.2: Schematic Time- Displacement Diagram (Settlement for Crown Point)

When a constant face advance rate is assumed, the displacement rate over time has to decrease continuously. Any acceleration indicates a destabilization, unless construction activities in the vicinity of the monitored tunnel section such as bench or invert excavation are ongoing. Usually after each excavation step a tendency towards stabilization must occur.

It is essential to consider that the displacements monitored in the tunnel are only a part of the total amount of displacements occurring. Fig. 8.3 shows a principle sketch of the total vertical displacements and the measurable amount of displacements in the tunnel. A certain amount of predeformation occurs already ahead of the face. When the excavation has reached the chainage of the monitoring section, an additional part of the total displacements cannot be measured due to the time required between excavation, installation of the monitoring section and the following zero reading of the section. Therefore, it is essential that installation and zero reading of monitoring sections are performed as fast as possible without any unnecessary delays.

In this respect, all zero readings in the tunnels shall be taken latest 6 hours after excavation of the relevant monitoring section.

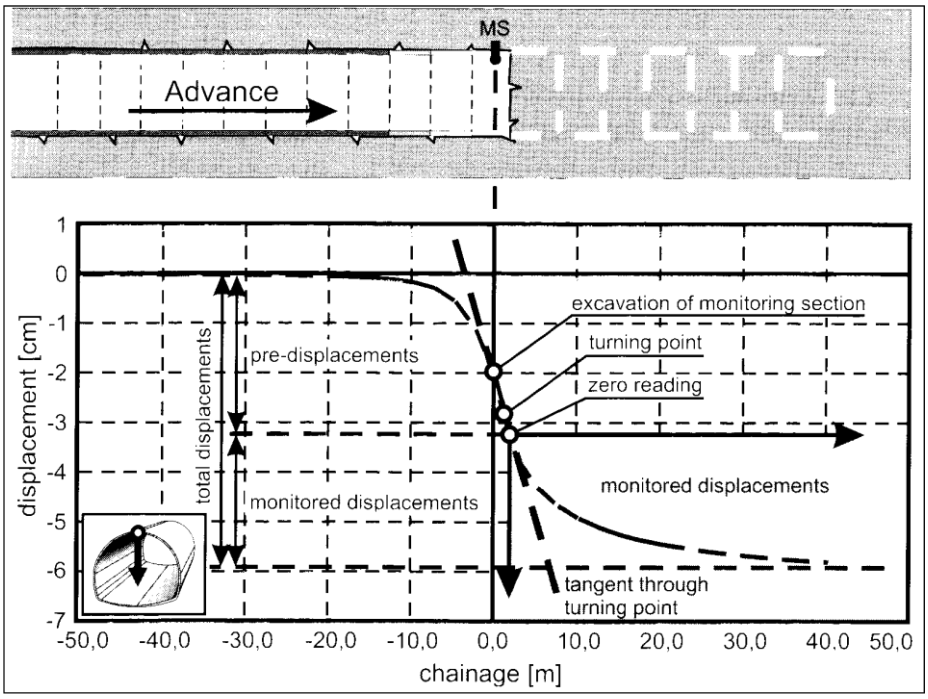


Fig. 10.3: Schematic Representation of Pre-Displacements and Monitored Displacements in Tunneling

10.2.3 Distribution of Displacements in Vector Diagrams

Displacement Vector plots allow the representation of the cross sectional displacements and their development with time.

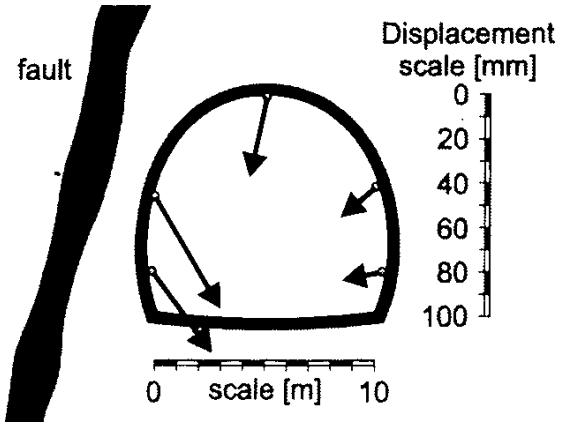


Fig. 10.4: Vector Diagram – Influence of Stratification

Displacement vector plots allow the detection of weak zones and / or faults outside the excavation area. They provide additional information about the rock mass structure and deformation phenomena close to the tunnel. In general, the displacement vector orientation in cross section reflects the influence of geological structures on the deformation behavior subparallel to the tunnel.

10.2.4 Lines of Influence

Lines of Influence are produced by connecting displacement values of a number of monitoring points along the tunnel axis at the same time, similar to a "deflection curve". Normally, a number of lines for a specified time span are shown on one plot. In addition, construction phases (top heading, bench, invert) are shown to allow for an immediate correlation between measured displacements and and construction activities.

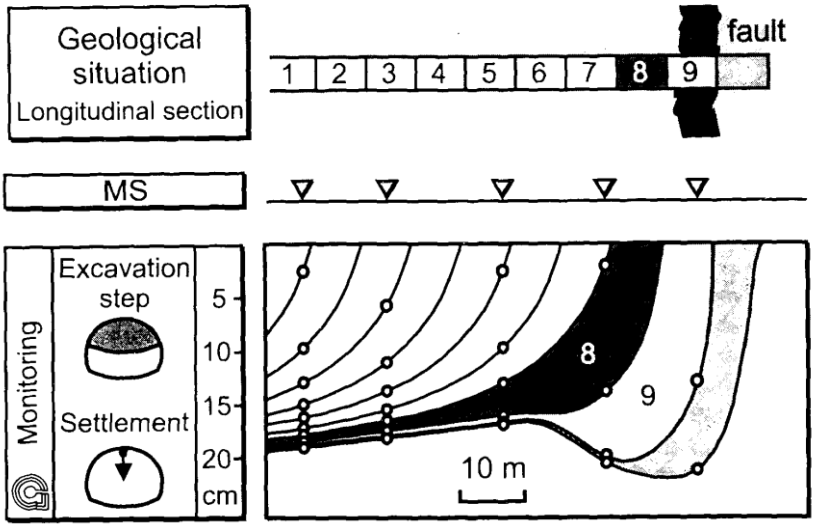


Fig. 10.5: Development of Lines of Influence when Excavation approaches a "Weak Zone"

The lines of influence in the simplified diagram above show the settlement of the crown resulting from top heading excavation. The uniform shape of lines corresponding to excavation steps 1 to 7 reflect a homogeneous ground mass with uniform behavior. As the excavation approaches the fault (9), in excavation step 8 already a significant deviation of the previously uniform behavior can be observed, extending also significantly behind the face. During tunneling through the fault a further increase in settlements is measured.

10.2.5 Trend Lines

Trend lines are generated by connecting settlement values of individual lines of influence at a predefined distance behind the face. They give a good overview of the displacement development along the tunnel and are quite useful for extrapolation of the displacement behavior ahead of the excavation face.

Trend lines which show increasing displacement can indicate critical situations and must be considered as a serious warning signal.

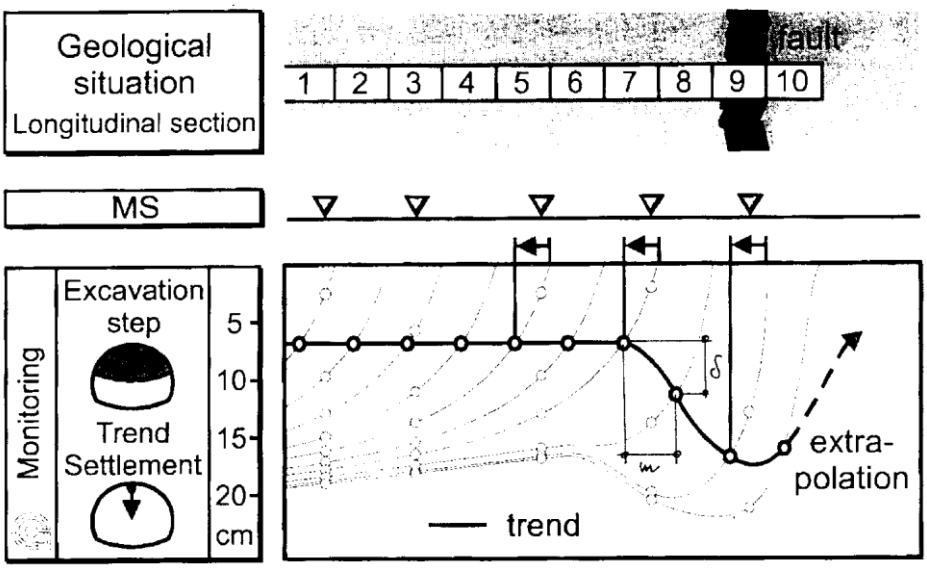


Fig. 10.6: Development of Trend Line when Excavation approaches a "Weak Zone"

10.2.6 Differential Settlements

This displacement option is used to show the difference in displacements between two monitoring points belonging to the same monitoring section.

Usually, the difference in settlements is displayed between:

- Crown and sidewall ($S_{crown} - S_{sidewall}$) = ΔS
- Δ S for both side walls shall be observed.
- And for horizontal displacements between:Left and right sidewall ($H_{left} - H_{right}$)
  - The values of ($S_{crown} - S_{sidewall}$) and ($H_{left} - H_{right}$) can provide valuable information foundation condition of the footing.

10.3 CONTROL LIMITS

Comparison of monitoring data with control limits will give a first indication for the identification of potential areas which are close to or exceeding design limits.

For the judgement of rock mass behavior and performance of the primary support, control limits are established in terms of primary lining displacements, displacement velocities, shotcrete strains, settlements etc.

10.3.1 Types of Control Limits

Under expected construction conditions the monitored displacements and other monitored data will be below the established threshold values, called control limits, which define certain design limitations.

The control limits are established by the following trigger levels.

(i) Alert Level

The alert level relates to threshold values representing the assessed behavior (predicted values), on accidence of which, certain routines will be started to impose an increased attention and surveillance to these specific areas.

The alert values indicate that the specific area is approaching a level where additional actions and / or contingency measures may be necessary. The need for adjustment of excavation and support procedures and / or monitoring shall be considered.

(ii) Alarm Level

The Alarm level relates to threshold values, on accidence of which the element of work may be approaching a critical state. The Geotechnical Engineer shall convene for judgement of the specific case and the overall support and rock mass performance. Implementation of additional support and / or contingency measures to avoid the accidence of the Action Level shall be considered.

(iii) Action Level

This level relates to threshold values on accidence of which the element of work is considered to be outside the expected range of assessed behavior and may be close to its ultimate limit capacity.

The overall performance shall be rechecked together with a related risk assessment. A design review shall be performed together with an assessment of the need for additional support. Additional support and / or contingency measures to guarantee the safety of the works shall be implemented.

For the case of identification of an unacceptable safety risk, the works shall be stopped and remedial measures shall be implemented immediately.

10.4 DEFINED MONITORING PARAMETERS

10.4.1 General

Control limits shall be defined by the Geotechnical Engineer for the following monitoring parameters:

a. Displacement velocities derived from 3D absolute displacement monitoring

b. Differential Settlements
   i. Shotcrete strains derived from strain measurements with shotcrete strain meters in the shotcrete lining

Information derived from other monitoring results such as extensometers, ground pressure cells etc. are used to confirm and supplement monitoring data and trends derived from the instruments above and to judge the overall performance and safety of the construction in case of exceedance of control limits.

The definition of control limits shall be considered as flexible and adjustable, which means control limits shall be updated regularly, if necessary. The control limits shall be adjusted on basis of experience gained during construction, if required.

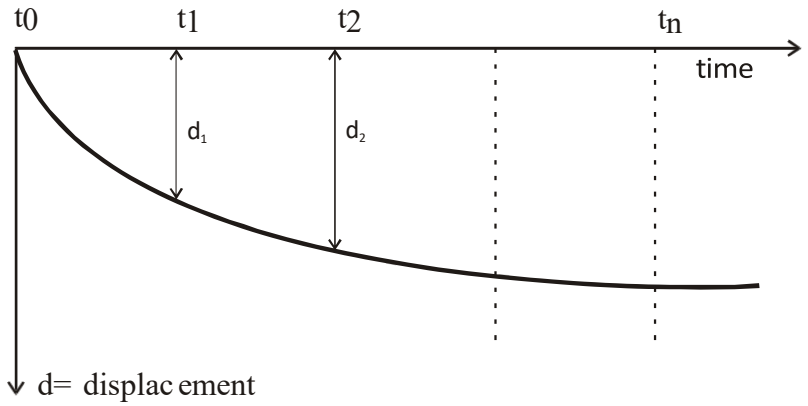
10.4.2 Displacement Velocity

Displacement velocities are calculated from the measured 3D optical displacements and are an important indicator for stability development. Usually, time intervals between observation points "t_n" are taken as one day. However, if the elimination of scatter effects related to monitoring inaccuracies is required, larger time intervals may occasionally be applied.

It is assumed that progress in the top heading will be 2 ~ 3 m per day.

Continuing or increasing displacement velocity indicates that the rock mass is not stable and may be indicative for progressive destabilization.

However, immediately after excavation an increase of displacement velocities is an expected phenomenon caused by stress redistribution. After installation of the primary support, these displacement velocities must decrease and stabilize after the excavation face has advanced further and the stress redistribution is completed.



$$v_1 = \frac{d_1}{t_1 - t_0}\,, v_2 = \frac{d_2 - d_1}{t_2 - t_1}\,, v_n = \frac{d_n - d_{n-1}}{t_n - t_{n-1}}$$

Fig. 10 .7: Definition of Control Limits for Displacement Velocities

As a guideline, the control limits related to measured displacement velocities are defined as follows:

Table 10 .2: Control Limits for Displacement Velocities

Control Limit	Displacement Velocity
ALERT	$\Delta_n = 0.8\ \Delta_{n-1}$
ALARM	$\Delta_n = 1.0\ \Delta_{n-1}$
ACTION	$\Delta_n = 1.1\ \Delta_{n-1}$

10.4.2 Differential Settlements Top Heading Crown – Top Heading Footing

Differential Settlements between the top heading crown and the top heading footing shall be monitored to identify potential instabilities at the shotcrete lining footing:

Differential Settlement: $\Delta s = S_{crown} - S_{footing}$

Table 10 .3: Control Limits for Differential Settlements Top Heading Crown

– Top Heading Footing

Control Limit	Differential Settlement
ALERT	+ 5 mm
ALARM	+ 1 mm
ACTION	- 3 mm

10.4.3 Trend Lines

Control Limits for trend lines are defined in terms of:

$$\frac{\delta}{\text{advance}}$$

With δ = Increase in displacement

Advance = corresponding face advance

Table 10.4: Control Limits for Trend Lines

Control Limit	Limiting Value [mm/mm]
ALERT	10^{-3}
ALARM	5×10^{-3}
ACTION	10^{-2}

10.4.4 Shotcrete Lining Strains

Table 10.5: Control Limits for Strains in Shotcrete Lining

Control Limit	strain in [%]
ALERT	0.2
ALARM	0.4
ACTION	0.6

10.5 CONCLUSION

This report provides information on the methodology of an Observational Design Approach, for tunnel Design after the principles of NATM.

Control parameters are used as an indicator to quickly identify areas of potential stability problems or risk, which consequently shall be observed closer and in more detail. Accidence of control limits may result in application of additional support or implementation of contingency measures. All available monitoring information together with other additional site related information (like geology, excavation activities, etc.) shall be used, compared and related to each other to judge the performance of the rock support and the rock mass behavior, whether it is stable, stabilizing, creeping or unstable.

Regarding control levels and limits it must be emphasized that these limits shall be understood as flexible and adjustable, as during construction activities additional experiences regarding rock mass behavior and rock mass – support interaction will be gained, thus allowing improvements in the definition of limits.

CHAPTER 11
SETTLEMENT AND BUILDING PROTECTION

CHAPTER 11

SETTLEMENT AND BUILDING PROTECTION

11.1 GENERAL

The Contractor shall design both his temporary and permanent works to ensure that ground movements at the ground are kept to an absolute minimum. The Contractor shall use proven techniques. Good workmanship is essential to restrict ground loss.

The Contractor shall be responsible for the control of all ground movements and for any resulting damage to buildings, bridges, tracks and roads. The Contractor's attention is drawn to the General Conditions of Contract and Employer's Requirements relating to repair of damage should any arise as a result of the Contractor's construction activities.

The Contractor shall take due regard of the presence of utilities over and adjacent to the Works. The Contractor shall carefully and regularly monitor the ground adjacent to open cut excavations and along tunnel drives to determine the rate and magnitude of any settlements.

Settlement shall be limited such that any individual structure or buildings shall not suffer damage greater than "Slight" as defined in the Damage Classification Table 11.1.

Settlement to Important Structures, Bridges, and Heritage Buildings shall be limited to "Negligible" as defined in the Damage Classification Table 11.1.

The general approach to settlement control and building protection shall involve the procedures described below.

Table 11.1: Building Damage Classification[1]
(After Burland et al, 1977 and Boscardin and Cording, 1989)

1	2	3	4	5
Risk Category	**Description of Degree of Damage**	**Description of Typical Damage and Likely Form of Repair for Typical Masonry Buildings**	**Approx[2] Crack Width (mm)**	**Max Tensile Strain %**
0	Negligible	Hairline cracks.		Less than 0.05
1	Very Slight	Fine cracks easily treated during normal redecorations. Perhaps isolated slight fracture in building. Cracks in exterior brickwork visible upon close inspection.	0.1 to 1	0.05 to 0.075

1	2	3	4	5
Risk Category	**Description of Degree of Damage**	**Description of Typical Damage and Likely Form of Repair for Typical Masonry Buildings**	**Approx[2] Crack Width (mm)**	**Max Tensile Strain %**
2	Slight	Cracks easily filled. Redecoration probably required. Several slight fractures inside building. Exterior cracks visible: some re-pointing may be required for weather tightness. Doors and windows may stick slightly.	1 to 5	0.075 to 0.15
3	Moderate	Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Tack-pointing and possibly replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Water tightness often impaired.	5 to 15 or a number of cracks greater than 3	0.15 to 0.3
4	Severe	Extensive repair involving removal and replacement of sections of walls, especially over doors and windows required. Windows and door frames distorted. Floor slopes noticeably. Walls lean or bulge noticeably, some loss of bearing in beams. Utility services disrupted.	15 to 25 but also depends on number of cracks	Greater than 0.3
5	Very Severe	Major repair required involving partial or complete reconstruction. Beams, load-bearing, walls lean badly and require shoring. Windows broken by distortion. Danger of instability.	Usually greater than 25 but depends on number of cracks	

[1] The table is based on the work of Burland et al (1977) and includes typical maximum tensile strains for the various damage categories (column 5) used in the stage 2 settlement analyses.

[2] Crack width is only one aspect of damage & should not be used on its own as its direct measure.

11.2 MINIMISING GROUND MOVEMENTS

The work shall be carried out in such a way as to minimize ground movements through immediate installation of support to the ground and to minimize the inflow of water. Care should be exercised to ensure that over excavation does not take place.

Construction from the surface shall be undertaken with due regard to the settlement associated with the particular method chosen.

11.3 PREDICTION OF GROUND MOVEMENTS

The Contractor shall obtain consent from the Engineer for his proposed methods of supporting and predicting settlements adjacent to structures. Proven methods based on practical experience shall be used.

The Contractor shall provide predictive assessments of the anticipated ground movements when making submittal for consent of his proposed method of construction of particular sections of tunnel.

11.4 STRUCTURE CONDITION SURVEY

The Contractor shall undertake a condition survey of all structures within the zone of potential influence as determined by the Contractor's analysis which are anticipated to incur movements in excess of the action level for Stage 1 specified in table 12.1 above. `Structures` includes all surface and sub-surface structures including historical monuments, buildings, bridges, roads, tunnels, utilities, culverts and sewers.

11.5 ASSESSMENT OF IMPACT ON STRUCTURES

The Contractor shall provide an assessment of the effect of the predicted movement on all structures within the zone of influence.

Settlements shall be limited as defined in Sub-Section 12.1 above.

Each building shall be categorised into one of the risk categories, in accordance with criteria listed in column of the Damage Classification Table 10.1.

Depending upon the level of risk, precautionary and protective measures shall be proposed by the Contractor and put into effect after consent from Engineer.

11.6 STAGED ASSESSMENT

Assessment of the effects of settlement shall be undertaken in one, two or three stages, depending upon the findings at each stage, as described below:-

11.6.1 Stage 1

The effect of building foundations on the pattern of settlement is ignored. Any structure where the predicted settlement is less than 10mm and the predicted ground slope is lessthan 1/500 need not be subject to further assessment. All other structures within the zone of influence shall be subjected to a Stage 2 assessment.

11.6.2 Stage 2

Structures subject to settlement from bored tunnels shall be individually assessed using a limiting tensile strain approach. This method of assessment takes into account the tensile strains in the ground and uses a simple idealised model of the building. Tried and tested references from the literature may be utilised as an alternative.

In the case of cut and cover excavations, the assessment shall be based on the work of Peck and Clough and O'Rourke using parameters derived from recent case histories or any other tried and tested method.

11.6.3 Stage 3

All structures which are placed in Category 3 or above in the Damage Classification Table 10.1, during the second stage assessment, shall be subjected to a further settlement assessment. A structural survey shall be undertaken by the Contractor to determine the structural form and condition of a building, followed by an analysis of how individual elements of the building would be affected by the predicted settlement. The method, extent and detail of the analysis will be determined on a case-by-case basis and may include, inter alia, an analysis of the soil/structure interaction, structural behaviour, and the possible effects of differential stiffness of the foundations.

As a result of the Stage 3 analysis, the requirement for any protective works shall be established and the details of any protective works including designs and method of working determined. Details of such works shall be submitted to The Engineer for his consent.

11.7 MONITORING

Monitoring of ground settlement shall be carried out during construction by the Contractor, to check that the ground is behaving as predicted. The Contractor shall submit for The Engineer's consent a monitoring system and procedures to immediately detect movements.

The extent of monitoring of structures shall be carried out on a case-by-case day to day or more frequent basis depending upon the assessment of risk of damage. Special attention

shall be paid to the historical buildings located along the alignment. Monitoring shall begin prior to commencement of the Works to enable base-line values to be determined accurately, and shall continue until all settlements due to the underground works, as shown by the monitoring, has effectively stopped for a period of three months.

The Contractor shall make monitoring results available for inspection by The Engineer at the construction site offices.

CHAPTER 12

OUTLINE DESIGN SPECIFICATION- EARTHWORK IN FORMATION

CHAPTER 12

OUTLINE DESIGN SPECIFICATIONS - EARTHWORK IN FORMATION

12.1 General

This part lays down criteria for design of formation in embankment/cutting.

12.2 Details of Structures to be designed

The Contractor shall design formation in embankment/cutting for various heights that are coming in C4 Package.

Design of embankment/cutting shall include, but not limited to, the following: -–

a) Design of formation for "DFC loading (32.5t axle load)"

b) Slope stability analysis and design of protection measures for erosion control

c) Design of drainage system- longitudinal and cross drains including catch water drains in cuttings.

d) Design of Trolley refuge

e) Design of hume pipe (NP-4) *of 450 mm dia/* Precast RCC box *of size 500 mm x500 mm for crossings future utilities*

f) Any other item which is required for complete design of formation in embankment/cutting

12.3 Design Criteria

For design of formation, the "Comprehensive Guidelines and Specifications for Railway Formation: RDSO/2020/GE: IRS 0004", issued by RDSO (hereinafter written as RDSO Guidelines) shall be followed. The geometric parameters of embankment/cutting shall also conform to Indian Railway Schedule of Dimensions (IRSOD) and Indian Railway Permanent Way Manual (IRPWM). Blanket material shall conform to RDSO Guidelines.

The design criteria for design of embankment/cutting slopes shall be as under-

a) A minimum side slope of 2H:1V for embankment shall be adopted up to 4m height. For higher embankments (more than 4m height.), the slopes shall be designed, however side slope shall not be steeper than 2H:1V.

b) Both 'End-of-Construction' (EOC) and 'Long-Term' (LT) stability with most adverse drainage conditions shall be considered, in design of slope.

c) Design shall be done using effective stress analysis method both for EOC and LT stability conditions, adopting realistic values of shear strength and pore water pressure parameters.

d) Width of berm shall be adequate to suit the mechanical compaction of earth with heavy rollers. However, berm width shall be kept minimum 2m *on banks and 4 m in cuttings*.

e) Erosion Control

i. The slopes of embankments and cutting shall be protected against erosion by providing a protective vegetative cover comprising perennial turf forming grass.

ii. The species of grass should be compatible with the local soil and climatic conditions.

iii. The materials and techniques proposed by the Contractor shall be suitable for the slope height and angle, soil type and climatic conditions and shall perform its function with minimum maintenance requirements.

iv. Coir netting shall be used for turfing of slopes of embankment/cuttings higher/deeper than 4.0m.

v. The coir netting shall not be lighter than 600 g/sqm. It shall conform to IS: 15869 'Open weave Coir Bhoovastra-Specification' and laid as per IS: 15872 'Application of Coir Geotextiles (coir woven Bhoovastra) for Rainwater Erosion Control in Roads, Railway Embankments and Hill Slopes-Guidelines' and IRC: 56.

vi. The contractor shall water and maintain the vegetation cover provided on slopes for a period of 12 months from Taking Over .

f) *Deleted*

g) *Deleted*

h) Drainage Arrangement

i. Top of the formation shall be finished to cross slope of 1 in 30 from centre of formation to both sides in case of single/ double line. However, in case of multiple lines, the cross slope shall be from one end to the other towards cess/drain provided in between.

ii. In the double track section, the longitudinal drain between two tracks shall not be provided *outside station yards*.

iii. In station yard a system of covered/underground pucca longitudinal and cross drains of adequate section shall be designed to ensure efficient drainage as shown in tender drawings. The Contractor shall submit a drainage plan for approval of the Engineer. Such plans should be sufficiently detailed. The longitudinal drains shall be extended as necessary to lead the water clear of the Works to natural drainage courses, culverts or any other suitable outlets.

iv. In high embankments (height > 6m), a system of RCC precast longitudinal drain of adequate capacity shall be designed along the toe of berm and RCC precast chute (at about 50 m interval) to collect and lead the surface runoff safely away from the toe of embankment. A concrete chamber shall be provided at the junction of longitudinal berm drain and chute. The chute shall be extended by about 1.0m beyond the toe of embankment to avoid erosion near the toe of embankment. At locations where retaining is provided, suitable outfall arrangement shall be provided to avoid of retaining wall foundation.

v. *In cuttings, a system of catch water drains of adequate capacity on both sides shall be designed to intercept the surface runoff of adjoining areas from entering into the cutting and to lead the surface runoff safely away from cutting. In addition, longitudinal side drains of adequate capacity on both sides of formation shall be designed to cater to the surface runoff from slopes and formation. Typical Section of cuttings has been shown in Tender drawings.*

vi. All the *cast-in-situ* drains shall be lined with CC of M20 grade.

vii. *Generally,* all the drains shall slope towards the nearest culvert or natural low ground or natural outlets existing nearby where the water shall be discharged with appropriately designed outfall arrangement duly consented by the Engineer.

12.3.1 Trolley Refuge

Trolly refuge shall be designed as shown in tender drawing. It shall be provided at *400m* center to center on each Up and Dn tracks in a staggered manner.

12.3.2 **NP-4** pipe of 450mm diameter, conforming to IS 458, shall be provided at about 500m interval throughout the alignment in embankments having fill heights upto 5m *including ballast cushion*. In embankments having fill heights more than 5m precast RCC box of 500mmx500mm clear size shall be provided for the purpose of future utilities. Installation conditions for the pipe shall be designed as per the IS-783, according to the fill heigh*t.*

12.4 Submittals

Prior to the start of construction operations, the Contractor shall submit to the Engineer all relevant documents, drawings, calculations and data including, but not limited to the following, and shall obtain the approval of the Engineer for the proposed materials, design, construction methods and quality control procedures

a) Geotechnical investigation reports and evaluation of sub-surface conditions along the alignment.

b) The Contractor shall submit the report detailing the identification of borrow areas for formation, blanket material, prepared subgrade. Geotechnical investigation reports for borrow areas duly indicating the soil properties of the proposed borrow areas.

c) Details of earthwork balance (cut & fill), properties of materials to be imported/exported, and management of excess materials. Material test reports for embankment fill, prepared sub-grade and blanket.

d) Cross-section of embankment/cutting along the alignment, at every 50 m interval in straight, at 20 m interval on curve and at junction with the structures

e) Slope stability calculations. Analysis of the stability and settlement of formation and design of remedial measures if required. Details of earthwork design solutions and criteria used

f) Deleted

g) Details of construction equipment.

CHAPTER 13

OUTLINE DESIGN SPECIFICATIONS -: BRIDGES

CHAPTER 13

OUTLINE DESIGN SPECIFICATIONS -: BRIDGES

13.1 General

The Bridges in HORC Project comprises of simply supported Prestressed U-slab / Steel Composite Girders with RCC sub-structure with open/deep foundation and RCC Box Bridges/Culverts.

Minimum Centre to Centre distance between two tracks has been kept as 5.3m according to IRSOD (BG).

All the bridges shall be provided with bridge number plaque, painting of HFL and bridge boards, where required. Approach embankment of minor bridge approaches shall be provided protection measures for a length of 15m on either side as shown in Tender drawings.

Approach embankment of major bridge approaches shall be provided protection measures for a length of 30m on either side as shown in Tender drawings.

13.2 Details of Structures to be designed

13.2.1 Bridges with superstructure of Composite Girder (CG)

Standard RDSO drawings for "25t Loading-2008" will be used for superstructure of bridges with CG. The Contractor is required to design foundation and substructure of these bridges for "DFC loading (32.5T axle load)".

Bridge elements to be designed by the Contractor includes, but not limited to, the following: -

i. Abutments & abutment caps including foundations & wing/return walls

ii. Piers & pier caps including foundations

iii. Load on bearings, design and drawings of bearing pedestals, inspection platforms including arrangements for access from track. Spherical bearings shall be designed and provided at locations where Composite girders are used at gradient.

iv. Provision of jacking arrangements on abutment caps & pier caps for lifting of superstructure

v. Seismic arrestors in pier/abutment cap

vi. Trolley refuge and man refuse on bridges, if required as per IR standards

vii. Provision of supports for placing OHE mast for traction system *of 2x25kv*

viii. Protection works of abutments as per tender drawings

ix. Inspection steps on approaches of bridges

x. Side pathway on bridges for maintenance (Arrangement for pathway shall be provided as per RDSO drawings No. CBS-0046)

xi. Drainage arrangements

xii. Arrangement for supporting signalling & telecom cables and other utilities

xiii. Ground improvement technique/procedures, if required according to the GT data and design requirements along with the method of verification of the bearing capacity after implementation of ground improvement technique.

xiv. Construction methodology

xv. Any other item which is required for complete design and construction of the bridges.

13.2.2 Bridges with superstructure of PSC U- slab

Standard RDSO drawings for "25t Loading-2008" will be used for superstructure of bridges with **PSC U- slab (**post tensioned). The Contractor is required to design foundation and substructure for these bridges for "DFC loading (32.5T axle load)".

Bridge elements to be designed by the Contractor includes, but not limited to, the following: -

i. Abutments & abutment caps including foundations & wing/return walls

ii. Piers & pier caps including foundations

iii. Load on bearings, bearing pedestals, inspection platforms.

iv. Provision of jacking arrangements on abutment caps & pier caps for lifting of superstructure

v. Seismic arrestors in pier/abutment cap

vi. Trolley refuge and man refuse on bridges, if required as per IR standards

vii. Provision of supports for placing OHE mast for traction system *of 2x25kV*

viii. Protection works of abutments as per tender drawings

ix. Inspection steps on approaches of bridges

x. Drainage arrangements

xi. Arrangement for supporting signalling & telecom cables and other utilities

xii. Ground improvement technique/procedures, if required according to the GT data and design requirements along with the method of verification of the bearing capacity after implementation of ground improvement technique.

xiii. Construction methodology

xiv. Any other item which is required for complete design and construction of the bridges.

13.2.3 RCC Box Bridges

RCC Box bridges shall be designed for "DFC loading (32.5t axle load)".

Bridge elements to be designed by the Contractor includes, but not limited to, the following: -

i. RCC Box

ii. Wing wall, return wall, drop wall, curtain wall

iii. Protection works as per tender drawings

iv. Inspection steps at approaches of bridges

v. Ground improvement technique/procedures, if required according to the GT data and design requirements along with the method of verification of the bearing capacity after implementation of ground improvement technique.

vi. Construction methodology

vii. Any other item which is required for complete design of RCC box bridge

Standard RDSO drawing for box culvert shall be followed, *if available*. If standard RDSO drawing is not available for desired sizes/fill height, box shall be designed by the Contractor. However, thickness and reinforcement of the box shall not be less than the closest available box size & fill height of RDSO drawing.

RDSO box culvert for double track are available upto 2m fill height. In case of higher fill heights, the size and reinforcement of box shall not be less than the that of RDSO box for single track with fill height of minimum 2m more than actual fill height.

Any variation from the above, if required due to site constraints shall be adopted after the prior approval of the Engineer.

13.3 Design Requirements

For loadings, load combinations, analysis, and design of structures, all relevant IRS, IS, IRC and other relevant codes shall be followed.

The superstructure/bearing, sub-structure and foundation will be checked for one track loaded condition as well as multiple/all track loaded conditions as well as for single span and two adjacent spans loaded conditions, as the case may be. The analysis and design will be carried out for all possible cases of loadings.

Design of structures shall take into account construction methodology/ construction sequence to be adopted during execution.

13.3.1 Railway Bridges

i. *Superstructure shall* conform to standard RDSO drawings for "25t Loading-2008" except for OWG bridges. Standard RDSO drawings for "DFC loading (32.5t Axle load)" shall be used for OWG.

ii. Substructure and foundation of bridges shall be designed for DFC loading (32.5T Axle load) as per IRS Bridge Rules and other relevant codes.

iii. Bridges shall be designed to accommodate curvature of the track alignment, wherever required.

iv. All ballasted deck bridges shall be capable of carrying long/continuously welded rail (LWR / CWR) as per the provisions of "UIC-774(3R) and RDSO guidelines.

v. Side pathway with hand railing shall be provided on steel superstructure bridges on outer side of Up & Down track *as per RDSO drawing No. CBS-0046 (Typical Plan of Side Pathway in Standard Composite Girders)*.

vi. Hand railing shall be provided for trolley/man refuge and inspection platforms on bridges. The design shall be such that it can be easily maintained and replaced, if required.

vii. Adequate arrangement shall be made on the bridges for providing electrical/ telecommunication cables and other utilities as required. Specifications and guidelines of the owning agencies in such cases shall be followed.

viii. Arrangements for enabling inspection of superstructure and bearings shall be provided as per RDSO report BS-113.

ix. Bridge bearings shall be as per corresponding standard RDSO drawings for bearings. All bearings shall be replaceable without major disruption to railway operations or to any activity underneath the bridge. Bearings shall be placed on bearing pedestals designed in accordance with applicable codes. Appropriate jacking points, on the pier/abutment cap in consideration with the requirements for lifting of superstructure, shall also be provided. The bearings shall be sandwiched between two true horizontal surfaces. Steel Wedge shall be provided to cater to longitudinal slope of superstructure, wherever required.

x. Expansion/Movement Joints/gaps and other necessary measures to control shrinkage and thermal effects shall be incorporated in the structural design so that the performance of the bridge/structures are not adversely affected during normal working conditions. Movement joints shall be designed so as to be easily maintained and replaceable.

xi. Height gauge for road – under – bridges shall be as per RDSO drawing no. RDSO/M-0001. *If RDSO drawing is not available, the Contractor shall design height gauge for the required span considering applicable loading. However, the section of height gauge shall not be less than RDSO drawing No. RDSO/M-0001.*

xii. *Minimum depth of foundation of waterway bridges shall be scour depth plus 1.75m below the bed level.*

13.3.2 RCC Box Bridges

i. Bridges shall be designed for "DFC loading (32.5t axle load)". In addition, the design shall consider the loading standards as applicable to the type of the crossing/existing road or Class A/Class 70R loading as per IRC 6-2017, as the case may be.

ii. *Size of the Box openings (minimum required) has been shown in the conceptual GADs. Height of box shown includes clear height and wearing coarse of 150mm. Overall height of box may vary as per site requirement and actual road/ground profile.*

iii. Barrel length of the culvert shall be decided based on the fill height and ROW.

iv. *Top of bottom slab of RCC box shall not be kept above the natural ground level beside the road. However, road level and vertical clearance above the road shall be maintained as shown in Tender drawings. Any variation due to site conditions as mentioned above shall be got approved from the Engineer*.

v. Fill Depth shall be the height of fill from the bottom of the sleepers to the top of the box and shall be inclusive of depth of ballast and depth of soil fill as per IRS Concrete Bridge Code (CBC).

vi. All waterway bridges shall be protected by a well-designed flooring system. The concrete floor shall be protected by curtain wall at upstream side and drop wall at downstream side. *Minimum depth of the curtain wall and drop wall shall be scour depth plus 1.75m below the bed level.*

vii. Other Requirements:

a. Deleted.

b. *The approach roads to the RUBs shall be provided from RCC box to ROW of HORC for the width equal to clear opening of RCC box in concrete of M35 grade.*

c. Height gauge for road – under – bridges shall be as per RDSO drawing no. RDSO/M-0001. If RDSO drawing is not available, the Contractor shall design height gauge for the required span considering applicable loading. However, the section of height gauge shall not be less than RDSO drawing No. RDSO/M-0001.

d. Crash Barriers / medians / footpaths / railings shall be provided as per the requirements of IRC Codes.

e. Inspection Steps shall be provided wherever required.

f. *Deleted*.

g. Provision for signages shall be kept on both side of RUBs.

h. Deleted

Detailed Design criteria for of the Bridges shall be as per the below mentioned Outline design specifications criteria.

13.4 Outline Design Specifications Criteria

13.4.1 ROADWAY AND RAILWAY CLEARANCES

The alignment of HORC crosses several existing roadways and existing railways. The general clearance requirements for these crossings shall be as follows:

a) CLEARANCES FOR ROAD TRAFFIC

Vertical clearance for road traffic shall generally be 100 mm more than the clearance specified in Clause 104.4.2 of IRC: 5 *or as per Conceptual GAD, whichever is more*.

General Arrangement Drawings at road crossings shall be approved by the owning authorities/stake holders.

b) CLEARANCES FOR ROLLING STOCK

Clearance for railway traffic shall be as per Schedule of Dimensions of Indian Railways. General Arrangement Drawing at railway crossings shall be approved by the relevant Railway Authority.

13.4.2 MATERIALS PARAMETERS

a) CONCRETE

1) Grade of Concrete & Cover

Grade of concrete shall be M-35 for RCC works and M-20 for plain cement concrete including levelling course. However, grade of concrete for bearing pedestals and seismic restrainers can be higher if required.

In case of foundation, cover shall be taken as 75mm for all conditions of exposure. For substructure, cover shall be taken as 50mm.

2) Cement

The minimum cementitious material content, maximum water-cement ratio, total chloride content by weight of cement shall be as per IRS-CBC.

3) Density

Density of concrete shall be taken as 25 kN/m^3 for PSC and RCC, 25 kN/m3 for Plain cement concrete and 26 kN/m3 for wet concrete.

4) Poisson's Ratio

Poisson's ratio for all grades of concrete shall be taken as 0.15.

5) Thermal Expansion Coefficient

Coefficient of thermal expansion shall be taken as 11.7 x10^{-6} ºC in accordance with IRS-Bridge Rules.

6) Time-Dependent Characteristics of Materials

Long-term losses should be calculated in accordance with IRS- CBC.

The design shall be done according to construction sequence to be adopted at site.

b) REINFORCEMENT STEEL (REBARS)

High strength deformed (HYSD) reinforcement bars of minimum Fe-500D grade, conforming to IS 1786 shall be used.

Young's Modulus (E)	=	200,000 Mpa
Yield Stress(fy)	=	500 MPa.
Density	=	78.5 kN/m3

c) STRUCTURAL STEEL (FOR COMPOSITE GIRDERS & OTHER STEEL STRUCTURES, IF ANY)

Structural steel used for composite girders and miscellaneous use such as railing, supporting utilities, coverings etc. shall be as follows:

1) Structural Steel for Composite Girders

(a) General

Structural steel conforming to IS: 2062(Grade E250-*B0*/E350 – B0) shall be adopted.

Fabrication shall be done as per provisions of IRS B1 (Fabrication Code).

Design of steel structures shall be done as per IRS steel Bridge Code.

IRC Code: 22 shall be referred for steel-RCC composite construction.

Welding shall be done following IRS Steel Bridge Code, IRS Welded Bridge code or relevant IS codes for welding.

(b) Young's Modulus shall be taken as 210000MPa as per IRS- Steel Bridge Code.

(c) Density: 7850 kg/m3

(d) Poisson's Ratio: 0.30 as per IRC: 24-2010.

(e) Thermal Expansion Coefficient: 12x10-6 as per IRC: 24-2010

2) Structural Steel for Miscellaneous Use

The design of miscellaneous steel structures shall be done as per IS: 800 and related provisions.

Hollow steel sections for structural use shall be as per IS: 4923.

Steel tubes for structural purpose shall be as per IS: 1161.

Steel for General Structural Purposes shall be as per IS: 2062(Grade E250-*B0*/E350 – B0).

13.4.3 LOADS TO BE CONSIDERED FOR DESIGN

Following loads shall be taken into consideration for analysis and design of structures as prescribed in IRS-Bridge Rules up to latest up-to-date correction slip.

i. DEAD LOAD

Dead load shall be based on the actual cross section area and unit weights of materials and shall include the weight of the materials that are structural components of the bridge and permanent in nature.

ii. SUPER IMPOSED DEAD LOAD (SIDL)

Superimposed dead loads include all the weights of materials on the structure that are not structural elements but are permanent. It includes weight of track from ballast/sleepers/rails/ fasteners/ cables/parapet/ hand-rail OHE mast/ cable trough/ Signaling equipment etc.

iii. SHRINKAGE & CREEP

Shrinkage and Creep effects will be calculated as per IRS CBC.

iv. LIVE LOAD (LL)

(a) Railway Vehicular Load

Live load shall be followed as per Sub-Clause 2.3 of IRS Bridge Rules.

(b) Dynamic Augmentation

CDA shall be considered as specified in IRS Bridge Rules.

(c) Footpath Live Load

Footpath live load shall be taken as 490 kg/m^2 as per IRS Bridge Rules

(d) Longitudinal Force

Longitudinal force shall be followed as per clause 2.8 of IRS Bridge Rules.

Tractive force of one track and braking force of another track will be taken in the same direction to produce worst condition of loading.

(e) Centrifugal Forces Due to Curvature of Superstructure

The horizontal centrifugal force due to moving load in curved alignment is to be considered as per IRS: Bridge Rules.

For double stack containers, this force shall be considered to act at a height of 3m (same as in case of DFC loading) above rail top level.

(f) Racking Force

The horizontal transverse force due to racking as specified in IRS-Bridge Rules shall be considered.

v. Earth/Surcharge load

Earth pressure and surcharge load/pressure shall be taken as per the provisions of IRS Substructure & Foundation Code.

vi. TEMPERATURE EFFECTS

(a) Temperature

(i) Overall Temperature (OT)

The loads shall be considered as per IRS-Bridge Rules and IRC:6. Temperature variation of +/- 35°C shall be considered, details of which are given below

Maximum Temperature considered as per Annex. F of IRC 6: +49°C

Minimum Temperature considered as per Annex. F of IRC 6: -0.4°C

Temperature variation as per Clause 215.2 of IRC 6 will be = (49-(-0.4)/2+10=34.7°C say 35°C.

(ii) Differential Temperature (DT)

The provision given in IRC 6, shall be considered to compute effect of differential temperature gradient in the absence of any provisions in IRS code.

(b) Deleted

vii. WIND LOAD (WL)

The wind load shall be calculated as per IRS: Bridge Rules and IS: 875 (Part 3).

Vb = Basic wind speed = 47 m/s for Delhi Zone (as per IS 875).

viii. SEISMIC FORCE (EQ)

Seismic design philosophy as stated in IRS Seismic Code shall be adopted.

HORC project area lies in Seismic Zone IV of seismic zone map of India. The peak ground acceleration denoted as zone factor shall be taken as 0.24 for zone IV.

Seismic Coefficient Method (SCM) shall be adopted for calculation of seismic forces.

Design horizontal seismic coefficient (Ah) shall be calculated as per Sub-Clause 9.4.1 of IRS Seismic Code. The expression is -

$$Ah = (Z/2) * (I/R) * (Sa/g)$$

Where,

Z = zone factor = 0.24

I = importance factor = 1.5

R = response reduction factor as per Table 3

Sa/g = average acceleration coefficient

The design vertical seismic coefficient shall be 2/3 of horizontal seismic coefficient.

Seismic load combinations shall be considered as per IRS Seicmic Code.

Seismic on soil mass behind the abutment and confined between the retaining wall shall be considered in addition to dynamic increment in earth pressure.

Reinforcement detailing of Piers/Portal Piers and joints with pier cap and foundations shall conform to ductility/capacity design requirements as per Annexure-B of IRS Seismic Code.

ix. ERECTION TEMPORARY LOADS (ETL)

Erection forces and effects shall be considered as per IRS-Bridge Rules.

The weight of all permanent and temporary materials together with all other forces and effects which can act on any part of structure during erection shall be considered in design.

Special care shall be taken that no damage is caused to the permanent structure during construction.

x. DERAILMENT LOADS (DR)

Check shall be made in accordance with the IRS-Bridge Rules.

xi. FORCES ON PARAPET

The parapets shall be designed to resist lateral horizontal force & a vertical force as per IRS Bridge Rules.

xii. DIFFERENTIAL SETTLEMENT (DS)

Differential Settlement (post construction) between two adjacent bridge piers shall be considered as follows:

12mm for Long Term Settlement

6mm for Short Term Settlement

Differential settlement shall be considered only in the design of continuous structures, if any.

xiii. BUOYANCY LOADS

The design of the foundation shall be done considering design ground water table as per Chapter-2 Outline Design Specifications-General.

In case of river/waterway bridges, stability check and calculation of base pressure, full buoyancy shall be considered on submerged portion of substructure and foundation up to HFL or LWL as the case may be, irrespective of the type of soil on which the foundation will rest.

Hydro dynamic forces will be considered as per IRS Seismic code.

xiv. WATER CURRENT FORCES

Water current force in submerged portion of substructures and foundations shall be calculated as per IRS Bridge Substructure & Foundation Code.

(a) VEHICLE COLLISION LOAD (VCL)

The vehicle collision load on piers: as per of IRC: 6.

All structure near railway track shall be checked for accidental impact from derailed trains as per IRS Bridge Rules as per Addendum & Corrigendum Slip No. 48 dated 22.06.2017.

(b) VIBRATION EFFECT

Effect of vibration due to movement of train on bridge structure shall be taken into consideration. This will be checked through dynamic analysis.

xv. LOAD COMBINATIONS

Provisions of IRS-CBC shall be followed. The partial load factors and load combinations shall be as per IRS-CBC.

Notes:

ULS-Ultimate Limit state.

SLS-Serviceability Limit state

Wind load and earthquake loads shall not be assumed to be acting simultaneously.

Load combination for Vehicle collision shall be as per IRC 6 but design of members under vehicle collision load combination shall be carried out as per IRS CBC.

13.4.4 DESIGN CHECK

a) FOR REINFORCED CONCRETE STRUCTURE

Design of all RCC/PSC structures shall be done as per IRS CBC for Serviceability Limit States (SLS) and Ultimate Limit State (ULS)

b) DESIGN CHECK FOR STEEL/COMPOSITE STRUCTURE

The design of steel structure shall be done as per IRS Steel Bridge Code/IRS-Welded Bridge Code. For composite action IRC :22 shall be referred.

c) DURABILITY & CRACK WIDTH

(a) DURABILITY

Provision of IRS-CBC shall be followed. The exposure condition is Moderate and in case of Nallah crossing the exposure condition may be treated as "Severe".

(b) CRACK WIDTH CHECK

For SLS Combination, crack width in reinforced concrete members shall be calculated as per IRS-CBC.

The allowable crack width shall be as per exposure conditions given in IRS-CBC.

(c) DEFLECTION

Deflections shall be taken into account as per IRS: CBC while checking appearance, efficiency of the structure and minimum specified clearances. Clause no. 13 of IRS CBC shall be kept in view while calculating deflection/deformation. Permissible values of deformation shall be in accordance with provision of UIC-776-3R.

d) FATIGUE

Fatigue phenomenon shall be analyzed for those structural elements that are subjected to repetition of significant stress variation (under traffic load).

(a) PRESTRESSED/REINFORCED CONCRETE STRUCTURE

The fatigue shall be checked as per IRS-CBC.

(b) STEEL/STEEL COMPOSITE STRUCTURES

IRS-Steel Bridge Code (up to latest correction slip) / IRS-Welded Bridge code shall be adopted for fatigue check of structural steel members and connections.

Annual Traffic Density for fatigue checks shall be considered as 50 GMT (Gross Million Tonnes per annum) per track (i.e. 100GMT for two tracks).

Simplified approach method given in Cl.14 of Appendix-G (Fatigue Assessment of steel bridges) shall be followed for fatigue assessment.

13.5 Drainage

The drainage of deck shall be designed to cater the maximum envisaged rainfall intensity and suitable longitudinal and transverse slope should be provided. Moreover the provisions of Clauses-10 & 15of IRS-CBC shall be followed.

The top of soffit slab will be profiled so as to collect the run-off water at multiple points by providing a cross slope of 2.5%. Drainage pipes will be provided to collect the run-off.

The drain pipe of double wall HDPE corrugated pipes with water collection box at top, shall be provided to discharge the water along pier with most pleasant aesthetics.

13.6 BEARING SYSTEM

(a) Type of Bearing System

In case of RDSO girders, standard bearing drawings shall be followed.

(b) Replaceability of Bearings

While finalizing the proposed bearing system, it shall be kept in mind that accessibility and replacement of each part of bearing are of paramount importance as the design life of bearings is shorter than that of the structure. Keeping in view the above cited criteria, all the bearings, pedestals and pier caps will be detailed for replacement of bearings in the future. The girders/end diaphragms shall be designed to facilitate the operations of jacks during maintenance.

(c) Uplift

If required a holding-down device connecting the deck and the pier head shall be placed in order to prevent the deck from overturning. The holding-down device may be integrated in the bearing system or be a separate system constituted of bars embedded in pier cap and bridge with appropriate details, permitting translation/rotation. Other systems can also be foreseen.

Due to the lack of appropriate guidelines in Indian codes, the design criteria for holding down device (upward force limit requiring holding down device, design formulas) will be taken from the latest international practice.

13.7 SUBSTRUCTURE SYSTEM

(a) Pier Cap

For designing the pier cap as corbel the provisions of IRS-CBC should be followed. In case of shear span to effective depth ratio being more than 0.6, pier cap will be designed as flexural member.

Height of pedestal should be in between 150mm and 500mm as per IRC: 78.

The Pier cap shape shall be suitable at transition pier supporting different types of superstructure instead of providing raised/column pedestal over pier cap.

(b) Piers

The effective length of a cantilever pier for the purpose of slenderness ratio calculation will be taken as per IRS-CBC. Ductile detailing is mandatory.

The design of pier shall be done as per IRS CBC. *Shear reinforcement and ductile detailing shall be done as per IRS CBC.*

In all SLS combinations, pier/column shall remain in compression.

(c) Foundation System

Foundation shall be designed as per IRS Bridge Substructure & Foundation Code, IRS Concrete Bridge Code, IRC-78, Manual on the design and construction of well foundation, IS- 2911.

Shear reinforcement & ductile detailing shall be done as per IRS/IS Codes.

i. Open Foundation

Open foundation has been contemplated as first choice. Soil replacement may also be resorted, if the difference of bearing pressure and bearing capacity is upto 20%, keeping other practical aspect and site conditions in mind.

Deep foundation shall be provided at the locations as shown in the tender drawings.

ii. Pile Foundation

In case of Pile foundation, foundation analysis and design will be based on IRS Code for Substructure & IRC-78. The forces applied by the pier are transferred to the bottom of the pile cap for this purpose. Reactions in pile are calculated using Rivet theory. The various specific assumptions made for the pile and pile cap design are as follows:

a. Bored-cast-in-situ multiple pile groups will be adopted.

b. Minimum 1.2m diameter (unless specified otherwise in tender drawing) bored cast-in-situ vertical piles in soil/rock have been contemplated for the foundation of piers. Minimum number of pile in each pile cap shall not be less than 4.

c. For piles and pile caps, load combinations shall be considered as per IRS-CBC, Table-12. The various specific assumptions made for the pile and pile cap design including pile load testing shall be as per IS: 2911, IRC-78 and IRS-Bridge Sub-structure and Foundation Code.

d. For pile bearing capacity, all SLS Load combinations as per IRS-CBC will be considered.

e. Increase in vertical load capacity of pile shall be done as per Table-1 of IS 1893-Part-1.

f. The lateral load capacity of pile shall be evaluated by using empirical formulae given in IS: 2911 (Part-1/ section-2) .

g. Initial load tests (not on working pile) will be conducted as per IS: 2911 - Part IV. Initial test is proposed to be conducted for a load of 2.5 times as per the safe load based on static formula.

h. The working load on pile for vertical and horizontal loads shall be verified through routine load tests during construction.

i. In case of multiple pile system, spacing between the piles shall not be less than 3 times the diameter of pile in soil and 2.5 times the diameter when founded on rock.

j. In general, the top of pile cap shall be kept about min 500mm below the existing ground level and weight of the earth cover will be applied on top of pile cap when unfavorable. The earth cover on pile cap for any favorable effect (stability, soil horizontal capacity.) will be neglected.

k. In case the location of foundation (all types) is within Load Impact Line of nearby passing load(rail/road) then the effect of surcharge (dead load + live load) corresponding to that passing load shall be taken into account.

l. Pile design shall be done according to IRS CBC. However, for crack control in piles, it will be clarified that actual axial load will be considered to act simultaneously.

m. Where there is a risk of liquefaction, the lateral soil resistance of the liquefied layer will be taken as zero.

n. Pile cap shall be designed based on IRS –CBC 1997. No support from soil below pile cap shall be considered.

o. The thickness of the pile cap shall be kept minimum 1.5 times diameter of the piles for multiple-pile group as per IRC 78.

p. The structural design of the pile cap shall be carried out as IRS CBC. Crack width shall be checked for load combination 1 IRS CBC.

q. Minimum reinforcement in pile caps at top shall be at least 0.12% in each direction in case of compression and in case of tension, it shall not be less than 0.2%.

iii. Well Foundation

Well Foundation shall be designed as per IRS Bridge Substructure & Foundation Code/ IRC: 78, IRS-CBC, Manual on the design and construction of well foundation.

13.8 CODAL PREFERENCE

The IRS Codes shall be followed in principle. Although main clauses have been mentioned in the ODS, the other relevant clauses as available in the IRS codes shall also be followed, whenever applicable. If provisions are not available in IRS, the order of preference shall be as follows, unless specified otherwise:

For railway loading related issues:

I. UIC Codes

II. Euro Codes

III. Any other code, which covers railway loading.

For other Design/ detailing related issues:

I. IS Codes

II. IRC Codes

III. EURO Codes

IV. AASHTO Codes

V. Any international code with approval of HRIDC.

CHAPTER.14

OUTLINE DESIGN SPECIFICATIONS: RETAINING WALLS

Deleted

CHAPTER 15
OUTLINE DESIGN SPECIFICATIONS: BALLASTLESS TRACK (BLT)

CHAPTER 15

OUTLINE DESIGN SPECIFICATIONS: BALLASTLESS TRACK (BLT)

15.1 GENERAL

i. HORC proposes to adopt BLT systems, which are proven and being used worldwide in railways successfully. The proven design may require some modifications to suit to HORC conditions.

ii. Operating Regime on HORC:

a) Axle load and Speed

Traffic Type	Axle Load	Speed
Goods Train	32.5T	100 kmph
Passenger Train	22T	160 kmph

b) Electric Traction (Minimum) : 25 kV AC.

c) Track Circuits : DC.

d) Gauge : Broad Gauge Nominal (1673mm)

e) Ambient Temperature : (-) 5˚C to 50˚C.

f) Rail Temperature : (-) 15˚C to (+) 76˚C.

g) Humidity : 100%

Note: The temperature range shall be commensurate with other provisions / guidelines through codes / manuals / specific circulars.

15.2 DESIGN REQUIREMENTS

i) BLT shall be designed for the following:-

a. Goods Traffic - 32.5T axle load & speed 100 kmph

b. Passenger Traffic- Main line for 22T axle load & speed 160 kmph (for passenger traffic)

ii. Dynamic augment may be taken as 2.5 (as prevailing on IR).

iii. Spacing of supports to rails – not more than 60 cm (wherever rails are supported on sleepers/ discrete supports) so that the permissible bending stress in rails are not exceeded beyond stipulated values. No joint shall be permitted in track on BLT and the transition portion. The values of permissible bending stress are as under:-

For LWR section – 25.25 km/mm² (for 90 UTS).

iv. Upward reaction / pressure from support base shall be clearly mentioned in design.

v. Design shall be as per relevant codes of practice such as BIS, EN, IRS, IRC and UIC with latest revision/ edition. If for any item/work, above mentioned codes are not relevant, best available Engineering practice / International codes shall be mentioned.

vi. Design & detail of suitable Transition System for smooth transition from ballasted track to BLT on both ends shall be part of the design.

vii. Design and detail of Expansion / Construction Joints in BLT at suitable intervals shall be part of the design.

viii. Technical parameters required for foundation of BLT shall be suitably considered for site conditions and shall be mentioned in the design along with their test code & procedure, A design monograph of varying sub-grade characteristics, if applicable, to be provided by the firm / designers.

ix. Design service life of BLT shall be a minimum of 60 years. Concrete for RCC structures shall comply with relevant para of Indian Standard IS: 456-2000 & relevant para of IRS-Concrete Bridge Code taking care of relevant durability clause for expected life of RCC as minimum 60 years.

x. BLT may get submerged during heavy rainfall. Suitable arrangement shall be provided for ensuring that BLT functions properly under submerged conditions. Provision of adequate cross slope for drainage purpose and suitable measures to prevent ingress of water must be considered. Design of proper drainage arrangements preferably sub-surface drains for BLT shall also be part of design. Design capacity of drainage system shall be adequate enough for the discharge from slab track and remaining catchment other than track slab for regular daily discharge and also discharge from rainfall as per the local conditions. Top surface of BLT shall have surface finish with proper cross slope such that there is no stagnation of water over it. Necessary field visit to ascertain local conditions may be done for suggesting suitable drainage system.

xi. No appreciable cracks or settlements or separation of parts shall be developed during service in the BLT leading to impaired service or failure. Minimum reinforcement must be ensured to achieve design crack width of 0.1 mm notwithstanding any provision in codes.

xii. BLT shall be designed for almost maintenance free conditions except replacement of worn-out fastening components after their service life is over. The 2% of the fastening components and other replacement items which are likely to be worn out / damaged ,shall be supplied as spares for need based replacement in this work. The offer shall be inclusive of the cost of 2% fastening components as spare. No additional cost shall be paid for the spares.

xiii. Stable formation is required to be provided below BLT as per the RDSO guidelines (No. RDSO/2020/GE: IRS-0004). Minimum bearing capacity at subgrade top level of 10 tons/sq.m shall be ensured. Ground improvement may be required before construction of BLT which need to be designed to avoid problems due to inadequacy of its formation.

xiv. The proposed system shall be easy to repair and expeditious to restore in case of damage due to derailment. The time & material requirement for repair shall be clearly defined along with detailed procedure of repair.

xv. Cost effective design & methodology with reasonably less construction period with opening of traffic with suitable speed restriction would be preferable.

xvi. A scheme giving details of the curing arrangements shall be submitted by the designer to ensure curing in conformity to the IRS- concrete Bridge Code and best international practices.

xvii. Adequate corrosion protection measures must be included in design to minimize corrosion of fastening components of proposed system for ballastless track as corrosion of fastening components in BLT is a major problem due to climatic condition and waterlogging due to rainfall. Adequate corrosion protection measures should be submitted as per EN 13146-6: 2012 –Test methods for fastening system – Effect of severe environmental conditions and corrosion test shall be done as per EN ISO 9227/ASTMB117-11, Corrosion tests in artificial atmospheres – salt spray tests for exposure period of 1000 hours (for Normal Salt Spray Test) and results shall meet the requirements of EN 13481-5:2012 regarding corrosion in fastening system.

Note:
The qualifications of DDC given above are based on Railway Boards letter No. 2016/39/CE-III/BR/BLT dated 06.02.2018. If the criteria given in Railway Boards letter is modified by Railway Board / concerned government authority / RDSO, the same will be followed. However, the modified criteria will not be stricter than the criteria given above.

xviii. The design shall be cost effective serving all functional requirements expected of BLT.

xix. Any other factor considered necessary by the designer.

Changes in the above parameters (ii) and (iii) may be considered, in case the Contractor is able to support it with the relevant documents and codes as per practice in other Railways.

15.3 TRACK DETAILS

BLT for HORC shall be designed for following track details:-

i. Rail section: Rail profile shall conform to UIC 60 (R260) and Rail material shall conform to IRS-T-12-2009 class-'A' including manufacturing and testing in accordance with IRS-T-12-2009 with latest amendments.

ii. Schedule of Dimensions (SOD) and Maximum Moving Dimension (MMD) of Indian Railways for BG shall be followed.

iii. Rail cant at Rail seat (inward): 1 in 20.

iv. Traffic: Mixed – passenger & freight.

v. During service if some parameter goes out in case of any unforeseen circumstances, the leeway / margin available to correct the parameter. Vertical: +10 mm / - 3mm, Horizontal: ± 3 mm.

vi. Design temperature range: 70 degree Celsius variation of rail temperature as per zone & chart of Indian Railway Permanent Way Manual and 40 Degree variation of

ambient temperature.

vii. Long welded rails (LWR) are to be used. The proposed design of BLT shall take into consideration of the forces due to LWR and interaction of LWR.

viii. It should be possible to do in-situ AT/Flash Butt welding as per the Indian Railways welding manuals.

ix. Track tolerances: Track tolerances over BLT when installed and later during service under floating condition shall be as under.

Note: The temperature range shall be commensurate with other provisions / guidelines through codes / manuals / specific circulars.

1.1 TABLE NO: 1

S. No.	Parameter	Installation	Service
1	Gauge (with reference to 1673 mm measured below 14 mm rail top) for straight track and for curve up to the radius of 350 m.	± 1mm	± 3mm
2	Cross level on straight and curved track	± 1 mm	± 3mm
3	Variation in versine on curved track(20 m chord with half overlapping)	± 3 mm	± 6mm
4	Vertical alignment over a 3.6 m chord	± 1 mm	± 6 mm
5	Lateral alignment over a 7.2 *m* chord	± 1 mm	± 3 mm
6	Twist on 3.6 m base	± 1mm	± 5mm

The above installation parameter are not sacrosanct and the Contractor can also advise their own limits for the above parameters along with basis for suggesting the changes. Variation in horizontal alignment, vertical alignment versine, twist and gauge shall not exhibit cyclic pattern.

15.4 TRACTION DETAILS

IR has diesels/Overhead Electric (25kV) traction. The BLT design shall have adequate electrical insulation for correct performance of signaling and traction equipment even in flooded condition during monsoon for which necessary local field visit may be done and the design should take care of return current as per traction.

15.5 SIGNALING DETAILS

For signaling, the track circuiting is provided through the rails. The BLT system should take care of the same with adequate insulation. A minimum electrical resistance of 40 Ω per km as per Indian railway signaling manual needs to be ensured.

15.6 DERAILMENT GUARDS

Suitable arrangements for prevention of derailment in tunnels/ viaducts as per instructions issued by Indian Railway from time to time in the form of derailment slab/ block shall be provided to keep the derailed wheels in confined space and prevent damage in case of derailment. Derailment guard shall be designed such that in case of derailment:

i. The wheels of a derailed vehicle under crush load, moving at maximum speed are retained on the viaduct or tunnel etc.

ii. Damage to track and supporting structures is minimum.

15.7 BALLASTLESS TRACK STRUCTURE

Track shall be laid on cast in situ reinforced concrete plinth or slab, herein after referred to as the "Track slab". The track slab shall be designed as plinth beam or slab type ballastless track structure. It shall accommodate the base plates of the fastening system. The minimum depth of concrete below the base plate should be decided based upon characteristics of underlying base and the design of the fastening system. In general, track slab on which the fastening and rail are to be fitted shall-

1. Resist the track forces.
2. Provide a level base for uniform transmission of forces from the rails.
3. Have geometrical accuracy and enable installation of track to the tolerances laid down.
4. Ensure drainage.
5. Resist weathering.
6. Be construction friendly, maintainable and quickly repairable in the event of a derailment. The Repair and Maintenance methods shall be detailed in the Maintenance Manual.
7. Ensure provision for electrical continuity between consecutive plinths/slabs by an appropriate design.

15.8 PERFORMANCE REQUIRED OF FASTENING SYSTEM

15.8.1 GENERAL

i. The fastening shall be designed to hold the two rails of the track strongly to the supporting structure in upright position by resisting the vertical, lateral and longitudinal forces and vibrations.

ii. The fastening shall be with a proven track record. Fastening system should have satisfactory performance record of minimum 5 years in service in BLT on any

established railway system. In this regard, supplier should submit certificate of performance from user railways administration including proof of use of the fastening system.

iii. The fastening shall provide insulation to take care of return current traction system.

iv. Fastening shall satisfy the required performance norms as stated in the following paragraphs.

15.8.2 TECHNICAL PERFORMANCE REQUIREMENTS OF FASTENING

The fastening shall-

i. Have design service life of 30 years in general. However, its components such as rubber pad, rail clip etc. can be designed for 300 GMT or 15 years whichever is less.

ii. Anchor bolts or studs used for fixing base plate to the concrete should not be required to be replaced during service life. Its components must not suffer any degradation during its service life to a degree so as to affect the performance and safety of the track. Full service life is to be attained under the following condition-
   a. Atmospheric ultra violet radiation
   b. Proximity of track up to 10m from salt water source
   c. Contact with oil, grease or distillate dropped from track vehicles

iii. Hold the rails to gauge and at the correct inclination within, tolerances laid down against horizontal forces generated by vehicles in motion especially on curves, and wheel set hunting, alignment irregularities and thermal forces.

iv. Permit quick and easy installation and replacement with special tools.

v. Be capable of vertical adjustment during service life up to 12mm using shims.

vi. Detailed calculations for the number of anchor bolts required on tangent and curved tracks shall be furnished by the contractor and approved by the Engineer.

vii. For all the fastening components as per approved assembly, the contractor shall furnish detail drawings, specifications and inspection & test plan to the Engineer.

viii. The contractor shall furnish the 'Installation and Maintenance Manual' which shall be approved by the Engineer.

15.9 SPARES

The Contractor shall supply *spare track fastenings and fittings equal to* 10% of the total requirement for the permanent works.

CHAPTER 16
LIST OF CODES

CHAPTER 16

LIST OF CODES

16.1 Introduction

The Contractor shall carry out the design on the basis of the codes and specifications given below. The list of codes mentioned herein is only for guidance. The Contractor may supplement these codes and standards with the consent of the Engineer if in his opinion it is essential to do so to comply with the Employer's Requirements.

The Contractor shall be responsible for detailing in his design report and specifications of the standards on which his materials and workmanship will be based and these will be of similar or higher standard than those listed below.

The Contractor shall also be responsible for getting the approval from the Engineer for the standards which he intends to apply for the detailing of his design and specifications additionally.

16.2 Relevant Standards

Apart from the basic data and specific requirements listed in the Employer's Requirement, all items of the Works shall be governed by the latest versions of the following codes and specifications as revised/corrected/amended (with latest correction slip) till the date of *opening of the Tender*. In case of contradiction in various codal provisions, the order of precedence shall be as follows:-

i. Specific provisions in the Employer's Requirements.

ii. IRS Codes and specifications

iii. IS Codes

iv. IRC Codes and specifications

v. International Codes

However, in case of ROBs and other highway loading related structures, IRC Codal provisions shall prevail over IRS Codal provisions. Notwithstanding the precedence specified above, the Contractor shall always seek advice from the Engineer in the event of any conflict for a final decision.

a) Loading Standards shall be as given in Design Requirements Criteria

b) Indian Railway Standard Codes and Specifications (IRS)

i. Bridge Rules

ii. Indian Railways Schedule of Dimensions (BG)

iii. Concrete Bridge Code

iv. Steel Bridge Code

v. *B1-Specification for fabrication and erection of steel girder bridges*

vi. Welded Bridge Code

vii. Indian Railways Bridge Manual

viii. Indian Railways Permanent Way Manual

ix. Indian Railways Works Manual

x. Bridge Substructure & Foundation Code

xi. Well and Pile Foundation Code

xii. Seismic Code for Earthquake Resistant Design of Railway Bridges

c) RDSO Guidelines

i. BS-113 Guidelines for providing Arrangements for Bridge Inspection

ii. Comprehensive Guidelines and Specifications for Railway Formation: RDSO/2020/GE: IRS 0004

iii. BS-114 RDSO guidelines for carrying out rail-structure interaction studies on Indian Railways

iv. BS-126 Guidelines for continuation of LWR/CWR over ballasted deck bridges on Indian Railways

v. Report No. GE: R-50: Transitional System on approaches of bridges issued by RDSO.

vi. Report No. BS-111: Guidelines for use of High Strength Friction Grip (HSFG) bolts on bridges on Indian Railways.

vii. Guidelines for design of Spherical and Cylindrical bearings (in case of Steel Bridges).- Letter No.: RDSO/CBS/Bearing dated 22-06-2011

viii. RDSO drawing for H beam sleepers

ix. RDSO guidelines for steel girders

d) Indian Road Congress (IRC) Codes and Specifications

i. IRC: 5 Standard Specifications and Codes of Practice for Road Bridges Section – I – General features of design.

ii. IRC: 6 Standard Specifications and Codes of Practice for Road Bridges –Section – II – Loads and Stresses – Seismic provisions of this standard are to be adopted for the bridge design.

iii. IRC:112 Code of Practice for Concrete Road Bridges

iv. IRC: 22 Standard Specifications and Codes of Practice for Road Bridges Section – VI – Composite Construction.

v. IRC: 24 Standard Specifications and Codes of Practice for Road Bridges – Section V, Steel Road Bridges.

vi. IRC: 54 – Lateral and Vertical Clearances for Vehicular Traffic.

vii. IRC: 83 (Part – III) – Standard Specifications and Codes of Practice for Road Bridges – Section – IX – Bearings Part – III, Pot, POT cum PTFE Pin and Metallic Guide Bearings.

viii. IRC: 83 (Part – IV) – Standard Specifications and Codes of Practice for Road Bridges – Section – IX- Bearings Part – IV, Spherical and Cylindrical

ix. IRC-78: Sub-structure for Road Bridges.

x. IRS-87: Design and erection of false work for road bridges.

xi. Specifications for Road and Bridge Works issued by Ministry of Road Transport & Highways (MORTH).

e) Indian Standards Codes and Specifications (IS)

i. IS: 456 Plain and reinforced concrete - code of practice

ii. IS: 800 Code of practice for General Construction Steel

iii. IS: 875 Code of Practice for Design Loads Part 1, 2 3, 4& 5 (Other than Earthquake)

iv. IS: 1080 Design and construction of shallow foundations in soils (other than raft ring and shell)

v. IS: 1364 Hexagon Head Bolts, Screws & nuts of product grades A & B Part 1 (part 1 Hexagon, Head Bolts (size range M 1:6 to M64)

vi. IS 1367 Threaded Steel Fasteners

vii. IS: 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces code of practice

viii. IS: 1489 Specification for Portland pozzolana cement (Fly ash based)

ix. IS: 1786 High strength deformed steel bars and wires for concrete reinforcement

x. IS: 1893 Criteria for Earthquake Resistant Design of structures

xi. IS: 1904 Design and construction of Foundations in soils: general requirements.

xii. IS: 2062 Specifications for weldable Structural steel

xiii. IS: 2502 Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement

xiv. IS: 2911 Design and Construction of Pile Foundation- Code of practice Part 1Concrete Pile- Section 2 Board Cast-in-situ-piles

xv. IS 2911 Design and Construction of Pile Foundation- Code of practice Part 4 Load test on piles

xvi. IS: 2950 Design and construction of raft foundations

xvii. IS: 3935 Code of Practice for Composite Construction

xviii. IS: 4326 Code of practice for Earthquake resistant design and construction of Buildings

xix. IS: 4923 Hollow steel sections for structural use -specification

xx. IS: 8009 Calculation of settlements of shallow foundations

xxi. IS: 269 Specifications of OPC cement

xxii. IS: 9103 Specifications of Concrete admixtures

xxiii. IS: 11384 Code of practice for Composite Construction in Structural Steel and Concrete

xxiv. IS: 12070 Code of practice for Design and construction of shallow foundation on Rocks

xxv. IS: 14593 Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks.

xxvi. IS 455Specifications for Portland Slag cement

f) International Standards

i. UIC Code 774-3 (R) Track and Bridge Interaction

ii. UIC Code 772-2 (R) Code for the use of rubber bearings for rail bridges

The list of standards given above is only indicative. The Contractor shall follow provisions of appropriate codes and standards in force for items which are not covered in the codes mentioned in foregoing paras.

Section VII: Employer's Requirements

Section VII-6: Outline Construction Specifications (OCS)- Civil and BLT

Chapter 1

GENERAL-CIVIL

1.1 GENERAL:

1.1.1 These Specifications contained herein shall be read in conjunction with other tender documents.

1.1.2 All Materials, works and construction operations for civil works shall conform to the following manuals:

a) Indian Railways Permanent Way Manual

b) Indian Railway Bridge Manual

c) Indian Railway Works Manual

d) Indian Railway Schedule of Dimensions

e) Indian Railways Unified Standard Specification (Formation Works, Bridge Works and P.Way Works), *North Western Railway Unified Standard Schedule of Rates 2019.*

f) The relevant IRS Specifications referred to in the above documents listed at (a), (b), (c), (d) & (e)

g) CPWD Specifications, Vol 1&2 – 2019 for building works *and Delhi Schedule of Rates (DSR) 2021*

h) In case of any contradiction in the various codal provisions, the order of precedence shall be as follows:-

i. IRS Codal provisions

ii. IRC Codal provisions

iii. IS(BIS) Codal provisions

1.1.3 The Work shall be carried out in accordance with the "Good for Construction" drawings and designs as would be issued to the Contractor by the Engineer duly signed and stamped by him. The Contractor shall not take cognizance of any drawings, designs, specifications, etc. not bearing Engineer's signature and stamp. Similarly, the Contractor shall not take cognizance of instructions given by any other Authority except the instructions given by the Engineer in writing.

1.1.4 The work shall be executed and measured as per metric units given in the Schedule of Quantities, drawings etc. (FPS units where indicated are for guidance only).

1.1.5 Absence of terms such as providing, supplying, laying, installing, fixing etc in the descriptions does not even remotely suggest that the Contractor is absolved of such providing, supplying etc. unless an explicit stipulation is made in this contract. The Employer shall bear no costs of materials, labour, equipment, duties, taxes, royalties etc.

1.1.6 The specifications may have been divided into different sections / sub-heads for

convenience only. They do not restrict any cross-references. The Contractor shall take into account inter-relations between various parts of works/trades. No claim shall be entertained on the basis of compartmental interpretations.

1.1.7 Reference to the Standard Codes of Practice:

a) The Contractor shall make available at site all relevant Codes of practice as applicable.

Legends	Definition
IRS	Indian Railway Standards
IR specifications	Indian Railways Unified Standard Specification (Formation Works, Bridge Works and P.Way Works)
IS	Indian Standards
IRC	Indian Road Congress
CPWD	Central Public Works Department
RDSO	Research Designs and Standards Organisation
UIC	International Union of Railways (UIC, French: Union international des chemins de fer)
MORTH	Ministry of Road Transport and Highways
EN	European Standard
ISO	International Organization for Standardization
ASTM	American Section of the International Association for Testing and Materials
BS	British Standard

1.1.8 Alternative or additional codes and standards proposed by the Contractor shall be internationally recognized codes and shall be equivalent to or better than, Indian Standards issued by the Bureau of Indian Standards or any other Indian professional body or organization, subject to being, in the opinion of the Employer's Representative, suitable for incorporation or reference into the specifications.

1.1.9 Contractor to Provide:

The Contractor shall provide and maintain at site throughout the period of works the following at his own cost and without extra charge, except for the items specified in the Bill of Quantities the cost being held to be included in the Contract

Rates:

a) General works such as setting out, site clearance before setting out and on completion of works. All weather approach roads to the site office should also be constructed and maintained in good condition.

b) All labour, materials, plant, equipment and temporary works, Overhead charges as well as general liabilities, obligations, insurance and risks arising out of GCC, required to complete and maintain the works to the satisfaction of the Engineer.

c) Adequate lighting for night work, and also whenever and wherever required by the Engineer.

d) Temporary fences, barricades, guards, lights and protective work necessary for protection of workmen, supervisors, engineers, General public and any other persons permitted access to the site. Contractor shall provide proper signages as directed.

e) All fences, barricade shall be painted with colour shades as specified by the Engineer. The barricading should be of adequate height to ensure visual obstruction of work from public view.

f) All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc.

g) Design mixes and testing them as per relevant clauses of specifications giving proportion of ingredients, sources of aggregates and binder along with accompanying trial mixes. Test results to be submitted to the Engineer for his approval before adoption on works.

h) Cost of Preparation and compliance with provision of a quality assurance control program.

i) Cost of safeguarding the environment.

j) A testing laboratory as specified *in Appendix 12, Section VII-9: Appendices, Part 2 Employer's Requirements shall be set up by the Contractor*.

1.1.10 Quality Assurance & Quality Control:

a) The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. The Contractor shall conform to the Quality standards prescribed, which shall form the backbone for the Quality Assurance and Quality Control system.

b) At the site, the Contractor shall arrange the materials, their stacking/storage in appropriate manner to ensure the quality. The Contractor shall provide all the necessary equipment and qualified manpower to test the quality of materials, assemblies etc., as directed by the Engineer. The tests shall be conducted at specified intervals and the results of tests properly documented. In addition, the Contractor shall keep appropriate tools and equipment for checking

alignments, levels, slopes, and evenness of the surfaces.

c) The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor may provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.

   i. The test shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory selected by the Engineer.

   ii. The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of the Contractor failing to arrange transportation of the samples in proper time the Engineer shall have them transported and recover two times the actual cost from the Contractor's bills.

   iii. All testing shall be performed in the presence of Engineer. Testing may be witnessed by the Contractor or his authorised representative if permitted by the Test House. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.

d) The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, all equipment including the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged, and the Engineer's approval obtained prior to starting of the particular item of work. This shall, however, not relieve the Contractor of his responsibilities. All materials which do not conform to these specifications shall be rejected and shall be removed from the site immediately. The Engineer shall have the powers to cause the Contractors to purchase and use materials from any particular source, as May in the Engineer's opinion be necessary for the proper execution of work.

1.1.11 Training

The Contractor shall arrange the following trainings for all his concerned persons and 25 persons of the Engineer and the Employer together:

a) 2 days training for Tunnelling by NATM and Cut & Cover method.

b) *3* days training for concrete, testing, scaffolding and formwork including one day for practical demonstration at site

c) The Contractor shall bear all the expenditure for training including boarding, lodging, airfare, transport, and remuneration of trainers. Training place shall be provided by the Employer free of cost. However, the Contractor shall bear the expenditure for refreshments and meals for all the participants during the training period. The syllabus of training and the

names of the trainers shall be submitted to the Engineer for approval. Training shall be imparted only by those trainers who are approved by the Engineer.

1.1.12 Dimensions:

a) Figured dimensions on drawings shall only be followed and drawings to a large scale shall take precedence over those to a smaller scale. Special dimensions or directions in the specifications shall supersede all others. All dimensions shall be checked on site prior to execution.

b) The dimensions where stated do not allow for waste, laps, joints, etc. but the Contractor shall provide at his own cost sufficient labour and materials to cover such waste, laps, joints, etc.

c) The levels, measurements and other information concerning the existing site as shown on the drawings are believed to be correct, but the Contractor should verify them for himself and also examine the nature of the ground as no claim or allowance whatsoever will be entertained on account of any errors or omissions in the levels or the description of the ground levels or strata turning out different from what was expected or shown on the drawings.

1.1.13 Setting out of Works:

The Contractor shall set out the Works indicated in the Contract. The Contractor shall provide suitable stones with flat tops and build the same in concrete for temporary benchmarks. All the pegs for setting out the Works and fixing the levels required for the execution thereof shall, if desired by the Engineer, likewise be built in masonry at such places and in such a manner as the Engineer may direct. The Contractor shall carefully protect and preserve all benchmarks and other marks used in setting out the works. The Contractor will make overall layout of complete work and get it checked from engineer. The cost of all operations of setting out including construction of benchmarks is deemed to be included in the quoted rates.

a) All the survey work except leveling work shall be carried out using total stations with one second accuracy. The leveling work shall be carried out using Auto level.

b) The triangulations point given by concerned organization before start of work shall be maintained during execution and handed over back to concerned organization after completion of work.

1.1.14 Materials:

a) Source of Materials:

It shall be the responsibility of the Contractor to procure all the materials required for construction and completion of the contract. The Contractor shall indicate in writing the source of materials well in advance to the Engineer, after the award of the work and before commencing the work. If

the material from any source is found to be unacceptable at any time, it shall be rejected by the Engineer and the Contractor shall forthwith remove the material immediately from the site as directed by the Engineer.

b) Quality:

All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Engineer and shall comply strictly with the tests prescribed hereafter, or where tests are not laid down in the specifications, with the requirements of the latest issues of the relevant Indian Standards.

c) Sampling and Testing:

All materials used in the works shall be subjected to inspection and test in addition to test certificates. Samples of all materials proposed to be employed in the permanent works shall be submitted to the Engineer at least 45 days in advance for approval before they are brought to the site.

Samples provided to the Engineer for their retention are to be labeled in boxes suitable for storage. Materials or workmanship not corresponding in character and quality with approved samples will be rejected by the Engineer.

Samples required for approval and testing must be supplied sufficiently in advance if required quality and number to allow for testing and approval, due allowance being made for the fact that if the first samples are rejected further samples may be required. Delay to the works arising from the late submission of samples will not be acceptable as a reason for delay in completion of the works.

Materials shall be tested before leaving the manufacturer's premises, quarry or resource, wherever possible. Materials shall also be tested on the site and they may be rejected if not found suitable or in accordance with the specification, notwithstanding the results of the tests at the manufacturer's works or elsewhere or test certificates or any approval given earlier.

The Contractor will bear all expenses for sampling and testing, whether at the manufacturer's premises at source, at site or at any testing laboratory or institution as directed by the Engineer. No extra payment shall be made on this account.

d) Dispatch of materials:

Materials shall not be dispatched from the manufacturer's works to the site without written authority from the Engineer.

e) Test certificates:

All manufacturer's certificates of test, proof sheets, etc. showing that the materials have been tested in accordance with the requirement of this specification and of the appropriate Indian Standard, are to be supplied free

of charge on request to the Engineer.

f) Rejection:

Any materials that have not been found to conform to the specifications will be rejected forthwith and shall be removed from the site by the Contractor at his own cost within two weeks or as instructed by the Engineer.

g) The Engineer shall have power to cause the Contractors to purchase and use such materials from any particular source, as may in his opinion be necessary for the proper execution of the work.

1.1.15 Storing of Materials at site:

a) All materials used in the works shall be stored on racks, supports, in bins, under cover etc. as appropriate to prevent deterioration or damage from any cause whatsoever to the entire satisfaction of the Engineer.

b) The storage of materials shall be in accordance with IS 4082 "Recommendation on stacking and storage or construction materials on site" and as per IS 7969 "Safety code for handling and storage of building materials".

c) The materials shall be stored in a proper manner at places at site approved by the Engineer. Should the place where material is stored by the Contractor be required by the Employer for any other purpose, the Contractor shall forthwith remove the material from that place at his own cost and clear the place for the use of the Employer.

1.1.16 Water:

a) Water from approved source:

Potable water only shall be used for the works. Contractor shall have his own source of water duly approved by Engineer. The water shall be free from any deleterious matter in solution or in suspension and be obtained from an approved source. The quality of water shall conform to IS 456.

b) Storage:

The Contractor shall make his own arrangements for storing water, if necessary, in drums or tanks or cisterns, to the approval of the Engineer. Care shall be exercised to see that water is not contaminated in any way.

c) Testing:

Before starting any concreting work and wherever the source of water changes, the water shall be tested for its chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such Tests shall be borne by the Contractor.

1.1.17 Workmanship:

a) All works shall be true to level, plumb and square and the corners, edges and arises in all cases shall be unbroken and neat.

Any work not to the satisfaction of the Engineer or his representative will be rejected and the same shall be rectified or removed and replaced with work of the required standard of workmanship at no extra cost.

1.1.18 Load Testing on Completed Structures

a) Load Testing of superstructure, in case of major bridges with OWG/ composite girders/ PSC girders and minor bridges with skew shall be done by the Contractor as per the directions of the Engineer. Cost of span load test is included in Schedule-C.

b) During the period of construction or within the defect liability period the Engineer may at his discretion order the load testing of any completed structure or any part thereof if he has reasonable doubts about the adequacy of the strength of such structure for any of the following reasons:

i. Results of compressive strength on concrete test cubes falling below the specified strength.

ii. Premature removal of formwork.

iii. Inadequate curing of concrete.

iv. *Overloading* during the construction of the structure or part thereof.

v. Carrying out concreting of any portion without prior approval of the Engineer.

vi. Honey combed or damaged concrete which in the opinion of the Engineer

vii. is particularly weak and will affect the stability of the structure to carry the design load, more so in important or critical areas of the structure.

viii. Loss of camber in OWG beyond permissible range as specified by Railway Board/RDSO.

ix. Any other circumstances attributable to alleged negligence of the Contractor which in the opinion of the Engineer may result in the structure or any part thereof being of less than the expected strength.

c) All the loading tests shall be carried out by the Contractor strictly in accordance with the instructions of the Engineer, as per IRS: CBC and IRC: SP-51. Such tests shall be carried out only after expiry of minimum 28 days or such longer period as directed by the Engineer.

d) The structure shall be subjected to the load as approved for SLS condition in the design. This load shall be maintained for a period of 24 hours before removal. Incremental loading shall be done in accordance with IRC: SP-51, unless otherwise directed by the Engineer.

e) In case the recovery of the structure is not as per codal provisions, the

structure shall be considered to have failed to pass the test and shall be deemed to be unacceptable.

f) In such cases the portion of the work concerned shall be taken down or cut out and reconstructed to comply with the specifications. Other remedial measures may be taken to make the structure secure at the discretion of the Engineer. However, such remedial measures shall be carried out to the complete satisfaction of the Engineer. Again, Load test shall be conducted as per codal provisions.

g) All costs involved in carrying out the tests (except integrity test for piles) and other incidental expense thereto shall be borne by the Contractor regardless of the result of the tests. The Contractor shall take down or cut out and reconstruct the defective work or shall make the remedial measures instructed at his own cost.

h) If the load testing is instructed on any ground other than mentioned in (i) to (ix) of Cl. 1.1.18(b), the cost of the same shall be reimbursed to the Contractor, if the result of the test are found to be satisfactory.

i) In addition to the load tests mentioned in these document, non-destructive test methods such as core test and ultrasonic pulse velocity test shall be carried out by the Contractor at his own expense if so desired by the Engineer. Such tests shall be carried out by an agency approved by the Engineer and shall be done using only recommended testing equipment. The acceptance criteria for these tests shall be as per provisions in the relevant Indian/International standards and as approved by the Engineer.

1.2 STRUCTURAL WORK:

1.2.1 Unless specified, only controlled concrete with design mix and weigh batching is to be used for the work.

1.2.2 Minimum cement content specified in the codal specifications is purely from durability point of view. Larger content of cement shall have to be provided if demanded by mix design.

1.2.3 Provision of cement slurry to create bond between plain / reinforced concrete surface and subsequent applied finishes shall not be paid extra.

1.2.4 Mix design using smaller aggregates of 10mm down shall also be done in advance for the use in the junction having congested reinforcement.

1.2.5 Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations if not otherwise directed by the Engineer.

1.2.6 All the water tanks and other liquid retaining concrete structures shall undergo hydro-testing.

1.2.7 Special benches shall be provided at site for stacking reinforcement bars of different sizes.

1.2.8 Formwork for beams of RCC areas shall be designed in such a way that the

formwork of the adjacent slabs can be removed without disturbing the props / supports of the beams.

1.2.9 *Deleted*.

1.2.10 Formwork is required for full height at all locations. Special precautions for such tall formwork shall be taken to ensure its safety. Extra costs for such formwork shall be deemed to have been included in the price quoted against relevant items.

1.2.11 In the mobilization period, the Contractor shall carry out expeditiously and without delay the following works:

i. Material testing and mix designs of concrete as contemplated in the specifications.

ii. Setting up of full-fledged site laboratory as per the requirements of these specifications.

iii. Any other pre-requisite items required for final execution.

iv. Site office for the use of the Engineer staff.

v. Casting yard with full facilities.

1.2.12 Deleted

1.2.13 Fabrication yard to have following minimum facilities:

i. Fabrication beds as required.

ii. All handling facilities.

iii. Stacking arrangements for precast elements.

iv. Storing of materials.

v. Proper drainage and approach roads.

1.3 SUPPLY OF PROGRES PHOTOGRAPHS AND ALBUMS (DIGITAL):

The work covers the supply of digital photographs to serve as a permanent record of various stages/facets of work needed for authentic documentation as approved by the Engineer.

The photographs shall be of acceptable quality and they shall be taken by a professionally competent photographer with a camera having the facility to record the date of the photographs taken in the soft copy. Each photograph in the album shall be suitably captioned and dated.

The photographs and materials shall form a part of the records of concerned organization and the same cannot be supplied to anybody else or published without the written permission of concerned organization.

1.4 SUPPLY OF VIDEO CDs:

The work consists of taking video films of important activities of the works as directed by the Engineer during the currency of the Project and editing them to a video film of playing time not less than 60 minutes. It shall contain narration of the

activities in English by a competent narrator. The edition of the film and script of the narration shall be approved by the Engineer.

Drone videography of the whole package for inspection and monitoring of structures shall be done by the Contractor once in a month.

The record of progress (photographs and videos) shall be submitted to the engineer on a monthly basis or as directed by engineer.

1.5 SURVEY WORK:

The said work involves at the very start of work taking-over of reference point from the Engineer, establishment of control points, triangulation points, bench marks, grid layout for all the piers and other structures maintaining horizontal and vertical control within the permissible limits, incorporating changes (if any), submission of full data in the tabulation form and survey drawings including setting and layout of various works during the progress of work and matching of the station area track alignment with the alignment of the approaches at station ends and incorporating the changes (if any).

1.6 BARRICADING AND PROJECT INFORMATION SIGNBOARDS

The Contractor shall provide barricading to demarcate Works Areas from the public area. All barricading shall be done at own cost by the Contractor. The detailed scope of work is as follows:

i. Providing and installing the barricade of the design and type as shown in the Tender Drawings and as per the approved plan firmly to the ground and maintaining it during the progress of work.

ii. Painting of the barricades shall be carried out to the design and colours as directed by the Engineer and the Contractor shall carry out re-painting of the entire barricades on a bi-annual basis.

iii. Providing lighting on the periphery of barricades for direction illumination.

iv. Project information signboards at each works area and Site Office shall be erected, not later than four (4) weeks, or such other period as the Engineer has given his consent, after the Date of Commencement of the Works. The types, sizes and locations of project signboards shall be agreed with the Engineer before manufacture and erection. Other advertising signs shall not be erected on the Site.

v. The consent of the Engineer shall be obtained before barricading and hoardings signboards are removed.

vi. Barricades and signboards shall be maintained in clean and good order by the Contractor until the completion of the Works. All the barricading and signboards etc. shall be mopped minimum once in a week and washed monthly.

vii. Damaged/worn-out barricades shall be replaced by the Contractor within 24 hours. Engineer's decision regarding the need for replacement shall be final and binding.

If no action is taken by the Contractor, the cost of any repairs will be deducted by the Engineer from any payment due to the Contractor.

viii. Dismantling of barricading and other temporary installations from the site and cleaning the site as per direction of Engineer upon completion and acceptance of work.

1.7 FINISHING WORK:

1.7.1 The Contractor shall incorporate seismic considerations of anchoring and isolation in the design and detailing of the finishes as directed by the Engineer. The element to be anchored shall have its motion suitably restrained whilst at the same time it shall be suitably isolated so as not to be affected by the deformations/ vibrations of the building during Construction.

1.7.2 Sub-Contractor:

Works as listed below and those dealing with proprietary materials/ products may be carried out by the Contractor through the Sub-Contractors as may be approved by the Engineer in writing. The Sub-Contractors must be firms of repute and long standing, having adequate experience and complete facilities to carry out all items of work required for completion as per Specifications and expected quality to the satisfaction of the Engineer. The Sub-Contractor must also have personnel experienced in preparing shop drawings. All such works, not limited to the following, shall be carried out under the direct supervision of the manufacturers of the proprietary materials/ products or their trained and accredited licensee.

i. Bearings

ii. Fabrication, assembly and launching of steel OWG

1.7.3 Responsibility for Shop drawings, Samples and Mock-ups:

Approval of shop drawings, samples and mock-ups for the various components shall not absolve the Contractor of his responsibility of completing the work to the specifications, standards, tests for performance and guarantees given in these documents and to a quality of finish as desired by the Engineer.

1.7.4 Cleaning:

Surfaces on which finishes are to be provided shall be cleaned with water jets or oil free compressed air or power tools with wire brushes and detergents all as approved by the Engineer.

1.7.5 Applicable Codes, Standards & Publications for Structural & Architectural Work:

The more important Codes, Standards and Publications to Contract are listed here under.

Any other code/publication, if found necessary by the engineer, may be referred to for such works. The latest revision along with all corrections slip & amendments shall only be followed

Sr. No.	Code No.	Code Name
General		
1.	IS: 875	Code of Practice for design loads (other than earthquake) for buildings and structures
2.	IS: 122 (part 4)	Methods of measurement of buildings and Civil engineering works-Stone masonry
3.	IS:1237	Specification for cement concrete flooring tiles
4.	IS: 1322	Bitumen felts for water proofing and damp-proofing
5.	IS: 1893	Criteria for earthquake resistant design of structures
6.	IS: 2185 (Part 1)	Concrete masonry units: Hollow and solid concrete
7.	IS: 2185 (Part 2)	Concrete masonry units: Hollow and solid light weight
8.	IS: 2185 (Part 3)	Concrete masonry units: Autoclaved cellular aerated concrete blocks
9.	IS: 2572	Code of Practice for construction of hollow concrete block Masonry
10.	IS: 3414	Code of practice for design and installation of joints in Buildings
11.	IS: 3462	Specification for unbacked flexible PVC flooring
12.	IS: 5318	Code of practice for laying of flexible PVC sheet and tile Flooring
13.	IS: 6408 (Parts 1,2)	Recommendations for modular co-ordination in building Industry-tolerances
14.	IS: 8183	Bonded mineral wool
15.	IS:10958	General check list of functions of joints in building
16.	IS:11817	Classification of joints in buildings for accommodation of dimensional deviations during

Sr. No.	Code No.	Code Name
		construction
17.	IS:11818	Method of test for laboratory determination of air permeability of joints in buildings
18.	IS:12440	Precast concrete stone masonry blocks
19.	CPWD	Specifications with up-to-date correction slips
20.	BS:476 (Part 7)	Method for classification of the surface spread of flame of Products
21.	BS:476 (Part 20)	Method of determination of the fire resistance of elements of construction (general principles)
22.	BS:476 (Part 22)	Methods for determination of the fire resistance of non-load bearing elements of construction
23.	BS: 1245	Specification for metal door frames (steel)
24.	BS: 3261	Specification for unbacked flexible PVC flooring
25.	BS:3261: Part 1	Homogeneous flooring
26.	BS:5215	Specification for one-part gun grade polysulphide-based Sealants
27.	BS:5606	Guide to accuracy in building
28.	BS:5725 (Part 1)	Specification for panic bolts and panic latches mechanically operated by a horizontal push-bar
29.	BS:6093	Code of practice for the design of joints and jointing in building construction
30.	BS:8200	Code of practice for the design of non-load bearing external vertical enclosure of building
31.	ASTM C 332	Specification for light weight aggregate for insulating Concrete
32.	ASTM C 635	Specification for the manufacture, performance and testing of metal suspension systems for acoustical

Sr. No.	Code No.	Code Name
		tile and lay-in panel ceilings
33.	SP 7	National Building Code of India
34.	SP 23 (S&T)	Hand Book on Concrete Mixes
Bitumen		
35.	IS:702	Industrial Bitumen
36.	IS:3384	Specification for bitumen primer for use in waterproofing and damp-proofing
Building Construction Practices		
37.	IS: 1838 Parts I and II.	Specifications for preformed fillers for expansion joint in concrete pavements and structures
38.	IS: 1946	Code of Practice for use of fixing devices in walls, ceilings, and floors of solid construction.
39.	IS: 3414	Code of Practice for design and installation of joints in buildings.
40.	IS: 6509	Code of Practice for installation of joints in concrete pavements.
41.	IS: 11134	Code of Practice for setting out of buildings.
42.	IS: 11433	Parts I and II. Specifications for one part Gun grade polysulphide based joint sealant
43.	IS: 12200	Code of Practice for provision of water stops at transverse construction joints in masonry and concrete dams
Cement		
44.	IS:269	33 grade ordinary Portland cement
45.	IS: 455	Portland Slag Cement
46.	IS: 650	Specification for standard sand for testing cement

Sr. No.	Code No.	Code Name
47.	IS: 1489 (Part 1)	Portland pozzolana cement: Fly ash based
48.	IS: 1489 (Part 2)	Portland pozzolana cement: Calcined clay based
49.	IS: 3535	Method of Sampling Hydraulic Cements
50.	IS: 4031	(Parts 1 to 13) Methods of physical tests for hydraulic cement
51.	IS:4032	Methods of chemical analysis of hydraulic cement
52.	IS: 6925	Methods of test for determination of water-soluble chlorides in concrete admixtures
53.	IS:8042	White Portland Cement
54.	IS: 8112	Specification for 43 grade ordinary Portland cement
55.	IS:12269	Specification for 53 grade ordinary Portland cement
56.	IS: 12330	Specification for sulphate resistant Portland cement
57.	IRS: T40	Indian Railways standard specification for special grade cement for use in concrete sleepers
Concrete		
58.	IS:456	Code of practice for plain and reinforced concrete
59.	IS: 457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures
60.	IS: 460 (Part I TO III)	Specification for Test Sieves
61.	IS: 516	Methods of tests for strength of concrete
62.	IS: 1199	Methods of sampling & analysis of concrete
63.	IS: 1200	Methods of measurement of building and civil engineering
64.	IS: 1343	Code of practice for prestressed concrete

Sr. No.	Code No.	Code Name
65.	IS: 1607	Methods of Test Sieving
66.	IS:2386	Parts I-VIII. Methods of tests for aggregates for concrete.
67.	IS:2430	Methods of Sampling of Aggregates of Concrete
68.	IS:2438	Specification for roller pan mixer
69.	IS:2514	Specification for concrete vibrating tables
70.	IS:2571	Code of practice for laying in-situ cement concrete Flooring
71.	IS:2645	Specifications for integral cement water proofing Compounds
72.	IS:2722	Specifications for portable swing batchers for concrete (double bucket type)
73.	IS:2770	Methods of testing bond in reinforced concrete part I pull out test
74.	IS:3025	Methods of sampling and test (physical and chemical) for water & waste water
75.	IS:3370	Code of practice for concrete structures for storage of Liquids
76.	IS:3935.	Code of practice for composite construction
77.	IS:4326	Code of practice for earthquake resistant construction of Building
78.	IS:6925.	Methods of test for determination of water soluble chlorides in concrete Admixtures
79.	IS:7242	Specifications for concrete spreaders
80.	IS:7251	Specifications for concrete finishers
81.	IS:7861	Parts I & II. Code of practice for extreme weather concreting

Sr. No.	Code No.	Code Name
82.	IS:7969	Safety code for handling and storage of building materials
83.	IS:8989	Safety code for erection of concrete framed structures
84.	IS:8142	Methods of test for determining setting time of concrete by penetration resistance
85.	IS: 9103	Specification for admixtures for concrete
86.	IS: 9013	Method of making, curing and determining compressive strengths of accelerated cured concrete test specimens
87.	IS: 9284	Method of test for abrasion resistance of concrete
88.	IS:10262	Recommended guidelines for concrete mix design
89.	IS: 4926	Code of Practice ready mixed concrete needs to be included in list
90.	MORTH	Specifications for Road and Bridge Works, Ministry of Road Transport and Highways (Roads Wing)
91.	SP 34	Handbook on Concrete Reinforcement and Detailing
92.	IRS	Concrete Bridge Code
93.	IRC 112	Code of Practice for Concrete Road Bridge
94.	IRC 83 (Part 4)	Standard Specifications and code of practice for road bridges Section IX Bearings (Spherical & Cylindrical)
95.	ASTM-C-94	Ready Mix Concrete
Construction Plant and Machinery		
96.	IS: 1791	Specification for batch type concrete mixers
97.	IS: 2505	General requirements for concrete vibrators: Immersion type.

Sr. No.	Code No.	Code Name
98.	IS: 2506	General requirements for screed board concrete vibrators.
99.	IS: 3366	Specification for pan vibrators
100.	IS: 3558	Code of Practice for use of immersion vibrators for consolidating concrete
101.	IS: 4656	Specifications for form vibrators for concrete.
102.	IS: 4925	Specification for concrete batching and mixing plant.
103.	IS: 11993	Code of Practice for use of screed board concrete vibrators.
Formwork		
104.	IS: 4990	Specifications for plywood for concrete shuttering work
105.	IRC: 87	Guidelines for the design and erection of false work for road bridges.
106.	IS: 806	Code of practice for use of steel tubes in general building construction.
107.	IS: 1161	Specification of steel tubes for structural purposes.
108.	IS: 1239	Specification for mild steel tubes, tubular and other wrought steel fittings
Gypsum and Gypsum Board		
109.	IS: 2095	Gypsum plaster boards
110.	IS: 2542 (Part 1/Sec to 12)	Methods of test for gypsum plaster, concrete and products: plaster and concrete
111.	IS: 2542 (Part 2/Sec 1to 8)	Methods of test for gypsum plaster, concrete and products: Gypsum products
112.	IS: 2542 (Part1)	Gypsum building plaster: Excluding premixed

Sr. No.	Code No.	Code Name
		lightweight plaster
113.	IS: 2547 (Part 2)	Gypsum building plaster: Premixed lightweight plaster
Handling and Storage		
114.	IS:4082	Recommendation of Stacking and Storage of construction materials
115.	IS:8348	Code of practice for stacking and packing of stone slabs for transportation
116.	IS:8759	Code of practice for maintenance and preservation of stones in building
Instruments for Testing Cement and Concrete		
117.	IS:5513	Specification for Vsicat apparatus.
118.	IS:5514	Specification for apparatus used in Le-Chatelier test.
119.	IS:5515	Specification for compaction factor apparatus.
120.	IS:7320	Specification for concrete slump test apparatus.
121.	IS:7325	Specification for apparatus to determine constituents of fresh concrete.
122.	IS:10080	Specification for vibration machine.
123.	IS:10086	Specification for moulds for use in tests of cement and concrete.
124.	IS:10510	Specification for vee-bee consistometer.
Joint Fillers		
125.	IS:1838 (Part 1)	Preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type): Bitumen impregnated fibre
Paints and Coatings		

Sr. No.	Code No.	Code Name
126.	IS:102	Ready mixed paint, brushing, red lead, non-setting, priming
127.	IS:109	Ready mixed paint, brushing, priming, plaster, to Indian Standard Colour No. 361 and 631 white and off white.
128.	IS:218	Creosote and anthracene oil for use as wood preservatives
129.	IS:347	Varnish, shellac, for general purpose
130.	IS:348	French Polish
131.	IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming
132.	IS: 4833	Methods of field testing of preservatives in wood
133.	IS:10013 (Parts 1 to 3)	(Part -1) Water soluble type wood preservatives
134.	IS:10013 (Parts 1 to 3)	(Part-2) Acid-copper-chrome preservative
135.	IS: 10013 (Part 1 to 3)	(Part-3) Copper-chrome-boron wood preservative
136.	BS:6496	Specification for powder organic coatings for application and stoving to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with powder organic coatings
137.	BS:EN:10152	Specification for electrolytically zinc coated cold rolled steel flat products. Technical delivery conditions
138.	ASTM A 164-71	Specification for electrodeposited coatings of zinc on steel
Pigment for cement		

Sr. No.	Code No.	Code Name
139.	BS:1014	Specification for pigments for Portland cement and Portland cement products
Reinforcement & Structural Steel		
140.	IS:206	Code of Practice for use of Steel Tubes in General Building Construction
141.	IS:210	Grey Iron Castings
142.	IS:280	Mild steel wire for general engineering purposes
143.	IS:432	Part I. Mild steel and medium tensile steel bars. Part II Hard drawn steel wire.
144.	IS:451	Technical Supply conditions for Wood Screws
145.	IS:806	Code of practice for use of steel tubes in general building construction
146.	IS:815	Classification coding of covered electrodes for metal arc welding of structural steels
147.	IS:1239	Specification for mild steel tubes, tubulars and other wrought steel fittings
148.	IS 1343	Code of Practice for Prestressed Concrete
149.	IS:1363	Black hexagon bolts, nuts and lock nuts and black hexagon screws.
150.	IS:1365	Slotted countersunk screws.
151.	IS:1566	(Part I) Specifications for hard-drawn steel wire fabric for Concrete reinforcement
152.	IS:1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
153.	IS:2502	Code of Practice for bending and fixing of bars for concrete reinforcement.
154.	IS:2629	Recommended practice for hot-dip galvanising of

Sr. No.	Code No.	Code Name
		iron and steel.
155.	IS:2751	Code of Practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
156.	IS 4000	Code of practice for high strength bolts in steel structures
157.	IS:4759	Hot-dip zinc coating on structural steel and other allied products.
158.	IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works
159.	IS:9417	Recommendations for welding cold-worked steel bars for reinforced concrete construction.
160.	IS:14268	Uncoated stress relieved low relaxation steel class 2 for Prestressed concrete
161.	IS:226	Structural steel (Standard Quality)
162.	IS:800	Code of practice for use of structural steel in general building construction.
163.	IS:813	Scheme of symbols for welding
164.	IS:814	Covered electrodes for metal arc welding of structural steel. (Part I & Part II)
165.	IS:816	Code of practice for use of metal arc welding for general construction in mild steel.
166.	IS:822	Code of practice for inspection of welds.
167.	IS:961	Structural steel (High Tensile)
168.	IS:1024	Code of practice for use of welding in bridges and structures subject to dynamic loading.
169.	IS:1030	Carbon steel casting for General Engineering Purposes

Sr. No.	Code No.	Code Name
170.	IS:1120	Coach Screws
171.	IS:1367	Technical Supply Conditions for Threaded Fasteners
172.	IS:1161	Steel tubes for structural purposes.
173.	IS:1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
174.	IS:1915	Code of Practice for Steel Bridges
175.	IS:2016	Plain Washers
176.	IS:2062	Structural steel (Fusion welding quality)
177.	IS:3063	Single Coil Rectangular Section Sprint Washers for Nuts, Bolts and Screws
178.	IS:3443	Crane Rail Sections
179.	IS:3757	Specification for high tensile friction grip bolts
180.	IS:5624	Specification for foundation bolts
181.	IS:3600	Code of practice for testing of fusion welded (Part I) joints and weld metal in steel
182.	IS:4923	Hollow steel sections for structural use.
183.	IS:6227	Code of practice for use of metal arc welding in tubular structure.
184.	IS:801	Code of practice for use of cold formed light gauge steel structural members in general building construction.
185.	IS:811	Specifications for cold formed light gauge structural steel sections.
186.	IS:8500	Structural steel Micro alloyed (Medium and high strength qualities)

Sr. No.	Code No.	Code Name
187.	IS:8910	General requirements of supply of weldable structural steel
188.	IS:9595	Recommendations for metal arc welding of carbon & carbon- manganese steels.
189.	IS 16172	Reinforced Couplers for Mechanical Splices of Bars in Concrete
Sand		
190.	IS:383	Coarse and fine aggregates from natural sources for concrete.
Scaffolding		
191.	IS:2750	Specification for steel scaffoldings
192.	IS:3696 (Part 1)	Safety Code of scaffolds and ladders: Scaffolds
193.	IS:3696 (Part 2)	Safety Code of scaffolds and ladders: Ladders
194.	IS:4014 (Part 1)	Code of practice for steel tubular scaffolding: Definition and Materials
195.	IS:4014 (Part 2)	Code of practice for steel tubular scaffolding: Safety regulations for scaffolding
196.	IRC:87	Guidelines for the design and erection of falsework for Road bridge
Sealants		
197.	IS: 10959	Glossary of terms for sealants for building purposes
198.	IS: 11433 (Part 1)	One part grade polysulphide base joint sealant: General requirements
199.	IS: 11433 (Part 2)	One part grade polysulphide base joint sealant: Methods of test
200.	IS: 13055	Methods of sampling and test for anaerobic adhesives and sealants

Sr. No.	Code No.	Code Name
201.	BS: 5889	Specification for one part gun grade silicone based sealants.
Wood		
202.	IS: 303	Plywood for General Purposes
203.	IS: 848	Synthetic resin adhesives for plywood (phenolic and aminoplastic)
204.	IS: 1141	Seasoning of Timber – Code of Practice
205.	IS:1328	Veneered decorative plywood
206.	IS: 1659	Blocks Boards
207.	IS: 2046	Decorative thermosetting synthetic resin bonded laminated sheets
208.	IS: 2202 (Part 1)	Wooden flush door shutters (solid core type): Plywood face panels
209.	IS: 2202 (Part 2)	Wooden flush door shutters (solid core (type): Particle face panels and hardboard face panels
Bearing		
210.	IRC: 83 Part-II	Standard specifications and code of practice for road bridges Elastomeric Bearings
211.	IRC: 83 Part-III EN 1337gh	Standard specifications and code of practice for road bridges Pot Bearings
212.	IRC: 83 Part-IV	Standard Specifications and Code of Practice for Road Bridges (Section – IX) Bearings (Spherical and Cylindrical)
Piling		
213.	IS: 2911 (All Parts)	Bored Cast in-situ Concrete Piles
214.	IRC: 78	Standard specifications and code of practice for road

Sr. No.	Code No.	Code Name
		bridges Foundation And Substructure
All Indian Railway & RDSO Standards, any other code or publication as approved by engineer in-charge		
Metal		
215.	IS: 276	Austenitic manganese steel castings
216.	IS: 733	Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purpose.
217.	IS: 737	Specifications for wrought aluminium and aluminium alloy sheet and strip for general engineering purpose.
218.	IS: 3614 (Part 1)	Specification for fire check doors: Plate metal covered and rolling type
219.	IS: 3614 (Part 2)	Specification for metallic and non-metallic fire check doors: Resistance test and performance criteria
220.	IS: 7196	Specification for Hold Fasts
221.	ASME set 2 Part A	Ferrous Material Specification
222.	ASTM B 221	Specification for aluminum-alloy extruded bars, rods, wires, shapes, and tubes
223.	BS: 4873	Specification for Aluminum alloy windows
224.	BS: 7352	Specification for strength and durability performance of metal hinges for side hanging applications and dimensional requirements for template drilled hinges
225.	BS EN: 10143	Specification for continuously hot-dip metal coated steel sheet and strip. Tolerances on dimensions and shape

Sr. No.	Code No.	Code Name
Stone and Facings/Linings		
226.	IS:1121-(Parts 1 to 4)	Methods of test for determination of strength properties of natural building stones
227.	IS:1121-(Parts 1 to 4)	(Part-1 Compressive strength)
228.	IS:1121-(Parts 1 to 4)	(Part-2 Transverse strength)
229.	IS:1121-(Parts 1 to 4)	(Part-3 Tensile strength)
230.	IS:1121-(Parts 1 to 4)	(Part-4 Shear strength)
231.	IS:1122	Method of test for determination of true specific gravity of natural building stones.
232.	IS:1123	Method of identification of natural building stones.
233.	IS:1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones.
234.	IS:1125	Method of test for determination of weathering of natural building stones
235.	IS:1126	Method of test for determination of durability of natural building stones.
236.	IS:1127	Recommendations for dimensions and workmanship of natural building stones for masonry work.
237.	IS:1128	Specification for Limestone (Slabs and Tiles)
238.	IS:1129	Recommendation for dressing of natural building stones.
239.	IS:1130	Specification for marble (blocks, slabs and tiles)
240.	IS:1597 (Part 2)	Code of practice for construction of stone masonry Ashlar masonry

Sr. No.	Code No.	Code Name
241.	IS:1706	Method for determination of resistance to wear by abrasion of natural building stones
242.	IS:1805	Glossary of terms relating to stones, quarrying and Dressing
243.	IS:3620	Specification for laterite stone block for masonry
244.	IS:3622	Specification for Sandstone (slab & tiles)
245.	IS:4101 (Part 1)	Code of practice for external facing and veneers: stone Facing
246.	IS:4101 (Part 2)	Code of practice for external facing and veneers: Cement concrete facing
247.	IS:4101 (Part 3)	Code of practice for external facing and veneers: Wall tiling and mosaics
248.	IS:4121	Method of test for determination of water transmission rate by capillary action through natural building stones
249.	IS:4122	Method of test for surface softening of natural building stones by exposure to acidic atmospheres
250.	IS:4348	Method of test for determination of permeability of natural building stones
251.	IS:5218	Method of test for toughness of natural building stones
252.	IS:8381	Recommended practice for quarrying stones for construction purposes
253.	IS:14223 (Part 1)	Polished building stones: Granite
254.	BS: 8298	Code of practice for design and installation of natural stone cladding and lining

CHAPTER-2.

SITE INSTALLATIONS AND SERVICES

2.1 GENERAL

2.1.1 Site installations, site clearance (including removal), services shall be carried out in accordance with the provisions of the Employer's Requirements.

2.1.2 The Contractor shall be responsible for providing plant, equipment, materials and labour for the provision of all necessary Temporary Works and services adequate for the execution of the Work under this contract.

2.1.3 The Contractor shall design, furnish, install, maintain and operate on the Site Constructional Plants as specified in this Chapter, including camps, workshops: warehouses, storage and assembly areas, all equipment, machinery, vehicles. Scaffolding, water and power supply etc.

2.1.4 Obtaining necessary clearance/ permission that are needed for construction, from various state/ central authorities for the equipment, water, power, sanitary and explosives shall rest with the Contractor.

2.1.5 Temporary Works and services carried out by the Contractor shall conform to the applicable Indian Standard Codes / laws, regulations and statutory requirements including compliance to railways codes/manuals/guidelines etc. stipulated for such purpose. In-case no National Standard is available, International Standards are to be applied as approved by the Engineer.

2.1.6 The design, construction, operation and maintenance of the Contractor's Temporary Works and services shall be subject to inspection and approval by the Engineer.

2.1.7 The rights or customs of adjacent property occupiers for access shall not be infringed by the Contractor.

2.2 SUBMITTALS

2.2.1 Within 28 days from the Letter of Acceptance, the Contractor shall submit to the Engineer, updated layout plans showing, to an adequate scale, the locations and arrangement of all enabling and temporary Works and facilities. These plans shall be consistent with the plans submitted by the Contractor with his tender as well as with any amendments and additions subsequently agreed to by the Engineer and the Contractor and shall include:

- **i.** Site offices, storages, parking areas, warehouses, materials yard, storage areas
- **ii.** Concrete and material processing plant including cement storage.
- **iii.** Temporary road including public road diversions.
- **iv.** Communication System.
- **v.** Service vehicles.
- **vi.** Camps for Contractor's Employees.
- **vii.** Medical facilities.

viii. Power supply and illumination, telephone services (radio and cable).

ix. Maintenance of Traffic.

x. Ventilation of Underground System.

xi. Air-cooling in underground works.

xii. Control of dust, silica and noxious gases in underground works.

xiii. Water supply.

xiv. Sanitation & sewerage, sewage treatment and disposal,

xv. Waste & garbage disposal.

xvi. Security and safety arrangements.

xvii. Field laboratory along with list of equipment as required under Quality Assurance Programme.

xviii. Equipment tools and mechanical workshops.

xix. Dumping areas, borrow, quarry and stockpile areas with development plans.

xx. Explosive magazines.

xxi. Adequate back up power system.

xxii. Measures to comply with environmental norms and various conditions.

xxiii. Muck disposal management.

xxiv. Site Signage.

xxv. Drainage plan during construction.

xxvi. Contractor Quality Plan

xxvii. Emergency Plan.

xxviii. Safety Plan

2.2.2 Within 42days from the commencement date, the Contractor shall submit to the Engineer the following:

i. Detailed drawings to a scale ranging from 1:100 to 1:500 showing the camp layout, buildings, roads, recreation areas, all utilities etc. and drawings to a scale of 1: 50 to 1: 100 showing typical building construction details.

ii. Drawings and Specification for the establishment of primary first aid stations dispensary and ambulances.

iii. Detailed design for industrial and potable water supply to the camps and working area as well as sewerage system, sewerage treatment and disposal with an estimate of number of people to be supplied with water. All the system shall comply with the environmental and pollution control norms as applicable.

iv. Detailed layout drawings for electrical installations and distribution systems on the site, showing voltages, outlets and routing of power lines. The system

should include necessary power back up arrangements for uninterrupted construction work.

v. Detailed design and drawings including manufacturer's drawings for concrete and materials processing plants, including details of equipment for transportation and placement of concrete in accordance with the requirements of the pertinent Chapters of these Specifications.

vi. Details of the excavation, drilling and grouting equipment in accordance with the requirements set out in the relevant Chapter of these Specifications.

vii. Details of the underground ventilation system, which shall include all calculations of fresh air supply volume, type of ventilation scheme, duct diameters. Materials, equipment, position of ventilators and dust arresters. Description of the working cycle including number of persons employed, number and capacity of diesel-powered equipment working at each heading face shall also be included.

viii. Details of the dewatering system.

ix. Details of Field laboratory to be set up at site by the Contractor.

x. Details of muck disposal and protection measures for compliance with Environmental, Social, Health & Safety Management Plan of the work specifications.

xi. The designs shall be consistent with the proposal submitted by the Contractor with his tender as well as with any subsequent amendments and additions agreed to by the Engineer and the Contractor. (The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.)

2.3 DETAILS OF INSTALLATIONS AND SERVICES

The installations and services to be provided by the Contractor for the execution of Works under this Contract shall include, but not limited to, the following:

2.3.1 CAMPS FOR CONTRACTOR'S EMPLOYEES

The Contractor shall design, construct, provide furnishings, maintain and operate construction camps at the suitable locations *as per provisions of Appendix 13: ESHS Manual, Section VII-9: Appendices, Part 2 – Employer's Requirements*.

2.3.2 The sewerage from the labour camps, work sites is to be properly treated before discharge by providing septic tanks, soak pits etc. or any other treatment as per norms recommended by the concerned authority.

i. Canteen facilities shall be provided by the Contractor in properly equipped canteen buildings for all his and his subcontractor's employees, if it is considered expedient.

ii. The Contractor shall be responsible for keeping the camps and buildings within it, in good hygienic conditions. The standards regulations presently in

force in the project area with regard to water treatment, sanitary conditions, and fire and accident prevention shall be duly taken into account.

2.3.3 Site Offices, Stores, Warehouses, Materials Yards

i. The Contractor shall provide and equip, for his own and his subcontractors' use, main and secondary offices, warehouses, materials stock areas, fuel storage areas and explosive magazines, all of which shall be maintained in good condition until the completion of Works.

ii. The buildings and warehouses expected to be constructed and equipped by the Contractor for use in the execution of the Works under this Contract, in addition to the facilities explicitly specified elsewhere in these Specifications shall be, but not limited to, the following:

a. Mechanical repair shop

b. Electrical repair shop

c. Metalwork fabrication and carpentry shop

d. Main warehouse and parts store

e. Bulk cement silo/cement store

f. Spare parts store.

iii. No dangerous goods, explosives, chemicals, fuels or similar items shall be brought onto the Site unless the Contractor has advised the Engineer of the intention to do so and has complied with all statutory requirements for its safe storage and security.

iv. The Contractor shall minimize the use of the Site for the storage of fuels, explosives and other dangerous goods as may be required for the construction of the works and shall not use the site or allow access for any purpose not connected to the Contract.

v. Dangerous Goods are only to be stored in nominated and approved storage areas and facilities which must comply with the Indian regulations governing such facilities.

vi. The Contractor has to make appropriate provision for material storage sheds and tarpaulin sheets for loose construction material.

vii. The Contractor has to make appropriate provision for dustbins and corresponding disposal of waste at labour campsite and at each work site.

2.3.4 Concrete and Materials Processing Plants

i. The Contractor shall install and erect all necessary material processing plants of sufficient capacity to meet the planned peak requirements during construction. The plants shall be subject to approval by the Engineer and shall be well designed and fabricated and kept in good running order to ensure compliance with the materials quality Specifications. All control and measuring equipment shall be regularly serviced and calibrated.

ii. The plants required to be assembled/erected by the Contractor shall be but not limited to the following:

a. Concrete plant (batching and mixing)

b. Concrete cooling plant (refrigeration and ice plant), if required.

c. Grouting plant.

iii. Concrete & material processing plants shall meet all environment guidelines, conditions imposed for construction of project by MOEF/ Government bodies/ State pollution control boards and other statutory bodies at no extra cost to the Employer.

2.3.5 Temporary Roads

The Contractor shall construct temporary roads / hauls roads, to various facilities. Contractor shall develop detailed drawings for the above and accordingly construct the same after approval of Engineer.

2.3.6 Communication System

i. Outside / Site Communication

ii. The Contractor shall install his communication system in the project area for national/ international voice and data communication. These facilities can be availed from the existing network of tele-communication or the Contractor shall make arrangement for providing these facilities through existing telecom operators.

iii. Communication System in Underground Works

a. Communication systems for underground space shall comprise of telephone/radio systems (walkie-talkie).

b. The Contractor shall install and maintain in operating condition, communication system by telephone or preferably an underground radio system approved by the Engineer between each heading face and entrance to the concerned tunnel / caverns. All the employer's site offices shall be well connected with the above communication system.

c. In case of telephone system, an intermediate Intercom station shall be located at least every 250m or less along the tunnel.

d. All Communication system shall have sources of energy independent of the main energy supply for Underground works.

e. The availability of the communication from inside to outside the tunnel shall be ensured at all times throughout the duration of the underground construction.

2.3.7 Check In/Check Out Procedure for all persons entering any underground space:

i. The Contractor must maintain an approved check-in/check-out procedure (in

form of Name tag boards and RFID/Biometrics) to ensure that above ground personnel maintain an accurate accounting of the number of persons underground and to prevent unauthorized persons from gaining access to the site.

ii. At any time when underground operations are underway, at least one designated person must be on duty above ground. This person is responsible for calling for immediate assistance and keeping an accurate count of employees who remain underground in the event of an emergency.

iii. In addition to establishing a check-in/check-out procedure, the Contractor must ensure safe access to and egress from all workstations at the construction site to protect employees from potential hazards, such as being struck by excavators, haulage machines, or other moving equipment.

iv. To help control access, all unused openings, including chutes and man ways, must be tightly covered, bulk headed, barricaded, or fenced off, and posted with warning signs that read, "Keep Out" or similar language.

v. RFID system/Bio-metric system for entry record into tunnel for all staff of contractor, employer and employer's representatives. Contractor shall submit record of entry and exit of all staff (Name, Personnel Type, Age, Gender and Agency) along with date and time every 1st and 15th date of month to the employer. The system should be able to transmit all recorded data between the desired dates through USB drive etc. Further the system should be able to generate fresh RFID tags/Bio-Metric entries when required for entry of new personnel previously not registered with the system.

2.3.8 Entry/Exit records for all vehicles (Employer, Contractor, Consultant etc.) including tunneling machineries entering any underground space:

i. The Contractor must maintain an approved Entry/Exit record (in form of RFID TAG system) to ensure that above ground personnel maintain an accurate record of time of Entry/Exit and prevent unauthorized vehicles from gaining access to the site.

ii. At any time when underground operations are underway, at least one designated person must be on duty above ground. This person is responsible for calling for immediate assistance and keeping an accurate count of the number and type of vehicles in the event of an emergency.

iii. RFID TAG System for record of entry/exit time for all vehicles: Contractor shall submit time record of entry and exit of all vehicles (Registration number, Vehicle Type and Agency) along with date and time every 1st and 15th date of month to the employer. The system should be able to transmit all recorded data between the desired dates through USB drive etc. Further the system should be able to generate fresh RFID tags when required for entry of new vehicles previously not registered with RFID system.

2.3.9 SERVICE VEHICLES

i. The Contractor shall furnish, operate and maintain sufficient service vehicles for use by his own staff and employees in the management, supervision and performance of the Work.

2.3.10 MEDICAL FACILITIES

The Contractor shall provide medical facilities *as per provisions of Appendix 13: ESHS Manual, Section VII-9: Appendices, Part 2 – Employer's Requirements.*

2.3.11 POWER SUPPLY AND ILLUMINATION

i. General.

a. Contractor has to make his arrangements at his own cost for entire construction power including any standby power requirements. Equipment/ transmission lines required for distribution and utilization of energy at Construction site for Power, light etc. shall be installed by the Contractor on their own.

b. Power to be used by Contractor for their Labour and Staff Colony shall be arranged by contractor on their own and at their own cost.

c. Contractor shall arrange DG sets of adequate capacity at his cost to meet back up and emergency power supply requirement including lighting, dewatering & ventilation.

d. Contractor shall indicate in his proposal of the phase wise requirement of Construction power (HT) at above-mentioned locations.

ii. Power supply and Illumination provided by the Contractor

a. The Contractor shall install, operate and maintain electrical distribution system, which shall include transformers, circuit breakers, disconnection and safety switches, voltage regulators, lines, poles, pole hardware, conductors, meters and other equipment necessary for power distribution throughout the Site and temporary facilities.

b. An alternative source of emergency lighting system shall be provided every 50m at key points underground to allow emergency securing operations and evacuation safely in the event of a primary power failure.

c. The Contractor shall ensure adequate illumination for all his operations on the Site and at the Camps, including illumination of the streets. The Contractor shall maintain equipment and arrange device to measure light intensities for illumination as follows:

	Area of Operation	**Luminous Intensity**
(a)	Excavation and dumping areas and outdoor access ways	35 Lux

	Area of Operation	Luminous Intensity
(b)	General construction areas, concrete placement, excavation and waste areas, access ways, active storage areas, loading platforms, refueling, and field maintenance areas.	50 Lux
(c)	Indoors: warehouses, corridors, hallways, and exit ways.	50 Lux
(d)	Tunnel and general Underground Work areas	50 Lux
(e)	Tunnel headings during drilling, mucking and scaling	100 Lux
(f)	General construction plant and shops, e.g. batching plants, mechanical and carpentry shops, active storerooms, barracks or living quarters, mess halls and indoor toilets	100 Lux
(g)	First aid stations, infirmaries and offices.	350 Lux
(h)	Welding	300 Lux

d. The vaults along the entire length of the tunnel shall be illuminated with electrical light throughout the duration of, construction works. The lamps shall be provided in two rows with each row lamp spacing of 10 m in unlined stretches and 20 m in lined stretches. Contractor shall suitably modify the spacing and capacity of lights to meet the illumination requirements mentioned above.

e. Electrical cables shall be well insulated, protected and firmly fixed to the walls of the tunnel by means of adequate insulators; lamps shall be well protected against damage.

f. The Contractor shall also provide suitable movable lamps to illuminate any area in Underground Works including areas for instrumentation and where the Engineer may wish to carry out inspection and rock mechanics tests or instrumentation.

g. No energized electrical cable shall be permitted nearer than 70 m to the heading face while charging explosives. Accordingly, suitable high-powered light arrangement shall be made to have adequate illumination at the tunnel face.

h. Lighting illumination by flame is expressly forbidden in the Underground Works.

i. Whenever more than one agency is working in the same area, the Contractor, who has already provided lighting I Power supply

arrangements, shall extend the facilities to the other Contractor, who shall pay for such facility of utility at mutually agreed rates. In case of disputes, the matter shall be decided by the Engineer, whose decision shall be final.

iii. Earthing of Wet work Areas, Control of Electric Discharges

a. All equipment and appliances, which are exposed to lightning, shall be earthed electrically, and the Contractor's specialized personnel shall periodically check the effectiveness or such earthing.

b. Personnel standing in water shall operate no equipment electrically powered by more than 24 Volts.

c. Only air, battery-powered or hydraulic tools shall be permitted in the wet areas.

d. Where electrical blasting is used, equipment shall be installed to control possible electric discharge in the ground due to storms, electric motors, etc. As soon as such discharges are noted, electrical blasting operations shall be suspended, or the detonator type changed.

2.3.12 MAINTENANCE OF TRAFFIC

i. The Contractor shall be responsible for the safety along the roads related to the Site. Where the work is carried out on the Site of, or close to an existing road, the Contractor shall maintain the vehicular and pedestrian traffic safe at all times. If his operations can cause traffic hazards, he shall repair or fence or take such other measures for ensuring safety that are satisfactory to the Engineer.

ii. The Contractor shall submit his activity, schedule and the locations of his work along the existing public roads to the authorities concerned and obtain all necessary approval prior to the commencement of the respective work.

iii. At the road crossings or in heavy traffic locations, the Contractor shall carry out the Work within the working hours as directed by the Engineer, and after the completion of the work he shall immediately make the necessary backfill and pavement at the crossings.

iv. The Contractor shall provide temporary passes and badges to give an access to the existing village houses, etc., to the satisfaction of the Engineer and the authorities concerned whenever he disturbs such existing way during the execution of works.

2.3.13 VENTILATION OF UNDERGROUND WORKS

i. General

a. The Contractor shall design, install and operate ventilation system for

the Underground Works and provide an underground atmosphere monitoring system.

b. All parts of the Works shall be maintained in a state, which will not be injurious to the health or the personnel. The air in underground works shall contain no less than 20% oxygen (by volume) and shall not contain concentration of gases, vapors or dust greater than is prescribed in the safety standards for the health or workmen.

c. If required, the ventilating system shall be kept in operation also after break- through in tunnels in order to maintain the fresh air-volume requirements stated hereinafter.

d. Intermediate fans attached to the main duel line shall be provided as required to ensure satisfactory removal of contaminated air. All ventilation ducts shall be maintained in a good condition to prevent any leakage.

e. Ventilation ducts shall be firmly fixed to the vaults in such position that a minimum clearance of 30 cm remains between the duct and the extremities of vehicular traffic employed in the Underground Works.

f. The Contractor shall ensure the required quantity of fresh air at the heading face. The check of the airtightness of joints and control of the air ducts for leaks shall be performed periodically. The Contractor shall immediately repair any deficiency discovered or reported by the Engineer.

g. If the volume and quality of fresh air at the heading face is less than that specified, then the whole duct system shall be pressure and volume tested in portions not exceeding a few hundred meters. Measuring stations shall be located not closer than 10 times the duct diameter from any fan or other flow disturbance within the Main Line.

h. No work shall be permitted to be carried out unless the ventilation is provided to the satisfaction of the Engineer. Indoor Air Quality standards as described in EPA,1986 (with latest amendments) be adhered to.

ii. Ventilation System for Tunnel excavation

a. The ventilating system shall be of such efficiency that the average air velocity in the largest excavated profile is not less than 0.3 meters per second. In case the presence of methane gas is detected or suspected, this value shall be increased to 0.5 meters per second.

b. The main ventilation system shall ensure that both following minimum fresh air volume requirements are satisfied at all times:

(a) 5.70 m^3 per minute for each person employed in the Underground Works at one time.

(b) A minimum of 2.00 m^3 of air per minute shall be supplied additionally for each metric horsepower of diesel-powered equipment deployed in the underground works alone time.

These fresh air volumes shall be cumulative, and the Contractor shall allow, in his design calculations, for the maximum number of persons and diesel-powered equipment deployed in the Underground Works at any one time. Any estimated losses, e.g. due to the leaks in the ducts, shall be added to the figures stated above.

c. The secondary ventilation equipment of the forced type shall be installed to provide an adequate ventilation of the area between the heading face and the air intake/outlet of the main system. This system shall be switched on prior to the blasting and shall remain operative until the main system has been put into exhaust mode of operation. The air intake shall be located at a sufficient distance from the heading face to ensure that blasting fumes do not permeate into this area and cause a recycling of blasting fumes. The outlet of this duct shall be located so close to the heading face that the driving of the blasting fumes and dust away from the face into main system is ensured. The minimum capacity shall be at least 70% of the main system's capacity. The end diameter of the duct shall be such that the air discharge velocity is not less than 20 meters per second.

d. Re-entry into the heading face and resuming of the work shall not be permitted until all blasting fumes have been ejected out.

e. Subject to meeting the minimum functional and safety requirements of ventilation the engineer may allow other systems of ventilation also as proposed by contractor. This shall in no way absolve contractor from his obligation to meet the necessary requirements of ventilation at any time during work.

f. All equipment and ventilation duct shall always be maintained in sound working order. Any damage to ventilation duct shall be repaired within 12 hours of the damage.

g. Ventilation ducts must be maintained in straights alignments as much as possible and with plain cross sections avoiding unnecessary curves, reduction and rotations of the cross sections and always without any damage of the ducts.

h. Ventilation ducts must follow the advance of the tunnel excavation, being the extremity of the duct no more distant from the front face than 20m. In any case this distance shall be reduced if the quality of the air in the front face does not follow health and safety specifications.

i. Whenever excavation proceeds more than 2 kms from any portal then contractor will be required to install booster ventilation fans to enhance

ventilation capacity and install LT lines to reduce transmission loss over long lengths if other methods are not effective, for which nothing extra shall be paid.

2.3.14 AIR COOLING IN UNDERGROUND WORKS

i. The Contractor shall make suitable arrangements for cooling of air so as to maintain the temperature in the underground construction sites below 300 Centigrade under all conditions.

ii. The temperature shall be measured by the Contractor daily. Temperature measurements shall be taken during normal working conditions with the specified degree of ventilation.

iii. The maintenance of construction progress and control of temperature shall be entirely the responsibility of the Contractor under all conditions. No claim or extension of time for the completion of Works shall be allowed on this basis of high / low temperatures experienced in the course of the work for any reasons, whatsoever. However, Geo-thermal conditions are not anticipated by employer, Temperature meter for measurement of temperature shall be supplied and or installed & maintained at required location by contractor at his own cost.

2.3.15 CONTROL OF DUST, SILICA AND NOXIOUS GASES IN UNDERGROUND WORKS

i. The Contractor shall install and operate equipment for the monitoring and Control of dust, silica and noxious gases in Underground Works as described here under.

ii. Dust and Silica

a. To reduce the amount of dust, only wet drilling will be allowed and during mucking, muck piles shall be kept constantly damp by sprinkling with water. The use of high-pressure water jets for this purpose will not be permitted.

b. The Contractor shall measure and monitor the concentration of fine dust and content of silicon dioxide. (Si02) in all dust producing underground operations by a method to be approved by the Engineer.

c. Air Samples shall be taken within 10 days of commencing underground excavation, at 30 days intervals thereafter and within 20 days following major changes in tunnel excavation operation, or whenever required by the Engineer. Samples shall be taken from actual working areas. A qualified person in laboratory to be proposed by the Contractor and approved by the Engineer shall perform the sampling and testing. A copy of the test results shall be submitted to the Engineer within 2 weeks of the sampling date.

d. The concentration of fine dust (diameter less than 0.005 mm) may not, in general exceed the value of 8.0 mg/m3 of air and this value will be further reduced depending upon the extent of SiO2 content in rock as detailed in the table below:

Content of SiO_2 in fine dust in percent by weight.	**Concentration of fine dust in milligrams per cum of air.**
1-15 %	8.0 mg / M^3
20 %	6.0 mg / M^3
30 %	4.0 mg / M^3
60 %	2.0 mg / M^3
80 %	1.5 mg / M^3
100 %	1.3 mg / M^3

e. Should the concentration of the fine dust exceed the limits stated above, the Contractor shall undertake such necessary measures and install such additional equipment which will ensure that the dust concentrations are within the specified safe hygienic limits.

f. All staff entering underground work site shall be equipped with PPE including respirators suited for the work.

iii. Noxious Gases

a. Use of internal combustion engines, other than approved mobile diesel-powered equipment will not be permitted in underground construction Sites.

b. The Contractor shall provide and maintain equipment for measuring and monitoring the content of noxious gases and oxygen at each heading face throughout the duration of excavation works. Tests for determining concentrations of carbon monoxide, carbon dioxide, nitrogen dioxide, methane, other inflammable gases, and oxygen Shall be made by qualified personnel before and after each blasting and at the beginning of each shift. A record of reading shall be maintained and be made available to the Engineer as and when asked for.

c. Gas concentrations in underground sites will not exceed the following limits:

0.005 %	50 ppm of carbon monoxide.
0.5 %	5000 ppm of carbon dioxide.

0.0005%	5 ppm of nitrogen dioxide.
0.001%	10 ppm of hydrogen sulphide.
0.1%	1000 ppm of methane.
0.01 %	Milligrams per litre of nitrous oxide.

d. After each blast, before entering the blast area, the concentration of toxic gases will be checked to ascertain the efficacy of ventilation system. The engineer in addition may direct the Contractor to measure the concentration of toxic gases during other operations also. Contractor will always keep all measuring instruments in a ready state. All such records shall be signed jointly by both parties immediately after measurement.

e. Concentrations of other inflammable gases shall not exceed 40 % of the lower explosive limit at the heading face and 20 % of the lower explosive limit elsewhere in the tunnel.

f. If concentrations of noxious gases or other inflammable gases exceed the permissible limits set forth above, all operations shall be interrupted immediately, and personnel shall be removed to a safe area. All sources of ignition shall be extinguished or removed. All equipment with the exception of ventilation equipment shall be shut down.

g. The required measures will be mutually determined and agreed to by the Engineer and the Contractor. In case of need, the Contractor shall engage the services of an independent Consultant experienced in gaseous tunneling. Re-entry and resuming of the Work shall be prohibited until the Engineer has authorized re-entry.

2.3.16 WATER SUPPLY

i. The Contractor shall design, Install, operate and maintain two separate water supply systems on the Sites

a. Industrial Water: For general construction use, treated to the extent necessary to meet specified requirements of Works.

b. Potable water: For supply to all buildings and plants requiring high quality water meeting requirements for drinking water supply.

ii. Water shall be, supplied by the Contractor from any suitable sources. The water being supplied shall be free of contamination and unaffected by the Site construction Work.

iii. The Contractor shall l furnish, install, operate and maintain all pumps, pipelines, fittings, valves, storage tanks purification plant and chlorination for the Water supply and distribution systems, adequate in quantity and pressure. Industrial water shall be used for construction purposes only. There shall be no cross connections of any kind between the industrial and potable water supply systems. Only potable water shall be piped into buildings.

iv. The Contractor shall provide adequate water treatment facilities so as to ensure that the treated water is supplied for drinking purposes to all the camps and construction places.

v. Ample number of drinking points of potable water shall be provided by the Contractor for the use of personnel in all working areas.

2.3.17 SANITATION AND SEWERAGE

i. Toilets shall be provided and maintained by the Contractor for the use of all personnel at all work locations, which are remote from the fixed sanitary facilities. The Contractor shall arrange for all chemical toilets to be attended to daily for proper sanitary disposal.

ii. All offices, workshops, laboratory and other occupied work buildings shall be provided with toilets connected to property constructed and regularly maintained septic tanks approved by the Engineer.

iii. The camp sites shall be provided with a complete, properly maintained and operated sewerage system, including septic tanks, sewage treatment and disposal facilities. Facilities for washing clothes shall also be provided and linked to the sewerage system.

iv. Sanitation, sewerage system and contaminated water from the tunnel excavation shall meet all environment guidelines conditions imposed for construction of project by MOEF / Government Bodies at no extra cost to the Employer.

2.3.18 DISPOSAL OF C & D WASTE

The Contractor shall make necessary arrangements for the management of muck disposal so that it meets all the environment guidelines / conditions imposed for the construction of project by MOEF / Govt. bodies / State Pollution control board and/or other statutory bodies.

2.3.19 WASTE AND GARBAGE DISPOSAL

i. The Contractor shall daily collect waste material and garbage from camps, offices and workshops and transport it to an area approved by the Engineer, where it shall be incinerated and buried or disposed off as approved by the Engineer.

ii. The site shall be kept clean and free of refuse at all times. No waste shall be dumped in areas other than those approved by the Engineer for waste disposal. No waste of any kind shall be deposited in any watercourses.

iii. Waste and Garbage disposal system shall meet all environment guidelines and conditions imposed for construction of project by MOEF/ Govt. bodies at no extra cost to The Employer.

iv. The Contractor has to make appropriate provision for Oil / Grease interceptor at refueling stations and at fuel storage locations.

2.3.20 SETTING UP OF FIELD LABORATORY

i. The Contractor shall establish a field laboratory for ensuring quality control measures for the Works, as detailed under Quality Assurance Programme described elsewhere in the tender documents.

ii. Prior to setting up of laboratory, Contractor shall submit detailed building plan with exhaustive equipment-list clearly showing the different area for equipment with sizes of the equipment and circulating area, and CV's of qualified personnel identified for laboratory work to the Engineer for approval. The laboratory shall be headed by an experienced graduate civil engineer. All the equipment shall be conforming to either the relevant IS or international standards.

iii. Upon receipt of Engineer's approval, the Contractor shall construct, maintain and operate an integrated laboratory which provides sufficient rooms and equipment to test aggregates, concrete samples, plain shotcrete and SFRS samples, soil and rock samples, rock bolts capacity tests, nuclear gauge tests to control the density of the compacted layers for earthworks, etc. The laboratory shall be established as early as possible but not later than three months from the date of issue of Letter of Acceptance.

iv. The Contractor shall collect the samples, carry out the relevant tests, prepare the complete reports and submit them to the Engineer.

v. All tests will be made according to approved standards, and the testing equipment shall comply with the same standards. All relevant standards shall be made available in the laboratory by the Contractor.

vi. The laboratory shall be provided with light, ventilation, water supply, tank for curing, toilet, office for operators and responsible for laboratory, archive etc. and be spacious enough in order to store indoor the test samples

2.3.21 LAND REQUIREMENT

i. The Employer has acquired the required land for permanent components of the project work which shall be handed over to the Contractor on as is where is basis. Tender drawings show the available land acquired and major permanent structures required to be constructed. The Contractor shall organize the installation site in a way that his temporary buildings, plants, equipment etc. will not hinder the final/permanent works. The land shall be used primarily for execution of work of the project. The Contractor will seek approval of the Engineer for setting up of site facilities on land acquired for the project. Employer's land shall not be used for setting up of labour camps. Nothing additional will be paid for re-shifting of any plants and machinery to the Contractor. Extra land if needed by the Contractor for setting up of any of his facilities, such cost of land will be borne by the Contractor.

ii. The Contractor shall submit his scheme of land utilization including muck disposal and subsequently construct the same after obtaining due approval of

the Engineer.

iii. Muck generated in the works may be used by contractor for constructing his facilities / filling works etc. free of cost. The royalty payment and/or any cess leviable by the statutory authority shall however be payable by the Contractor by such usage.

iv. Any Government duties, cess etc. levied by the statutory authority for land use outside *HORC* land shall be borne by the Contractor at no extra cost to the Employer.

v. Before demobilization, the Contractor shall remove all his temporary facilities which were installed for execution of the work and restore the land to its original state for all such land used as in (i) above.

2.3.22 FENCING AND SITE SECURITY

i. The Contractor's offices, workshops and storage compounds, camp sites and all construction areas, where exclusion of unauthorized personnel is necessary for safety and security, shall be adequately fenced, gated and guarded. A central guardhouse shall be established at each main entrance to the Site.

ii. The Contractor shall employ adequate force of properly trained security guards at the worksite and at the construction camps on 24 hours duty including Sundays and holidays. Storage areas shall be fenced, lighted and regularly patrolled by security guards. Warehouse buildings and explosive magazines shall be kept locked and keys accounted for at all times.

iii. All employees engaged in the execution and maintenance of the Works shall wear identification badges when at the worksite.

iv. The Contractor shall be entirely responsible for the losses occurring in his installations and those of the Engineer, resulting from carelessness on the Contractor's part.

v. The Contractor has to make appropriate provision for LED Lights on top of the barricading and provision of the noise enclosures over the tunnel portals.

2.3.23 SITE SIGNAGE

i. Prior to the commencement of work at the Site, the Contractor, at the direction of the Engineer, shall supply and erect reflector site sign at all work sites for the information of the public at all entrances to the Site, containing the following information, clearly visible and legible (In English and Hindi language) to passersby intended for the information of those affected by the Contract Works, for the guidance of those making deliveries and for general public safety:

   a. Name of Project;

   b. Name of Employer;

   c. Name of Contractor;

d. Restrictions on access and appropriate safety warnings.

ii. The Contractor shall also maintain such signs throughout the contract period with up to date information and free from disfigurement.

2.3.24 The Contractor shall also supply, erect and maintain appropriate reflector site signage and safety warning signs as are appropriate for the nature of the work being undertaken. No other signage or advertising materials shall be permitted on the Site, except with the specific consent of the Engineer.

CHAPTER -3

SURVEYING

3.1 GENERAL

3.1.1 The employer has already established certain benchmarks and alignment references. These benchmarks and alignment markers are required to be validated by the Contractor. Any error found in these benchmarks and alignment markers shall be rectified by the Contractor with the approval of the Engineer. The Contractor is also required to maintain these benchmarks provided by the employer throughout the period of construction. The survey to be done by the Contractor shall be done by establishing the control points along the proposed railway alignment through the use of DGPS. All these control points will then be connected to the nearest GTS Benchmark using the Total Station *and Digital Auto level*.

3.1.2 These services cover in general transfer of control points to working area, the establishment of axis, centerlines, alignments of project structures and features, the setting out for construction thereof; the accompanying control surveys for correct locations, dimensions and elevations as well as the necessary surveys for measurement to permit quantity calculations for billing.

3.1.3 Such surveys shall be based on and/or referred to existing basic grid of datum points, triangulation points and benchmarks extended adjacent to the Work in the project area. This grid shall be the sole basis of reference for all survey work and measurement.

3.1.4 High precision direction measurement of the alignment shall be done at every approx. one km of excavation or as decided by the ENGINEER by use of surveying gyroscopes i.e Gyromat or similar, at the cost of the Contractor.

3.1.5 Contractor has to make the survey of the excavated profile and control the tunnel sections after mucking, after installation of the primary support, prior to the installation of the felt for the protection of the water proofing membrane and after the lining works all along the length of the tunnels to control alignment, envelopes, excavated areas, primary support thickness and the position of the work-forms and final lining geometry, thickness and areas. The quality plan to be submitted by the Contractor to the engineer should give a detailed methodology duly indicating the schedule required to cover all the aforesaid survey items that the Contractor has to deliver to Engineer and also has to include when the topographical survey of the tunnels and portals has to be carried out.

3.1.6 Responsibility of carrying out the work to correct line and level shall, however, continue to devolve on the Contractor notwithstanding the fact that approval for any benchmark and/or alignment marker may inadvertently have been accorded by the Engineer. Consequently, any expenditure incurred by the Contractor for rectification of the permanent and/or temporary works constructed to wrong line/level shall not be payable by the Employer.

3.2 SUBMITTAL

3.2.1 Within 28 days from the Letter of Acceptance, the Contractor shall submit to the Engineer for his approval a proposal of the sequence of the survey works to be

performed, the biodata of the key personnel & in-charge of survey works, the list of survey equipment and instruments the Contractor will have available at the site, and a brief outline on methodologies of survey works to be applied for the various types of survey.

3.2.2 At least 7 days prior to the commencement of any survey work, the Contractor shall inform the Engineer of his intention to perform the survey work. The Contractor shall indicate the purpose of the survey, the area to be surveyed, the structure or facilities involved, the methods to be applied and the survey period.

3.3 MATERIAL AND INSTRUMENTS

3.3.1 The Contractor shall provide, maintain and operate suitable and appropriate equipment, instruments, materials and auxiliary equipment, commensurate with various tasks and precision requirements of the survey works.

3.3.2 Type and accuracy of the survey equipment to be used by the Contractor shall correspond to the nature of the construction, erection works and the construction technique.

3.3.3 All equipment, instruments, materials and auxiliary equipment shall be in perfect operating condition. Prior to the start of survey activities, equipment, instruments, etc., shall be checked as to their proper functioning and accuracy.

3.3.4 During the construction period, the survey instruments shall be checked and adjusted / calibrated at regular time intervals.

3.3.5 Instruments and equipment which have suffered from use, damage or accidents to the extent that they are unfit for further use at the site, shall be removed from the site and replaced immediately.

3.3.6 The Contractor should ensure availability of sufficient quantity and quality of survey instruments including provision of professional staff, to avoid any delay in the construction.

3.4 EXECUTION

3.4.1 General

i. For the execution of the survey work the Contractor shall employ and provide experienced professionals and auxiliary staff. All survey and measurement work shall be recorded and filed thoroughly.

ii. The Contractor shall provide, maintain, adjust when necessary and operate the required survey and auxiliary equipment for the performance of the Work.

iii. All survey and measurement activities shall be recorded in maps and field books as directed/approved by the engineer. Where required, the production of drawings and maps shall be deemed to be part of the work.

iv. The Engineer shall have the right to check work performance, accuracy stations, etc., and all survey results, measurements and calculations as well as conformity with plans and drawings.

v. The Contractor shall keep and maintain professional records of all field surveys and measurements, the related computations and calculations, manuscripts, plans, drawings and maps, and shall make them available to the Engineer whenever requested.

vi. If in the opinion of the Engineer, deficiencies and/or inaccuracies in field and office work have been found, such work shall be repeated and made good to the satisfaction of the Engineer at the Contractor's expense. The Contractor shall be solely responsible for accuracy of Survey maps and drawings prepared out of the surveys.

3.4.2 Preparatory Works

i. Prior to starting survey works, the Contractor shall inform his surveyors of the general construction procedure, survey requirements and time limits. The surveyors shall make adequate terrain investigations with respect to sightings, vegetation to be removed, placement of datum points, reference monuments and benchmarks, taking into consideration future construction work which may affect the survey. Based on these investigations, a survey plan shall be developed comprising existing basic data, the survey grid to be developed, the equipment required for the particular survey task. Staff and time requirements arrangement in a way to warrant smooth progress of construction works. The plan shall be submitted to Engineer in charge for approval.

ii. All survey work shall be done within greatest care and precision.

3.4.3 Verification of Survey Grid

i. The Contractor shall verify the basic survey grid.

ii. All coordinates and elevations as shown on the Drawings are based on the basic survey grid. If after having executed the verification, the basic survey grid reveals inconsistencies, which may affect the location, alignment and elevation or structures of the works, the Engineer shall be forthwith informed of these inconsistencies by the Contractor.

iii. The Contractor shall record all calculations, control surveys, setting out and check surveying in a suitable permanent form for verification, which shall be available to the Engineer on request at all times.

3.4.4 Augmentation of Basic Survey Grid

i. Existing datum points and benchmark located very near to the permanent structures may be endangered by construction activities. The Contractor shall therefore in due time establish additional datum points at safe locations and elevations to augment or extend the basic grid.

ii. The new datum points shall be of permanent nature and shall be constructed as, directed by the Engineer.

iii. The Contractor shall also establish reference monuments for center lines and

line control of structures, which need frequent and extended control surveys for tunnel alignment and connected works.

iv. New datum points, reference monuments and benchmarks shall be protected and maintained in the same way as the original grid points.

3.4.5 Survey of Ground Profiles

i. Original Ground Profiles.

The Contractor shall inform the Engineer in writing, at least 14 days before commencing such work, of his intentions to perform any work which will result in a change to the topography of the existing site for the permanent works and or for temporary works. Thereupon, before commencing any work, the Contractor shall survey the original topography with the approval of the Engineer over the entire area to be occupied or disturbed. Such survey may again be required after removal, of vegetation, topsoil or other overburden. The Contractor and the Engineer shall record the information so obtained. The Contractor shall then provide the Engineer with a reproducible copy of each drawing to serve as a permanent record of the purpose of determining the quantities of excavation or earth works carried out in the construction of the permanent structures, such records will also be required to ascertainthe extent to which Temporary works shall be removed or temporary excavations shall be refilled upon completion of the works.

ii. The Contractor shall also survey all excavated and final surfaces for the purpose of recording as constructed details, and for the measurement of quantities. Such survey shall be required at the following two stages:

a. On completions of excavation and prior to placing concrete or other work.

b. On completion of works.

3.4.6 Setting Out Works

i. The Contractor shall perform all setting out and check surveying of the Works in accordance with methods approved by the Engineer. The methods and programme of checking shall be such as to ensure the construction of every part of the Work to the correct line and level. The Engineer may at any time ask the Contractor to submit proof that his own setting out has been satisfactorily checked.

ii. The number of points required for setting out as well as the spacing between these points shall be determined by the Contractor in accordance with the type of work. The Engineer may require that some or all of the given points and datum levels be clearly marked during construction in such a way that the marks can be retained after completion of construction.

3.4.7 Setting Out Checks

i. Contractor should carry out the Net Survey (Close traverse) regularly at least

once in two months while executing the work of underground excavation and will submit the results to the Engineer to ensure that progress of excavation is correct as per design alignment.

ii. The Contractor is expected to liaise with the Engineer to program the check survey to be carried out during non-production periods or in parallel to construction activities such that the minimum delay or inconvenience is caused to production works, wherever and whenever possible. The Contractor shall afford the Engineer, every cooperation and assistance in this regard including but not being limited to the provision of survey equipment, drainage, lighting, ventilation and the removal of Contractor's equipment and other obstructions such that they do not interfere with the setting out checks.

3.4.8 Tunnel Alignment and Gradients

i. The Contractor shall establish and maintain at suitable distances from tunnel portal at least three (03) reference monuments and benchmarks on the extended tunnel axis/alignment, to warrant that control surveys during tunnel construction can always be referred to such reference monuments. They shall be secured by auxiliary fixed points permitting the reconstruction of the reference monuments in case these have suffered any damage during tunnel excavation periods.

ii. Establishment and control surveys of the tunnel alignment and the gradient shall always be referred to such reference monuments.

iii. Underground alignment and level survey and control thereof shall be performed by the use of suitable precision instruments preferably of the pulsed laser type of equivalent instruments, and auxiliary equipment. Underground survey equipment and methodology shall be subject to the approval of the Engineer.

iv. In addition to the regular survey, carried out by the Contractor, if required an independent survey organization engaged by Engineer at his own cost, will perform confirmatory survey of Tunnel alignments. The first confirmatory survey is likely to be performed after the 1st 100 m of tunnel has been excavated, following confirmatory survey will be carried out after every 200m of excavation or as decided by Engineer. The Contractor shall be notified in advance about the date of such confirmatory surveys. The Contractor shall cooperate with such surveyor and provide any assistance as required (including stoppage of work, if required) at no extra cost to employer. In this regard, the Contractor may please note the contents of clause no. 2.4 of chapter 2 under section 5 of the tender document

v. Contractor should carry out precision gyroscopic measurements (GYROMAT equipment or equivalent) at regular intervals at least every 1 (one) Km progress of the main tunnel and escape tunnel, for accurate high-precision azimuth determination, by specialized agency. A detailed report should be submitted to the Engineer after every gyroscopic verification with

the obtained results.

3.4.9 Accuracies and tolerances

i. Accuracies

Accuracy of survey works shall be within the following tolerances:

Triangulation	
Allowable error of closure • Average not to exceed • Maximum not to exceed	 5 Seconds 10 Seconds
Traversing	
Allowable error of closure Allowable error of distance	10 mm per Kilometer *10 mm per Kilometer*
Leveling	
Allowable error for each 1 km measured forward and backward Allowable error of closure	10 mm 10 √S mm

(Where S is the total distance of leveling expressed in km)

ii. Tolerances

a. The tolerance given below shall be the maximum permissible deviations from the specified dimensions, levels, alignments, positions etc. as shown on the Drawings of the structures of structural elements.

b. In addition, at the interfaces with mechanical components, concrete surface be finished flush and shall also meet any additional tolerances required by the mechanical designs or works respectively.

c. Where the tolerances overlap, the severer tolerance shall apply. Determination of centerlines for alignment of tunnels, access tunnels, galleries, caverns and shafts etc. shall meet the following criteria.

Plan positions of central line	$\pm$30 mm
Elevation	$\pm$10 mm

3.4.10 Subsidiary Monuments and Benchmarks

i. The Contractor shall erect and establish all necessary additional survey monuments, fix points, benchmarks etc. required for setting out of the work and construction control including determination of coordinates and elevations.

3.4.11 Handing over of Basic Survey Data

i. General Requirements

a. Prior to the commencement of the survey works, the Engineer shall hand over to the Contractor all information and data of the verified basic survey gird and benchmarks to which the Contractor's survey work shall refer. Upon handing over, the Contractor shall review this information and data and shall verify the existence of the datum points and benchmarks by field checks. Furthermore, the Contractor shall take responsibility for maintenance and protection of these basic datum points and benchmarks.

b. Should field checks reveal that points and benchmarks have been damaged, displaced or destroyed, the Contractor shall inform the Engineer of this facts, and the Engineer shall give instructions regarding the re-establishment of such datum points and benchmarks.

c. Should it become necessary that basic datum point and benchmarks be removed because of foreseeable construction works, the Contractor shall inform the Engineer of the need thereof and obtain approval and instruction for the establishment of new basic datum points and benchmarks and/or auxiliary points.

d. If, within 2 months upon handing over, inconsistencies within the basic grid or related datum points and benchmarks are detected by the Contractor, he shall inform the Engineer immediately thereof and produce the evidence. The Engineer shall subsequently inform and instruct the Contractor on remedial measures to be taken. Any survey work, setting out or measurement already taken or performed prior to the detection of such inconsistency shall be rechecked and corrected by the Contractor.

e. Additional basic datum points and benchmarks established by the Contractor for the convenience of this work shall have at least the same quality and durability as those of the existing points and meets the accuracy requirements.

ii. Data and Documentation Available

a. Existing topographical maps based on the surveys, covering the area of the works can be made available to the Contractor upon request to the Engineer.

b. Topo mapping of areas for temporary facilities like the Contractor's camp, constructional buildings, construction plant, etc., shall be prepared by the Contractor prior to the construction of such facilities. The Contractor shall also perform surveys works for construction roads and bridges including preparation of maps.

iii. Survey Records and Documentation

a. The Contractor shall keep records of all survey activities such as sketches, field books, calculations, etc., for the duration of the entire construction period. The Contractor shall upon request of the Engineer put at his disposal all records and documentation or provide copies thereof in format agreed by Engineer. On a monthly basis, the Contractor should submit along with the monthly progress report, a detailed report focused on the performed survey work (excavation profiles, tunnel alignment, traversing, etc) and relevant results. After every round, the Contractor shall submit to the Engineer the excavation profile obtained through Tunnel profiler.

CHAPTER -4

DEWATERING, DRAINAGE, PUMPING *AND WATERPROOFING*

4.1 GENERAL

4.1.1 The specifications described herein under relate to the work of dewatering, drainage & pumping and installation of water proofing membrane to be carried out by the Contractor, which shall include supply of all labour, construction plant and materials and performance of all services required to remove service water and natural surface flow or ground water seepage under all conditions including rain and flood water from the working areas on the surface as well as from the underground sites for the construction of various structures covered under the contract.

4.1.2 The Contractor shall design, furnish, build, install, operate, maintain and remove all the temporary dewatering facilities as specified herein or as required by the Engineer.

4.1.3 Minimum buffer stock of one month is required to keep at site for all water proofing membranes, Geo-textiles and other water proofing structures as per agreed works program.

4.2 SUBMITTALS

4.2.1 Within 28 day from the commencement date, the Contractor shall submit, to the Engineer, the detailed design of dewatering system.

4.2.2 This design shall be consistent with the outline description submitted by the Contractor with his bid and shall include the following:

- **i.** Design assumptions and calculations.
- **ii.** Layouts of drainage facilities.
- **iii.** Layout and capacity of pumps and pipes, sumps, drains both open and covered, well points etc. and details of standby dewatering arrangements.
- **iv.** Any other arrangements or installation, the Contractor may propose for dewatering of the working areas both in open and underground Construction sites.
- **v.** The dewatering design should include standby emergency pumping arrangement to deal with any kind of water inflow.

4.2.3 At least 28 days prior to the scheduled construction of the particular work, the Contractor shall submit, to the Engineer, full details of the equipment to be installed and all necessary construction details required for dewatering purpose.

4.2.4 The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.

4.2.5 At least 56 days prior to the scheduled installation of water proofing membrane, the Contractor shall submit, to the engineer, full details of:

- **i.** Certificates of compliance attesting that the materials meet specification requirements.

ii. Manufacturer's instructions for installation of felt backing and water-proofing membrane, including procedures for preparation, fixing, welding and splicing, flashing etc.

iii. Manufacturer's and installer's qualifications to include evidence of experience of the manufacturer and the installers, as well as resume of lining installation supervisors.

iv. Samples as listed hereafter:

a. Membrane: One square meter of each type membrane (3 Nos.).

b. Protective felt: One square meter of each type of felt (3 Nos.).

c. Welded splice: 1 m of welded membrane splice for each type of membrane. (3 Nos.).

d. Fixings and fittings: 10 samples from different lots of rondels and nails, 2 samples of sealing flanges for projections passing through the membrane.

v. Shop drawings showing all necessary installation details for felt and waterproofing membrane, including installation sequence, position of joints, treatment of projections, connection to water stops, connection to waterproofing of structures in open cut, local reinforcements etc.

4.3 GENERAL

4.3.1 Dewatering of the surface as well as the underground Construction sites shall be undertaken by gravity, wherever possible. Where, however, dewatering by gravity is not practical, pumping shall be resorted to after this mode has been approved by the Engineer.

4.3.2 The pumped water carried in pipes or flumes shall be discharged at point sufficiently away from the edge of foundation excavation as directed by the Engineer. Care shall be taken to ensure that there is no seepage and flow of water back to the pit working area.

4.3.3 Power for operating the dewatering system shall be arranged by the Contractor at his own cost. The Contractor shall make his own arrangements to ensure sufficient standby power at his cost to carry on the Works during any interruption of power.

4.3.4 Water proofing membrane

i. Shall be provided to prevent leakage of groundwater into the tunnel and to protect the final concrete lining against deleterious chemical influences. Waterproofing shall be applied to crown and sidewalls above footing or invert arch level. The waterproofing membrane shall always be located between primary shotcrete lining and the final concrete lining. No membrane waterproofing will be provided for tunnel inverts.

ii. The waterproofing system shall consist of two layers: the first shall consist of a protective felt fastened to the shotcrete surface; the second layer shall be the

actual waterproofing membrane properly fixed by special means as recommended by the manufacturer.

While the sealing function shall be provided by the membrane, the layer of felt is required to protect the waterproofing membrane against damage from contact with the shotcrete surface, to prevent interlocking between concrete and shotcrete in case of differential movements of primary shotcrete lining and final lining, and to provide a drainage layer allowing to drain off groundwater into the longitudinal lateral drainage pipes, thus preventing a build-up of hydrostatic pressure on the tunnel lining.

4.4 DEWATERING OF UNDERGROUND CONSTRUCTION SITES

4.4.1 General

i. The Contractor shall perform all works necessary to collect and drain service and infiltrating ground water and flood water entered into the underground construction sites (if any), convey it to main HS/Conduits and lead it out from underground works such as tunnels and shafts. Water pumped or drained out of tunnels shall pass through oil skimmer or other oil separator, then through sedimentation basin or by other means as approved by engineer designed for the maximum expected flow before disposal into natural drain / river to ensure clear water discharge. Construction fencing of 1.8m minimum height or other effective protection shall be installed to prohibit unauthorized persons from trespassing into the area of the sedimentation pond.

ii. The work shall include, but not be limited to, the following:

   a. Design and construction of pits and trenches, flood protection walls at the entrance/exit portals of tunnels/shafts

   b. Design, furnishing, operation and maintenance of dewatering equipment.

   c. All auxiliary works required for the safe and continuous dewatering of the underground sites.

iii. The Treatment tank shall have arrangement to segregate the PP fibers from water before disposal into natural drain / River to ensure minimum damage to environment. All such fibers so collected shall not be used back on the project and shall be disposed off safely according to manufacturer's recommendations and engineer's approval.

4.4.2 Requirements and Design

i. The Contractor shall design and provide a complete dewatering system for all underground construction sites.

ii. All excavated areas shall be drained off all service and ground water. In order to keep the construction areas free from water, the dewatering systems shall be able to operate at any time during the whole construction period in any part of the works at the required design capacity.

iii. The Contractor shall provide adequate pumping capacity, including a sufficient number of standby pumping units, to handle all water entering including sudden gush of water / flowing ground water condition/ flood water into any portion of Underground works. These units shall be connected to the dewatering systems in such a way that proper and uninterrupted drainage is guaranteed throughout the entire construction period.

iv. The Contractor shall make arrangement for sufficient stand-by power at his own cost to carry on the works during any interruption of power. The standby power supply shall undergo weekly trial runs lasting at least 30 minutes. No claims shall be entertained, and contractor shall be answerable for lack of progress on this account.

v. All components of the system shall always be maintained in ready for service condition and all access to pumps and other equipment shall be kept in good condition under the most adverse conditions.

vi. The Contractor shall ensure that all drainage water is disposed off without causing interference to his own or other Contractor's operations elsewhere on the site, and that no drainage water runs into adjacent works.

vii. The dewatering system shall be designed and installed in such a way that modifications and extensions to the system are possible while they are in full operation.

viii. All the components of the dewatering system shall be installed and operated in accordance with the approved method and the construction time schedule, or approved modification thereof.

ix. The approval by the Engineer of the dewatering system shall not relieve the Contractor from being fully responsible for the design, construction, operation, maintenance, safety and removal of the facilities provided for the dewatering system and he shall be liable for any damage or delays caused by its failure. The Contractor shall indemnify the "Employer" against claims arising out of any such failure made by a third party.

4.4.3 Materials and Execution

i. The Contractor shall construct the drainage trench in invert of the tunnel as required at site and approved by the Engineer.

ii. After the excavated profile has been checked, the ground water which runs or drips into the excavated space shall be diverted into the drainage trench by means of water collectors and pipes for collecting the seepage water from rock surfaces or laggings. Damp surfaces or seepage areas with low volume inflows can be sealed off with a quick setting-sealing compound.

iii. Special care shall be exercised where excavation passes through material, which is liable to soften or swell when it comes in contact with water. In such locations, water entering the excavated space shall be collected as soon as possible and conveyed away / disposed off in such a way that the water does

not come in contact with such material. Should the Contractor neglect to observe this requirement and a deterioration of the excavated surface of tunnel invert results from water being allowed to flow over or stand upon the sensitive or swelling material, the Engineer may order the removal of the material from affected surface and its replacement with concrete. The Engineer may order installation of additional rock supports in connection with such remedial work at the cost of the Contractor.

iv. If any water from another portion of the underground works flows into a lower section where concreting is being done, which is likely to be affected by water, all such water shall be diverted past this area in such a way that no damage occurs to the concrete. The length of the affected sections over which water has to be diverted shall be ordered by the Engineer.

v. The Contractor shall perform regular checking and cleaning of the drawing trench and all dewatering equipment and accessories during the construction period.

vi. The dewatering facilities shall be kept in operation according to the approved schedule, which shall be related to the progress of the work. No pumps shall be stopped, no pipes, ducts, trenches, etc. shall be taken out of service without the permission of the Engineer.

vii. Any openings such as pipes, boreholes, ducts, pumps, sumps etc. used for temporary drainage purposes. In any part of the work shall be completely sealed by filling with grout, mortar or concrete when no longer required, unless otherwise directed by the Engineer in writing. The Contractor shall notify the Engineer in writing before any such openings are permanently closed.

viii. Water proofing membrane (Material)

A. Protective Felt

a. The protective felt shall be a continuous filament non-woven poly-propylene geotextile of uniform thickness and surface texture meeting the requirements listed below.

Property	Specified Value	Standard
Unit weight	500g/m^2 min	DIN 854
Thickness at 0.02 bar	3.9 mm min	DIN 53855/3
Thickness at 2.0 bar	1.9 mm min	DIN 53855/3
Tensile strength	1000 N/cm^2 min	DIN 53857/2
Extension at break	70 % min	DIN 53857/2

Property	Specified Value	Standard
Extension at 30% of Tensile Strength	20 % min	DIN 53857/2
Permeability in plane at 0.02 bar	$5x10^{-1}$ cm/s min	*
Permeability in plane at 2.00 bar	$5x10^{-2}$ cm/s min	*
Resistance against acid and alkaline solutions (pH 2-13)	Loss of strength 10% max	DIN 53857/2
Resistance to Punching	2000 N	DIN 54307

B. * *Test according to Franzius Institute, Hannover, BRD*Waterproofing Membrane

a. The waterproofing membrane shall be Polyvinyl Chloride (PVC).

b. The membrane shall be supplied with a signal layer, i.e. a thin sheeting of different color, bonded to one side, which is intended to facilitate the detection of damages.

c. PVC Waterproofing Membrane (poly-vinyl-chloride) will satisfy following specifications:

d. Accessories: Fixing material, flashing, reinforcement for expansion joints, sealing flanges and preparation of corners and intersections shall be made as recommended by the manufacturer of the membrane.

Property	Specified Value	Standard
Thickness(mm)	≥2.0	EN1894-2
Tensile strength at break(N/mm^2) Elongation at break (%)	≥17 ≥300%	EN12311-2
Resistance to tearing (N/mm)	≥100	EN12310-2
Puncture static test (kN)	≥2.5	ENISO12236
Water tightness (B method–24hoursat0.5N/mm^2)	Watertight	EN1982

Property	Specified Value	Standard
Change of dimensioning after heating at +70°Cfor2 hours	Stable	EN1110
Cold bending(°C)	≥-35	EN495/5
Resistance to acidic and alkaline at 28days	20% maximum elongation.	DIN16726
Resistance of joints (N/mm^2)	≥10.5	EN12317-2
Fire reaction classification	Class E	EN13501-1

C. Waterproofing Membrane (Installation)

D. Surface Preparation

a. All surfaces to which waterproofing is to be applied shall be sufficiently clean, smooth and free from deleterious materials and projections.

b. The following treatment of surfaces shall be performed prior to the installation of waterproofing:

1. For the fixing of the protective felt and the waterproofing membrane, a minimum shotcrete cover of 50 mm to rock is required.
2. Irregularities of the shotcrete lining surface shall be eliminated by means of additional shotcrete. The ratio of the diameter to depth of irregularities shall be not less than 5:1. Rounding at rock bolts (where applicable), etc. shall have a min. radius "ra" of 0.3 m. Details are given in Figure below.
3. Transitions and intersections of tunnel profiles shall be rounded off with a minimum radius of 500 mm.
4. Protruding steel bars, wires, spacers, pipes etc. shall be cut off unless treated with additional shotcrete cover.
5. Exposed steel parts such as rock bolts, if not intended to remain accessible, shall be covered with shotcrete.
6. If required, as per the instruction of the Engineer shotcrete surface shall finally be smoothened with fine-graded shotcrete (rounded aggregates, grain size 0 - 4 mm), applied in a layer of 30 mm average thickness.

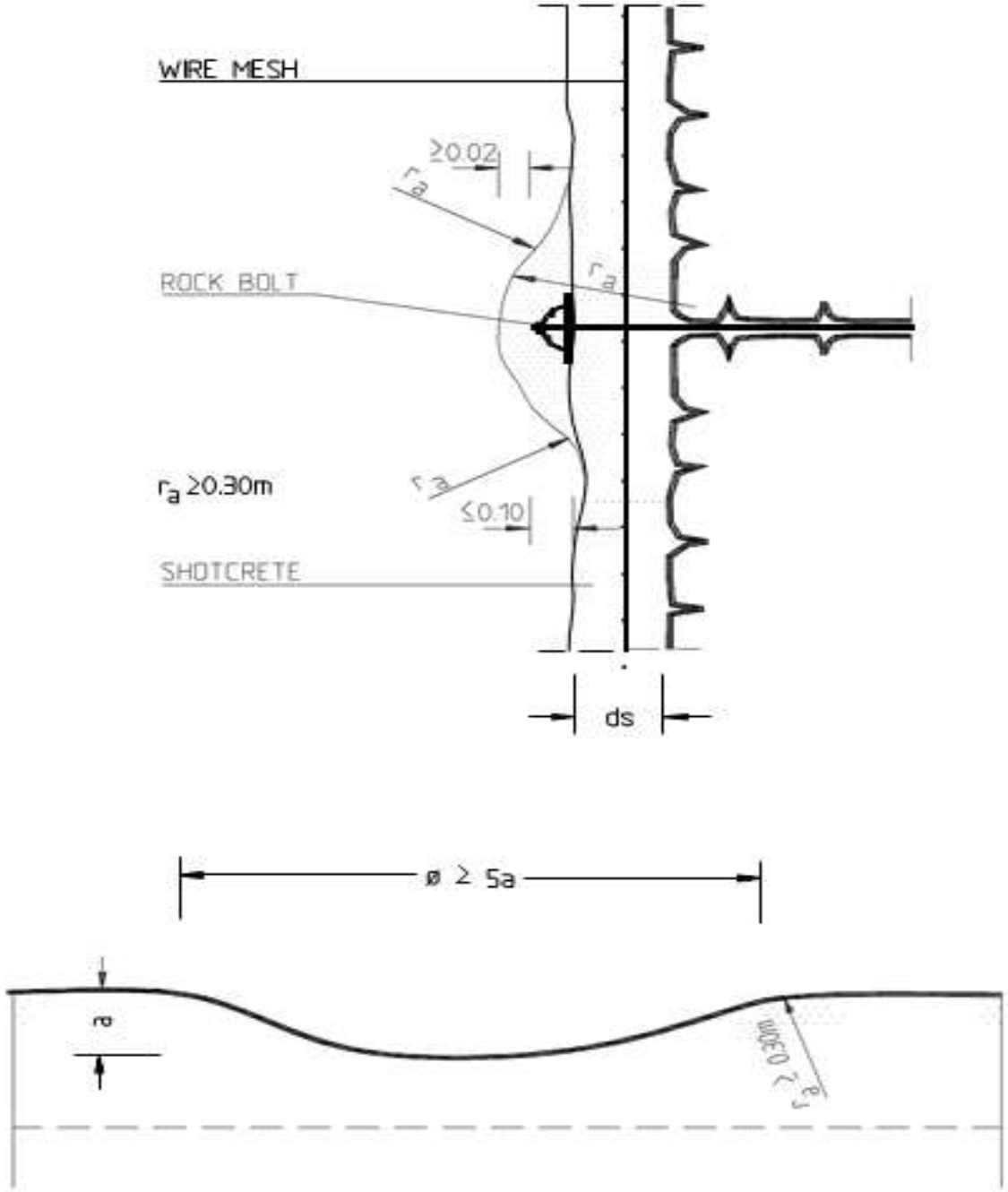


Figure 1: Requirements on surface irregularities of shotcrete

E. Application

a. General: Prior to the application of the waterproofing, all surfaces to which it shall be applied, shall be inspected and approved by the ENGINEER. The application shall follow the written instructions of the manufacturer. Special preparations will be required for waterproofing at tunnel intersections and for projections passing through the membrane. They shall be carried out according to the manufacturer's recommendation.

b. Fixing of Felt: The protective felt shall be attached to the shotcrete surface using suitable fixings specified by the manufacturer.

Depending on the location 2 to 4 nos. fixing elements shall be used per square meter. The felt shall be laid with enough slack to avoid overstress during concreting. Adjacent sections of felt shall be overlapped by 100 mm and joined by point welding or similar suitable method. Along the bottom of the tunnel side walls the felt shall extend sufficiently to cover the lateral drainages as shown on the drawings.

c. Fixing of Waterproofing Membrane: The waterproofing membrane shall be installed to cover the felt and shall be attached to the felt fixings and to each other and to the washers by means of thermal welding. No perforation of the membrane shall be allowed for installation purposes. The waterproofing membrane shall be laid with the signal layer towards the inside and with enough slack to prevent overstressing during concreting. Adjacent sheets of waterproofing shall be joined by a double weld. Along the bottom of the tunnel side walls the membrane shall extend sufficiently to cover the lateral drainages as shown on the drawings. Connections to water stops and to the waterproofing of structures in open cuts shall be carried out according to drawings to be furnished by the supplier.

F. Testing of seams

a. General: All seams shall be tested, and records of these tests shall be submitted by the Contractor to the ENGINEER.

b. Seam Test with Compressed Air: For seams between adjacent sheets of waterproofing membrane the testing for tightness shall be carried out by means of compressed air pumped into the test channel which is formed by the double welded joint. Initial test pressure shall be 2 bar for a test period of 5 minutes or 1.5 bar for a test period of 10 minutes. The joint shall be considered waterproof if the loss of air pressure is in both cases not more than 20%.

c. Seam Test with Vacuum Equipment: For the testing of areas of membrane of limited size such as special con- figurations of joints or local repairs with patches, vacuum equipment shall be employed, as instructed by the ENGINEER. This equipment consists of a vacuum bell which, after being fitted tightly over the area to be tested, is evacuated by pumping in order to detect leaks in the membrane.

d. Protective Measures: Every care shall be taken not to damage the waterproofing membrane during or after installation. Any damages occurred shall be repaired and tested before the casting of the final concrete lining.

4.4.4 WATER STOPPER

i. Polyvinyl Chloride (PVC)/ rubber water stops shall be furnished and installed for watertight construction at various locations of concrete structures / components covered under these specifications. In order to ensure proper alignment and fixing of water stops in correct position / place, the same shall be rigidly secured to the form work or reinforcement steel as direct/approved by the ENGINEER.

Number of joints in PVC/rubber water stops, when installed in place shall be the barest minimum and joints, thus made, shall be suitably vulcanized/welded using best method/Engineering practice satisfactory to the ENGINEER.

ii. All types of water stops shall be tested in a recognized laboratory prior to transport to the site. Test specimens shall be furnished by the manufacturer and the tests shall be carried out at the manufacturer's place.

iii. Water stops shall be tested as to their tensile strength, elongation, duration, water absorption, specific gravity, effect of alkali and impact resistance. The PVC Water stops shall meet the following requirements:

iv. The Contractors shall submit to the ENGINEER for approval the test results from recognized institution showing that the material supplied meets the requirements specified. The ENGINEER may carry out the additional tests, for which the Contractor shall supply specimens from the same material to be used in the work. Test specimens, if required shall be of the shape and dimensions as required in the individual test methods.

Requirement	**Method of Test**
Tensile strength using die "C" not less than 150	ASTM D-412
Ultimate elongation using die "C" not less than 330%	ASTM D-412
Stiffness in flexure, 6 mm span: not less than 28	ASTM D-747
Tear resistance: not less than 30 kgf/cm2	ASTM D-624
Specific Gravity: not less than 1.20	ASTM D-792
Shore Hardness: 60A to 80A	
Water Absorption: not more than 5% in a 7 days test	

v. Precautions for Water stopper:

a. PVC water stops will be provided according to drawings in transversal and longitudinal positions at all along the lining tunnel extension. These bands must be welded (heat or vulcanization) among them at the intersection points. For the fault areas, an Omega PVC band will be affixed to the waterproofing membrane. The geometry and type of these water stop bands and Omega band are defined in specific project drawings. To weld the ends of the water, stop bands in transversal joints or in the intersections between transversal and longitudinal water stops

bands the parts that must be vulcanized have to be prepared. It is responsibility of the Contractor the preparation and the vulcanization of the water stops unions.

b. When delivered to site, the water stop products must be unloaded carefully and inspected immediately for completeness and integrity, including form and dimensions. Before installation the water stops must be kept in a sheltered place on boards or some other firm base (e.g. pallets, concrete surfaces) and protected from contamination or damage.

c. Water stops must be protected from direct sunlight, especially in summer, e.g. by covering. In high outside temperatures water stops must be taken to the point of installation and laid out under no tension.

d. Water stops should be kept in covered storage if possible and then be put in heated rooms for at least one full day prior to their installation, to make their handling and installation easier and less prone to damage (thermoplastic material).

vi. Installation of water stopper

a. Fixing Internal Water stops: Internal water stops are anchored to the reinforcement. The water stops are fixed to the edge anchors with the special waterstop clip or, in the case of waterstops with steel plates (FMS, FS) to the edge perforation of the steel plates at maximum intervals of 25 cm.

b. Spacing Between Joints in the waterstops Themselves: The spacing between two joins in the waterstops themselves should be 0.50 m minimum. In every configuration the length of the free waterstop ends should be1.00 m minimum so that these connection joints can be formed easily and correctly on site.

c. Embedding of External Waterstops: Waterstops must be free from contamination and ice when casted in. If necessary, they should be cleaned before concreting (e.g. removal of any accumulated site debris such as sawdust, sand, concrete residues, cement laitance, oil, grease, snow, ice etc.). This is particularly important for external waterstops in the base of a structure.

d. Clearance between Poker Vibrators and Waterstops: The poker vibrators must never touch the waterstop or its fixings (minimum clearance ≥10 cm). It is usually preferable to compact around external waterstops with external vibrators, which will also give better compaction around stop end anchors.

e. Protection of Exposed Waterstops on Site: The waterstops should be protected from damage until they are fully casted in.

4.4.5 Permanent Groundwater Drainage

i. General

a. This Chapter applies to the installation of the permanent groundwater drainage system in the tunnel.

b. This Chapter covers the requirements for the permanent groundwater drainage system inside the tunnel.

c. The drained groundwater will flow from the highpoint of the tunnel alignment to Main tunnels.

d. The permanent groundwater drainage of the tunnel shall consist of a main collector pipe along the entire length tunnel and lateral drainage pipe(perforated) with transversal connection pipes to the main collector pipe at regular interval along tunnel sections where major water inflow occurs. The decision of the groundwater drainage system to be installed along a certain tunnel section will be made by the ENGINEER.

e. Drainage gutters shall be located along the entire length of the tunnel at the bottom of either tunnel side wall for collecting groundwater possibly entering through the tunnel lining. The water shall be diverted into the main collector pipe by means of transversal connection pipes.

f. Along tunnel sections with lateral drainage pipes and without invert arch, perforated pipe will be installed at the bottom of the tunnel as invert drainage.

g. At the intersections of the main collector pipe with the transversal connection pipes maintenance manholes shall be installed. Manholes shall also be installed for the maintenance of the invert drainage.

ii. Materials

a. The lateral drainage pipes shall consist of circumferentially slotted, PVC pipes with a minimum diameter of 200 mm as shown on the drawings. The slots shall be within the corrugated area. The width of slots shall not exceed 1.0 mm. The total area of the slots for water intake shall be more than 100 cm2 per metre length of pipe.

b. The main collector pipe in the main and escape tunnels shall be virgin HDPE pipes as per design drawings. The HDPE pipe shall be confirming to I.S. 4984/ 4151 / 12786/ 13488 with necessary jointing material like mechanical connectors i.e. thread / insert joint / quick release coupler joint / compression fitting joint or flanged joint

c. The transversal connection pipes shall be PVC pipes with a minimum diameter of 150 mm.

d. The cleaning access pipes shall be PVC pipes with a minimum diameter of 150 mm.

e. No-fines porous concrete shall be used for embedment of the lateral drainage pipes and of the invert drainage pipe. No-fines porous concrete

shall also be installed at the bottom of Regular Tunnel Cross Section Type as shown on the respective drawing. No-fines porous concrete shall be composed of ordinary Portland cement and single-sized aggregate of nominal size of 40 mm according to IS 383 (with a maximum grain size of 40 mm). The ratio of aggregate to cement shall be 8:1 by volume or 10:1 by mass.

f. Maintenance manholes as well as the drainage gutters shall be made of concrete grade M30 according to IS 456: 2000. (Reaffirmed 2011)

g. Inspection shafts that will be installed in the ballast less track of the Main Tunnel shall be constructed in accordance to the requirements of the BLT design and approved by the BLT engineer.

iii. Execution

a. The water appearing and/or collected during construction behind the waterproofing membrane shall be diverted permanently into the lateral drainage pipes installed at the bottom of each sidewall of the tunnel.

b. The lateral drainage pipes shall be covered and protected by no-fines porous concrete.

c. Inspection chamber shall be installed in the inner concrete lining for permanent maintenance (flushing) of the lateral drainage pipes as shown on the drawings.

d. The Contractor shall ensure that the permanent ground water drainage system is used only for the control of groundwater. Throughout the construction regular inspection and servicing shall be provided.

e. The Contractor shall protect and maintain the permanent ground water drainage system during construction phase so as not to compromise the effectiveness of the system during operation.

f. All pipes for control of the ground water shall be installed to line and grade as shown on the drawings.

g. No-fines porous concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to coat all of the aggregate particles without forming excess grout. The no-fines porous concrete shall be compacted by hand only.

CHAPTER -5

DEWATERING OF SURFACE CONSTRUCTION SITES

5.1 DEWATERING OF SURFACE CONSTRUCTION SITES

5.1.1 General

i. The Contractor shall perform all works necessary to drain the surface construction sites of rain, flood water, ground water and service water. The Work shall include, but not be limited to the following:

   a. Design and construction of drainage, ditches, pits, dykes/bunds and pump sumps.

   b. Design, furnishing, operation and maintenance of dewatering equipment.

   c. Relocation of dewatering facilities required for the performance of other Works.

   d. All auxiliary Works required for safe and continuous dewatering of the construction sites.

ii. Dewatering of surface construction Sites located near and above a river/stream shall be done up to the existing water level in the river / stream by gravity as directed by the Engineer. Suitable drainage shall be made joining the course downstream of the construction Site to provide required gradient to facilitate proper and efficient dewatering. Below the water level of the stream, dewatering shall be done by pumping water collected in the sumps and discharging the same into course of the river/stream downstream of the construction Site.

5.1.2 Requirements and Design

i. The Contractor shall design and install complete facilities at the surface construction Sites.

ii. The surface water dewatering systems shall be designed to accommodate, without undue disruption to the work, any rainfall event and considering the extent of the Sites to be dewatered and the dewatering arrangements proposed.

iii. Claims for extension of time due to delays caused by unfavorable weather conditions will not be considered.

iv. The Contractor shall provide adequate pumping capacity, including standby units, to handle all water entering any of surface construction Sites. In addition, he shall provide sumps and pumps and or well points in the immediate vicinity of the structure foundations using such water conductors as are necessary to conduct the water away from the excavation and concrete placement operations in an approved manner, so that such operation shall be kept free from standing or running water.

v. Power for operating the dewatering system shall be arranged by the Contractor from existing poling points. The Contractor shall also make his own arrangement for enough standby power at his own cost to carry out the works during any interruption of power.

vi. The Contractor shall ensure that all drainage water is disposed off without causing interference to his own or other Contractors' operations elsewhere on the Site and that no drainage water runs into adjacent Works.

vii. The dewatering systems shall be designed and installed in such a way that modifications and extensions to the systems are possible while they are in full operation.

viii. All the components of the dewatering systems shall be installed and operated in accordance with the approved method and the construction time schedule, or approved modification thereof.

ix. The approval by the Engineer of the dewatering system shall not relieve the Contractor from being fully responsible for the design, construction, operation, maintenance, safety and removal of the facilities provided for the dewatering system and he shall be liable for any damage or delays caused by its failure. The Contractor shall indemnify the Employer against claims arising out of any such, failure made by a third party.

5.1.3 Materials and Execution

i. Catch water drains shall be excavated along the top of excavated slopes and on the berms. Such drains shall be kept well back from the excavation edges in order to prevent saturating the upper part of the slopes. The drains shall be regularly cleaned out of all accumulated silt and other matter so that water may always flow freely .

ii. Where excavation is to be made below the ground water table, the Contractor shall lower the water table sufficiently below any working surface by means of properly screened wells and/or ditches to ensure that the foundation surfaces remain free of standing water and undamaged by the passage of construction traffic. All drains shall be outside the foundation areas. The water shall be collected and removed by pumping, if no outflow by gravity is possible.

iii. Where concrete is to be placed, the water table shall be maintained below the lowest part of the finished excavation for minimum one day following the raising of structure above the natural ground water table, and for such additional time as may be necessary to preclude damages to structure foundation.

iv. In trenches and foundations, the dewatering shall always enable to carry out the excavation Work in dry, and in a manner that will prevent loss of fines from the foundation.

v. Upon completion of dewatering, temporary pipes and pump sumps beneath permanent structures shall be closed off and filled with grout, mortar or concrete as required by the Engineer.

CHAPTER -6

EXPLOSIVE AND BLASTING

6.1 GENERAL

6.1.1 The Specifications described herein under relate to supply transportation, handling, storage and use of explosives. All operations shall be carried out by the Contractor as per Indian Explosive Act, statutory requirements and regulations as applicable in India.

6.1.2 Contractor may obtain license from statutory authority for procuring, transporting, storing and using explosives. The same may also be arranged through existing approved suppliers/license holders in the project area. The Contractor may also have his own magazine for the storage of explosives etc. In either case, no claim from the Contractor will be admissible on account of any delay in obtaining any mandatory permissions or in arranging the same for progress of the work.

6.1.3 The Contractor will be required to draw the explosives, transport to the site and keep it safely as per safety guidelines of Indian Explosive Act. He shall acquaint himself with all applicable latest laws and regulations concerning storing handling, safety and use of explosives. The Engineer may issue modifications, if required, and the Contractor shall comply with the same without these being made a cause for claim whatsoever, against "EMPLOYER".

6.1.4 Word "Explosives" would also mean the accessories related I similar substances for the purpose of safety unless otherwise specified.

6.2 SUBMITTALS

6.2.1 At least 56 days prior to the commencement of the excavation works, the Contractor shall submit to the Engineer for approval, the details relating to transportation, storage and use of materials such as explosives, detonators, Detonating I safety fuse coils, Blasting Cables, Exploders, Loading Poles and tamping materials etc.

6.2.2 The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.

6.3 STANDARDS

6.3.1 Transportation, handling, storage and use of explosives shall be carried out under Indian explosive regulation, 1984 in a safe and efficient manner and shall also conform to the following Indian Standards or where not covered by these Standards, to equivalent International Standards.

Indian Explosive Act 1883 and Explosives regulations 1984 (Amended 2005)

IS 4081 Safety code for blasting and related drilling operation underground excavation in rock.

IS 6609 Methods of test for commercial blasting explosives and accessories.

IS 10081 Terms relating to commercial explosives, Pyrotechnics and blasting practices.

IS 15447(Part-I) Commercial blasting explosives specification- Nitroglycerin based.

IS 4863 Glossary of mining terms (drilling and blasting)

IS 7526 Detonating fumes.

IS 7632 detonators.

IS 5878(Part-II/Sec. I) Code of Practice for construction of tunnels

6.3.2 In case of conflict between the above standards and the Specifications given herein the specifications shall take precedence.

6.4 SUPERVISION

6.4.1 Before taking up blasting operation, contractor/Explosive manufacturer shall submit face wise blast pattern covering blasting pattern, minimum safe charge, vibration control / monitoring etc. for various class of rock mass likely to encounter during excavation to be approved by Engineer/institute of repute as approved by Engineer. Such study report shall have to be got updated improved periodically during the excavation period.

6.4.2 Design and excavation by blasting shall be permitted only under the supervision of competent and trained workmen who are fully experienced in the work and who have received adequate instructions. The Contractor shall make sure that his blasting crew is fully conversant with the rules and regulations concerning storing handling and use of explosives. *The design of blasting and vibration monitoring shall be got approved from CIMFR Dhanbad by the Contractor at his cost before submitting to the Engineer for approval. Initial blasting in rock shall be supervised by officials of CIMFR. Blasting near portal P1 shall also be supervised supervised by officials of CIMFR. All expenditures incurred on the visit of officials of CIMFR shall be borne by the Contractor.*

6.4.3 Blasting specifications should include detailed description of state-of-the-art detonators, explosives and blasting patterns as well as blasting expert services including training of actual site personnel to be provided on site at the start of the project.

6.5 TRANSPORTATION AND HANDLING

6.5.1 Explosive shall not be transported to the Site of operation except in suitable cases or containers, which are so made as to prevent any spillage of explosives during conveyance. No explosive shall be removed from such cases or containers except when it is to be used forthwith for the purpose of the work.

6.5.2 Suitable Explosive Vans, duly approved by the Engineer, shall be used for transportation of explosives and detonators. The following rules shall be observed for use of Explosive Van:

i. Vehicles shall have springs under the body. Tyre pressures shall be as per Indian Explosives Regulations.

ii. Detonators and igniters shall not be carried in the same vehicle with explosives.

iii. Beside the driver, only one helper shall be accommodated in the Explosive Van. The vehicle carrying the explosives shall not be used to transport workmen or other materials to workshops although there may be enough space for men or materials.

iv. Driver shall not leave the vehicle unattended while transporting explosives.

v. All vehicles transporting explosives shall be marked or placarded on both sides and with the word "EXPLOSIVES" in bold letters. All explosive boxes shall bear explosive's Batch details, Mfg. Date and specifications etc. clearly on them.

vi. A motor vehicle carrying explosive shall not be refueled except in emergencies and that too only when motor is stopped, and other precautions taken to prevent accidents. Such vehicles shall invariably have at least two fire extinguishers placed at convenient points.

vii. Use of Mobile phones shall be restricted while carrying detonators or while refueling takes place.

viii. Explosives Vehicle should have the seat belt for driver and the use shall be mandatory for the driver.

ix. Vehicles transporting explosives shall never be taken into a garage, repair shop parked in congested areas, or in a public garage or similar building.

x. Explosives shall not be transported on a public highway during hours of darkness except in extreme emergency and that too only with the written approval of the Engineer.

xi. Explosives shall not be transported in any form of trailer, nor shall any trailer be attached to a motor truck or vehicle hauling explosives.

xii. No transfer of explosives from one vehicle to another shall be made on any highway except in case of emergency.

xiii. Persons employed in the transport or handling of explosives shall not carry with them or in the vehicles, matches, loaded firearms, petrol or any flame-producing devices.

xiv. All explosives shall be adequately protected against theft.

xv. Smoking shall be prohibited during handling, transportation and use of explosives. The places of Explosives storage shall be clearly marked as "No Smoking".

xvi. The speed of the vehicle shall not exceed 25 km per hour on rough roads and 40 km per hour elsewhere.

xvii. The interior of the body of the vehicle shall not have any exposed metal parts except those of copper, brass and other non-Sparking metals and shall be preferably lined with wood.

6.5.3 Motor vehicles used for transporting shall be carefully inspected daily to ensure that:

i. No petrol driven vehicle shall be used.

ii. Filled and serviceable extinguished are in position.

iii. The electric wiring is well insulated and firmly secured.

iv. Chassis, engine and body are clean and free from surplus oil and grease.

v. Fuel tank and feed lines are not leaking.

vi. Lights, brakes and steering mechanism are in good working order

vii. Vehicle is in proper condition in all respects for the safe transportation of explosives.

viii. Two nos of red flags shall be present at the left and right top front ends of the vehicle

ix. Condition of Van doors and locking arrangement shall be checked to ensure that rainwater or moisture doesn't damage the explosives case.

6.5.4 Boxes or explosives shall not be handled roughly or allowed to fall.

6.5.5 Containers of explosives shall be opened only by means of non-sparking tools or instruments.

6.5.6 After the loading of a blast is completed, all excess explosives and detonators shall be removed to a safe location or returned at once to the storage magazine, observing the same rules as when being conveyed to the blasting areas.

6.5.7 Containers for detonators shall always be used for storing detonators only.

6.5.8 Explosives and detonators shall be carried in separate containers and by separate persons to the loading face. Only non-electric detonators shall be used.

6.5.9 The drivers of the vehicle carrying explosives shall be trained in use of fire extinguishers on his vehicle.

6.5.10 If any fire occurs on a vehicle carrying explosives the driver shall take all practicable steps to ensure that all other traffic is stopped at least 300 m from the vehicle and that all persons in the vicinity are warned of the danger.

6.5.11 Loadings, unloading and handling of explosives shall, be supervised by qualified personnel. At the time of loading or unloading of explosives no electric switch shall be operated.

6.5.12 Explosives shall not be placed where these may be exposed to flame, excessive heat sparks or impact or hazards of similar nature.

6.5.13 The covers of the explosives cases or packages shall be replaced every time after taking out part of the contents as long as any explosives are left in them.

6.5.14 Explosives shall not be carried in any way other than as specified in The Explosives Act & The Explosives Rules.

6.5.15 Contractor shall ensure no misuse or mishandling of explosives such as carrying the explosives material in the pockets or folds of clothing etc. by any person.

6.5.16 Primers shall not be made up in advance. Priming shall be carried out only when charging of the face starts except emergency for which written approval from Engineer shall be required.

6.5.17 Nothing shall be inserted in the open end of a blasting cap except fuses.

6.5.18 No person shall strike, tamper with, or attempt to remove or investigate the contents of a blasting cap or an electric blasting cap or attempt to pullout the crimped safety fuse out of a blasting cap.

6.5.19 No attempt shall be made to soften the explosives by any specific treatment such as heating over a fire or by rolling the explosive on the ground.

6.5.20 The blasting powder, explosives, detonators, fuses, etc. shall be in good condition and not damaged due to damp moisture or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed immediately.

6.5.21 No attempt shall be made to reclaim or use fuses, blasting caps, electric blasting caps or any other explosives, which have been water, soaked, even if these have been dried out. The manufacturers shall be consulted for this.

6.5.22 The Contractor shall make all necessary arrangements for the security of the explosives during transportation. However, the Engineer, upon a request by the Contractor, may arrange protection by the Govt. security forces for large quantities of explosives, and the corresponding cost shall be borne by the Contractor.

6.6 STORAGE

6.6.1 The Contractor may either obtain necessary licenses and consents and provide secure storage facilities for all explosives and equipment in accordance with Indian explosive act and requirements of local administration and engineer or may arrange explosives from *any* existing explosive supplier in the region. In either case, the Contractor shall take approval of engineer and keep him initiated of the source of explosives. No claims on account of any delays will be admissible in this regard.

6.6.2 If the Contractor has arranged the required licenses and decided to establish his own magazine for the storage of explosive etc. then: -

- **i.** The Contractor will be required to draw the explosives, transport to the site and keep it safety as per safety guidelines of Indian Explosive Act and the Explosive Rules. The magazine shall always, be kept scrupulously clean.
- **ii.** All the explosives like dynamite shall be stored in a dry clean, well ventilated and fireproof building' constructed in accordance with Indian Explosives Act, on an isolated Site. The area around the magazine for 8 m shall be kept clear of all vegetation and combustible matter.
- **iii.** There shall be a barbed wire fencing and security lights around the magazine and security guards shall be posted around for 24 hours to prevent loss or theft of explosives.
- **iv.** Explosives, detonators and fuse coils shall be stored separately.

v. The Contractor shall maintain a record of storage and withdrawal of all explosives. This record shall be made available to the Engineer on request. The Engineer shall be promptly notified of any loss or theft of explosives.

vi. Explosives shall be stored and used chronologically to ensure that the ones received earlier are used first. There shall be enough space between the stacks.

vii. A "preparation area" shall be identified close to the charging face prior to every blast for preparatory work by experienced men as required for the work. All safety measures shall be ensured in the "preparation area".

viii. Unauthorized persons shall not be allowed at any time to enter the magazine.

ix. The person-in-Charge of the magazine shall, always, ensure that the magazine is securely locked.

x. Explosives shall be handled and used only by the Contractor's duly authorized personnel. The names and qualifications of such personnel shall be submitted to the Engineer in writing in advance of any possible use of explosives.

xi. The magazine on no account is to be opened during or on the approach of a thunderstorm and no person shall remain in the vicinity of the magazine during such storm. Enough lightning conductors shall be provided on top of the magazine.

xii. Magazine shoes, without nails, shall always be kept in the magazine, and a wood tub or cement trough, about 30 cms high and 45 cms in diameter filled with water shall be fixed near the doors of the magazine.

xiii. Persons entering the magazine shall put on the magazine shoes provided for the purpose and be careful not to allow the magazine shoes to touch the ground outside the clean floor.

xiv. Persons with bare feet shall before entering the magazine, dip their feet in water, and then step direct from the tub over the barrier (if there is one) on to the clean floor.

xv. A brush or broom shall be kept in the lobby of the magazine for cleaning the magazine on each occasion it is opened for the receipt, delivery or inspection of explosives.

xvi. No matches shall be allowed in a magazine.

xvii. No person having articles of steel or iron on him shall be allowed to enter a magazine.

xviii. Oily cotton rags, cotton waste and articles liable to spontaneous ignition, shall not be taken into a magazine.

xix. No tools or implements other than those of copper, brass, gun metal or wood shall be allowed inside the magazine. Tools shall only be used with great gentleness and care.

xx. Boxes of explosives shall not be thrown down or dragged along the floor and shall be stacked on wooden trestles. Where there are white ants, the legs of the trestles shall rest in shallow, copper, lead or brass bowls, containing water.

xxi. Package containing explosives shall not be allowed to remain in the sun.

xxii. Empty boxes shall not be stored in the magazine nor let any packing material lie loose.

xxiii. Blasting caps and electric blasting caps shall never be stored in the same box, magazine or building with other explosives.

xxiv. The following shall be hung in the lobby of the magazine:

a. A copy of these rules;

b. Display of Magazine License No and the capacity

c. A statement showing the stock in the magazine and

d. Certificate showing the last date of testing of the conductor

xxv. Adequate firefighting equipment shall be provided in the magazine.

xxvi. Signboards reading "DANGER HIGH EXPLOSIVES" "PROTECTED AREA" "NO SMOKING etc. shall be conspicuously displayed in front of the magazine.

xxvii. No explosives shall be stored in the tunnel and adit except for the purpose of charging for an immediate blast. Such storage shall be close to the face and for the quantity limited to the immediate blast requirement. Primed cartridges shall be seated by even steady pressure only.

6.7 DISPOSAL OF DETERIORATED EXPLOSIVES

6.7.1 All deteriorated explosives shall be disposed off in an approved manner as per Explosive Regulation- 1984, The quantity of deteriorated explosives to be disposed off, shall be intimated to the Engineer prior to its disposal.

6.8 DRILLING

6.8.1 Preferably, Boomer automation software shall be used to finalize drill pattern, hole orientation, termination depth, sequence etc. The boomer shall be total station navigated before drilling holes. All holes should end at same depth. Manual mode shall not be resorted to. A report of the drill hole data (Measured while drilling) along with drilling report shall be generated and handed over to engineer after the drilling. Without affecting drilling quality, Engineer may allow other methods to finalize and execute drill pattern with permission of employer.

6.8.2 The holes shall be drilled in automatic mode preferably, so that drilling accuracy is guaranteed. Drill pattern and drilling sequence created on PC through supported

software shall be transferred to the drilling rig for this purpose. Without affecting drilling quality, Engineer may allow other methods for drilling of holes with permission of employer.

6.8.3 Preferably parallel cut drilling pattern shall be adopted. The perimeter holes shall be located within 0.10m deviation from approved blasting plan and never within the design line of excavation. Lookout angle for perimeter holes shall not exceed 2º and drilling deviation of shall not exceed 5% of the borehole depth to a maximum of 250mm at the end of hole. Engineer, with permission of employer, may allow other type of cuts which do not increase the blast damage zone compared to specified type of cut.

6.8.4 All holes shall be of greater diameter than the diameter of the cartridges of explosives used.

6.8.5 Perimeter boreholes shall not be more than 0.6m apart. Distance between perimeter and next row of boreholes shall not be more than 0.9m, unless adoption of greater distance does not harm the rock outside design perimeter.

6.8.6 Loading and drilling shall not be carried out with Electric detonators in the same tunnel simultaneously.

6.8.7 Under no circumstances shall any holes be charged until completion of all drilling operations at the face.

6.8.8 A drill or pole shall not be inserted in sockets of old holes even its examination fails to disclose explosives.

6.8.9 Drilling shall not be resumed after-blasts had been fired until a thorough examination has been made to make sure that there are no misfires and sockets with explosives which the drills may strike.

6.8.10 Drilling shall not be started until all remaining sockets of old holes are examined for unexploded charges.

6.8.11 Drilling crew shall be provided with approved respirators in siliceous dusty atmosphere arising out of drilling operations.

6.8.12 Blast design should cater to the changes in geology and/or geotechnical parameters for each face and shall be decided face wise on ground

6.9 LOADING AND CHARGING

6.9.1 The holes shall be cleared of all debris before a cartridge is inserted.

6.9.2 In loading the holes, tamping, if required shall be done with a wooden mallet having no exposed metal parts.

6.9.3 Primed cartridges shall be first inserted and shall be seated by even steady pressure only.

6.9.4 All loaded holes or charges shall be checked and located before firing.

6.9.5 When holes are sprung ample time shall be left between spring shots for the hole to cool, and between the last springing shot and the loading of the main charge.

6.9.6 When practicable, no more cartridges shall be primed those are required for a round of blasting.

6.9.7 Detonators shall be inserted at the end of the primary cartridge facing the end of the drill hole, which is prepared specially for the purpose.

6.9.8 Holes in cartridges for inserting the detonator shall be made with a sharpened wooden stick.

6.9.9 When blasting on the surface the entire area to be blasted must be covered with blasting mats, in locations where surface structures are to be protected, from damage by flying rock fragments.

6.9.10 Detonating cord shall be cut from supply reel before attaching to explosive or tamping in hole. Use of the short pieces of fuse shall be prohibited for detonation purposes.

6.9.11 No welding shall be done inside the tunnel / cavity at the time or loading or charging of the face, till the blast has been taken.

6.9.12 Naked flames and lamps shall be kept away at the time of the loading of holes.

6.9.13 Before starting the charging/loading of holes all electrical lines must be disconnected.

6.9.14 Contractor shall arrange visits of Explosive manufacturer's technical team to design and execute the blast, train the blasting crew and supervise the blasting crew as per the direction of the Engineer.

6.9.15 A team from explosive manufacturer shall be arranged by contractor to remain at site until the definitive drilling patterns/blast plans are defined for each support class.

6.10 TYPE OF EXPLOSIVES & ACCESSORIES

6.10.1 Explosives

i. **For enhancing safety of operations, saving in time and better control of blast quality, bulk type explosives shall be preferable**. However, packaged explosives may also be used.

ii. Explosives shall meet following criterion: -

S.No.	Parameter	Packages Explosive	Bulk Explosive
1.	Density of explosive	1.15±0.05 g/cc	0.6-1.1 g/cc
2.	Relative weight strength	110 -120 %	90 -110 %
3.	Relative bulk strength	155 -165 %	110 -160 %
4.	Velocity of Detonation	4000±500 m/s	3000 – 6000 m/s

These parameters shall be met before seeking Engineer's approval. Additionally, Engineer may collect random samples during any charging cycle, in case of any suspicion.

iii. Explosive as approved by competent statutory authorities shall only be used. These explosives shall be of safe to handle and use, exhibit excellent water resistance and liberate low volumes of noxious gases.

iv. Manual Mixing of chemicals to form any explosives shall not take place and such explosives shall not be used.

v. Any Explosives having shelf life less than 6 months shall not be used.

vi. Explosives being used shall be capable of performing in low temperatures.

6.10.2 Detonators

i. Priming of the explosives shall be done only with Non - Electric detonators with shock tube containing fine spray of around 13-16 mg/m HMX/AL powder

ii. The detonators shall be truly Non-electric in nature.

iii. The shock lube shall be of the nature that the color of the tube gets changed post blast and can be located easily for misfires etc.

iv. Identification tag and J - hook shall be placed at the end of the tube for identification and easy connectivity respectively.

v. Ultrasonic seal shall be provided at the end of the tube to make it waterproof.

vi. Shelf life of the detonators shall be one year.

vii. Non - Electric detonators shall be safe against stray currents, static Electricity, Radio-frequency Energies and accidental initiation by impact, shock, friction and time as per the standards fixed by the appropriate authority.

viii. The delay range of detonators should comprise of a minimum 0 - 15 delays firing completely in not less than 8000 ms for long period detonators.

ix. Short delay series shall contain a nominal delay interval of 25 milli second (ms).

x. Electric detonators shall not be used except for the initiation of Detonating Fuse.

xi. Strict control over delay intervals will be required to control the blasting damage in first 50m of each tunnel portal or underground areas within 25m distance (Vertical/Horizontal) to ground surface/pre-existing underground structures. In such cases contractor shall use electronic detonators if required in opinion of Engineer in Charge. Payment shall be made to the Contractor through extra items depending on type and specification of the required electronic detonator after subtracting cost of Nonelectric detonators.

6.10.3 Detonating Fuse / Safety Fuse

i. Detonating Fuse shall be used for connecting Non-Electric detonators.

ii. Nominal Weight of PETN shall be 10 gm/m in detonating fuses (DF).

iii. Detonating Fuses shall be able to get initiated by No.6 electric detonators.

iv. Water resistance shall be excellent.

v. Detonating fuse shall be used only to initiate the plain detonators.

6.11 WIRING

6.11.1 All detonators in a single blast shall be of the manufacture.

6.11.2 Each electric blasting cap used for initiation of shot shall be tested with an approved galvanometer (circuit Tester) to determine whether it will carry the current. All testing shall be done away from the heading face. Testing of a single detonator at any time shall be avoided.

6.11.3 After testing the leg wires of electric blasting caps, they shall be short circuited by twisting the 'bare ends together and shall remain so twisted until ready to be connected into the circuit prior to connection to the firing line.

6.11.4 Unless, the power supply is heavy it is recommended that all electric blasting caps shall be wired in series and the firing line shall not be smaller than No; 14B and S-gauge copper wire.

6.11.5 The number of electric blasting caps used in a circuit shall not exceed, the tested capacity of the blasting machine.

6.11.6 The circuit including all caps shall be tested with a circuit tester or galvanometer, operating accurately before being connected to the firing line.

6.11.7 In surface blasting the cartridges shall not be primed nor a hole during the approach of a thunderstorm or while it is in progress. If a charge has been primed or holes loaded, every person shall be ordered to a safe distance until the storm is over.

6.11.8 Blasting circuit wires and/or detonators leg wires shall never touch other wires carrying electric current.

6.11.9 Blasting operation control shall consist of two switches; a safety switch and a firing switch located at least 2 meters apart, the connection between the switches to be made by a "plug-in" jumper, which may be permanently attached to the safety switch. The plug-in jumper Is so made that it cannot be plugged into or connected to the firing switch until the firing switch is unlocked, and the jumper must be disconnected from the firing switch before the firing switch can be locked.

6.11.10 Both the safety switch and the firing switch shall be of the locking, double pole, double throw type which, when opened and locked in downward position short circuit and ground the leading wires.

6.11.11 Both the safety switch shall be locked immediately after firing the shot and before any person can return to the area. Keys to the switches shall always remain in the possession of the starter.

6.12 **FUSE BLASTING** will not be allowed.

6.13 **FIRING**

6.13.1 Shots shall, so far as practicable is fired electrically and only apparatus especially designed for the purpose shall be used. Power lines shall not be tapped for the purpose. No shot shall, be fired except by a licentiate blaster authorized by the Engineer.

6.13.2 The charge shall be fired successively and not simultaneously.

6.13.3 Prior to the firing of a shot all persons in the blasting area shall be warned of the blast through audible warning and ordered to a safe distance from the area.

6.13.4 Competent flagmen; equipped with red flags and whistles shall be posted to stop traffic at access points on each possible route of travel to the vicinity of the blasting area.

6.13.5 Blasting shall be done at fixed hours approved by the Engineer and the blasting times shall be displayed on a Notice Board.

6.13.6 Order to fire shall be given only by the Supervisor-in-Charge of the work after giving three warning signals to enable all the workmen to reach safe shelters.

6.13.7 Blast shall not be fired until it is certain that every person has retreated to a safe distance.

6.13.8 The person-in-Charge of blasting shall be the first one to leave the area to be blasted.

6.13.9 A bugle or an electric buzzer with a distinctive note shall be used to give warning signals. This bugle shall not be used for any other purpose. All the labour shall be made acquainted with the sound of the bugle buzzer and shall be strictly warned to leave their Site of Work immediately for safe shelters at the first warning signal and not to leave the shelters till all clear signal has been given.

6.13.10 An all-clear signal shall be given when the blasting is over.

6.13.11 Definite places of shelter, natural or artificially constructed, shall be assigned to the crew. Workers shall be made to go to these shelters rather than trust each other's judgment about a safe place.

6.13.12 In special cases suitable extra precautions shall be taken. The Engineer may, however, permit blasting for underground excavation without restriction of fixed time provided he is satisfied those proper precautions are being taken and that the work of other agencies on the site is not unduly hampered.

6.13.13 Only Supervisor-in-Charge shall be responsible for the safe custody of the firing apparatus.

6.13.14 For blasts in series, only detonators of the same brand and same electrical resistance shall be used. All detonators shall be checked before use.

6.13.15 The firing cables shall be with a proper insulating cover to avoid short-circuiting due to encountering water, metallic parts or rock.

6.13.16 Use of earth, as a return line shall not be permitted.

6.13.17 The firing cable shall be connected to the source of current only when nobody is in the area of blasting.

6.13.18 Mats or rubber tyres tied together *with* rope shall be used as protection from flying debris to cover the charges where blasting may expose persons or *property* to injury or damage.

6.13.19 Blasting shall be permitted only after adequate provisions have been made for the protection of persons, the works, and public and private property. The Engineer's approval of any of the Contractor's blasting operations shall not relieve the Contractor of his sale responsibility for the safety of persons and property. Any damage done to the works or property by blasting shall be repaired by the Contractor.

6.14 INSPECTION AFTER BLASTING (Misfire drill)

6.14.1 Immediately after a blast has been fired, the firing line shall be disconnected from the blasting or other source of power.

6.14.2 After each blasting operation the tunnel drive shall be sufficiently ventilated to remove any nitrous gases and the atmospheric conditions shall be constantly checked prior to personnel accessing the excavated face. No persons can enter the blasted area before 20 minutes after firing.

6.14.3 After a blast has been fired, a careful inspection shall be made by the blaster to determine if all charges have been exploded. The blaster shall count the number of the exploding shots in blasting. Misfires in fuse blasting shall not be examined for a enough time after its failure to explode. Electric blasting misfires shall not be examined for at least 15 minutes after failure to explode. Other persons shall not be allowed to return to the area of blast until an "All Clear" signal is given.

6.14.4 The shot-firer must keep a record of the number of shots fired, their time of firing, type and weights of explosives used per delay and total explosives used in the round and the type and number of detonators used, together with a record of the post-blast situation for each and every location. A copy of the record shall be available to the Engineer at the end of every shift on which shots are fired.

6.14.5 All wires shall be carefully traced, and search made for any unexploded cartridges by the person-in-Charge of the blasting operation.

6.14.6 Loose pieces of rock and other debris shall be scaled down from the sides of the face of excavation and the area made safe before proceeding with the work.

6.15 MISFIRES

6.15.1 Misfired holes shall be placed in the charge of a competent person.

6.15.2 If broken wires, faulty connections, or short circuits are determined as the cause of a misfire, proper repairs shall be made, the firing line reconnected; and the charge fired. This shall be done, however only after a careful inspection "has been made of burdens remaining in such' holes and no hole shall be fired when the burden has been dangerously weakened by other shots.

6.15.3 The charge of explosives from a misfired hole shall not be drilled, bored or picked out.

6.15.4 Misfired charges, tamped with solid material shall be detonated by the following method:

- **i.** Float out the stemming by use of a water or air jet from hose until hole has been opened to within 60 cm of charge;
- **ii.** Water shall be siphoned off or pumped out;
- **iii.** New charge shall be placed and detonated.
- **iv.** Whenever this method is not practicable; then a new parallel hole, not nearer than 60 cms, shall be drilled, loaded and detonated. A careful search shall be made of unexploded material in the debris of the second stage.

6.15.5 If misfire has been found to be due to defective detonators or dynamite, whole quantity or box from which the defective article was taken must be withdrawn from the works site for return to the manufacturer or destruction as decided by the Engineer.

6.15.6 The Contractor shall report, in writing, to the Engineer, all cases of misfire, causes of the same and steps taken in connection therewith.

6.16 BLASTING FOR UNDERGROUND TUNNEL

6.16.1 General

- **i.** Blasting in tunnels and cavities shall be carried out with Non-Electric detonators only except for the cord initiation by electric detonators.
- **ii.** A separate circuit, independent of power and light circuits, shall be used for blasting.
- **iii.** No electrically energized circuit shall be installed on the same side of the tunnel, or cavity with the blasting circuits.
- **iv.** All electric lights or other energized circuits shall be disconnected for at least 70 meter from the point of loading.
- **v.** All tracks, airlines & vent pipes shall be kept properly grounded.
- **vi.** For loading purposes, the employees shall be equipped with permissible battery lamps.
- **vii.** The safety switch and the firing switch shall be placed on opposite sides of the tunnel / cavity.
- **viii.** Only explosives, which produce less than 0.005 m^3 of poisonous gas (carbon monoxide and hydrogen sulphide) per 1.25" X 8" (3.15 cm X 20 cm) cartridge shall be used for Underground Work.
- **ix.** No fire, flame, smoking or open lights shall be allowed within 6 meters from any explosive except for the purpose of firing a charge.
- **x.** Adequate warning notices shall be given to air persons employed indicating the period, or danger at the time or firing and it shall be the duty of the

Contractor to provide adequate shelters or screens for protection of workers exposed to risk of injury from the explosion or from flying material.

xi. After the blast takes place in Underground Works the workmen shall not be allowed to go to the face till all the toxic gases are evacuated from the face.

xii. Under water Blasting

a. Only water-resistant blasting caps and detonating cord shall be used in underwater blasting operations.

b. Loading tubes and casings of dissimilar metals shall not be permitted because of possible electrical transient current from galvanic action.

c. When more than one charge is placed underwater a float device shall be attached to an element of each charge in such manner that it shall be released by the firing.

d. No drilling, digging or excavating shall be permitted until all misfires have detonated or the explosives are removed from the missed holes.

6.17 MONITORING OF BLAST

6.17.1 General

i. The Contractor shall supply and operate at least four approved Engineering Seismometer (Triaxial) or Seismograph to measure 3-components of ground vibration and air blast overpressure. The equipment shall have enough memory space to store at least 300 events and shall be equipped to measure wide range of ground vibration and air blast overpressure. It also shall be equipped with a microphone attachment, permanent paper trace output with built in strip chart printer, LCD display and PC retrieval attachment for data to be used as and where directed by ENGINEER" to monitor blasting work.

ii. Unless otherwise agreed in. writing by "ENGINEER" trial blasts, initial blasting in general, and initial blasts in new areas and blasts adjacent to complete concrete structures and sensitive areas shall be monitored. For structures in the proximity of blasting the peak particle velocity shall be' measured at the locations immediately adjacent to the structure nearest to the face being stated or another location where it is necessary to limit vibration as instructed by engineer. Apart from monitoring on its own the Contractor must provide supports for measurement to other agencies appointed by "EMPLOYER" in tunnel excavation, monitoring shall specially be undertaken with change in rock mass. in shallow cover zone and or as directed by Engineer.

iii. The measured vibration results shall be transmitted to "ENGINEER" together with all the useful information concerning the completed information (cut of the face / slope of the cutting face; particle size distribution of the excavated material etc.; drill marks; vibration wave form in three directions-radial,

transverse & vertical; air overpressure waveform; print out of Peak Particle Velocity (PPV) and associated predominant frequency in each direction).

iv. Assistance shall be taken from blasting consultants / experts as specified in Quality Manual document.

v. In case the defined thresholds be exceeded, blasting operations shall be stopped in order to finalize the new blasting pattern or the choice of another methods of proceeding with the excavations.

vi. In general, the methods, parameters to be measured and equipment for measurement of vibration shall be in accordance with IS 14881 unless otherwise specified.

6.17.2 Restriction of Blasting

i. All blasting works shall be completed before pouring the first structural concrete, unless otherwise specifically agreed by "ENGINEER" in writing. When excavation is carried out using explosives the Contractor shall arrange his excavation and concrete placing programmed so that as far as practicable it shall not be necessary to use explosives close to permanent construction. The Contractor shall be responsible for avoiding damage to adjacent structures from fly rock by erecting barricades and/or the use of blast mats or other means by installing shielding device acceptable to "ENGINEER". The maximum allowable limit of noise overpressure in blasting shall not exceed 110 dB (beyond 100m in any direction from blast) In surface blasts: It must be measured close to the structure to be protected from blasting. Ground vibration induced by blasting shall be measured in terms of the Maximum or Peak Particle Velocity (PPV) in mm/s and predominant frequency of the ground vibration.

ii. The measurement of peak particle velocity shall be obtained from instruments capable of measuring along three orthogonal axes, one of which shall be aligned parallel to the center line of the excavation and another shall be vertical. The Contractor is to provide supports for the measuring instrument if so, required by the manufacturer's instructions.

iii. The measurements of the particle velocities (PPV) shall be the responsibility of the Contractor. Copies of the readings in an agreed form shall be supplied to the Engineer.

iv. The following limit on peak particle velocity are given as a guide and may be modified by "ENGINEER" based on seismograph records and observations during the progress of works.

a. PPV shall not exceed 30mm/sec at 20m distance from the tunnel face.

b. For existing surface structures adjacent to excavation areas, including structures of following types:

(i) Not forming part of the contract,

(ii) Belonging to Employer and

(iii) Not belonging to Employer,

The frequency and peak particle velocity dependent safety criteria as per Director General of Mines Safety (DGMS) criteria shall be followed for protection of nearby structures in surface blasts.

v. Where circumstances dictate, such as when blasting adjacent to partially cured concrete, the peak particle velocity permitted may be reduced by "ENGINEER"

vi. For specific structures and if requested by "ENGINEER" the Contractor shall fulfill the following criteria:

a. At a 20 m radius of the blast, the interstitial velocity, for frequencies inferior to 100 Hertz, shall be limited to 4 cm per sec. (40 mm/sec.)

b. After blasting and scaling of blasted surface, 60% of the half bore holes (barrels) must be visible,

c. Smooth/control blasting is mandatory, in case of "Smooth blasting the spacing of perimeter holes should not exceed 40 cm c/c and the distance between perimeter row of holes and the buffer row of holes should not exceed 0.7 m.

d. Bores holes space is 45 cm maximum.

vii. If necessary, "EMPLOYER" may require the Contractor to restore at his own expense any building, structure, masonry and equipment damaged by blasting, through direct or indirect effects.

6.17.3 Recording blasting operations

i. The Contractor shall keep records of all blasting carried out showing the time and location of each blast, the type and amount of explosive used, together with any other relevant data in an agreed format approved by "ENGINEER".

ii. During the site works, as mentioned before each blasting pattern shall be submitted to "ENGINEER" for approval at least 24 hours before the blasting operation is due to begin. This shall be in the form of a presentation sheet setting out all the information concerning:

a. The type(s) of explosives to be used.

b. The x, y, z coordinates of each firing hole and the firing polygonal,

c. The diameter, depth, charge and the packing of each hole,

d. The method of ignition and the type of detonator for each charge,

e. If using a sequential exploder, the connection of the different lines and a plan showing the effective delays of the charges.

iii. The total quantity explosives for the firing of the round: always, "ENGINEER" can interrupt the explosive operation or request the Contractor

to modify to the blasting patterns and the cost on this account shall be borne by the Contractor.

CHAPTER 7

INSTRUMENTATION

7.1 SCOPE OF WORK

7.1.1. This section specifies the requirements for the geotechnical measurements in the tunnels and at the surface above the tunnel designed according to the NATM for the purpose of observing and recording deformations, settlements, and load variations on supporting elements and in the adjacent rock.

7.1.2. As part of safety concept 3-dimensional (3-D) deformations of the tunnel lining shall be monitored by means of optical methods. The points to be observed are marked by targets or reflectors mounted on standard convergency bolts.

7.1.3. Measurement shall be carried out with a free-station high precision Total Station. The flow of data shall be fully automatic. The software shall allow determination of displacements in an absolute coordinate system with an accuracy of +/- 1 mm in minimum.

7.1.4. The work of geotechnical measurements includes the installation of geotechnical instrumentation and devices.

7.1.5. Necessary conclusion shall be drawn from the geotechnical measurements, from their magnitude, alterations and tendencies about stability of the primary lining and surrounding rock, performance of the initial support applied and utilization of the support elements.

7.1.6. The location and spacing between geotechnical measurement sections shall depend upon geological conditions, frequency of geological alterations, rock mechanical behaviour, length of tunnels, primary stress conditions, size of tunnels. The location of measurement sections shall be decided during tunneling according to the local geological conditions and the experience gained during tunnel driving and as required by the Designer or Engineer.

7.1.7. Reading of instruments, interpretation and evaluation of monitoring results as well as geological mapping during excavation will be carried out by the Designer/Engineer.

7.1.8. The Contractor shall supply, install, calibrate, test, survey and maintain instrumentation in the Tunnels, Chambers and shafts etc. as specified in this Section or as directed by the Engineer. **Minimum instrument stock for 3 months shall be maintained at site as per approved instrumentation program.** The Contractor shall supply and install all ancillary measuring equipment, read out units and construct terminal structures, protective surrounds for instruments, excavate pits and trenches, backfilling, drill holes, install pipes and fittings, and cast concrete where required. Contractor shall get approved instrumentation plan prior to installation of any instrument. All the instruments to be installed by the Contractor in all the structures shall be procured from very reputed manufacturers who have supplied such instruments at other similar projects also and have good credentials of having satisfactory working of those instruments. The specifications and the source of instruments shall be got approved by the Contractor from Engineer before procuring them.

7.1.9. The extent, type and location of the individual instruments as shown on the Construction Drawings, the number and location of the instruments may be altered by the Engineer during the construction period, according to the requirements.

7.1.10. The Contract Documents give only the numbers, general type, and general arrangement of the instruments to be supplied and installed by the Contractor.

7.1.11. Instruments shall be preferably vibrating wire type. All instrumentation operating on electrical or hydraulic systems shall be accompanied by individual test certificates and shall be tested in the presence of the Engineer prior to installation, unless specifically stated otherwise.

7.1.12. All instruments shall be installed to the lines and elevations shown on the Construction Drawings or as established by the Engineer as the work progresses during construction.

7.1.13. The installation of instruments may interfere with the overall construction progress. The Contractor shall make provision for any such interference in his construction planning. He will not be entitled to any compensation or extension of the Time for Completion by reason of any such delays, including repair and - replacement of damaged instruments.

7.1.14. No instruments or any of their components shall be purchased prior to Engineer's approval. However, approval by the Engineer of the Contractor's proposals and drawings or data shall not relieve the Contractor of his sole responsibility to meet all the requirements under this Contract.

7.1.15. All instruments shall be guaranteed against defects in installation / manufacturing till completion of Defect Liability Period. The Contractor at no cost to "Employer" shall replace all defective instruments during the period of guarantee. However, the buried defective instruments shall not be returned to the Contractor.

7.1.16. All the instruments shall be supplied with at least 3 copies of instruction manuals explaining installation procedures, Calibration Charts, guidelines, necessary protection measures and necessary maintenance requirements etc. complete in all respects.

7.1.17. The measuring devices to be provided shall be manufactured by a reputed manufacturer with a proven record and acceptable to the Engineer.

7.1.18. The Contractor shall take utmost care in the recording and analysis of the readings and prevent mixing of readings from different instruments.

7.1.19. During execution of the works, the Contractor shall observe, record and submit readings of all the instruments in specified format along with analysis of observed data and at specified frequency / period to the Engineer.

7.2. SUBMITTALS

7.2.1. Within 56 days from the commencement date, the Contractor shall submit details of the instruments proposed for the installation. These shall be consistent with the general information on the instrumentation submitted by the Contractor with his tender as well as with any modifications subsequently agreed to by the Engineer and the Contractor and shall include:

i. Detailed description of all instrumentation, cabling and accessories including

any ancillary measuring equipment he proposes to install.

ii. Evidence of successful performance of the instrumentation proposed for installation.

iii. Manufacturer's instruction for the installation, testing and operation of the instruments.

iv. Schedule of monitoring of instruments.

7.2.2. All the instruments for monitoring load on support and tunnel deformation shall be installed as soon as possible after the blast and as near as possible to the tunnel face as possible but in any case, before blasting the next round. This is an essential requirement of the proposed method of tunnel excavation.

7.2.3. The monitoring instruments must include

i. Instrumented bolts in place of anchor Load Cells,

ii. Strain Meter for Monitoring Rock Bolt behaviour

iii. Stress Cell for measuring / monitoring efficacy of shotcrete

iv. Multipoint Borehole Extensometer (MPBX) (with measuring points at 3m, 6m, 9m)

v. Vibrating Wire Piezometer with Accessories to measure pore water pressure in ground if water seepage is observed

vi. Optical Targets for measuring 3-D deformation using Total Station.

vii. Deleted

viii. Seepage Measurement System to measure flow of water from face of tunnel using V-notch

ix. Inclinometer with accessories and Data logger to measure the slope gradient

x. Crack Extensometer to measure rock cracks

7.2.4. Same numbers and locations of Instrumentation are envisaged for full face excavation and excavation with top heading and benching.

7.2.5. For Main monitoring cross sections, either strain meters or Stress Cells shall be installed at alternate sections.

7.2.6. Standard Monitoring Cross Section shall essentially be consisted of Displacement Monitoring Points (DMP) with Optical Targets for 3D Displacement Monitoring.

7.2.7. Deleted.

7.2.8. Deleted.

7.2.9. Main Monitoring Cross Section with Extensometer shall essentially be consisted of Multi Point Borehole Extensometer (with Measuring Points At3m, 6m & 9m) along with Displacement Monitoring Points (DMP), Strain Meter (SM), and Stress Cell (SC).

7.2.10. The numbers, locations and frequency of instrumentation are subject to change

according to site conditions & as per Engineer's instructions on site.

7.2.11. During the execution of the works, the Contractor shall submit any further details regarding the instrumentation required by the Engineer. The Contractor shall prepare surveys and furnish "AS BUILT" drawings for all the installed instruments.

7.3. Specific Requirements for NATM

7.3.1. General**:** The Contractor shall submit a complete comprehensive instrumentation, monitoringand reporting scheme prior to any construction to achieve the following:

(a) Safety during and after construction by providing early warning of any excessive and undue ground movement inside the tunnel.

(b) To provide deformations and loading data for the verification of the initial and final support of the tunnel.

(c) To provide information about tunnel behaviour in order to optimize excavation and support activities during construction

7.3.2. Special Requirement:

a) The instruments shall be installed at locations and in accordance with a time schedule as per approved scheme or at vulnerable locations encountered during excavation.

b) The geotechnical instrumentation and the monitoring program may be subject to alterations and modifications if required by the actual geological or geotechnical conditions.

c) All instrumentation shall be installed in accordance with the manufacturer's recommendations and with the additional requirements specified in this document.

d) The installed measuring equipment as well as the required space for measuring must be kept free and accessible for all the duration of construction.

e) All instruments shall be protected against damage by blasting and tunnel traffic. Where required protective covers or housing may be used to prevent damage of the instruments.

f) Readout units as dial gauges or tape extensometers shall be available at any time during tunnel construction. Spare parts and spare units shall be maintained on site.

g) All instruments and equipment used and required for the geotechnical measurements shall be made available for the inspection/verification of the Engineer throughout the construction period.

h) Sufficient length of cables shall be provided to with each installed instrument so that the accessibility for taking measurements is not hampered after benching.

7.3.3. Reading & Plotting Data:

a) Reading of the instruments, data processing and plotting of the measurement results shall be carried out by qualified personnel of the Contractor as approved by the Engineer.

b) For the optical displacement monitoring a software package shall be used which allows a direct data flow. This software shall include features as follows:

(i) Free stationing of the theodolite and calculation of standard deviation in all three coordinate directions.

(ii) Automatic target identification and recognition of new zero readings.

(iii) Calculation of 3D-coordinates and displacements of any desired point and its radial distance to the theoretical profile.

(iv) Correction of errors based on physical effects.

(v) Transformation of coordinates after control measurements.

(vi) Measurement results shall be tabulated and presented in graphs.

c) The software processing the data shall include following features:

(i) Development of displacements with time, directly associated with tunnel driving activities.

(ii) Plot of displacement vectors within the cross section.

(iii) 3D Displacement vector orientations

(iv) Excavation program related evaluation and presentation of displacements (Influence lines showing the influence of daily excavation on displacements of measuring points).

(v) Assessment of displacements prior to zero measurement.

(vi) Development of differences in displacement with time e.g. roof settlement minus settlement of top heading footing.

(vii) Calculation of stresses and safety factors or degree of utilisation for the shotcrete lining based on optical displacement monitoring, and time dependent shotcrete strength.

(viii) Other evaluations as required by the Engineer and the Designer.

d) For the monitoring of geotechnical instruments, a software package shall be used which allows a direct data flow. This software shall include features as follows:

(i) Presentation of data related to the time and excavation progress within one plot.

(ii) Cross-sectional visualisation of measuring anchor and extensometer data.

(iii) Multiple plot capabilities (Forces/Radial strains in rock

mass/displacements).

(iv) Shotcrete stress calculation based on strain measurements and material law for young shotcrete as tested in situ.

e) The first measurements (zero-readings), for each measuring instrument, shall be made immediately after installation or as soon as the particular instrument may allow.

f) The frequency of the further measurements or readings can be envisaged for each measuring section as follows:

(i) 1st week: daily

(ii) 2nd week: twice a week

(iii) 3rd & 4th week: once per week

(iv) Later: monthly and bi-monthly

(v) When the bench is approaching the instrumentation, section installed during top heading, reading frequencies shall be increased again.

(vi) The actual frequency of readings will however be influenced by the construction stages i.e. top heading/bench heading in the tunnel and shall be proposed by the Designer through Contractor.

g) Data of the optical displacement monitoring shall be processed on the same day and plots shall be available at late afternoon or as requested by the Engineer. Other data from measurements must be processed within 24 hours after the readings have been taken and must be plotted. All processed data and visualised diagrams must be available for the Engineer scrutiny at any time. A copy of all records shall be permanently kept on site and made available to the Engineer. If required, the Engineer may instruct shorter data processing and visualisation time.

h) The Contractor has to immediately inform the Engineer in case he observes obvious unusual and unexpected readings or makes other unusual observations in the tunnel.

7.3.4. Methods of data evaluation and interpretation

According to geo-mechanical relevance, the main monitoring parameters for tunnelling shall be as follows:

a) Time – Displacement Diagrams, Magnitude of Displacements Time-Displacement diagrams shall show the development of the displacement of one point versus time. Time-displacement diagrams shall be generated for all three components of the displacement vector (vertical, horizontal and longitudinal displacement). Construction phases (top heading, bench, and invert) shall be shown on the same diagram to allow for an easy correlation between displacement behaviour and construction activities.

b) Distribution of Displacement Vectors in Cross-section - Displacement Vector

plots shall allow the representation of the cross-sectional displacements and their development with time. Displacement vector plots shall allow the detection of weak zones and / or faults outside the excavation area. They shall provide additional information about the rock mass structure and deformation phenomena close to the tunnel.

c) Lines of Influence - Lines of Influence shall be produced by connectingdisplacement values of a number of monitoring points along the tunnel axis at the same time, similar to a "deflection curve". Normally, a number of lines for a specified time span shall be shown on one plot. In addition, construction phases (top heading, bench and invert) shall be shown to allow for an immediate correlation between measured displacements and construction activities

d) Trend Lines - Trend lines shall be generated by connecting settlement values of Individual lines of influence at a predefined distance behind the face.

e) Development of Longitudinal Displacements close to the excavation face: This shall indicate changes in ground stiffness ahead of the face.

f) Trend of advancing displacements due to bench excavation: This shall reflect the influence of individual bench excavation steps on the already excavated tunnel sections.

g) Development of Differential settlements: This displacement option shall be used to show the difference in displacements between two monitoring points belonging to the same monitoring section.

(i) Usually the difference in settlements shall be displayed between: Crown & side wall (S crown – S sidewall) = ΔS

ΔS for both side walls shall be observed.

(ii) And for horizontal displacements between: Left and right-side wall (H left – H right) = ΔH

7.3.5. Control limits for Trigger (Alert, Action & Alarm) levels

Monitoring parameters (including the control parameters) based on the design and anticipated ground behaviour and support performance to asses alarming situation. The examples of control parameters are:

(i) Displacement velocities derived from 3D absolute displacement monitoring

(ii) Differential Settlements

(iii) Trend Lines (increase in displacements corresponding to face advancement)

(iv) Shotcrete strains derived from strain measurements with shotcrete strain meters in the shotcrete lining.

7.4. SKILLED PERSONNEL

7.4.1. The whole of the instrumentation work shall be carried out under the direct supervision of a senior supervisor, approved by the Engineer, and employed by the Contractor who

is well experienced in all types of instrumentation and installation work and who understands the purpose and function of all instruments being installed.

7.4.2. Installation and calibration of instruments shall be carried out by skilled technicians, well experienced in the installation of instruments and who have a thorough understanding of the purpose and function of the instruments being installed, acceptable to the Engineer.

7.5. INSTALLATION

7.5.1. The Contractor shall install and calibrate all instrumentation conforming to the supplier's instructions and shall, where necessary, expose all partially installed instruments, cables and tubes to continue their installation, including carrying out all survey work required to locate such instruments. A representative of the instrument's manufacturer shall be present during the entire process of installation. The Contractor shall submit a certificate issued by the manufacturer regarding the installation of instruments as per the instrument's manual, to the Engineer. The Contractor shall tag all cables and tubes with identification tags approved by the Engineer at intervals of 15 m or at such closer intervals as necessary to provide continuous identification.

7.5.2. Instrumentation shall be installed and calibrated in the presence of the Engineer, and when he considers it desirable, instruments shall be installed preferably during daylight hours. At all times, the Contractor shall ensure that adequate lighting is available, whether by natural or artificial means, to ensure proper execution of the work.

7.5.3. Cables and tubes shall be installed in the maximum lengths practicable. Splicing and coupling, if essential, shall be performed in accordance with the manufacturer's recommendations. Calibration readings shall be taken prior to and immediately after splicing. Open ends of all incomplete lines of tubing and casing shall be kept plugged or sealed and the Contractor shall always during installation keep the insides of casings and tubes free from foreign matter. Cables and tubes shall be protected from mechanical damage.

7.6. CARE OF INSTRUMENTATION

7.6.1. No traffic or equipment shall be allowed to pass over any part of any instrument or connections unless suitably protected as recommended by the instrument supplier and approved by the Engineer. The backfill material shall be carefully compacted in such a way that the density of backfills will become equivalent to the surrounding materials to the satisfaction of the Engineer.

7.6.2. The Contractor shall protect all instruments and connections from damage and displacement during the progress of the work. If damage or displacement of the instruments or connections occurs during the progress of the work, they shall be repaired or replaced immediately by the Contractor.

7.6.3. The Contractor shall be fully responsible for the maintenance and repair of all instrumentation during the contract period.

7.6.4. The Contractor shall recalibrate instruments at the frequency / period as specified by manufacturer as approved by Engineer.

7.7. READING OF THE INSTRUMENTS

7.7.1. Calibration of all the instruments shall be done by the Contractor and all the facilities for the same shall be arranged by him. An initial set of readings on all instruments installed at any elevation will be taken immediately after their installation, and the Contractor shall not place concrete over the instruments or tubes or cables at this location until these readings have been taken.

7.7.2. The Contractor, after consultation with Engineer, shall program his work and make all necessary arrangements to record the reading of instruments as soon as possible after their installation. Such arrangements shall include, where necessary, the provision of temporary read out points.

7.7.3. During the construction, the Contractor shall read the instruments once a day till the tunnel is advanced at least 8 to 10 D distance from a monitoring location (D is the maximum dimension of excavated tunnel), and thereafter once a week till the deformations are stabilized or as directed by the Engineer. The Contractor shall inform the Engineer when reading of the instruments will take place.

7.8. INSTRUMENTATION AND MONITORING FOR STRUCTURES

7.8.1. The Contractor shall supply and install the measuring devices, carry out additional excavation, drilling, construct concrete or mortar pads, backfilling with concrete, perform the measurement, and record the readings at frequency / period specified by Engineer for the following instruments:

I. Topographical markers / survey points

II. Automatic Weather Station

III. Cables

IV. Cable splicing kit.

V. Junction Boxes

VI. Readout units.

VII. Tiltmeter

7.8.2. The instruments shall be supplied, installed and monitored by the Contractor as directed by Engineer in order to assess the behavior of the structure and other structures during the Construction of the work.

7.8.3. Topographical Markers.

I. The Contractor shall supply, install and survey studs, base plates, observation pillars and survey targets along with accessories, as shown on the drawings for precision surveying. Base plates and leveling studs shall be used to measure the vertical movements of the structure top or parapet wall & other concrete structures. Survey targets and observation pillars shall be used for measuring horizontal movement or deflection. Observation pillars shall be installed on the downstream side banks and targets mounted on the structure at various elevations as shown on the drawings.

II. Observation pillar shall be of size 600 mm X 600 mm X 900 mm (projecting 300 mm above ground), RCC of M30 Grade having 4 nos 10 mm longitudinal reinforcement bar with 4 nos 6 mm reinforcement bar stirrups. Observation pillar shall be of size 600 mm X 600 mm X 900 mm (projecting 300 mm above ground), RCC of M30 Grade having 4 nos 10 mm longitudinal reinforcement bar with 4 nos 6 mm reinforcement bar stirrups.

III. Survey studs shall be of stainless steel of 15 mm Ø and 250 mm long and of the shape and size as shown on the drawings.

IV. Leveling studs/ base plates shall be installed as soon as possible after placement of concrete at the locations where required. The base plate shall be 100 X 100 X 3 mm stainless steel plates or brass plate with 4 MS spikes (hold fasts) about 5 mm Ø X 70 mm long to hold the plate in concrete. The top surface of the plate shall be a perfect plane.

V. Survey targets shall be made of solid brass or stainless steel of about 35 mm Ø on top and 75 mm long. Its top there will be an engraved cross mark 1 mm thick and 1 mm deep. The Contractor may suggest some different type of targets also for approval of the Engineer.

VI. Immediately after installation of any studs / base plates, its position and level shall be precisely surveyed. The level and coordinates shall be computed and submitted in writing to the Engineer within 24 hours of installation.

VII. Thereafter, the Contractor shall read the targets once a day till the tunnel is advanced at least 8 to 10 D distance from a monitoring location (D is the maximum dimension of excavated tunnel), and thereafter once a week till the deformations are stabilized or as directed by the Engineer. The Contractor shall inform the Engineer when reading of the instruments will take place.

7.8.4. Automatic Weather Station

I. Contractor shall supply and install weather station (automatic type) and take observations during construction period and hand over to the Employer at the end of the construction period.

A. The Automatic Weather Station (AWS) must permit to record automatically and continuously the following meteorological data:

a) Wind speed

b) Air temperature

c) Rainfall

d) Relative humidity

B. The Sensors of the AWS shall meet the following requirements:

a) Wind speed Sensor

Range : 0.5 to 100 m/s

Resolution : 0.5 m/s

b) Air temperature Sensor

Range : -10°C to +60°C???

Resolution : 0.1°C

c) Rainfall Sensor

Maximum Range : 10 mm /min

Resolution : 0.02 mm

d) Relative humidity Sensor

Range : 5% to 99%

Resolution : 0.1%

C. The sampling interval shall be adjustable from 1 to 3 hours.

D. All the sensors must be operated with solar cells with provision for power module.

E. DELETED.

F. The data storing unit of the AWS shall have the facility to store all data for a period of at least 6 month and shall permit instant display/USB transfer of data.

G. The Contractor shall supply and install a complete AWS including all instrument shelters within one month from the date of commencement.

7.8.5. Cables

I. Cables connected to instruments shall be laid as per the detailed cable routes submitted by the Contractor and approved by the Engineer.

II. Cables shall generally be of following types:

A. 12 core cable: it shall have 7 / 0.25 mm ATC PE insulated, with six twisted pair (12 core), color coded, screened with water blocking aluminum foil or jelly filled, polyester taped, inner polythene sheeted, 0.3 mm galvanized iron wire braid armored with 50 % coverage, overall polythene sheathed and overall diameter of around 14 mm.

III. Special cables, where required, for various gauges shall be of standard market quality, as approved by the Engineer.

7.8.6. Cable Splicing Kit

I. It is required for joining two cable ends of four-core cable. It shall be suitable to make a water resistance sealed joint and shall have requisite amount of cable jointing compound like epoxy and silicon grease. The splicer shall be made of

stainless steel and shall be able to withstand a pressure of 30 kg / cm^2 and a tensile force of 12 KN.

7.8.7. Junction Box

I. The junction box shall be mounted at appropriate locations as shown on the drawings or as directed by the Engineer. The junction box shall be a device to provide connection between core cables leading from the different instruments and multi-core cables leading to the multiplexer unit. The junction box should have a connector socket for the fly leads from the portable read out unit and a rotary switch to select individual instruments.

II. All switchable junction boxes shall be double ended. This is essential to remove the possibility of one rogue instrument interfering with the performance of the others. The junction box shall have an arrangement for connecting minimum 20 instruments. The wires and terminals within the junction box shall be fitted with entrance hubs to protect them against danger of water penetration.

III. The junction box shall be of drip tight sheet steel and shall be provided with stuffing box for special measuring cables and connecting cables and shall have built in terminals and socket strips. The junction box shall be provided with an arrangement for protection against over voltage. The sheet steel metal construction of the distribution box shall be properly treated and coated with corrosion resistant paint. The junction box shall also be provided with an arrangement for earthing and shall be supplied along with its accessories. The specifications for the junction box given herein indicate broad requirements only.

7.8.8. Tiltmeter:

I. Tiltmeters shall be installed at appropriate locations on structures to measure small changes of inclination due to tunnel construction.

II. The position of the tilt meter should be determined immediately after installation and parallel to the zero measurement.

7.9. SPECIFICATIONS OF INSTRUMENTS

7.9.1. General

I. The Contractor shall supply and install the measuring devices as shown in the drawings of various underground works or as directed by the Engineer to carry out additional excavation, drilling, construct concrete or mortar pads, backfilling with concrete, perform the measurement, and record the readings at frequency / period specified by Engineer for the following:

A. Topographical markers/ survey points.

B. Load cells

C. Measuring tape extensometer

D. Tape convergence points

E. Single and multiple point borehole extensometers

F. Readout units.

G. Bi-Reflex Targets and Electronic Total Station.

H. Stress Cells.

I. Piezometer.

J. In place inclinometer

K. Data logger for in-place Inclinometer to log data from IPI sensors.

II. The measuring devices to be provided shall be manufactured by a reputed manufacturer with proven record and acceptable to the Engineer.

III. The Contractor shall take utmost care in the recording and analysis of the readings and prevent mixing of readings from different instruments.

IV. During execution of the works, the Contractor shall observe, record and submit readings of all the instruments in specified format as approved by engineer along with analysis of observed data and at specified frequency / period to the Engineer.

7.9.2. Load Cells

I. Only vibrating wire-based Load cells shall be installed to monitor the behavior of steel ribs/Lattice girder supports installed.

II. The load cells shall have the following characteristics:

A. Capacity	:	300kN
B. Overload Capacity	:	150 % of Full scale
C. Accuracy	:	0.5 % of Full scale
D. Material of Element	:	Stainless Steel
E. Remote electrical read out unit	:	

III. Each load cell shall be supplied with a cable of 20 m length.

IV. At the beginning, the readings shall be taken daily. Later, weekly readings shall be taken till the cessation of any movement or until the Engineer permits termination.

7.9.3. V.W wire based instrumented bolt (Rock bolt load measurement)

I. It shall be 4-point VW type instrument installed at every 100m or as directed by engineer and shall measure load at 3-4 places along the same rock bolt.

II. It is required to measure load on rock bolt at various depths after installation.

III. It shall have the capacity to measure load upto 300 KN with 0.5% accuracy.

7.9.4. Tape extensometer

I. It is required for measuring distance for "Convergence measuring points". It shall have the following characteristics:

A. It shall be temperature resistant, water resistant and tear resistant Tape.

B. The tape shall be not less than 30 m in length.

7.9.5. Convergence Measurement

I. Convergence measurement shall be performed in underground excavation works to determine the relative displacement of opposite measuring points placed around the excavation perimeter.

II. The measuring points shall consist of convergence bolts made of stainless-steel pins molded on a short reinforcing bar grouted into predrilled hole.

III. The distance changes between the opposite convergence bolts shall be measured by means of tape extensometer connected to the bolts and tensioned between them. Change of length shall be read on a digital gauge. Reproducibility of measurement shall be ±0.5 mm.

IV. The distance changes between the opposite convergence bolts may be measured by means of Total station also.

V. The convergence bolts shall be installed within the heading zone after the installation of supports. At the beginning, the measurement shall be carried out daily. Later weekly readings shall be taken for several months up to the cessation of any movement by latest when the placing of the concrete lining commences. The convergence measuring tape extensometer and the digital gauge shall be calibrated on their corresponding calibration devices before and after each measurement. Digital readout shall be in metric unit. Whenever instructed by engineer, the same shall be replaced by reflector type paper target points which can be remotely spotted for convergence measurements. Removable bi-reflex optical targets shall be installed as near as possible from the face along with protection caps to prevent damage during blast.

7.9.6. Vibrating Wire type Multipoint Bore-Hole Extensometers to accommodate in 45-50 mm dia holes)

I. These extensometers shall be installed in underground excavation to measure displacements in the rock mass surrounding the excavation.

II. The extensometers shall be installed in the boreholes drilled radially on a plane perpendicular to the centerline of the underground structure. The exact location of each measuring section will be determined by the Engineer.

III. The borehole diameter should be less than 50 mm or as recommended by the supplier of the extensometers. The measuring heads shall be installed in recesses excavated around the collar prior to the drilling of the hole and shall be protected from damage by a cover plate.

IV. Extensometers will have a typical rod length of 2,5,10 and 20.

V. Reading of the extensometers shall be done with a readout unit. At the beginning, the readings shall be taken daily. Later, weekly readings shall be taken till the cessation of any movement or until the Engineer permits termination but latest when the placing of the concrete lining commences. The readings so taken along with report (comprising of data observed, analysis of data etc.,) shall be reported to the Engineer.

7.9.7. Electronic Total Station:

The electronic total station shall have the minimum precision:

I. Horizontal angle measurement : +/-1" (0.3 mgon).

II. Vertical angle measurement : +/-1" (0.3 mgon).

III. Distance measurement : +/- (1 mm+ 1.5 ppm).

7.9.8. Absolute 3D Displacement Monitoring

I. Absolute monitoring shall be performed in underground excavation works to determine the spatial position of measuring points placed around the excavation perimeter.

II. The measuring points shall consist of the targets mounted on special bolts.

III. The targets should be installed immediately behind the face on the last round and zero reading should be taken. Construction sequence (top heading- bench excavation etc.) should be recorded simultaneously with absolute displacement monitoring.

7.9.9. Stress Cells:

Shotcrete/ Concrete Stress cells NATM style vibrating wire stress cells to measure radial and tangential stresses in shotcrete or concrete. Capacity of stress cells - tangential 200Kg/cm^2 and radial 50Kg/cm^2. Accuracy of 0.5%, each cell should be marked with capacity, serial no. etc. along with the sufficient Teflon / PVC or similar cable shielded, integral with stress cell for taking observations using the proper readout, Connections/switch/junction box to be attached to the cable stress cell for connecting to readout. The readout should be compatible to vibrating wire stress cell, rechargeable battery operated, LCD display, stress cell should be calibrated with this readout, connector to connect the stress cells, perfectly sealed to make it dust and moisture proof including battery charger and one extra rechargeable battery.

7.9.10. Piezometer:

Supply, fixing and monitoring (as per specifications) of Piezometer (vibrating wire sensors type) as per the drawing or as per directed by Engineer-in-charge. The piezometer shall be designed for water table measurements and measuring pore pressure up to 2MPa with an accuracy of + /-0.5% of full scale The rate shall include all accessories required for installation and as per approved method statement.

7.9.11. In place inclinometer:

Supply, Installation and monitoring of in place inclinometer to measure lateral movement in slope & embankment suitable for depths up to 30 m. Each Inclinometer system consisting of following accessories complete in all respect:

1. Biaxial sensor with SDI-12@ 3 m interval, with pair of wheels for up to 30m depth
2. Suspension kit with protective cap and placement tubing: 1No.
3. Spacer assembly for 3 m gage length
4. Bottom wheel assembly with plug: 1no.
5. Protective rope to prevent loss of sensor down hole: 1no.
6. Suspension stainless steel wire rope for positioning sensors: 1 no.
7. Self-aligning ABS tubing, 70mm OD, 58 mm ID, 3 m length for up to 50m depth.
8. ABS fixed coupling for 70 mm OD. Access tube, 77 mm OD x 160 mm length as required for jointing of ABS tubing.
9. Bottom cap for ABS tubing: 1no.
10. Dummy probe with 30 m cord: 1no.

7.9.12. Data logger for In-place Inclinometer to log data from IPI sensors having Memory capacity 2 million data points and communication port to download data on Laptop/ PC. Real time accuracy: +/- 1 minute/ year.

7.10. Readout Unit for Electrical Instruments

7.10.1. The Contractor shall supply a readout unit for load cells and Extensometers.

7.10.2. The read-out unit shall be portable, battery operated, designed to read vibrating wire gauge/ resistance gauges / thermistors. The LCD display shall present maximum information including output signal period, linear or frequency reading, gauges temperature, thermistor's Ohm value gauge factor and type.

The unit shall be able to log data having minimum 500 channels and 2000 readings. Power supply shall be through rechargeable battery.

<u>Note:</u> Monitoring, Recording and the Control Process of Underground works is mentioned in Annexure to Chapter 7: Instrumentation.

ANNEXURE TO CHAPTER 7

INSTRUMENTATION MONITORING RECORDING AND THE CONTROL PROCESS OF UNDERGROUND WORKS

1.1 GENERAL

a) The Contractor shall submit to the Engineer for agreement a detailed method statement for instrumentation and monitoring, including instrumentation layout, trigger, design and allowable values and procedures for evaluating the monitored data.

b) The Contractor shall appoint within his site team an experienced Instrumentation & Monitoring Engineer who shall lead the Contractor's monitoring team. The Instrumentation & Monitoring Engineer shall present the results of the previous day's monitoring in the daily monitoring meeting with the Engineer where they shall be presented to the Engineer by the Instrumentation & Monitoring Engineer.

c) The frequency of such review meeting may be increased if requested by the Engineer.

d) The Contractor' Tunnel Construction Manager shall attend monitoring review meetings if requested by the Engineer.

e) The accuracy and precision of the measurement required will depend on the purpose of the monitoring.

f) Assessments shall be carried out to establish the zone of influence due to tunneling works and to determine the likely damage that will occur to existing above ground and subsurface infrastructure.

g) The outcome of the assessments shall determine the type and amount of monitoring that will be required.

h) Early preconstruction instrumentation requirements shall be determined so that baseline measurements can be taken for an appropriate period, to establish the stability of the monitoring system and any possible effects of any underlying environmental trends that could be attributed to the Works.

1.2 Ground Monitoring

a) Unless otherwise provided for in the contract, the Contractor shall monitor the effects of tunnel construction at the surface including all ground movements and the effects on all structures, including the Works. Where specifically requested, the subsurface effects, including movements of the water table, shall also be monitored.

b) Unless otherwise provided for in the contract, monitoring equipment and instruments shall be provided by the Contractor to enable the response of structures to be determined, Equipment and instruments shall be installed to the manufacturer's instructions and shall be calibrated and tested as appropriate.

Monitoring pins and devices shall be securely fixed in position. Due regard shall be given to the construction of the structure to be monitored and the layout of its primary support.

c) Monitoring shall be referenced to stable survey stations located outside the zone of influence of the Works and not subject to ground movement. Such benchmarks and coordinated stations shall be established and agreed with the Engineer before any ground is excavated and before any ground treatment or dewatering takes place. They shall be checked at intervals during the duration of the Works.

d) The Contractor shall observe, record and analyze the readings to establish trends in movement and reconcile movements measured with those predicted. He shall provide a copy of all recorded results to the Engineer. He shall make available results to the Engineer in accordance with an agreed programme: however, movement greater than predicted shall be reported to the Engineer immediately.

e) Prior to Construction Works commencing, a defect survey shall be carried out of all structures within the zone of influence and a schedule of defects shall be prepared. This schedule shall be agreed by the Contractor and the owner of the structure, or his representative, prior to the start of construction. Existing pipelines, tunnels and services shall be regarded as structures.

f) During the execution of the Works, defects which have been scheduled shall be inspected and monitored as necessary. Defects which arise during the course of the works shall be recorded. The Contractor shall keep records of such inspections and a copy shall be available to the Engineer.

g) Monitoring of settlement, scheduled defects and defects arising during the course of the works shall continue at agreed intervals for a period of at least 6 months after completion.

1.3 Monitoring of Tunnel Excavation

a) The Contractor shall survey, monitor and record tunnel and shaft construction as it proceeds, to form a record of the work. Monitoring shall generally be per unit of advance and include line, level, cross-sectional accuracy, shift advance, total advance.

b) Where grouting is carried out, the type, volume and pressure of grout shall be recorded.

c) All information recorded by the Contractor shall be provided to the Engineer on a daily basis unless another interval has been agreed.

d) Where the Contractor considers that any corrective actions he may take will exceed the tolerance in the contract he shall so inform the Engineer and obtain his agreement.

e) The strata exposed in the tunnel face shall be mapped and recorded where possible and the nature of the excavated material shall be noted in all cases.

f) All significant groundwater ingress shall be recorded and monitored.

g) All atmosphere testing shall be recorded and monitoring for all gases carried out in accordance with relevant code.

h) The Contractor shall keep copies of all recent face records at the workface for the information of supervisory personnel.

1.4 Daily Review Meeting (DRM)

a) The monitoring instrumentation shall be read on a regular basis- as per Drawings and monitoring plan and the record made available for a Daily Review Meeting (DRM) attended by the Senior members of the Contractor's and the Engineer's staff. Input into the meeting shall also include current Geotechnical Investigations, Measurement While Drilling (MWD) report, face logs, and any recent non-conformance reports relating to the tunnel construction.

b) This DRM shall be held daily during the excavation of the tunnels unless otherwise agreed by the Contractor and the Engineer.

c) At the meeting the Contractor shall present the current results of monitoring of the tunnels, together with records on these results and comparison with the deformation predicted by the calculations.

d) The outcome of the meeting shall be a report Required Excavation and Support Sheet (RESS) agreed by the Contractor and Engineer, which states that tunneling may continue as proposed or gives the requirements for modification to the tunneling (e.g. shorter advances, smaller heading).

e) If no agreed report is available by a specified time each day then the tunnel shall be made safe and tunneling be stopped.

f) All records from these meetings including face logging and monitoring results shall be kept and be available for inspection until the termination of the contract.

1.5 Key Performance Indicator (KPI)

a) A Key Performance Indicator (KPI) system shall be developed for monitoring movements so that action can be taken in a timely manner, thereby ensuring that damage to existing buildings and subsurface infrastructure is within calculated predictions.

b) The KPIs to be used to guide construction shall relate to specific monitoring activities.

   i. In-tunnel convergence monitoring (SCL)

   ii. Ground movement monitoring

   iii. Monitoring of adjacent and overlying structures.

c) The KPI values specified in the design documentation shall be used to indicate whether or not there is cause for concern during tunnel construction. To ensure

that the response is appropriate for any specific concern, certain procedures shall be implemented when a KPI is exceeded. These are summarized below:

i. A full review of the lining performance shall be conducted for the relevant tunnel section and checked against the KPI values. This includes checks on the ground/soil conditions, the quality of construction and the monitoring results provided by the Contractor.

ii. A comprehensive review of the trends for monitoring data specific to the area of concern shall be carried out by the Contractor and the Engineer.

iii. The Contractor shall assess the extent to which the deformations comply with the SCL serviceability and extreme limit conditions.

iv. Together with the Engineer, the Contractor shall decide whether changes in the SCL excavation sequences are required. This is an interactive process that will determine whether it is safe to proceed with construction or, if there is reasonable cause for concern, the extent to which it is necessary to implement additional measures or emergency procedures. These measures will be included in a new RESS.

v. The Contractor and Engineer shall implement the Action Plan, the emergency response to implement contingency measures. If there is reasonable cause for concern, it is emphasized that the response must be rapid.

vi. The performance of the tunnel is kept under continuous review until the monitoring data indicate that KPI trends show a stable condition.

a) At least three trigger values shall be established: a green, amber and red limit. The green limit marks the boundary of normal behaviors. The amber marks the boundary of serviceability while the red trigger should be set below the ultimate capacity of the lining. The Contractor's Action Plan should include pre-planned contingency measures that can be taken if a trigger value is exceeded.

b) If a trigger value is reached, first the site team should check that the reading is correct and consistent with the readings from other instruments. If the rigger has really been breached, then contingency measures will be investigated in accordance with a predefined Action Plan and as directed in the DRM. The contingency measures are designed to correct any anomalous behavior.

1.6 RESS- Required Excavation and Support Sheet

a) Based on the design and the evaluation of the result of monitoring, a RESS will be issued at the outcome of the Daily Review Meeting (DRM). In the absence

of any approved changes the RESS will reflect exactly what is shown on the relevant design drawings.

b) The RESS shall be prepared and endorsed by the Contractor's Tunnel Construction Manager responsible for the tunneling works, the Designer (for specific issues) and the Engineer on site. Unless all the three signatures are obtained, the proposals indicated on the RESS shall not be implemented.

c) The RESS shall address, but not necessary be limited to the following matters:

i. The tunnel section (chainages) to which the RESS is applicable

ii. The support to be installed

iii. The excavation sequence

iv. The method of working related to ground support including staging of application of sprayed-concrete layers and lapping of reinforcement.

v. Monitoring to be installed in the tunnel section in question

vi. Measures to be taken during stoppage of works

vii. Other instruction relevant to the tunnel section in question

viii. Reference to relevant Design Drawings

d) A copy of the RESS will be given to the Head Foreman in charge of the work in the tunnel and shall be kept at the working face.

e) A RESS is required for every metre of the length of the tunnels.

f) If for any reason the approved design method of working is changed, then this will be reviewed prior to the DRM and subject to acceptance by the Engineer a new RESS will be issued.

1.7 Contingencies measures and Emergencies procedures

a) The Contractor shall determine contingency measures to deal with potential hazards that may affect the Works. The Contractor shall submit for approval to the Engineer an action plan which shall detail the actions, procedures and contingency measures to be followed in the event that the monitoring system shows unacceptable levels of deformation movement if potential hazards occur.

b) Hazards to be addressed include

i. changing ground condition

ii. excessive movement of the linings

iii. Excessive ground movement

iv. Excessive settlement of the existing structures

v. Unplanned stoppages

vi. Mechanical excavation plant failure

vii. Insufficient labour resources

viii. Failure of services to underground work (air, light, power etc.)

ix. Incidents within underground works

x. Delay in supply of sprayed concrete (SCL)

c) In underground construction works, changes tend to be progressive with evidence of structure or ground behavior becoming apparent before failure occurs. For this situation a system of hierarchical trigger levels will be appropriate. This allows proportionate response to adverse indications from monitoring.

d) Trigger levels will be based on the results of assessments of at-risk infrastructure. If the assessment indicates that the at-risk infrastructure is unlikely to be able to tolerate the change due to the Works, then triggers will be set based on the levels of change that will be tolerable.

e) There may be some situations where change is less progressive and monitoring may simply be required to give a yes/no response. In these cases, reporting is simple and systems of triggers are not appropriate.

CHAPTER -8

UNDERGROUND EXCAVATION

8.1 GENERAL

8.1.1 The specifications described herein under relate to the excavation work for the underground structures and shall include all labour, materials, equipment all drilling and blasting, loading, transporting and disposal of materials in spoil or stockpile areas as well as the removal of all loose material and cleaning of excavated surfaces, to be carried out by the Contractor under this contract. In general, the excavation work shall be done by mechanical equipment or drill and blast (DBM) and in exceptional cases, by manual means.

8.1.2 Excavation shall be made to the lines, grades and dimensions shown on the drawings or as otherwise directed by the Engineer, which shall be required to be backfilled with acceptable material and compacted by contractor in a manner acceptable to the engineer.

8.1.3 Structural supports, structural steel support, rock bolts, shotcrete, grouting, concrete lining and dewatering works are covered in other chapters of Outline Construction Specifications.

8.1.4 The Contractor shall be required to perform surface exploratory drilling during excavation of the tunnel whenever required.

8.1.5 The approval given by the Engineer to the Contractor's methods and equipment shall not relieve the Contractor of his full responsibility for proper and safe execution of underground excavations, or liability of injuries to or death of person or any obligations under this contract.

8.1.6 The Contractor shall comply with all safety procedure and requirements as stipulated elsewhere in the tender documents.

8.1.7 All excavations done inside ground with overlying material left in place shall be treated as underground excavation.

8.1.8 STANDARDS:

The specifications, production, working etc. shall conform to the following latest Indian Standards or where not covered by these Standards, to the equivalent International Standards. The list is for guidance purpose only. The Contractor shall abide by all codes/regulations/specifications as are deemed necessary for the satisfactory completion of work.

Railway Guidelines:

i. GE-G-0015 – Guidelines for Civil Engg. Inspection, Maintenance and Safety in existing Tunnels.

ii. GE-G-0016 – Guidelines for Safety in Tunnels during Construction.

iii. GE-G-0017 – Guidelines for Design and Construction of Tunnels

Indian Standards:

iv. IS: 4756: - 1978 – Safety Code for Tunnelling work

v. IS: 3764 –1966 – Safety Code for Excavation work

vi. IS: 4081-1967 – Safety Code for Blasting and Related drilling operations

vii. IS: 4138-1977 – Safety Code for Working on Compressed Air

viii. IS: 7293-1974 – Safety Code for Working with Construction Machinery

ix. IS: 5878 (Various parts) – Codes of practices relating to tunnelling and underground excavations

x. Indian Explosive Act -1988

xi. Indian Explosive Rules -1983

xii. IS: 823 -1964 – Code of procedure for manual metal Arc welding of mild steel

xiii. IS: 816-1969 – Code of practice for use of Metal Arc welding for General Construction in Mild steel.

8.2 SUBMITTALS

8.2.1 At least 28 days prior to the commencement of underground excavation, the Contractor shall submit details of his excavating methods and sequences for all underground works and portal excavation, including equipment, ventilation air cooling equipment, rock support, details of methods for drilling probe holes, grouting and safety measures. Contractor shall get approval for excavation and sequences from the Engineer.

8.2.2 The description of drilling and blasting procedures shall include the following:

i. Diameter, spacing, depth, pattern and orientation of blast holes.

ii. Pattern of delays to be used per blast.

iii. Sequence of various activities of the excavation works in different. Heading faces with indication of corresponding time requirements.

iv. Excavation methodology shall include proposed exaction cycle time for each class of rock mass along with advance rock stabilization measures.

v. The details to be backed up by supporting calculations & details of trials.

8.2.3 To enable the Engineer to verify all necessary setting out and elevations carried out by the Contractor, the latter, shall notify the Engineer in writing, giving at least 1 (One) week notice of his intention to start excavation.

8.2.4 During the advance of underground excavations, the Contractor shall record and submit weekly to the Engineer, 3 copies of the following:

i. Advance of each heading face and chainage of heading face before the blasting of each round.

ii. Amount, location, spacing, and type of steel support/Lagging installation in various zones, as defined hereafter.

iii. Surface area of shotcrete installed in various zones.

iv. Number, length, and type of rock bolts installed in various zones.

v. Occurrence of gas, if any.

vi. Water inflows at the heading face including its temperature.

vii. Personnel employed during various stages of the operation and their qualification.

viii. Unusual occurrences, all delays and the reason of delays.

ix. Type and number of drill holes, and length of each round.

x. Pattern of drill holes their diameter and length.

8.2.5 The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.

8.2.6 For geological overbreak and adverse geological occurrence Contractor shall be responsible for preparing geological plans and survey plot cross section at required intervals by tunnel profiler to allow for reasonably accurate assessment of the volumes and taking video / still photographs of overbreak in the presence of the representative of Engineer and providing copies of the same to "ENGINEER". The exact locations and / or chainage shall also be included therein. Such incidences shall be reported immediately to the ENGINEER. Detailed report on adverse geological occurrences shall also be prepared along with probable reasons and submitted to engineer as soon as possible. All cavity and voids formed due to geological overbreak shall be measured in situ, quantified and proposed by contractor for immediate approval of Engineer, If possible, before the excavation of the subsequent blast.

8.2.7 The drilling parameters retrieved from the Jumbo machine will be submitted to the Engineer before every blast.

8.3 DEFINITIONS

8.3.1 Conventional Excavation

Excavation performed underground by conventional methods using mechanical means (except TBM) or drilling and blasting and in exceptional cases, by manual means.

8.3.2 Tunneling Face

The advance end of a tunnel at which the work is progressing.

8.3.3 Heading Zone

Heading zone refer to tunnels (upstream and downstream headings) excavated by conventional method and is defined as a zone between the newly established face and 7m or equal to the excavated diameter of the tunnel behind the face, measured along the tunnel centerline.

8.3.4 Rear Zone

Rear Zone is the whole length of tunnel between the heading zone and the portal.

8.3.5 Excavation Rate per working day

The daily excavation rate is the average of daily rates calculated over a period of 1 month.

8.3.6 Working Days (WD)

Working days are calendar days on which work is performed. When working days are mentioned in writing, they must be indicated with additional indices such as WD1, WD2 or WD3 in order to show whether on the day in question 1, 2 or 3 shifts will be working.

8.3.7 Crown

Crown is the top arch of the tunnel above the spring line.

8.3.8 Spring Line

The level at which overt and vertical I wall of the tunnel meet is called Spring level and horizontal line passing through the junction points of tunnel is called Springing Line.

8.3.9 Round length (Pull): Maximum distance (along tunnel axis) between any two points on two successive tunneling faces by which the excavation is advanced from previous face to next face by conventional drill and blast or any other method in one go.

8.4 General

8.4.1 The Contractor shall always be responsible for the safety and security of excavations during the execution of the Contract.

8.4.2 Mechanized techniques for excavation shall be used.

8.4.3 Excavation shall generally be full face, heading and benching or multi-drift as defined in the construction drawings.

8.4.4 The Contractor shall provide details of his proposed methods for excavation support and spoil removal to the Engineer for agreement. No excavation shall take place until the Engineer's agreement has been obtained. Such agreement shall not relieve the Contractor of any of his obligations under the Contract.

8.4.5 Excavation shall be carried out in a uniform and controlled manner and over-cutting shall be kept to a minimum consistent with the need to maintain the necessary clearance for construction of the Works.

8.4.6 The invert of the tunnel shall be protected against damage and deterioration which may be caused by construction traffic. Any other surfaces which deteriorate or are damaged shall be made good to a standard agreed with the Engineer. After invert casting, tunneling muck will be filled, levelled and compacted over concrete invert.

8.4.7 Excavation shall be carried out in sections limited to such lengths, depths and widths as may be safely executed having regard to all the circumstances and as appropriate to the ground conditions and the equipment and method of construction being used.

8.4.8 In water-bearing strata the Contractor shall use such methods and take such steps as are necessary to control flows and maintain the stability of the excavation.

8.4.9 Where necessary to ensure the safety and security of the Works, excavation shall be continuous by day and night.

8.4.10 Weekends, general holidays and enforced stoppages will require the Works to be made safe and inspected by the Contractor at intervals agreed with the Engineer.

8.4.11 Any voids formed during the excavation process by machine overcut slips, falls of material, overbreak and temporary works shall be filled either completely or partially in agreement with engineer, with grout, concrete, sprayed concrete or other approved durable material.

8.4.12 Where the Contract specifies limits to surface settlement and/or protection in respect of existing services or structures, the Contractor shall provide calculations demonstrating that the method of excavation will result in compliance with those requirements. Details of the monitoring arrangements which are proposed for the recording of movements and the verification of the degree of any settlement or damage to services or structures shall be in accordance with the specified limits.

8.4.13 Where agreed or required by the Engineer, temporary support shall be left in the Works. Generally, untreated timber shall not be left permanently in the Works.

8.4.14 The volume of excavated material shall be measured and recorded as the Works proceed. The Contractor shall present to the Engineer after every 50m of advance, a Chainage wise reconciliation of volumetric advance of tunnel against volume of materials excavated and quantum of support installed (Bolts/Shotcrete), concrete placed, length of drilling of holes and grout injected.

8.4.15 All excavation shall be carried out to a profile as close as possible to the specified minimum excavation line.

8.4.16 The Contractor shall be constantly aware of the possibility of slips and ground movement which may be caused by his method or order of excavation. He shall maintain on-site material, and equipment, for use in ensuring the stability of the face.

8.4.17 The proximity of other tunnels and excavations shall be considered when determining the method of excavation.

8.4.18 Enlargement of tunnel cross section or excavation of bypass tunnel shall also be done as wherever required as per instruction of Engineer.

8.5 EXCAVATION LINES AND TOLERANCES

8.5.1 Definitions:

i. **Theoretical excavation line:** The excavation profiles as shown on the cross-section drawings refer to the theoretical excavation lines.

ii. **"A" Line"** – Depending on the quality of the rock, an appropriate enlargement of the theoretical excavation profile shall be made in order to provide enough

space for the anticipated radial deformations. The "A" Line takes into consideration the anticipated radial deformations above the theoretical excavation line.

iii. **"B" Line** – Line within which neither rock bolts nor sprayed concrete or any part of the primary support shall intersect except for bolt end hardware.

iv. **"C" Line** – A Line within which the final lining shall not protrude and be constructed within -0/+50mm radially (Negative value radially inward). The Contractor shall accommodate all his construction tolerances for excavation and support installation within this given allowance.

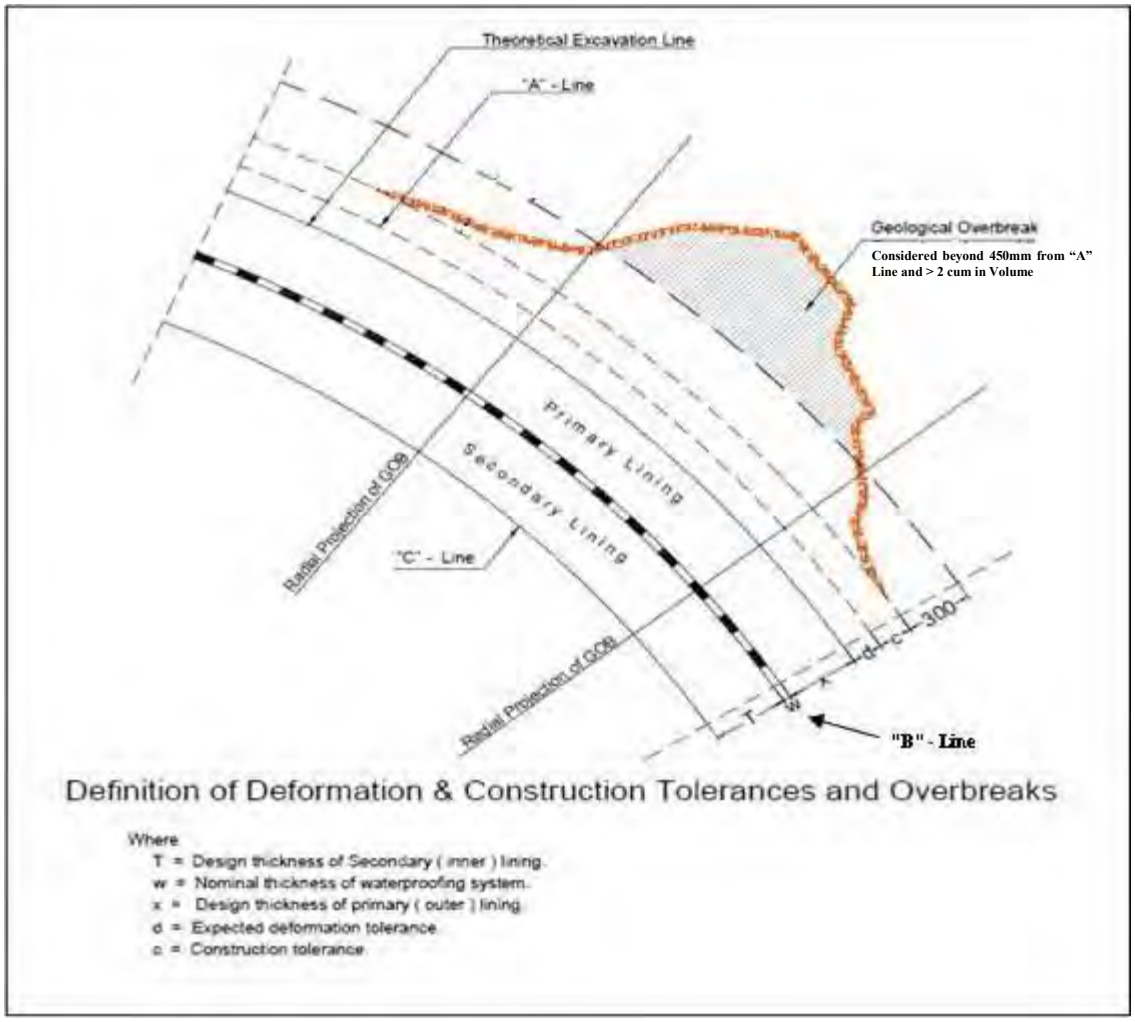


Figure: Definition

Typical cross section, minimum excavation lines and dimensions of excavations will vary for different Support Section Types required to be installed. Radial Deformation tolerances (δ) as mentioned in drawings shall be adjusted by the engineer to suit actual deformations as experience is gradually gained during excavation. The "A" Line shall accordingly be modified, and the Contractor shall be bound by all such adjustments.

8.5.2 Regulation for installation of Primary and Secondary Lining Support

I. Primary Lining Support: After scaling, entire excavated profile will be measured in situ with tunnel Profiler.

For the support classes with shotcrete and bolts only, the design thickness shall be applied directly on the excavated profile. Payment shall be made for the theoretical quantity increased by a thickness of 75mm only, based on the design drawings.

For the support classes with lattice girders/steel ribs, the excavated profile shall be placed with Shotcrete upto the "A Line". Thereafter, Design thickness of shotcrete and other supports shall be applied below "A Line", as indicated in the drawings.

For the case of the support types with Steel Ribs or Lattice Girders, the application of the shotcrete should respect the design thickness after the A line and reach to the corresponding B Line. In between the steel ribs or lattice girders, the shotcrete application less than the B line can be allowed, upon approval by the Engineer, respecting the following two criteria:

A. Satisfy the shotcrete design thickness as per approved drawings

B. Satisfy the waterproofing membrane waviness criteria

The finished profile of shotcrete shall be checked with tunnel Profiler and shall meet the tolerance for surface finish requirements for installation of waterproofing membrane (Chapter 4). Smoothening layer of shotcrete shall be applied as per drawings or as instructed by engineer.

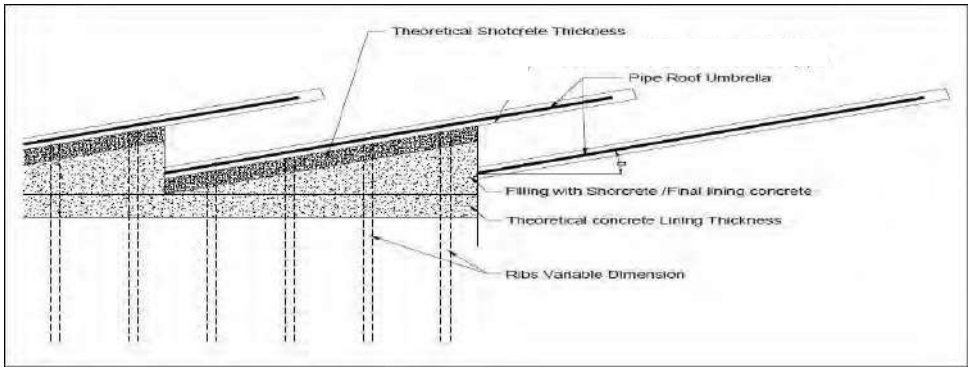
II. Secondary Lining Support: Before application of water proofing membrane, Profile of existing shotcrete surface shall be recorded with tunnel Profiler to establish actual deformation occurred. Any eventual space between the shotcrete surface and "C" Line shall be filled with the inner lining concrete. This eventual space comprises of concrete volumes required on account of portion of radial deformation (δ) which did not occur, added to the volume of theoretical lining thickness.

The actual occurred deformations before the installation of the Final lining will be measured with the convergence target at the closest monitoring cross-section of each support class.

8.5.3 The drilling jumbo should be positioned as per precise survey reference points/lines and shall preferably be laser/total station navigated before it's usage in drilling etc.

8.5.4 The Contractor shall measure the excavated profile by means of a 3 D laser tunnel profiler after each round or as per direction of the Engineer. Excavation not shown on drawings, but which the Contractor considers necessary for his own purposes such as excavation from mucking pits, pump sumps, niche for vehicle parking/turning, drain ditches other than those shown on the drawings and specifications etc. for supply facilities shall only be carried out with the approval of the Engineer.

8.5.5 In case of pipe roof umbrella, the excess of excavation below the steel pipes will be filled with Shotcrete/final lining concrete as instructed by Engineer.



8.5.6 Tolerances for Lining:

i. Secondary Lining: Finished surface of Secondary Lining shall not protrude "C" Line and be constructed within tolerance of -0/+50mm radially (Negative value radially inward).

ii. No reduction of the theoretical thickness of the inner lining is permitted unless approved by the Engineer. To achieve this requirement, no support elements such as primary shotcrete, rock bolts and steel ribs etc. shall penetrate the theoretical outer boundary of the inner lining.

iii. In the area of the invert and the foundation beams, no rock parts or rock peaks shall protrude into the theoretical excavation line.

8.5.7 Tolerance for Excavation level on invert:

i. For tunnel sections with no concreted invert arch the Contractor shall excavate the bottom level of the invert with an accuracy of -0 to +100(Negative value radially inward) mm related to the theoretical excavation line of the invert.

ii. If the bottom excavation level, after cleaning loose materials etc. is more than 100 mm below the designed theoretical excavation line, the Contractor shall backfill such areas up to the designed, theoretical level by means of sub-base material or as directed and approved by the Engineer.

iii. For tunnel sections with a concrete invert arch no reduction of the designed, theoretical thickness of the concrete structure is permitted. Over excavation must be compensated with structural concrete/ shotcrete for the invert arch as specified. The inside face of a concrete invert arch may deviate not more than +/-50 mm in elevation from the theoretical cross section.

8.6 PROFILE CONTROL

8.6.1 Scope

i. The Contractor is required to perform a careful and systematic checking of the final clearance of the primary tunnel lining in order to accommodate the designed nominal thickness of the secondary (inner) lining without interfering with the clearance requirements of the underground structure.

8.6.2 Method of Profile Control

i. For profile control for the shotcrete lining see Chapter 11.

ii. It is the Contractor's responsibility to ensure that the minimum clearance for the final (inner) lining as shown on the drawings is provided. On approval, the Engineer will issue instructions regarding the systematic checking of the geometry of the template during profiling operations.

iii. The Contractor may prefer to use advance surveying techniques and data processing to establish the final clearance profile. In which case he shall define a method of marking out areas of deviation from the theoretical profile to be approved by the Engineer.

8.6.3 Execution

i. The checking of the final clearance shall not proceed before the geotechnical measurements show that the radial displacements at any position of the tunnel have, in the opinion of the Engineer, largely stopped.

ii. The final clearance profile after the completion of support works of the tunnel and after deformation as per this Clause shall conform to the minimum clearance profile as indicated on the drawings. Final control is required before water proofing system is applied.

iii. In case of an existing under profile, the Contractor shall submit a proposal for the remedial works to the Engineer for approval.

iv. No reshaping (re-profiling) of the tunnel support shall be carried out without the approval of the Engineer.

v. Geotechnical measurements before, during and after the respective reshaping measures shall be carried out in compliance with the relevant design. The measurement points such as convergence bolts and/or extensometers shall be retained or substituted well in advance in order to establish "transfer - zero - readings".

vi. Geotechnical measurement stations shall not be removed and abandoned without the approval of the Engineer.

8.6.4 Records

i. Records shall be kept for each stage of the remedial measures executed.

ii. The clearance profile i.e cross-sections of excavated profile shall be recorded at every meter of tunnel Chainage in longitudinal direction and at multiple points, 0.5 mtr apart along the periphery of the tunnel or as instructed by the Engineer.

The clearance profile shall be recorded by non-contact method (by manually or automatically) i.e by means of a "Tunnel profiler". The checking of the clearance profile shall be done in presence of the Engineer.

iii. For the shotcrete lining, the final checking of the clearance profile after completion of re-profiling and surface preparation in compliance with this Specification shall be done in presence of the Engineer.

8.7 SUPPORT FOR UNDERGROUND EXCAVATION

8.7.1 The provisional and permanent supports for the underground excavation shall principally consist of spot or pattern rock bolts, shotcrete, *lattice girder/steel ribs, forepoling and piperoofing* supports as approved by the Engineer.

8.7.2 The Contractor shall install the support system as shown on the drawings or as directed by the Engineer in any part of the underground excavation based on rock conditions encountered during the work.

8.7.3 The Contractor shall employ a team of qualified geologists, who have adequate working experience in rock supporting work to act as support supervisor(s). The support supervisor(s) shall examine the rock conditions after each excavation advance and shall verify that the rock support system is installed as directed. The support supervisor(s) shall take necessary steps in consultation with Engineer in order to install additional supports or to stop further advance if, in his opinion, the conditions are unsafe. However, he shall have no right to cancel type or amount of rock supports previously directed by the Engineer. The support supervisor(s) shall be present at each heading face throughout the duration of underground excavation work.

8.7.4 The required supports shall be installed concurrently without delay during the process of excavation within the heading zones. In the rear zones additional supports shall be installed immediately after it is observed by monitoring that the supporting system previously installed is not enough to prevent further loosening of the material surrounding the excavation.

8.7.5 Shotcrete shall be applied, in accordance with the provision of relevant Sub Chapter of "Shotcrete". The Contractor shall consider in his construction planning, that placing of shotcrete protection will be required immediately after blasting a round in conventional method of drill and blast.

8.7.6 The use of timber will not be permitted for tunnel supports in any form. However, the Engineer, in exceptional circumstances may permit use of timber for providing temporary supports, which shall be removed as early as practicable.

8.7.7 The Contractor shall keep on the site all necessary construction plant and equipment for installing rock bolts and shotcrete, ready for operation in the excavation heading zones during the entire excavation period.

8.7.8 The Contractor shall bear the whole responsibility for the proper and safe excavation. With the prior approval of Engineer, extra supports and special protection for the personnel when the conditions so require can be provided.

8.8 CLASSIFICATION OF UNDERGROUND EXCAVATION

8.8.1 Excavation

i. This section covers the description of rock mass types and rock classes relevant to the underground excavation with respect to the geotechnical properties of rock encountered and its behavior under the influence of tunnel construction. The terminology "rock" in this context shall also include soil conditions. The rock (ground) classes are derived not only from the rock parameters, but also from considerations of a number of external factors such as overburden, size of excavated section and length of round, driving sequence, ground water, water infiltration, results from geotechnical measurements, etc. which can essentially influence the classification.

According to Ö-NORM 2203 Classification, rock masses are divided into 3 main types which are A, B and C:

- A (Stable to over breaking): Stresses acting on rock mass do not cause major failures
- B (Friable): Disintegration due to structural weakness and/or lack of interlocking
- C (Squeezing): Strength of rock mass is exceeded to great depth; this type also includes rock bursts and swelling rock.

Type of support section required shall be based on based upon behavior of rock masses under load and monitoring the performance of underground excavations during construction.

ii. Rock (ground) classes are determined on the grounds of the appearance of the rock at the excavation face of the tunnel before the commencement of the respective excavation sequence. The results of geotechnical measurements under similar rock conditions shall be considered for prediction of deformations and for the determination of rock classes. The aforesaid classifications may not be applicable for a situation requiring multi drift excavation or locations encountering unexpected geological conditions requiring extra measures, for which the support system would be decided by the engineer depending upon the judgement of the rock type being encountered. In case of a drive subdivided into top heading - bench - invert excavation, the rock conditions of the top heading drive shall govern the classification. Following are the various types of Rock mass types and relevant rock mass behaviors.

Rock Mass Types	Rock Mass Behavior
A1 (Stable)	Minor deformations that decline rapidly, no spalling

Rock Mass Types	Rock Mass Behavior
A2 (Over breaking)	Minor deformations that decline rapidly; some spalling at the crown due to discontinuities
B1 (Friable)	Minor deformations that decline rapidly; structural weakness and blasting operations lead to loosening and the separation of blocks in the crown and upper wall
B2 (Very Friable)	Deformations decline rapidly; poor structural strength, little interlocking, high mobility of rock mass and blasting operations lead to rapid and deep loosening where unsupported
B3 (Rolling)	Excavation even in small cross sections leads to inflow of rock material; lack of cohesion and interlocking are responsible for insufficient stability
C1 (Rock Bursting)	Sudden release of energy leads to explosive rock failure
C2 (Squeezing)	Pronounced deformations that take long to decline; development of failure zones and plastic zones in plastic, cohesive rock mass
C3 (Heavily Squeezing)	Large deformations, rapid at the beginning, taking long to decline; development of deep reaching failure zones and plastic zones
C4 (Flowing)	Very low cohesion, low friction, soft and plastic consistency of rock mass; material will flow into the tunnel even through very small unsupported areas
C5 (Swelling)	Rock mass with mineral content that increases in volume by absorbing water, e.g. swelling clay-minerals, salts, anhydrite

iii. **SUPPORT SECTION TYPE**

a. The Support Section Type classes are the Rock Support Type classes given in the *Design Basis Report and Geotechnical Interpretative Report* , Section-VII-8:Tender Drawings and Documents.

b. The selection of Support Section Type and its adjustment shall be according to NATM or any other Controlled Convergence Method with observational feedback through3D instrumentation and monitoring.

c. The defined Support Section Type classes reflect the excavation system, the round lengths of each advance and the support requirements under consideration of the behavior of the rock mass.

d. The defined Support Section Type classes are derived not only from the rock parameters, but also from considerations of a number of external factors such as overburden, size of excavated section and length of round, driving sequence, ground water, results from geotechnical measurements, etc. which can essentially influence the classification.

e. The Support Section Type to be applied must be determined on site through Tunnel Face Mapping, 3-D Geo-logging at the excavation face of the tunnel before/prior the commencement of the excavation sequence.

f. The Support Section Type at the face for each round shall be jointly agreed between the Contractor and the Engineer. In case of disagreement, the decision of the Engineer is binding.

g. The results of geotechnical measurements and monitoring during tunnel construction shall be considered for prediction of deformations and for the determination of Support Section Type to be applied for future excavations.

h. The behavior of the rock in a newly exposed round is time dependent, i.e. rock mass quality will decrease with the free span if no support is installed within a reasonable time. Accordingly, the maximum length of a round which can be excavated and supported in time is a criterion for the rock classification.

i. Advance probing shall be carried out during tunnel excavation as and when required, as per instruction of Engineer. During advance probing, joint measurements & collection of data with contractor and Engineer shall be carried out.

j. The selection of the Support Section Type shall be done jointly by Contractor and the Engineer in writing on agreed form-sheets. The classification record is a collection of all classification sheets, which shall be kept accessible for consultation and modification whenever excavation works are under progress/post construction phase. In case of disagreement, decision of the Engineer shall be binding.

k. Notwithstanding the duties of the Engineer, the Contractor is solely responsible for the safety of the works under construction.

iv. The Contractor will adopt the round length for each blast as instructed by the Engineer. The Engineer's decision to adopt a round length will depend on the behavior of rock mass in previous few rounds and the Support Section Type required to be installed in the round under consideration.

v. **Variability for Each Support Section Type:** The defined Support Section Type includes some parameters variability (Round length, Support installations and locations) that should be managed during excavation using

the parameters like Q Value, RMR Value and Behavior in last few rounds. During execution, the Round length, Support installations and locations may vary on upside or downside from the given values, however only the net effect of all such variations shall be considered.

vi. After each round, support section required shall be decided by the Engineer and Contractor on the basis of recorded observations. Geological face mapping sheet and Geo-mechanical classification of the excavation which face shall be elaborated by the Contractor and validated by the Engineer. Required Excavation and Support Sheet (RESS) shall be used as detailed in Annexure to Sub- Chapter 6: Instrumentation

vii. Pull for next round will not be taken unless already excavated tunnel section in previous round has been supported to the satisfaction of Engineer.

viii. After each blast, fumes shall be ventilated immediately within 15 minutes and scaling shall be done subsequently to remove loose or hanging rock pieces. Contractor's geologist at the time of scaling shall prepare a tunnel geological map registering joint sets, foliation, joint, infill materials, weak zones etc.

ix. After completion of mucking, a period of 30 minutes and a man lift platform (Employer's half hour) shall be kept ready by the Contractor at the excavated face for engineer to check for any loose scaling, visually inspection and checking of rock classification carried out by Contractor and to come to a mutual agreement of the support section to be adopted. In case of any dispute, decision of Engineer shall be final.

x. Immediately after decision on support section, supports shall be installed. The behavior of the rock in a newly exposed round will be time dependent, i.e. rock mass quality will decrease with the free span if no support is installed within a reasonable time. Therefore, contractor is required to respect the cycle time for timely support installation.

xi. The Contractor shall document time taken for various activities, blast pattern adopted, charging of holes, blast sequence, geological mapping, scanning of tunnel profile before and after installation of support, actual support installed etc. in any excavation cycle on a shift basis and the record shall be got approved from engineer.

xii. Additional excavation tolerance has already been inbuilt which shall be further established through a system of well documented monitoring observations, during excavation.

xiii. The assignment of an individual support class shall always apply to the whole of the round length.

xiv. For mixed face conditions, applicable support system shall be guided by the conditions representative of more than 50% of the mixed face. Engineer may direct to adopt a different support class also in such conditions. In case of any dispute, decision of Engineer shall be final.

8.8.2 Support System for Tunnels

i. The Contractor shall understand and recognize the technical and design concepts of the NATM for the mined tunnels and shall appreciate the function and merits of each component of the tunnel support.

ii. The type and amount of tunnel support to be installed immediately after excavation is directly related to the rock classification as established. The initial support system associated with the established Rock mass types and relevant rock mass behaviors classification is shown on the Bid Drawings for reference. However, as a consequence of variations from the anticipated rock conditions the initial support system as shown on the drawing for each rock mass type may require modifications and adjustment during construction as per agreement between the representative of the Engineer and Contractor. Decision of the Engineer shall be final.

iii. The Contractor shall ensure that support elements will be installed or applied in such a manner and sequence as to prevent disintegration and loosening of the rock mass in front and around of the excavated tunnel.

8.9 EXECUTION

8.9.1 General

i. Prior to commencement of excavation, Tunnel portal, Tunnels, junction of tunnels with cross passages shall be strengthened as per construction drawings or as directed by Engineer.

ii. All rock material projecting inside the minimum excavation line shall be removed.

iii. All loose rock shall be removed from the underground construction sites and disposed off in the approved dump areas.

iv. The Contractor shall constantly check the progress of excavation by means of Laser survey in order to avoid any substantial rectification of the already opened profile and eventual rearranging of the installed rock supports.

v. Where excessive inflows of water occur at the heading face, the Contractor shall take all appropriate measures to execute the excavation work safely and properly including provision of extra supports and protection of workmen and any special equipment necessary for working in waterlogged conditions.

vi. *Deleted*.

vii. The Geological Report, as a part of these documents, contains the results of Geological studies carried out on this component of the Project.

viii. The orientation of the tunnel as indicated on the drawings is subject to modification. It may be necessary to introduce slight shifting of the axes of the tunnel after additional information is available. The drawing showing the final

orientation will be prepared by the Contractor prior to start of work and he shall be required to execute the Work as per drawings or as directed by the Engineer.

ix. Sheared or shattered rock zones, foliation shears, thick joints with gouge or other thick discontinuities may be encountered during excavation. Whenever shear zones and poor rock bands are encountered along the tunnel, Additional provisions of fore-poling, pipe roof, face bolting, etc. will be undertaken at once by the Contractor to avoid any cavity formation as shown on the drawings or as directed by the Engineer.

8.9.2 Method of Excavation

i. The Contractor shall establish by trial blast and use drilling and blasting techniques, which will produce a smooth final profile a minimum of Overbreak and a minimum of fracturing of the rock beyond the minimum excavation lines. The techniques used shall always be subject to the Engineer's approval, who may direct several blasting tests to be undertaken by the Contractor to substantiate his proposed blast design.

ii. Only controlled blasting techniques shall be used. It shall be performed as described below:

a. Pre splitting: Consists of drilling a single row of closely spaced holes along the final excavation perimeter. These holes are Lightly charged and simultaneously detonated before the main blast to produce a presplit crack, which limits the propagation of crack from the subsequent main blast, and in such a way, reduces damage in the rock beyond it. The blasting of the main excavation zone requires a reduced explosive charge in the line of hole nearest to the presplit line and a limit on the distance between the presplit line and the nearest line of main blast holes. The presplit holes shall be drilled deeper than the depth of the pull.

b. Smooth Blasting: Consist of drilling several closely spaced holes along the final excavation perimeter, placing light charges in the holes and detonating the charges simultaneously after the main blast. The outer line of drill holes for the main blast is set at an approved distance inside the final perimeter leaving an annulus of rock to be peeled off the damaged final excavation perimeter by the smooth blast The smooth blast holes are drilled, charged and blasted in the same tunneling cycle as the main blast.

c. Cushion Blasting: As special case blasting in which considerable air space of stemming surrounds charges in the holes and serves to reduce undesired blast effect on the final excavation perimeter.

iii. During the progress of excavation the drilling and blasting pattern specifically the number and depth of holes, quantity, quality and distribution of explosives, shall be varied as necessary to suit the rock conditions encountered taking into consideration the information obtained from the probe/exploratory holes, the

actual drilling work (velocity, color of rinsing water, etc.,) as well as the previous blasting results.

iv. Only wet drilling will be permitted in order to reduce dust in the underground excavations.

v. Perimeter drill holes shall be placed such that the over excavation beyond the minimum excavation line is minimized. The Contractor shall pay utmost attention to obtain a smooth and uniform excavated surface.

vi. Should the entire length of most of the perimeter drill holes not be visible after each round of blasting, the Contractor shall make an adequate adoption in the blasting pattern used and submit it to the Engineer for approval.

vii. The depth of a new round shall never exceed that which was determined and approved prior to commencement of basting. The Engineer may order reduction of the adopted round depth if the actual rock condition requires it.

viii. Blasting of new round will not be permitted if no, or insufficient, personnel are available to perform the mucking and subsequent support work afterwards. This applies to Work before holidays, non-working weekends etc.

ix. Blasting that may damage the rock beyond the required excavation lines or the tunnel installations will not be permitted. Any damage to, or displacement of the supports and any damage to, any part of the Works caused by blasting or any other of the Contractor's operations shall be repaired by the Contractor in a manner satisfactorily to the Engineer.

x. No new round shall be blasted until the supports required within the heading zone have been installed.

xi. All loosened material that is likely to fall shall be removed immediately following blasting, at frequent intervals during the progress of the Wonk, and finally during the clean-up prior to placing the final tunnel lining.

xii. After excavating, the Contractor shall adequately protect the tunnel invert, surface from damage caused by the construction traffic, should small grain or broken excavation material be used for such protection, it shall be removed prior to placing the final tunnel lining. No vehicular traffic will be permitted over tunnel invert after removal of the protective material.

8.9.3 Excavation of Shaft

i. The methodology for excavation of shafts in soil or soil & rock shall ensure safety during construction. Adequately designed support system to cater lateral earth pressure and hydrostatic pressure under worst drainage conditions shall be provided to safeguard long term stability. The Contractor shall submit a method statement for approval of the Engineer.

8.9.4 Cleaning of Excavation Surfaces

i. Even prior to the removal of the bulk of the material loosened by blasting, the Contractor shall undertake scaling activities to clean the newly exposed rock

surface from loose rock fragments, dust and debris to permit if required, the application of the first lay of shotcrete.

ii. Cleaning shall be done by directing a jet of water or air at the rock face. Compact washable rock shall be cleaned with compressed air water jets. Rock, which is prone to quick disintegration, swelling, heaving or is interspersed with clay filled fissures, shall be cleaned with compressed air only. The cleaning shall be done to the satisfaction of the Engineer.

iii. The cleaning is separate from the cleanup of excavated surface required immediately prior to placing of the final lining described in Section of "Cement Concrete".

8.9.5 Tunnel Maintenance

The Contractor shall be responsible for maintaining the completed underground works throughout the construction and contract period. As part of this maintenance, remedial work shall be carried out when repairs are required to the structural or other systems or when grouting is required to stop water inflow.

i. The Contractor shall monitor the tunnel support systems and record any damage to the support systems. If necessary, remedial action shall be taken with temporary propping, including evacuating the area and posting warning signs accordingly.

ii. The Contractor shall, in addition to monitoring the support system, carry out regular maintenance of the underground works, including but not limited to bench marks, 3D monitoring, drainage and pumping systems, light bulb replacement, cleaning, water removal, water pipe maintenance, ventilation system signalling system, communication system, toilets, containers and emergency equipment, and all cabling, transformers and pipes for different purposes and its maintenance, and cable maintenance. Maintenance shall include all repair work required to maintain all equipment in working order.

8.9.6 Site Traffic on Final excavation levels

i. (Formation level) for pavement construction shall be protected against any wear or deterioration of rock properties following site traffic by backfilling with rock material excavated in the tunnel or similar, to a minimum thickness of 0.5 meters. The access to the main drainage control shafts shall be possible at any time. These must be protected and marked on the side wall for later recovery.

ii. Pounding water and traffic through pounding water for vehicles or pedestrians shall not be allowed.

iii. Any deteriorated material shall be removed and replaced prior to pavement works as directed by the Engineer.

iv. The backfill material used for protection purposes shall be removed in the main tunnel only until immediately prior to pavement construction works.

8.9.7 Site Traffic on Invert Support

To avoid damage to the Invert structures, these should be duly protected by giving a course constituted of excavated material and having an approximate average thickness of 0.5m. No site traffic shall be allowed to run on unprotected invert structures. Boulders larger than 100mm dia should not normally be used for this purpose.

8.10 DISPOSAL OF EXCAVATED MATERIALS

8.10.1 Muck/ Rubble generated from tunnel excavation/ hard rock cutting will be property of the Contractor and shall be taken away by the agency under proper authority letter from HORC authorized representative & shall be dumped outside of HORC limit by Contractor's own means, with all lead, lift, transportation charges, and other incidental charges etc complete as directed. The Contractor has to make his own arrangements for land required for dumping areas outside of Railway limit for muck/ rubble dumping at no cost to the employer.

8.10.2 Excavated materials, which are not suitable or are in excess of the permanent construction requirements, shall be disposed off outside HORC premises including labour, loading, unloading, transportation, all lead & lift, T&P, Taxes, octroi etc. complete in nominated dumping ground with prior approval from respective Departments/ Municipalities and Engineer in the course of the work.

8.10.3 The Contractor shall shape and trim the dumping areas of contractor and stockpiles to the lines and grades as directed or approved by the Engineer and shall provide for adequate diversion of existing water courses. The area over which the excavated material is to be disposed of shall be stripped of all vegetation. If the area is steeply dipping, precautions shall be taken to ensure stability of the material in the area, including base drainage and surface protection against erosion and providing retaining wall / gabions ate wherever required. The material dumped shall be compacted, by movement of the dumping vehicles and grading as necessary, in layers not exceeding 0.5m in depth. It shall be the responsibility of the Contractor to remove any material from any slide that may occur in the disposal dump or its base and redispose the removed material properly to the satisfaction of the Engineer at his own cost. Prior to the commencement of excavation work the Contractor shall have prepared the disposal area to the satisfaction of the Engineer and the methods proposed for disposal shall also have received approval of the Engineer.

8.10.4 The Contractor shall be liable for any damage to Temporary or Permanent Works or to the property of third parties caused by poor drainage in the waste disposal or stockpile areas.

8.10.5 If additional areas are required for disposal of the excavated material, the Contractor shall propose such area for approval of the Engineer.

8.10.6 The Contractor shall ensure that no excavated materials are disposed off in the stream or at locations, where in the opinion of the Engineer these are liable to be washed away by the floods.

8.10.7 The disposal of the excavated material in the dumping area shall not damage the environment and will be regulated as per the norms of Government of India. In spite muck disposal area shall be suitably covered off with retaining structures. Before taking up such works the Contractor shall propose the construction methodology of retaining wall with RR Masonry/ gabions approved from the engineer.

8.11 ILLUMINATION

8.11.1 The Contractor shall install an adequate illumination system in the Underground works as stipulated in Section of "Site Installations and Services."

8.12 CONTROL OF DUST, SILICA AND NOXIOUS GASES IN UNDER-GROUNDWORK.

8.12.1 The Contractor shall install and operate equipment for the control and monitoring of dust, silica and noxious gases in Underground Works as stipulated in Section of "Site Installations and Services".

8.13 COMMUNICATION SYSTEM

8.13.1 The Contractor shall install and operate the communication system between each heading face and entrance to the tunnel, shaft or cavern/chamber as stipulated in Section of "Site Installations and Services".

8.14 GEOLOGICAL MAPPING

8.14.1 The purpose of engineering geological mapping and follow-up is the documentation of rock and rock mass conditions as encountered during excavation. The documentation shall enable the verification of the suitability of the designed support and excavation measures, the prediction of rock mass conditions ahead as well as the interpretation of results of the geotechnical monitoring concerning ground deformations. After each blast, Mucking and scaling shall be done. After completion of scaling, a period of 30 minutes (Employer's half hour) shall be kept by the Contractor for engineer to visually inspect and check the rock classification carried out by Contractor and to come to a mutual agreement. In case of any dispute, decision of Engineer shall be final.

8.14.2 If stand up time of unsupported tunnel is very less, then the mutual agreement on rock classification may be required to be arrived at during mucking and scaling activities for early installation of the required support.

8.14.3 ENGINEER shall use mapping and related information along with the rock mechanics test and instrumentation monitoring results shall be used to optimize design of the final lining and rock reinforcement for the tunnel (s), shaft, cavern and chambers.

8.14.4 The Contractor always shall provide adequate lighting, proper ventilation, reasonable access, cleaning and washing of the walls and crowns for checking correctness of mapping by "ENGINEER" representative.

8.14.5 Documentation:

i. The mapping and documentation of encountered geological conditions during the excavation shall be based on uniform legend and terminology for Rock Types / Rock Mass Types, Discontinuities, Jointing, Water seepage, Weathering, Rock Strength, Behavior of Rock Mass and other features which are needed to be described for complete record.

ii. The documentation of the tunnels shall be based on the mapping of the face and the full periphery mapping method. The full periphery mapping method shall be applied for the permanent walls only. The frequency shall be adjusted to the variability of the encountered ground conditions. In case ground conditions are frequently changing within one round length each round shall be mapped. Each drive which is under construction shall be checked at least once a day. Support types will also be checked during periphery mapping studies.

iii. Face mapping sheets: In general, the mapping shall be performed in a scale 1:100 and shall have a grid of 1 x 1 m for easier drafting, marked with "+". If necessary, details shall be mapped at other suitable scales. Using the uniform terminology, remarks can be stated directly on the mapping sheet or can be referred to the data sheet.

iv. Data Sheets: The data sheet format shall be got pre-approved and shall consist of details like Tunnel, Location, Chainage, Excavation method, Name of mapping geologist, Date and Time, Rock Mass/Types, Discontinuities, Jointing, water, weathering, Behavior, General remarks etc.

v. Vertical and Horizontal Sections: Based on the follow-up of mapping and data sheets, a vertical as well as a horizontal cross section shall be drawn, where the actual mapping results are incorporated continuously daily. The vertical section shall be located along the axis of the tunnel. The horizontal section must be fixed according to the chosen excavation cross section (full face, top heading - bench etc.). In case the tunnel is excavated by top heading - bench excavation the horizontal cross section shall be drawn on the level of the invert of the top heading. Horizontal and vertical scale shall be the same.

vi. The position of the laser beams on the face as well as the steel rib connections may be marked as drafting guides.

vii. Remarks can be stated directly on the mapping sheet or can be referred to the Face Mapping Sheet.

8.15 MEASUREMENT AND PAYMENT

8.15.1 General

i. This is a lump sum contract hence no separate payment will be made for any of items separately. Bidders shall consider all expenditures in their total offered cost. However, all detailed measurement shall be recorded for all the works executed for the purpose of quality check, Preparation of completion/ as built drawings and future operation & maintenance.

Excavation occurring due to overbreak beyond "A" line shall not be paid and will be deemed to be included in the overall amount quoted for complete work under this contract. by the Contractor.

ii. The Overall amount quoted for complete work under this contract. shall be deemed to include the entire cost of, but not be limited to the following:

A. The installation of pumps and pipes as well as their maintenance along the excavation for water inflows. In upward tunnel drives, the measurement of the water inflow shall be carried out 25 m behind the tunnel face. In downward tunnel drives, measurement shall be performed for the water inflow occurring within the last 5 m behind the tunnel face. There is no separate payment for power consumption shall be paid.

B. Provision of all labour equipment and materials required for the Underground excavation including drilling holes for blasting.

C. Developing and improving controlled blasting methods, blasting tests and performance of blasting.

D. Cleaning, washing, protection and maintaining excavated surfaces in satisfactory conditions and protection of tunnel invert until concrete lining is placed,

E. All enlargements and additional excavations or any temporary supports required by the Contractor for his construction methods,

F. In case of shafts, the entire cost of following items shall also be deemed to be included in the quoted amount for complete work under this contract:

a) Supply, transport, assembly and removal of equipment including hoisting equipment.

b) Use, Operation and Maintenance of Special equipments (such as raise climber etc.).

c) Drilling of pilot holes/ driving of pilot tunnels/ shafts.

d) Reaming.

e) Slashing.

G. Loading, hauling and dumping the excavated material on stockpiles, dumping area or points of incorporation into Permanent Works, shaping and trimming of the excavated materials in the dumping areas as specified, clearing of the stockpile areas, formation and maintenance of stockpiles, rehandling of suitable materials including segregating, grading, draining and drying of materials suitable for use in embankment construction or as backfill.

H. All delays during excavation work resulting from installation of rock

supports and instrumentation measures as advised by engineer required by the Geo-technical conditions of the material encountered, irrespective of the distance from the heading face.

I. Complying with all requirements of statutory laws and regulations relating to underground works and any restrictions resulting therefore obtaining all necessary permits and licenses for the purchase use storage and transport of explosives and other materials.

J. Surveying, setting out, checking of excavated profile, alignment and any subsequent rectification works resulting from undue or incorrect surveys provision of suitable equipment for and delays due to carrying out his work.

K. Furnishing, installation, operation, maintenance and removal of communication, illumination and ventilation system, observing safety precautions and measurement, monitoring of dust silica and noxious and Inflammable gases.

L. Recording and preparation of reports related to excavation progress and procedures. No separate remuneration shall be paid for geological mapping during tunnel excavation.

M. All works Involved with and any partial or short interruptions or inconvenience caused by the check surveys, performance of the rock mechanic test, installation and monitoring of instruments and geological mapping, for which no separate payment is provided elsewhere in these specifications.

N. Seepage/ingress of water suitably collected and drained away by gravity.

O. For Support Section Type where Forepoling is required, no separate remuneration for excavation beyond "A" line will be made and shall deemed to be included in the overall amount quoted for complete work under this contract.

P. For Support Section Type where Pipe roof is required, in Figure under Para 8.5.7. no separate remuneration for excavation beyond "A" line will be made and shall deemed to be included in the overall amount quoted for complete work under this contract.

Q. The payment towards the preparation of Muck disposal plan shall be deemed to be included in the overall amount quoted for complete work under this contract.

R. No separate compensation for the provisions for the start of tunnel excavation from the pre-cut is envisaged. The quoted amount for complete work under this contract shall include all costs required for the construction of the canopy structure (false portal), if required.

S. No extra Payment will be made for hauling the excavated material to entry point of disposal area or entry point of permanent works where excavated materials are to be incorporated.

T. Deleted.

U. No separate payment shall be made for multiple drifting. No separate remuneration shall be paid for the removal of temporary support installed at the tunnel face or at the top heading invert.

V. All delays during excavation work resulting from fore probing and grouting activities required to achieve the specified water tightness on the project.

8.15.2 Overbreak

i. No payment shall be made for excavation occurring due to overbreak either avoidable or unavoidable.

ii. Deleted.

8.15.3 Exclusions

i. Rock supports required due to the Contractor not observing approved drilling and blasting techniques will not be included for payment.

ii. No extra measurement for payment or payment will be made for:

A. Geological mapping as described in this chapter or performed at site.

B. Over breaks.

C. Any rectification Works resulting from incorrect surveys and l or blasting.

D. Over excavation including the works mentioned in section "Excavation Lines and Tolerances" above, required for Contractor's convenience. The concrete and grout required to fill such excavation shall also be at the Contractors expense.

E. Extra work or material required for repairing any damage to the tunnel invert caused by construction equipment.

F. Draining, shaping and trimming of the dumped material to the lines and grades as directed or approved by the Engineer.

G. Excavation of tunnels, other than those shown on the drawings carried out by the Contractor for his convenience and plugging thereof.

8.15.4 Royalties

Soil or rock spoils such as stones, boulder, pebbles, gravels etc. available from excavation, if are found suitable for use in works as per required specifications, can be used free of cost but the legally payable royalty and taxes are to be paid by contractor to the concerned authorities.

CHAPTER - 9

STRUCTURAL STEEL SUPPORT

9.1 GENERAL

9.1.1 The specifications described herein under relate to the work which includes all labour, materials, equipment and services required for the supply, handling, fabrication and installation of structural steel supports consisting of steel ribs and lagging, Lattice girders and Lining stress controllers to be carried out by Contractor in the underground excavation to the shape and dimensions as shown on the drawings.

9.1.2 Structural steel supports shall be installed either as complementary measure to the previously installed rockbolts and shotcrete when those prove to be insufficient to stabilize the excavation profile, or as immediate supports after excavation in the heading zone when the material encountered in the process of excavation requires such measures.

9.1.3 Steel ribs shall be furnished complete with bracing, bolts, nuts, washers, plates, tie rods, and other accessories necessary for installation of the supports. Horizontal or bent bracing in the invert may be required in some reaches.

9.1.4 Precast RCC or steel lagging shall be furnished separately for steel ribs.

9.1.5 The Contractor, if he considers necessary, may install temporary supports for his convenience and safety of his workmen / equipment during execution.

9.1.6 The supports shall be bent to the required shape by cold bending process only.

9.1.7 Minimum buffer stock for one-month quantity as per agreed work's programme of Re-Bars for (size decided by engineer) Steel ribs and lattice girders. However, towards work closure, the Contractor may use these quantities with prior approval of Engineer.

9.2 SUBMITTALS

9.2.1 Within 4 (four) weeks from the commencement date but before procuring the equipment or mobilization to the site, the Contractor shall submit to the Engineer, the description and drawings showing enough details of the layout, type and capacity of the equipment proposed for the fabrication of steel ribs.

9.2.2 At least 8 (eight) weeks in advance of the excavation of underground works being carried out on the site, the Contactor shall submit to the Engineer the schedule for fabrication of ribs and the method statement for erection to the engineer for agreement.

9.2.3 The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.

9.3 STANDARDS

9.3.1 The fabrication and installation of structural steel support shall conform to the following latest Indian Standard or where not covered by these Standard to the equivalent International Standards:

i. IS: 5878 Code of practice for construction of tunnels conveying (Part-IV) water

ii. IS: 800 Code of Practice for general construction in steel.

iii. IS: 814 Covered electrodes for manual metal arc welding of carbon and carbon manganese steel.

iv. IS: 816 Code of practice for use of metal arc welding for general construction in mild steel.

v. IS: 1786 Specification for High strength deformed steel base and wire for concrete reinforcement.

vi. IS 2062 Hot Rolled Medium and High Tensile Structural Steel

vii. IS: 2502 Code of Practice for Bending and Fixing of Bars for concrete Reinforcement.

viii. IS: 2751 Code of Practice for welding of mild steel Plain & Deformed Bars for Reinforced concrete construction.

9.3.2 In case of conflict between the above standards and the specifications given herein, the specifications shall take precedence.

9.4 NECESSITY & DETAILS OF STRUCTURAL STEEL SUPPORTS

9.4.1 GENERAL

i. Steel support shall be installed to support crown and wall of underground excavation in all areas where, in the opinion of Engineer, alternative methods of rock supports like rock bolts and Shotcrete shall not provide adequate support either for construction safety or for permanent stability.

ii. The exact requirement for steel supports in any area shall depend on actual conditions encountered as excavation progresses.

iii. The design and details of the steel supports and steel supports accessories, precast RCC or steel lagging, including size, weight, spacing and method of installing in all parts of the excavation shall be subject to review / revision by the Engineer depending upon the rock conditions encountered.

9.4.2 STEEL RIBS

i. The steel ribs shall comprise of I-beam or built up sections as shown on the drawings.

ii. Rib splices shall be welded or made of bolted plates in such a manner as not to reduce the section moment of resistance.

iii. Preferably one section size of steel rib profile shall be used for each portion of the Underground Works and the structural requirements due to rock conditions encountered shall be met by varying the spacing of the ribs as directed by the Engineer.

9.4.3 STEEL RIB ACCESSORIES

Steel support accessories shall include, but not be limited to, collar braces, tie rods, spreaders, liner plates, cribbing, blocking wedges, foot blocks, sills and invert struts which are fabricated from steel plates or sections or other steel products. Steel support accessories shall be used exclusively in conjunction with the steel ribs in the underground excavations and shall be used elsewhere when required by the Engineer.

9.4.4 ***Deleted***

9.4.5 Lattice girders

The lattice girders shall be installed in a similar manner as steel ribs. Lattice girder segments shall have butt plates and the method of installation shall ensure tight connection of all elements. The accessories of lattice girders like plates, bolts, nuts and washers etc. shall be like steel rib accessories. Lattice girders shall be fully encased in shotcrete. Under no circumstance shall lattice girders be installed under unsupported ground.

9.5 EXECUTION

9.5.1 Steel ribs shall be cold bent with an allowance of one percent to the shape as shown on the drawings. Re-shaping of the bent ribs at the place of installation may only be undertaken with Engineer's consent and only if the material properties would not be impaired.

9.5.2 Excavation of the underground works shall be completed true to the lines shown on the drawings before installation of steel ribs. The steel ribs shall be placed at the minimum excavation line and at spacing as shown on the drawings or as determined by the Engineer.

9.5.3 Concrete blocks or steel profiles shall be provided as footing for the steel ribs. Use of timber, as foot blocks shall be strictly prohibited. The footplates shall be of enough size and rigidity. If required, the legs of the ribs shall be anchored to the rock by the rockbolts. Where invert bracing is required, it shall be fixed securely to the lower legs of the rib in such a way that buckling is not induced in the steel rib by the presence of such bracing. In case of invert overbreak, the void between the rock and the lattice girder footing shall be filled with pre-cast concrete slabs / blocks.

9.5.4 Steel sections and plates shall be cut, welded, bolted or otherwise provided to the shapes and dimensions indicated on the drawing or as directed by the Engineer.

9.5.5 Immediately after placing the ribs in a correct position, they shall be interconnected and braced by mean of steel bars or beams in order to prevent any displacement and to maintain spacing. Use of timber spreaders shall be strictly prohibited.

9.5.6 Immediately prior to concreting, casting or spraying, the arches, ties and struts shall be rendered clean and free from deleterious matter.

9.5.7 The space remaining between the outer flange of the steel rib and the rock surface shall be backfilled immediately, after the rib has been placed, with concrete or shotcrete over the entire circumference of the steel rib in order to provide uniform load distribution. In over excavation, the bulk of the void space may be filled with concrete / shotcrete.

9.5.8 The Contractor shall duly record the position of all steel ribs installed in order to facilitate drilling operations later on for grouting/drainage purposes etc. Their position shall be marked on the finished concrete lining surface.

9.5.9 Blocking and wedges used to set the steel may be steel, or concrete blocks.

9.5.10 Structural steel supports be maintained in position by the Contractor after installation. Any steel ribs installed improperly or damaged by the Contractor's operations shall be adjusted, repaired or replaced as appropriate by the Contractor without delay after notification by the Engineer.

9.5.11 *Deleted*.

9.5.12 During work the Contractor shall maintain a sufficient reserve of steel ribs complete with all accessories on each work site.

CHAPTER -10

ROCK BOLTS, WIREMESH, FOREPOLING AND PIPEROOFING

10.1 GENERAL

10.1.1 The specifications described herein under relate to the Work which includes all labour, material, equipment and services required for the supply, installation, testing and monitoring of rockbolts, pipe-roofs etc. and also the supply and installation of wire mesh and mesh anchors as specified herein or as shown on the drawings.

10.1.2 Rockbolts, pipe roofs etc. shall be furnished complete with all accessories and other materials necessary for their installation, stressing and grouting.

10.1.3 If directed or approved by the Engineer, the Contractor shall supply and install flat steel plates or rolled steel sections to connect together two or more rockbolts.

10.1.4 The Contractor shall maintain on site or have immediately available atleast one month buffer stock as per agreed work programme of any of the support element s i.e. Wiremesh, Self-Drilling bolts, Fiber glass bolts or any other specialised bolts required according to the rock mass classifications and as per drawings. However, towards work closure, the Contractor may use these quantities with prior approval of Engineer.

10.1.5 STANDARDS:

The specifications, production, working etc. shall conform to the following latest Indian Standards or where not covered by these Standards, to the equivalent International Standards. The list is for guidance purpose only. The Contractor shall abide by all codes/regulations/ specifications as are deemed necessary for the satisfactory completion of work.

i. **Indian Standards:**

a. IS: 1786 – 1985 (Reaffirmed 2000), Specification for high strength deformed steel bars and wires for concrete reinforcement

b. IS:11309 – 1985 (Reaffirmed 2001), Method for Conducting Pull-Out Test on Anchor Bars and Rock Bolts

c. IS:1611 – Steel Tubes for Structural purposes- Specification

ii. **American Society for Testing and Materials (ASTM):**

a. ASTM A36/A36M - Standard Specification for Carbon Structural Steel

b. ASTM C150 - Standard Specification for Portland Cement

c. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete

d. ISRM - Doc.2, Part 1 "Suggested Method for Rock-bolt Testing".

10.2 SUBMITTALS.

10.2.1 At least 8 (eight) weeks prior to the commencement of excavation works, the Contractor shall submit, to the Engineer, the details of equipment to be used for testing and installation of Rock bolts / Pipe roofs / wire mesh etc.

10.2.2 The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.

10.2.3 Test reports of tensile strength tests and pull out tests, routine pullout tests (IS:11309) shall be submitted immediately within 3 hours after the test is carried out.

10.3 GENERAL

10.3.1 For the sake of convenience, the terms used in the Chapter are defined as follows:

- **i.** Reinforcement Element is a general term of rockbolts, pipe roofs, wiremesh etc.
- **ii.** Rockbolt is a stressed (or tensioned) reinforcement element consisting of a rod, grouted anchorage, and plate and a nut for stressing by giving torque to the nut or for retaining tension applied by direct pull. It is synonymous with "active rock anchor".
- **iii.** Individual rock bolting refers to the installation of reinforcement elements in localized area of in stability or weakness as determined during excavation. It is synonymous with spot bolting.
- **iv.** Pattern Rock bolting refers to the installation of reinforcement elements in a regular pattern over the excavation surface.
- **v.** Water expandable bolts: High-pressure water shall be injected into the steel tube, which causes the steel tube to expand and to form it to the irregularities in the drilled hole.
- **vi.** The reinforcing bar steel used shall be from sources as indicated in the Section – Material for construction. Corroded steel bars shall not be used.

10.3.2 The following types of reinforcing elements are proposed to be used:

- **i.** SN Bolts: Resin-grouted and cement grouted.
- **ii.** Water expandable bolts.
- **iii.** Self-Drilling anchors as Rock bolts or Fore Poles.
- **iv.** Pipe roofing umbrella.

10.3.3 The type, length, diameter, inclination and pattern of the rockbolts shall be as shown on the drawings or as approved by the Engineer. The Contractor shall provide manufacturer's test certificate for all batches of rockbolts supplied. At least 5 samples shall have been tested for tensile strength until failure from each individual batch of rock bolts which is marked with the same manufacturer's identification number. All the results of the tensile test shall comply with the specified data of the manufacturer.

10.3.4 Bearing plates shall conform to IS 2062 and be flat or dished steel plates having minimum dimensions suitable to carry take full load for Rock bolt is installed (Atleast

1 plate of 200x200x12 for 32mm dia bolts and 1 plate of 150x150x10mm for 25mm dia bolts). The washers to be used shall be bevel or hemispherical.

10.3.5 All surfaces of the bearing plates, nuts, washers and wedges, and threads on the projecting ends of rockbolts shall be protected and lubricated with rust preventive compound.

10.3.6 Corroded bolts or steel or other elements shall not be used.

10.3.7 When rockbolts are used in conjunction with wire mesh, the mesh shall be connected firmly to the bolts by means of extra steel plates and nuts.

10.3.8 Wire mesh shall not be placed between rock and the bearing plate of the rockbolts. Additional plates shall be provided for this purpose.

10.3.9 Couplers may be required for the bolts. When coupler is used, the threading in the bar shall not reduce the effective diameter of bar. Coupler itself should be able to transfer at least 125 % of the yield load of the bar. Couplers shall not be permitted for rock bolts less than 4m in length.

10.3.10 Minimum one PVC centralizer per rock bolt shall be provided. In long rock bolts, one centralizer at every 6m shall be provided along the length of the bolt.

10.4 TESTING AND MONITORING OF ROCKBOLTS / ROCK ANCHORS.

10.4.1 The Contractor shall furnish atleast two sets of testing equipment including hydraulic jacks, fixing device, hydraulic pump with pressure gauge / manometer, extensometer and all necessary accessories. The testing equipment shall be capable of stressing the largest diameter rockbolt to the yield stress of the bolt.

10.4.2 Proof Tests

i. A detailed test program set up on basis of above-mentioned document shall be approved by the Engineer prior to all testing work.

ii. Specific deviations from the ISRM suggested method shall be approved by the Engineer.

iii. A test report shall be issued immediately after completion of the tests. It shall be submitted for approval to the Engineer.

iv. For each type of rock bolt submitted information shall comprise:

   A. type of bolts

   B. testing equipment

   C. location and installation records

   D. Applied testing loads and records of deformation

   E. Otherwise the evaluation of test results as specified in ISRM's document

   F. Interpretation and suggested action for failed pull-out tests

v. Proof tests shall be carried out for all types of bolts to be used for this project prior to the commencement of tunnelling to demonstrate the effect and the A service capacity of the bolts in the field.

vi. The tests shall be performed in similar geological ground conditions as expected during tunnel drive. The location of the bolts to be tested shall be selected by the Engineer.

vii. A minimum of five bolts of each type shall be tested. Depending on the testing procedure and the test results the Engineer may require further bolts to be tested.

viii. Adequate testing equipment, as specified in the above mentioned ISRM document shall be provided to record bolt elongation, movement of the bolts and tension forces.

ix. The maximum load to be applied shall be the bolt´s yield load or as otherwise approved by the Engineer.

10.4.3 Testing during Tunnel Driving:

The Engineer will select rock bolts for testing of production bolts. For each type of rock bolts five bolts will be selected from the first 100 bolts placed in the tunnel. From the remaining bolts five per 500 bolts will be selected for testing purpose. The testing force to be applied shall be equal to 80% of the rock bolt yield load.

i. Bolts which fail the tests, or which are pulled out shall be replaced.

ii. For each failure, the Engineer shall require further bolts to be tested inthe vicinity.

iii. Otherwise as per relevant clause above.

10.4.4 ***Grout mortar:***Prior to acceptance tests of rock bolts, tests with available cements and sands shall be carried out to determine an appropriate mix design to achieve the specified strength and a proper workability in association with the grouting equipment used. Additives will be used to improve workability. The grout mortar shall be tested on cubes 5x5x5 cm. The cubes shall be cured in water. Five numbers of cubes shall be prepared for each compressive strength test. The resultant strength is the average evaluated from the three remaining values after elimination of the highest and the lowest. During construction, cube sample shall be taken weekly at each five bolts drivage from the grouting hose at the nozzle. Preparation and evaluation shall follow the procedure as described above.

10.4.5 If any rockbolt fails due to improper workmanship or defect in materials or due to any reason whatsoever, the Engineer may order a test on all adjacent rockbolts and all rockbolts so failing shall be rejected, replaced and retested.

10.4.6 The bolts and anchors shall be checked for their straightness Tolerance with $\pm$ 1 mm.

10.4.7 The pullout trials shall be conducted in conformity with IS: 11309.

10.4.8 Further sampling and testing for quality control will be got done as directed by engineer at contractor's cost.

10.5 DRILLING HOLES & PREPARATION FOR INSTALLATION

10.5.1 Holes for rockbolts shall be drilled as specified herein and in accordance with the provisions set out in Section of "Drilling and Grouting"

10.5.2 The minimum diameter of each hole shall be as specified below or as directed by engineer:

i. Rock Bolt of 25mm dia: Hole dia 45mm with coupler and 38mm without coupler

ii. Rock Bolt of 32mm dia: Hole dia 64mm with coupler and 50mm without coupler

10.5.3 The length of drill hole shall be such as to receive the specified rockbolt and to provide for its satisfactory anchorage.

10.5.4 After drilling, each hole in compact, washable rock shall be washed out with clean water and cleaned by blowing out all drill cuttings and debris with compressed air. The holes in rock, which tend to swell or are interspersed with clay filled fissure shall be cleaned with compressed air only. The compressed air shall not contain any oil or other material preventing the bond.

10.5.5 Prior to installing the rock bolts, which will be stressed, the rock surface adjacent to the hole shall be prepared for the bearing plate. Only bevel washers shall be used which shall be placed between the bearing plate and the nut, or dished bearing plate and hemispherical washer used to ensure uniform bearing.

10.5.6 If a rock bolt is not installed immediately after drilling the hole, the hole shall be washed and cleaned as stipulated above, immediately prior to installing the rockbolt.

10.5.7 Fresh holes, as directed by the Engineer, shall be drilled by the Contractor at his expense to substitute such holes as have been drilled out of place or alignment.

10.5.8 The rock surface around the drilled holes to receive the bearing plate shall be chipped smooth or be covered with a smooth quickset cement pad.

10.5.9 All bolts within 10 m of a blasting operation shall be retightened to the specified torque within 4 hours after each blast. If it is found that any bolt does not take the required torque without anchorage slip, a new bolt shall be installed in the immediate vicinity of the unsatisfactory bolt.

10.6 Installation Records

Comprehensive records about details of the installation of rock bolts during drivage, such as grout consistency, drilling depth, length and type of rock bolts, deviations from the theoretical position, type and time of grouting, time of tightening, special observations, etc. shall be kept for each round by the Contractor and countersigned by the Engineer's supervisory personnel. Copies of these records shall be submitted to the Engineer.

10.7 ROCK BOLT RESIN-GROUTED (SN Bolt)

10.7.1 Rockbolts shall consist of deformed steel bar of 25 mm or 32 mm Ø (Grade Fe-500D conforming to IS 1786). Each bolt shall have one end chamfered and the other end threaded with a coarse thread over a length of 200 mm.

10.7.2 After the hole is drilled and cleaned, fast setting resin cartridges shall be placed in the fixed length of the drill hole at bottom as determined by the pull-out tests and slow setting resin cartridge in remaining length of drill hole. These cartridges shall be tamped with the bolt for proper packing. The rock bolt shall then be advanced and rotated steadily through the capsules at the rate recommended by the manufacturer by means of a pneumatic tool and a coupling attached to the threaded end of the bolt. The rotation shall be continued after the bolt has been fully inserted for a further 30 seconds. Bolt shall be stressed by torqueing/jacking, by means of an approved and regularly calibrated stressing device to the level as directed by Engineer. The bolt shall be stressed before setting time of slow setting resin cartridges as suggested by manufacturer. The Contractor shall demonstrate the resin cartridges used satisfy the specified strength requirements of the bolts to the satisfaction of Engineer, before use.

10.7.3 Bolts shall be thoroughly cleaned before being placed in the drill hole.

10.7.4 The minimum capsule diameter should be proposed for each drill bit dimension, considering that the hole must be fully filled with resin. The drill bit diameter should be defined by the manufacturer, however, as guidance, for a 32 mm resin capsule diameter, the drilling should not be more than 38 mm.

10.8 ROCK BOLTS CEMENT GROUTED (SN Bolt)

10.8.1 Rockbolts shall consist of deformed steel bar of 25 mm or 32 mm Ø (Grade Fe-500D conforming to IS 1786). Each bolt shall have one end threaded with a coarse thread over a length of 200 mm.

10.8.2 Anchor bars/anchor bolts shall be thoroughly cleaned before being placed in the drill hole. The hole shall be filled with grout constituting 1:1 cement/sand mix with low water cement ratio, by inserting the grout hose to the full depth of the hole and withdrawing as the grout is pumped in. The nozzle shall be kept buried in the grout as the pipe is withdrawn so that air is displaced as the hole is filled. The bolt is then pushed into the hole. Admixtures for fast setting and low shrinkage may also be required.

10.8.3 In case of coupled rock bolts, partly collapsed boreholes, or major water- flow from the borehole, grouting may be done after installation of the bolt (post-grouting). The hole is then grouted by a special attachment which allows the mouth of the borehole to be sealed whilst the grout is pumped in. Air is displaced from the hole via a tube which is attached to the full length of the rock bolt as it is installed. Grout is then pumped in and the hole can be seen to be full, when grout escapes from the end of the tube.

10.8.4 The nut of the grouted rock bolts shall be tightened not later than 12 hours after installation to achieve a force at the anchor plate of approx. 20 KN. This force shall be applied by a calibrated torque wrench.

10.9 SWELLEX TYPE WATER EXPANDABLE BOLTS

10.9.1 Water expandable rock bolts shall be manufactured from a mechanically reshaped steel tube with bushing pressed onto the ends, sealed through welding. The bolt shall havean expansion pressure rating of 300 bar and wall thickness of minimum 3mm. The bolt shall have separate protective coating (zinc epoxy/bitumen/plastic/polymer) that isolates and actively protects the steel. The lower bushing shall have a flange to hold a face plate in place. High-pressure water (about 300 bars) shall be injected into the steel tube through a hole in the lower bushing. This causes the steel tube to expand and to form it to the irregularities in the drilled hole. A 200 mm long sleeve tube made of steel prevents the bar from swelling at the drill hole mount. As the swelling process occurs, the lower part of the steel tube shortens, pulling the face plate firmly against the rock face. The water pressure is released after installation and the water allowed draining out of the expanded steel tube. The drill hole diameter has to be adjusted to suit the size of rock bolt according to the Manufacture's recommendations. The water expandable rock bolts shall have characteristic minimum breaking load of more than 150 KN and shall undergo upto 10% minimum elongation before failure.

10.9.2 All face plates, washers and other accessories used shall be from original manufacturer of the bolt. Face plates shall be spherical dome type.

10.9.3 The bolts shall be supplied, installed and tested as per recommended procedure of the manufacturer. Standard pull testing shall be done with pull tester along with it's other parts as manufactured by OEM. Additional bolt material testing, if required, shall be carried out as determined by Engineer in charge depending on site conditions.

10.10 SELF DRILLING ROCK BOLTS

10.10.1 This is a high-grade (Yield load more than equal to 230KN) hollow core seamless steel bar with continuous threaded surface for mechanical coupling. In addition to hollow core seamless steel bar, other parts of the assembly consists of Hexagonal nut, bearing plate, extension couplings and sacrificial drill bit. Before and during installation, thread ends will be kept cleaned to allow hex nut and coupler threadability. Construction and drilling shall be as per manufacturers guidelines.

10.10.2 SDA Bolts shall have outer dia of minimum 32mm and inner diameter less than equal to 18mm. Length of rod to be procured shall be decided in agreement with engineer.

10.10.3 Bearing plates shall allow articulation of 5 to 7 degrees in all directions.

10.10.4 Drill bit to be used shall be selected according to installed length of bolt, geology and size of bolt.

10.10.5 Couplers and Nuts shall exceed the tensile strength of bars by minimum 20%.

10.10.6 The bolt shall be grouted according to manufacturer's guideline (to a minimum pressure of 6 bars) with manufacturer's grout material supplied along with bolt. Alternatively, grout mix (M-35 grade) may be prepared using OPC 53 cement and sand having maximum particle size of less than 0.3mm. Grout mix shall have a water cement ratio less than 0.4 and shall contain PC based super plasticizer (Minimum 2%) and expanding

plasticizer (allowing upto 3.5% expansion in neat cement) from reputed manufacturer. Admixtures containing chlorides and alkali shall not be used.Face of the Bolts shall be sealed off with GP2 or Similar rapid setting grout to prevent grout leakage during build-up of pressure.

10.10.7 These bolts may also be used as forepoles.

10.10.8 All accessories of self-drilling rock bolts shall be suited to the main anchor rod type and shall be procured from original manufacturer of the bolt.

10.11 WIRE MESH AND MESH ANCHORS

10.11.1 WELDED WIRE MESH

i. Welded wire mesh shall be installed in surface and underground excavation as reinforcement for shotcrete, usually in combination with rockbolts. It may also be used with steel ribs, when it shall be laid over the outer flange of the rib and pinned or fixed to the excavated surface between the ribs where necessary.

ii. Welded wire mesh shall conform to the requirements of IS: 1566. The fabric shall have a minimum square mesh of 150x150x6 or 100x100x4, made of wires having a strength not less than 480 Mpa and diameter 3 to 5 mm or as directed by engineer.

iii. Where possible, the welded wire mesh shall be placed at the same time as rockbolts are installed. It shall not be placed between the rock surfaces and bearing plates of rockbolts but shall be placed over the heads of rockbolts and fastened to them by separate plates and nuts. Sufficient intermediate mesh anchors, or if directed by the Engineer, additional rockbolts, shall be placed to ensure that the mesh is drawn close to the excavated surface so that when shotcrete is applied subsequently, the mesh neither sags nor vibrates excessively and impairs the effectiveness of the shotcrete.

iv. In case the welded wire mesh is placed at such locations where rockbolts have not been provided, wire mesh anchors of a type acceptable to the Engineer shall be used to secure the edges of wire mesh tight to the rock surface to provide anchorage at overlaps and to provide intermediate support. The wire mesh anchors shall have a minimum length of 450 mm.

v. The use of wooden pegs and pins for fastening the wire mesh to the rock surface will not be permitted.

vi. Welded wire mesh shall be firmly stretched between the rockbolts. Care shall be taken to ensure that air pockets are not formed behind the wire mesh, when used as reinforcement for shotcrete. Overlaps in the wire mesh shall not be less than 300mm.

10.12 PRE-EXCAVATION SUPPORT MEASURES

10.12.1 In general, all poor reaches shall be supported by regular supporting measures (Rock reinforcement, shotcrete, Steel Ribs, Lattice Girders, pre-injection grouting etc.) as specified in drawings. However, certain ground conditions may require tunnel support

ahead of face before it's excavation. For such situations, **after completion of Pre-Excavation grouting ahead of face**, the advance support measures as described below shall be implemented if required at site as per direction of Engineer.

10.12.2 Grouting of pre-excavation support measures (Forepoles, Piperoof and Fiber glass bolts):

- **i.** OPC 53 / 53Scement shall be used for grouting.
- **ii.** Cement grout shall attain minimum M20 strength.
- **iii.** Viscosity of grout shall be such that it shall not leak down from vertical holes in the bolt/plate and adheres immediately to rock.
- **iv.** Water cement ratio of cement grout shall be in the range 0.50 to 0.75 as decided by Engineer and 1.5% PC admixture shall be used to increase flowability of grout..
- **v.** Admixture shall be added to achieve the workability required for the operation and prolong the initial set to minimum 1 hour.
- **vi.** Starting pressure for grouting of cement grouted bolt and forepoles shall be 10 bars and grouting shall be continued till sufficient grout take has been accomplished throughout its length.
- **vii.** Face of the Bolts/forepoles/pipes shall be sealed off with GP2 or similar grout to prevent grout leakage during build-up of pressure..
- **viii.** Sufficient numbers of grouting packers shall be available at site to grout same stage of 6m in multiple pipe roofs. Packers will not be disturbed before final setting time of grout.

10.12.3 **FOREPOLING:** Fore poles shall be 25/32 mm diameter self-drilling anchor bars or SN bolts or pipes having outer dia less than 48mm of this sub chapter having length of 6 meters or more. The fore poles shall be placed along periphery of the tunnel inclined at angle and pipe spacing (mentioned in drawings), at the heading face and cement grouted in place as directed by the Engineer.

10.12.4 **PIPE ROOFING:** When ground conditions are such that face cannot be supported by forepoling, then pipe roofing shall be required to be implemented. Pipe roofing consists of high tensile seamless steel pipes(Having a minimum outer diameter of 76mm and a minimum yield load of 1200 KN) conforming to IS: 1611 (Maximum 24 m long) placed along periphery of the tunnel in one or two layers, each layer inclined at angle and pipe spacing (mentioned in drawings) at the heading face or as directed by the Engineer. Engineer may require use of Self drilling 76mm dia pipes. Other pipes of larger diashall be connected to each other by nipple coupling or squeezed connection or seamless butt-welded producing a leak proof connection. Standard threaded connection shall not be permitted. The cement (OPC 53 or other) grouting of pipes shall be done. In case of perforated pipes grouting shall take place in stages using packer in each stage and starting at deepest location first. Sacrificial ring bits should be used. AT-casing system

(or similar) shall be used and orientation of drilling shall be guided by means of equipment installed on the jumbo boom.

10.13 FIBRE GLASS BOLTS

10.13.1 Fibre glass bolts shall be 32/15 configuration with load carrying capacity of more than 300 KN and shall be grouted immediately after installation.

10.13.2 Fibre glass bolts of other configuration or strength may be used by contractor with approval of engineer.

CHAPTER -11

SHOTCRETE

11.1 SCOPE OF WORK

11.1.1 The specifications described herein under related to the work, which includes all labour, materials, equipment and services required for the shotcrete work (plain and fiber reinforced) to be carried out by the Contractor under this Contract.

11.1.2 All shotcrete work shall be carried out in accordance with guidelines specified in this section. The shotcrete work shall be performed to the dimensions as shown on the drawings or as otherwise directed by the Engineer.

11.1.3 ***Compressive strength of shotcrete shall be met by compression testing of cylindrical cores extracted from Tunnel wall. The sample prepared for testing shall have a 100mm length and 100mm diameter (Equivalent of a cube).***

11.1.4 The approval given by the Engineer to the Contractor's equipment of their operation or of any construction methods shall not relieve the Contractor of his full responsibility for the proper and safe execution of Shotcrete work or any obligations under this Contract.

11.2 SUBMITTALS

11.2.1 Within 28 days from the commencement date, but before procuring or mobilizing to the site, the equipment, the Contractor shall submit to the Engineer, updated and detailed plans and descriptions, of the following:

- **i.** Batching and Mixing Equipment
  - a. Description and details of the equipment, which the Contractor intends to use to determine and control the quantity of shotcrete ingredients and mixing thereof into uniform mixture. This shall also include automatic dosing equipment for various admixtures and fibers. All equipments shall be capable of monitoring and recording the dosage during production process.
- **ii.** Placing Equipment
  - a. Full details, of the equipment to be used for placement of shotcrete (Robotic Shotcrete machine) and details of standby equipment.
- **iii.** Details of methods and equipment which the Contractor proposes to use to control the temperature of aggregates and water during extreme hot and cold weather conditions.

11.2.2 At least 28 days in advance of any shotcrete work being carried out on the site, the Contractor shall submit, to the Engineer the following:

- **i.** Notifications of any admixture and Pozzolana, which the Contractor proposes to use, manufacturers thereof and information about the chemical names of the principal ingredients and the effect of under or over dosage.

ii. Description and details of methods which the Contractor proposes to adopt for Shotcrete.

11.2.3 The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.

11.3 STANDARDS

11.3.1 The Shotcrete materials, production, methods of application, testing and admixtures shall conform to the following latest Indian Standard or, where not covered by these standards, to the equivalent International Standards.

11.3.2 Indian Standards

i. IS: 456 Code of Practice for Plain & Reinforced concrete.

ii. IS: 269 Specification for ordinary Portland cement.

iii. IS: 383 Specification for coarse and fine Aggregates from natural source for concrete.

iv. IS: 516 Method of test for Strength of concrete.

v. IS: 9012 Recommended practice for Shotcrete.

vi. IS: 2645 Specification for Integral cement water proofing compound.

vii. IS: 9103 Concrete Admixtures.

viii. IS: 12269 Specification for 53-grade ordinary Portland cement.

ix. IS: 15388 Silica-Fumes.

x. IS:7861 Code of practice of extreme weather concreting.

xi. IS: 1199 Methods of Sampling and Analysis of Concrete.

xii. IS: 5878 Code of Practice for Construction of Tunnels.

11.3.3 International Standards have been mentioned at relevant locations in the section.

11.3.4 In case of conflict between the above standards and the specifications given herein, the specifications shall take precedence.

11.4 General

11.4.1 Shotcrete shall be applied by either the wet process to the circumstances. All aspects of the application of shotcrete shall be subject to the agreement of the Engineer. Particular emphasis shall be placed on the provision of adequate ventilation.

11.4.2 The Contractor shall develop a shotcrete mix and a plan for its production and application. Specifications of constituent materials shall comply with those listed in this. Admixtures shall be compatible with each other and the mix.

11.4.3 The shotcrete mix design shall, unless otherwise stated, comply with the characteristic strengths specified by the Designer for early-age and long-term loading.

11.4.4 Contractor's shotcrete expert should be on site at all times to check that the materials and workmanship are consistent with the design intent, and to ensure that ground and

groundwater conditions are in accordance with design assumptions. The Contractor shall establish a procedure to respond effectively to changes in ground and groundwater conditions from the design assumptions.

11.4.5 The Contractor shall establish and maintain the instrumentation and monitoring required by the design. The Contractor shall establish a procedure that will enable prompt and regular review and effective response to the results from the instrumentation and monitoring. The Engineer shall be included in the monitoring review procedure.

11.5 DEFINITIONS

11.5.1 Shotcrete: Shotcrete for the purpose of this work is defined as wet mix of cement concrete (plain) or fiber reinforced (SFR) applied from a spray nozzle by mean of compressed air. The Engineer may, in exceptional cases, allow use of dry mix for plain shotcrete. Shotcrete shall contain approved additives like Accelerator, Superplasticizer, retarder, stabilizer, Pumpability improving additive or curing agents suitable to attain desired properties as mentioned in these specifications and site conditions.

11.5.2 Rebound: Rebound is defined as the portion of shotcrete mix or any of its constituents, which bounces away from a surface against which it is being projected.

11.6 MATERIAL FOR SHOTCRETE

11.6.1 Material for shotcrete shall comprise cement, aggregates, fiber, water and approved admixtures, micro-silica/silica fume as specified herein.

11.6.2 Cement:

i. Cement used shall be ordinary Portland cement of 53/53S grade.

ii. ***For M30 Grade Shotcrete: Minimum OPC 53/53S content will not be less than 385 Kg/cum. Minimum 15 Kg/cum Micro-silica/silica fume will be added to enhance mix durability and reduce life cycle cost of shotcrete.***

iii. Preferably cement fineness shall not be less than 275 m^2/kg for OPC 53 and 370 m^2/kg for OPC 53S.

iv. Maximum temperature of the cement in the mixing plant silos should be limited to 70°C and it should not exceed 50°C at the time of mixing. Cement should be preferably purchased in bulk and fresh cement shall be stored in a suitable silo.

11.6.3 Aggregates:

i. All fine and coarse aggregates to be used shall be supplied from approved sources, which shall not be changed without permission in writing from the ENGINEER Aggregates shall conform to the requirements of IS:383.

ii. The aggregate shall be checked for chemical reactions, such as alkali–aggregate reaction, with latent hydraulic binders and admixtures, especially accelerators.

iii. The aggregates size for shotcrete **shall not exceed 10 mm**. The proportion of aggregate larger than 8mm in size should not exceed 10%. The aggregate shall be well graded, and no fraction shall constitute more than 25 % of the total. The

contents of the crushed and non-cubical material under 0.1mm shall not exceed 8 %.

iv. Acceptance of source by Engineer shall not be construed as constituting the acceptance of all aggregates to be taken from that source or grading of aggregates to be in conformance with contract.

v. It is the responsibility of the Contractor to choose the most suitable grading for the process and materials available from the range given in table below. The grain size distribution of aggregates shall be within ±2% for each sieve size as shown below:

Standard Sieve	Sieve Size [mm]	Passing in %
IS	10.0	100
IS	8.0	90-100
IS	4.0	73-100
IS	2.0	55-90
IS	1.0	37-72
IS	0.50	22-50
IS	0.25	11-26
IS	0.125	4-12

11.6.4 Fibers: Macro Synthetic fibers shall be used which shall conform to specifications mentioned below.

i. The macro-synthetic fibers shall be in accordance with BS EN 14889-2. Fibers shall be dry and free from oil, grease and chlorides and shall be provided with arrangements to deliver anchorage properties. The fibers shall satisfy the following parameters:

Class	**Class-II (EN 14889-2)**
Length of fibers	45-55 mm.
Type of handling	Mulchable paper bags.
Geometric shape	Regular cross section (More than 0.30mm of equivalent Diameter) fully embossed.

Class	**Class-II (EN 14889-2)**
Tolerances and sampling	In accordance with EN 14889-2.
Aspect Ratio (Length / Diameter)	≥64
Tensile strength	≥550 MPa, when tested in accordance with EN 10002-1.
Modulus of Elasticity	≥5 GPa.
Quantity of fibers	Maximum 5 Kg/ M^3 (E700) Maximum 7 Kg/M^3 (E1000) (Subject to mix design/field trials)

ii. Mixing procedure adopted by the Contractor should be such that there is no fiber balling.

iii. Storage: Fibers shall be stored, handled and dosed in accordance with the manufacturer's recommendations. Generally, this will require them to be stored in dry, sealed containers until ready for use and shall be free from oil, grease, chlorides and deleterious materials which may reduce the efficiency of mixing or spraying processes, or which may reduce bond between the fibers and the shotcrete.

11.6.5 Air used for spraying shotcrete shall be clean and free of oil.

11.6.6 Water used for mixing shall comply with IS-456. Water to cement ratio shall be less than 0.43.

11.6.7 Admixtures: Admixtures conforming to IS:9103 shall be used to develop quick set and high early strength, to ensure good workability, low pumping pressure, adequate slump retention and low rebound as approved by the Engineer, conforming to the requirements of the relevant standards. The proportion of admixtures shall be kept less than 10-12% of the weight of cement or as determined by testing prior to any shotcrete work.

i. General

a. Technical criteria, approved documentation, test reports and test certificates shall be furnished to the ENGINEER for approval.

b. Admixtures shall be stored under the conditions specified and recommended by the manufacturers. The related storage Specifications and recommendations shall be presented to the ENGINEER before approval of such admixtures.

c. The manufacturer's safety instructions shall be observed Admixtures shall be free of chlorides such that the percentage of chlorides shall not exceed 0.1% by weight.

d. The required characteristic values and consistency of delivery to the site shall be agreed in writing with the manufacturer of each admixture before commencement of concrete spraying.

e. Written confirmation of the stability of admixtures with the mix water shall be provided prior to commencement of site trials.

f. The content of SO3 shall not exceed 4.8% by weight of total binder content.

ii. Accelerators

a. Accelerators are used to produce a fast set and to get sufficient early strength development. Accelerating admixtures shall be compatible with the cement used. The compatibility shall be tested in the laboratory by the Manufacturer and verified by the Contractor in field suitability tests to achieve the required properties for early and final strength.

b. The accelerator must mix with the concrete in the nozzle and begin the hardening immediately after the concrete hits the rock.

c. Only liquid alkali-free accelerators (pH 2.0 to 8.0 and having alkali content less than 1% by weight Na_2O equivalent) shall be used. Additives based on Lingo sulphates (P agents) shall not be used due to retarding and reduced early strength.

d. The accelerators shall be added at the nozzle and only the minimum quantity of accelerator necessary shall be permitted in normal concrete spraying operations. The quantity shall be determined by site trials, subject to maximum dosage of 7% by weight of cementitious materials. Higher dosages of upto 8% accelerator can be considered subject to establishing the effect of the dosage rate on the medium and long-term strength development on the in-situ concrete. At no stage in the strength development should the strength of the accelerated mix drop below 0.7 times the strength of the unaccelerated concrete mix.

e. Testing of accelerators and the base mix with respect to acceleration of setting, early strength and decrease of strength at a later age (28 days), shall take place in due time before commencement of concrete spraying.

f. Laboratory testing of the selected type(s) of accelerator shall be carried out at dosages as recommended by the manufacturer, to establish the variability of the above properties with dosage. Accelerators showing excessive variability with dosage will not be permitted.

g. Accelerators shall be selected so that, at the dosage chosen for use in the Works, the characteristic compressive strength of any shotcrete at an age

of 28 days can be achieved. Compliance with this clause shall be demonstrated by site trials.

h. Accelerators delivered to site shall be tested at least once every two months for their reaction with the Portland cement used, with particular reference to the setting behavior and strength decrease after 28 days. The stability of accelerators during storage shall be visually inspected at similar intervals. Storage times and working temperature ranges shall be in accordance with the manufacturer's recommendations. The manufacturer's safety instructions shall be observed.

iii. Super Plasticizers and retarders

a. Used to reduce the quantity of the mixing water and to improve the pumpability of the concrete. The effects and optimum dosages shall be determined by site trials.

b. The above-mentioned desired properties shall only be attained through superplasticizers.

c. Shall be added at the batching plant to keep the shotcrete mix workable during transportation and to ensure good pumpability to an acceptable low water cement ratio.

d. The influence of the superplasticizers and retarders within the concrete mix shall be checked regularly for setting time, water reduction, and development of strength. These values shall be compared with the results from the pre-commencement trials.

e. Compatibility of superplasticizers and retarders with Portland cements, latent hydraulic binders and accelerators shall be verified by observation and site trials. Traditional retarders shall not be allowed.

iv. Hydration control admixtures

a. Hydration control admixtures may be used to control the hydration of the mix as appropriate to expedite construction of the Works. The effects and optimum dosages of hydration control admixtures shall be determined by site trials.

b. Compatibility of hydration control admixtures with Portland cements, latent hydraulic binders and accelerators shall be verified by observation and site trials. Hydration control admixtures shall be used in accordance with the manufacturer's instructions.

11.6.8 Additives: Micro-silica or silica fume

i. Micro-Silica or Silica fume shall conform to ASTM C1240 / IS-15388. Contractor shall submit MTC from original manufacturer. Manufacturer shall furnish evidence of factory production control systems.

ii. The performance of the shotcrete mix with optimum dosage of additives shall be determined by field suitability tests. Testing of Silica fume shall be carried out by contractor before or anytime during its usage at discretion of engineer.

iii. Micro Silica/ Silica fumes shall have a bulk density between 600-700 kg/m3. Micro Silica/ Silica fumes shall be added in the mix at the batching plant facilitating the mixing and distribution of fibers to reduce fiber rebound and improve bond between cement matrix and fibers. Dosage of Micro Silica/ Silica fumes shall be as per Mix design subject to minimum 15 Kg per cum of shotcrete mix.

11.6.9 Curing agents

i. External curing agents and internal curing admixtures shall be allowed to maximize hydration of the cement by reducing uncontrolled water evaporation.

ii. The curing agent selected should not affect the bond of further layers/coatings or be easy to remove. Solvent based curing agents should be avoided

iii. External curing agents are sprayed onto the surface of the shotcrete shortly after it has been applied. When set accelerators are used, an external curing agent should be applied within 15 minutes after the end of spraying. When no accelerators are used it should be applied within 30 minutes.

iv. Internal curing admixtures are special admixtures added to the mix (see 4.6). Compatibility of curing agents with cements, hydraulic binders, accelerators and other admixtures should be verified in site trials. Particular care must be taken to ensure adequate mixing when used in the dry-mix process.

11.7 MIX DESIGN AND PROPORTIONING

11.7.1 The type of shotcrete to be used in a particular location shall be as per drawings and as directed by the Engineer.

11.7.2 The mix proportions of cement, aggregates, and permitted admixtures in each class shall be determined by the Contractor satisfying the requirements given in Table no. 1 below and shall be subject to the approval of the Engineer. The mixes shall be such as to permit placement without excessive rebound and segregation.

Table-1

28-day Characteristic compressive strength of Cylindrical cores (after applying a factor of 0.85 for In-Situ coring effects)	**Aggregate size/grading**	**Cementations content, (C) kg/M^3**	**Water cement ratio**

30 MPa (Average of 4 consecutive non-overlapping tests)	Size grading: D_{max}≤10 mm, Aggregate flattening coefficient ≤20.	Refer para 11.6.2	≤0.43

11.7.3 The water content of the mixes shall be limited to prevent sloughing. The water: cement ratio of fresh shotcrete in place shall be less than 0.43.

11.7.4 Slump of mix shall be kept less than 200mm, as high value of slump will affect fiber distribution in the shotcrete.

11.7.5 The Mixes shall be such that aggregate gradation and cement content after placing are as those obtained from samples taken from test panels produced from approved trial mixes. All constituents shall be uniformly dispersed throughout the mix.

11.7.6 Proportioning of aggregates and cement shall be only by weigh batching.

11.7.7 Moisture content of the combined aggregate at the time of mixing with cement shall not exceed 6 % (Six percent) by weight of the over dry aggregate.

11.7.8 Mixed material shall be used within 90 minutes after addition of water to cement. This period may be extended by the use of hydration control admixtures, subject to the approval of engineer.

11.7.9 The addition of fibers shall be at a stage in the mixing suitable for the sprayed concreting equipment. Fibers shall be added and mixed in a manner to avoid clumping and bending of fibers. Any fiber clumps in the mix shall be diverted and removed by means of a screen placed over the shotcrete hopper. Fibers shall be uniformly distributed throughout the mortar matrix without isolated concentrations.

11.7.10 Approved mix proportions may have to be varied, during execution stage, to obtain required strength of shotcrete, to maintain rebound to the minimum and to meet other requirements of Contract. The Contractor shall notify to the Engineer of all variations to the mixes.

11.7.11 The Contractor shall carry out all field tests before hand and then propose mix design for shotcrete to meet the requirements of the specifications for prior approval of the Engineer. The quantities of super plasticizers may be adjusted to compensate the slump loss because of fiber. The mix design shall provide the following details for one cubic meter of Shotcrete.

a. Ordinary Portland Cement Kg

b. Microsilica Kg

c. W/C Ratio

d. Aggregate

   i. Natural fine aggregate Size Kg

   ii. Natural coarse aggregate Size Kg

   iii. Crushed fine aggregate Size Kg

iv. Crushed coarse aggregate Size Kg

e. Super Plasticizer Agent Kg

f. Retarder or Stabiiser Kg

g. Internal curing Kg

h. Pumpability iimprover Kg

i. Alkali free Accelerator Kg

j. Fibre (Aspec Ratio/Length) Kg

k. Slump mm

l. Density (Wet) Kg/cum

11.8 Equipment

11.8.1 Details of all equipment to be used shall be made available to the Engineer prior to commencement of site trials.

11.8.2 The equipment selected and approved by the Engineer will be capable of maintaining the ratio of concrete and accelerator as selected from the trials and approved by the Engineer. The actual ratio of accelerator to concrete selected shall be identified at the nozzle and take into account the filling efficiency of the equipment and the efficiency of the accelerator dosage equipment to overcome the air and concrete pressure at the nozzle while spraying at typical outputs and air flows. ***Contractor shall provide shotcrete machine data in digital format after every cycle whenever required by Engineer.***

11.8.3 Equipment shall be thoroughly cleaned at least once per shift. The spray nozzle shall be checked for wear and where necessary replaced.

11.8.4 Transport pipes consisting of hoses and pipes shall be designed to convey the concrete efficiently and without leakage or blockage. The transport pipes shall have uniform diameter appropriate to the mix characteristics determined by site trials and be free of any dents or kinks between the shotcrete machine and the nozzle.

11.8.5 Working area for sprayed concreting shall be well illuminated and ventilated. Dust pollution shall be minimized by choice of appropriate equipment and by means of additional ventilation, water sprays, and by maintaining equipment in good order. Protective clothing and dust masks shall be provided for and used by all persons present during spraying.

11.8.6 The equipment shall allow for air and water in any combination to be available for preparation of surfaces and/or cleaning of finished work.

11.8.7 Recipe of mix shall be entered into PLC control prior to spraying.

11.8.8 A boom mounting or similar device shall be provided for the spray nozzle unless it can be demonstrated to the Engineer that the use of such equipment is impractical.

11.8.9 In particular, the spray nozzle shall be kept as perpendicular as possible to the surface and care shall be taken to achieve a regular properly compacted coating of the correct thickness.

11.8.10 The shotcrete shall emerge from the nozzle in a steady uninterrupted flow. Should the flow become intermittent for any cause, the nozzleman shall direct it away from the work until it again becomes constant.

11.8.11 The thickness and position of the shotcrete shall be defined by screed boards, lattice arches, guide wires, depth pins, lasers or other means.

11.8.12 The site trials shall employ the equipment which will be used in the Works and the constituent materials shall be fully representative of those to be used in the Works. A clean, dry mixer shall be used, and the first batch discarded.

11.8.13 The equipment proposed for the application of concrete in the Works shall be used for the trial. The trial will establish whether the selected equipment is capable of efficiently mixing concrete, accelerator and air at the nozzle, and be capable of positioning the nozzle at a suitable distance and orientation to the surface geometry of the structure to which the concrete is to be applied.

11.8.14 During the trials the Contractor will establish the volume of air required to give adequate compaction of the material using the nozzle and conveyance lines selected for the Works. If the delivery equipment or nozzles are to be changed during the course of the works, the volume of air required will need to be verified again. The equipment will be maintained adequately, to ensure that the required volume of air can be maintained while spraying. Air pressure can only be used as a control if the air delivery system is not altered from the original verification trial. No additional taps or restrictions will be permitted to be added into the system without repeating the verification trials.

11.8.15 The static compressed air capacity measured at the shotcrete pump shall be according to the manufacturer's recommendations and generally as per EFNARC guidelines G 8.3.2 for wet process and G 8.3.3 for dry process.

11.9 QUAITY CONTROL AND TESTING

11.9.1 The Contractor shall enable the Engineer access to the shotcrete Works at all times and shall allow the Engineer access to inspect the excavated ground surface prior to spraying if requested.

11.9.2 The quality control and testing of shotcrete (Plain and SFR) shall be carried out by the Contractor in the presence of Engineer. Tests for Field suitability (to determine mix design) and In-situ suitability (to control quality) shall be carried out separately. Field suitability tests shall be carried out on minimum three test panels for initial establishment of suitable range of accelerator/superplasticizer dosage (All types of Shotcrete), and fibre content of hardened concrete and Energy absorption class (SFR) for the required strength of shotcrete mix. The pressure at which the shotcrete shall be applied to the test panels shall be the same as will be used in actual works at the place of application. Mechanical rebound hammers shall not be used to obtain indirect compressive strength of shotcrete.

i. Control of Fresh shotcrete:

a. Water/Cement ratio: Daily by calculation or test method.

b. Aggregate gradation: Weekly by standard sieving.

c. Accelerator/Superplasticizer: Daily through record of quantity added.

d. Slump: For Each batch separately, measured any time during application, at the pump and should conform within 25mm of the target slump range established earlier and approved by engineer.

e. Fibre content: For fresh shotcrete, one test every 100cum or 500m^2 (Whichever achieved first) of shotcrete applied in accordance with EN 14488-7. For hardened shotcrete, testing shall be done when testing energy abortion capacity.

f. Early (0-24hrs) strength development: Strength results shall conform to Class J2 as per EN-144887-1 unless specified otherwise in the design drawings. In-situ test shall be carried out every 250m^2 of shotcrete applied subject to minimum 2 test per month in accordance with EN 14488-2 (Strength up to 1.0 N/mm^2 shall be determined by Penetrometer and in the range between 1.0 and 16 N/mm^2shall be determined using the HILTI shot bolt method).

ii. Control of hardened shotcrete:

a. In-situ strength shall be carried out on shotcrete applied at the tunnel face and shall be determined by crushing of cylindrical shotcrete specimens. Samples shall be collected with core drilling equipment from In-situ shotcrete applied on tunnel wall/or from test panels as the case may be, after lapse of 1 day. Cores for strength testing shall be obtained from random locations. The cores will be visually inspected and the dimensions and comments regarding the quality of the cores will be recorded. The cores will be free from lamination. No sets of cores to be tested at any given age shall come from the same panel/In-situ location. Sets of cores to be tested at different age may come from the same panel/In-situ location. For each test at least one spare specimen shall be provided. The cores for determination of strength shall be cured in temperature-controlled water until 3 days before further testing. The specimens shall have a diameter of 100mm and be cut to a height of 100mm. Where the nominal required shotcrete thickness is less than 100 mm, the cores for the compressive strength testing shall be taken from areas where the actual thickness is greater than 100 mm. Alternatively additional shotcrete thickness shall be applied in selected areas agreed by the Engineer for subsequent coring of test specimens.

b. Further (1-7days) Strength Development: Average strength of 3 cores tested at 3 days and 7 days each shall exceed 12.5MPa and 70% of 28-day strength requirements respectively. The ENGINEER may also require the

drilling of cores from the test panels perpendicular to the spraying direction.

c. Final strength: 3 cores shall be further tested at 28th day and at completion of 6 month each and the 28-day strength obtained shall exceed 28-day strength requirements mentioned in Table-1 at 11.7.2. Strength results at 6 months shall not be less than 28-day results.

d. Energy absorption class for Fibre Reinforced Shotcrete: Field suitability tests shall be conducted to ascertain the fiber content required for different energy absorption classes. One test every 100cum or 500m2 (Whichever achieved first) of shotcrete applied in accordance with EN 14488-5. Two classes are required to be designed i.e. E700 and E1000. The design shall be considered satisfactory when each test result exceeds the required energy absorption value by a margin of 5% or more. Fibre content of hardened concrete shall also be measured in accordance with EN 14488-7. These tests shall be performed on site in contractor's field laboratory setup for this purpose. No extra cost on account of testing shall be payable to the Contractor.

iii. Shotcrete thickness: In addition to recording tunnel wall profile before and after shotcrete by tunnel profiler etc., the Contractor will be required to undertake confirmatory shotcrete thickness testing of the in-situ tunnel lining. The basic test shall consist of 4 nos. drill holes drilled on a 1m² pattern. The average thickness of the 4 holes shall exceed the specified design thickness. If not, the ENGINEER shall propose remedial measures and/or further drill testing. All such drill holes shall be subsequently filled back by Non shrink mortar. Nothing extra shall be paid on this account.

iv. Bond Strength

Bond strength of shotcrete shall be tested every 1250m2 (in case of Ground strengthening) or min 3 tests (in other cases) of the shotcrete applied in accordance to EN 14488-4. Bond strength between plain shotcrete and fiber reinforced shotcrete shall also be established.

v. Contractor shall keep at site various testing tools like Penetrometer, HILTI shot bolt, Shotcrete core cutter, Test panels etc. along with all spares required as per standards and specification mentioned above. The frequency of testing, test type or the testing method will not be altered without approval of Engineer. Shotcrete from both the field suitability test panels and the In-situ quality control shall be tested by the Contractor in the presence of Engineer. Engineer may ask contractor to undertake further tests for examination purposes.

11.9.3 Dimension, tolerances and sampling of fibers shall be in accordance with EN 14889-2. Criterion for Tensile strength, Ductility and Modulus of Elasticity have been specified earlier. Furnishing evidence of manufacturer's factory production control system meeting requirements of EN 14889-2 and EN ISO 9000 shall be mandatory and sufficient for QC of fiber, however the Contractor shall be ready to demonstrate the

same by carrying out initial type tests (EN 14889-2) in approved laboratories as required by engineer before or anytime during usage. No payments for conducting these tests shall be made by the employer.

11.9.4 The Contractor shall propose to and agree with the Engineer trial mixes for the works at least 56 days before their commencement. Tunneling shall not be permitted to start until the Field suitability tests have been approved by the Engineer.

11.9.5 The site trials shall be repeated if the source or quality of any of the materials, mix proportions or placing equipment is to be changed during the course of the Works.

11.9.6 Where shotcrete does not comply with the required strength, the Contractor shall execute remedial work which may involve additional shotcrete or replacement in sections where it is safe to do so. The Contractor shall take into account any limits placed on the tunnel profile dimensions resulting from the Specification. The Contractor shall submit to the Engineer for agreement, a method statement, specification and calculations for remedial work. The Engineer shall, in the event of repeated failure in Quality Control, require the Contractor to adjust the mix to achieve the required strength.

11.9.7 The Contractor shall keep a record in a form to be agreed with the Engineer of all tests on shotcrete, which shall be kept on site identifying the tests with the section of work to which they relate.

11.10 ROBOTIC SHOTCRETE MACHINE

11.10.1 Shotcrete shall be carried out by Robotic shotcrete machine.

11.11 PLACING OF SHOTCRETE

11.11.1 Rock or previously applied shotcrete surfaces to be shotcrete shall be carefully cleaned of all loose material, scale and other contaminations. It may be necessary to use compressed air and a water jet. The surface to receive shotcrete shall be damp but shall not exhibit free water.

11.11.2 Where groundwater flow could interfere with the application of shotcrete or cause reduction in the quality of shotcrete the Contractor shall take all action necessary to control groundwater. Such action shall include the channeling of water by means of pipes and chases.

11.11.3 The optimum distance between nozzle and surface of application is 1.5 to 2.0 meter. The nozzle shall be positioned at right angles to the surface of application.

11.11.4 For vertical and near-vertical surfaces application shall commence at the bottom and the leading edge of the work shall be maintained at a slope. Downward spraying shall be avoided where possible. The nozzle may be inclined sufficiently to ensure reinforcement is properly embedded.

11.11.5 If the design thickness must be applied in more than one layer, then the previous layer must have developed sufficient strength to support the additional layer(s). Lattice girders, roof ties, wire mesh and other reinforcement shall be embedded in shotcrete as

shown on the drawings. The minimum cover of wire mesh and re-bars applied at the inner side of a tunnel lining shall be 2 cm or as shown on the drawings.

11.11.6 Prior to continuation of spraying from a joint or leading-edge position or in any other circumstances where shotcrete has hardened beyond its initial set, loose material shall be removed by jetting with a compressed air lance. Any laitance which has been allowed to take final set shall be removed and cleaned by jetting with air and water.

11.11.7 If more than one layer of reinforcement is used, the second layer shall not be positioned before the first one is embedded and covered with shotcrete. Exemptions are to be approved by the ENGINEER.

11.11.8 The temperature of the mix before placing shall not be below 15^0C and shall not exceed 35^0C unless special provisions are made. Spraying shall not be undertaken when ambient temperature is below 15^0C unless special measures can be taken to provide protection against frost until the shotcrete has developed a compressive strength of at least 5 MPa.

11.11.9 A system of delivery notes shall be maintained to record the date, the time of mixing, mix design number, quantity, delivery point, time of delivery and completion of placing. The delivery notes shall be available to the ENGINEER for inspection.

11.11.10 Rebound shall be removed immediately after finishing of each shotcrete application. In particular at horizontal shotcrete connections due to separate excavation sequences and at all construction joints the rebound shall be removed, if necessary, by pneumatic hammers, prior to further application of shotcrete.

11.11.11 Under no circumstances rebound material shall be worked back into the construction. The work shall be continuously kept free of rebound material.

11.11.12 Measures to establish the thickness of shotcrete shall be set up by the Contractor and approved by the ENGINEER. These may include visual guides installed prior to shotcrete, holes drilled after completion of shotcrete or a full control by laser scanning.

11.11.13 Shotcrete shall be left in its natural finish without further working except as required to trim excess thickness where the shotcrete shall be allowed to stiffen sufficiently before being trimmed with an approved cutting screed.

11.11.14 If deemed necessary by the ENGINEER, curing of the shotcrete shall be performed by water spraying or other appropriate measures subject to the approval of the ENGINEER in the first 48 hours after application.

11.11.15 Major ground water seepages shall be drained off or sealed off by grouting prior to spraying or after application of a first sealing layer.

11.11.16 Construction joints or stop joints shall be provided, as directed by the Engineer and shall be sloped at 45^0 to the adjacent shotcrete surface in a clean, regular edge. Before placing the adjoining work, the sloped portion and adjacent shotcrete shall be prepared as specified in clauses above.

11.11.17 Before a succeeding layer of shotcrete is placed, the preceding layer shall be checked for defects. Areas of work shall be properly compacted and bonded and free from

honeycombing, laminations, dry or sandy patches, voids, sagged or slumped material, rebound, excessive cracking and overspray.

11.11.18 Where defects occur, the Contractor shall agree with the Engineer proposals for the removal of the defective material and replacement by material without defect and the area to be replaced shall in any event be not less than 300mmx300mm at such locations.

11.11.19 Gloves and necessary protective clothing shall be worn to protect against dermatitis.

CHAPTER -12

DRILLING AND GROUTING

12.1 SCOPE OF WORK

12.1.1 The specifications described herein under relate to the Work of drilling and grouting, which includes all labour, materials, equipment, accessories and operations and required for the performance of drilling grout holes, holes for rock bolts/anchors and instrumentation, washing and water pressure testing of grout holes and supplying, transporting, storing, mixing and injecting grout materials and additives for consolidation and curtain grouting including void filling/contact grouting within the underground constriction sites and from surface, at locations shown on the drawings or where directed by the Engineer.

12.1.2 Grouting operations shall include the following:

- **i.** Contact grouting: To fill voids between final concrete lining and primary support system applied to rock surface.
- **ii.** Consolidation grouting, of the rock surrounding the excavated hollow space, which shall commence after placing of the concrete lining/shotcrete and completion of contact Grouting.
- **iii.** Consolidation grouting in the heading zone during excavation to consolidate the heading face before further advance in zones of sheared and disturbed material and/or in zones of high-water inflow.
- **iv.** Fill grouting, ofkarstic cavities, drainage trench, conduits and sump pits, and of exploratory drill holes and drain holes.
- **v.** Crack grouting, to seal open cracks and joints in the structural concrete lining.
- **vi.** Chemical grouting in zones of fine sand and soils, and to control the water inflow and increase the stability and strength of the formations that are too tight to be grouted with a cement grout.
- **vii.** Compensation grouting: Pre-injection of grouting at a controlled pressure prior to tunneling permeate the area to avoid deformations due to tunneling activities

12.1.3 The final number, length, location and inclination of the drill holes, as well as the composition and consistency of the grout mixes, grouting pressures pumping rates and sequence in which the holes are to be drilled and grouted shall be governed by actual conditions encountered on site and shall be at all times subject to approval by the Engineer.

12.1.4 Contractor shall follow the grouting strategy as approved by Engineer.

12.1.5 Contractor shall maintain one-month buffer stock of grout materials as per agreed programme or as directed by Engineer.

12.2 SUBMITTALS

12.2.1 At least 14 days prior to the start of grouting works, The Contractor shall provide a grouting method statement for the Engineer's agreement. The proposals shall include

details and location of the mixing plant and grout pump, mix design and constituents, pumping rates and pressures, injection points, methods of monitoring, recording and controlling the sequence, preventing grout leakage and reconciling the volume of grout placed with the theoretical volume required, including specifications of all equipment, tools and all grouting materials to be used, and qualification and experience of the proposed personnel.

12.2.2 Grouting shall be carried out by operatives skilled in the work and notified in advance to the Engineer. They shall produce evidence of satisfactory performance on projects where the purpose of the work and extent was comparable. The skilled operatives shall further undergo training from OEM whose equipment is being proposed to be used at site.

12.2.3 An overall drilling and grouting Program shall be drawn up jointly between the Contractor and the Engineer. Grouting mixes, pressures, pumping rates, and sequencing will be selected, subject to modifications, to meet local conditions encountered during the performance of the work. Grouting works shall be planned in such a manner that they can be carried out according to the approved plan concurrently with other activities.

12.2.4 The Contractor shall decide and consult with the Engineer details of the proposed grouting scheme including:

- **i.** Information and case records to support the grouting proposed in respect of its ability to penetrate the strata and its ground enhancement effect.
- **ii.** Specific criteria to measure the adequacy, sufficiency or completeness of the ground treatment.
- **iii.** Details of the treatment zone and grout injection patterns with respect to the Works and adjacent structures.
- **iv.** Details of plant proposed.
- **v.** Method statement and programme including arrangements for storage of materials, mixing grout, Quality Control of grout, recording grouting pressures and grout take and tests to prove the efficacy of the grout in the ground, health aspects associated with the materials and grout proposed at all stages of the process and during excavation of treated ground, and means of protecting persons from any adverse effects
- **vi.** An assessment of the environmental impact of the materials and methods proposed.
- **vii.** An occupational health risk assessment, including methods of risk reduction on all aspects of the grouting operation.

12.2.5 Contractor shall record grouting pressures and flows and produce ongoing assessments of the grout performance in relation to the requirements of grouting objectives.

12.2.6 During the performance of the grouting works the Contractor shall keep complete daily records of all grouting operation which shall include the following:

- **i.** Number and location of the drill holes.

ii. Results of water pressure tests.

iii. Grouting method.

iv. Date and time of commencement and of each change in grouting operations.

v. Rate of pumping.

vi. Grouting pressures and gauge reference number.

vii. Water-cement ratio and its variations.

viii. Quantities of cement, sand, bentonite, fly ash, admixtures and chemicals used.

ix. Connections, if any, with other holes and cracks, as well as any surface leakage of water or grout. Location, how caulked and the success of caulking shall be described.

x. Number of holes and depth of holes left for re-drilling.

xi. Time of completion.

xii. Name of the Foreman in-charge.

12.2.7 Grouting reports in an approved form shall be compiled from these records and submitted to the Engineer for approval. Results of water pressure tests and grout intakes shall be presented graphically. The above reports shall also cover the interpretation of the test results and the actions proposed to be taken by the Contractor for improving the quality of grouting pattern.

12.2.8 The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents.

12.3 STANDARDS

12.3.1 Materials for grouting and performance of grouting works shall conform to the following Indian Standards or where not covered by these standards, to the equivalent International Standards:

i.	IS: 12269	Specification for 53 grade ordinary Portland cement.
ii.	IS: 383	Specification for coarse and fine Aggregates form natural source for concrete.
iii.	IS: 5529(Part-II)	Code of practice for in-situ permeability tests.
iv.	IS: 5878 (Part-VII)	Code of practice for construction of tunnels conveying water: Grouting
v.	IS: 9103	Concrete Admixtures: Specification
vi.	IS: 6066	Recommendations for pressure grouting of rock foundations in river valley projects.
vii.	IS:10874	Portland Micro-Fine Cement Specification
viii.	IS:14343	Choice of grouting materials for alluvial grouting

12.3.2 In cases of conflict between the above standards and the specifications given herein, the Specifications shall take precedence.

12.4 DEFINITIONS

12.4.1 Cement grout

i. Cement grout is defined as a mixture of cement and water with the addition of admixtures (sand and bentonite, if directed by engineer), which is forced under pressure into prepared holes or pipes in order to fill voids or consolidate the rock mass as a whole.

ii. Cement grouts are subdivided into stable and unstable mixtures:

a. Unstable mixtures are simple suspensions of cement in water. These suspensions are homogeneous as long as they are in movement and the sedimentations starts as soon as the movement is stopped.

b. Stable mixtures are colloidal suspension dissolved in water of which grain size is so small that no appreciable sedimentation occurs during the grouting operation. These suspensions are obtained by high speed mixing of cement with addition of bentonite.

12.4.2 Chemical Grout is defined as mixture of two or more solutions which combine chemically and form a gel or a solid matter, the solutions may react either prior to pumping into, or within the void. The chemicals may be used in combination with cement or other grout as determined by testing and approved by the Engineer.

12.4.3 Single-Stage Grouting is carried out by introducing the grout at either the collar of the hole through a nipple or by means of a grout supply pipe at the bottom of the hole. The entire length of the hole is grouted in one operation.

12.4.4 Multiple Stage Grouting

i. Multiple stage grouting is carried out by introducing the grout into a predetermined section of the hole, which is blocked off by a packer. The grouting of the entire length of hole is performed in successive stages either in ascending or descending arrangement.

ii. The terms ascending or descending arrangement mean the sequence of the grouting stages, either from bottom to the collar of the hole or in reverse, irrespective of the effective direction of inclination of the hole.

iii. When grouting is done in ascending arrangement, the hole is drilled to its full depth, washed out, and the packer is set at the top of the deepest section to be grouted at the required pressure through the grout supply pipe. The packer is allowed to remain in place until there is no backpressure and then withdrawn to the top of the next section to be grouted. The water pressure testing and grouting is repeated successively, section by section, until the entire length of the hole is filled with grout.

iv. When grouting is done in descending arrangement, the work is accomplished in section from the collar of the hole. The hole is drilled to a limited depth,

washed out and the packer is set just above the section to be grouted. The section is then water-pressure tested and grouted at the required pressure. The grout within the hole is removed before it takes a hard set while the grout surrounding the hole is allowed to obtain its initial set, before the holes is drilled to an additional depth. Repeating thus successively drilling, water-pressure testing, and grouting at various depths until the entire length of hole is completely drilled and grouted.

12.4.5 Split spacing Grouting means the system of locating an additional grout hole approximately mid-way between two previously drilled and grouted holes.

12.4.6 Water Cement Ratio is the proportion by weight of water to cement in a water-cement mixture.

12.5 GENERAL

12.5.1 During drilling, grouting, washing and pressure testing operations, the Contractor shall keep concrete and rock surfaces free and clean of oil, grease, drill cuttings, grout, cement, excess of water or any kind of waste. At all times during the progress of Work pertaining to this item, contractor shall protect all open drill holes from becoming plugged or filled with oil, grease, drill cuttings, grout or waste. The Contractor shall clean up and remove all waste in each area on completion of the work.

12.5.2 Before starting the grouting, the Contractor shall give due notice thereof to the Engineer, to enable him to be present during the grouting operations, which shall always be done in his presence.

12.5.3 The grout mix that might flow out or otherwise get spilled on the concrete lined surface shall be removed expeditiously without allowing any time for the grout to set on the concrete surface.

12.5.4 After finishing of grouting, each grout hole shall be re-drilled to ⅔rd of theoretical lining thickness and fitted with dry pack mortar.

12.6 SAMPLING AND TESTING

12.6.1 The Contractor shall provide samples of materials and prepare trial mixes as directed by the Engineer and test in the presence of Engineer at least 30 days before the commencement of any grouting. The materials for use in grout mixes shall be tested with applicable requirements stipulated in these specifications.

12.6.2 The Contractor shall carry out the following tests:

i. Laboratory Tests

a. Grain size distribution and moisture content of sand and bentonite, including aerometer analysis.

b. Atterberg limits.

c. Chemical analysis of water and solids.

d. Compressive strength.

e. Viscosity (by fan-viscosimeter and Marsh cone).

f. Density.

g. Decantation and setting time (by Vicat needle).

h. Shrinkage of grout.

ii. Field Tests.

a. Density by hydrometer or mud balance.

b. Viscosity by marsh cone.

12.6.3 All Chemical grouts shall be tested in NABL approved laboratory under conditions identical to those to which they will be subjected in the field, in order to determine the suitability of various chemicals and proportion of the ingredients to satisfactorily complete the work.

12.6.4 During the actual grouting operations, contractor in the presence of the Engineer will carry out tests on grout mixes at the same time as grouting, and will plot values of viscosity, sedimentation limits, compressive strength, and maximum viscosity possible for the grouting on a diagram. The frequency of testing will be once for each grouting jobsite or until acceptance criteria have been met. However, if a significant change in the cement source occurs, sampling and testing shall be repeated.

12.6.5 Further sampling, testing and quality assurance will be as per approved 'Quality Assurance programme submitted by the Contractor.

12.7 GROUTING MATERIALS

12.7.1 All grouting materials shall require approval of engineer before their application. Contractor shall arrange to carry out all testing required to the satisfaction of engineer before seeking any approvals.

12.7.2 General

i. The following kinds of grout mixes shall be used:

a. Cement grouts (OPC 53/53S and OPC based Micro/ultrafine cements).

b. Mineral grouts (Colloidal silica or Polyurethane).

c. Combination grouts: Combination of any of the above-mentioned grouts.

d. Admixtures (like super plasticizer, accelerators, Micro silica/Silica fume etc.) shall be added in dosage required to achieve its benefits.

e. Only PC based super plasticizers and alkali free liquid accelerators shall be used with OPC 53/53S, MFC, UFC etc.

ii. All cement based grouts shall use required dosage of super plasticizers (PC based and minimum 1.5% of cement weight), accelerators (1-2% if required), Micro silica/Silica fume (1-2% if required) and other additives and shall be tested on site to achieve following properties. The tests shall be performed both initially (for

design approval) and subsequently just after preparing grout for injecting into strata (Once for each type of grout mix per shift):

a. Marsh cone time of less than 35 seconds. (IS: 14343 Annex-A)

b. Bleeding of less than 2% till 2 hours. (IS: 10874 Annex-C)

c. Initial setting time of more than 120 minutes. (IS: 4031 (Part-5))

d. Final setting time of less than 240 minutes. (IS: 4031 (Part-5))

iii. At few locations engineer may direct the Contractor to adopt lesser setting times also. This will be achieved by increasing the dosage of accelerator.

iv. The use of toxic chemicals such as acrylamide/Poly-acrylates shall not be permitted for use in the works. Pre-blended cements shall not be permitted.

v. Cement (OPC 53/53S, MFC, UFC) shall not be older than 3 months/Manufacturer's specified shelf life at the time of usage.

12.7.3 OPC 53/53S grade Cement

i. The cement shall conform to requirements of Section of "Materials for Construction" and relevant standards and shall be free from lumps. Any cement containing lumps and foreign matter detrimental to the results of grouting shall be rejected by the Engineer.

ii. Additionally, OPC 53 and OPC 53S used for grouting shall have Blaine value not less than 275 m^2/kg and 370 m^2/kg respectively.

12.7.4 Micro Fine Cement (MFC) shall conform to IS:10874, additionally;

i. Micro fine cement should have specific surface (BET method IS: 15388) more than 600 m^2/kg and D_{95}< 15µ. Original MTC to be submitted for approval of engineer before usage. Contractor at his own cost shall get the same tested from 3rd party at direction of engineer.

12.7.5 Ultra-Fine Cement (UFC) shall conform to IS:10874, additionally;

Ultra-Fine Cement should have specific surface (BET method IS: 15388) more than 900 m^2/kg and D_{95}< 12µ. Original MTC to be submitted for approval of engineer before usage. Contractor at his own cost shall get the same tested from 3rd party at direction of engineer.

12.7.6 Colloidal Silica (CS):

i. Colloidal silica shall be environment friendly, highly stable and having ultralow viscosity of less than 6 mPA.s at 25°c.

ii. Gel time of Colloidal silica shall be adjustable from 60 minutes to 10 minutes by increasing the accelerator dosage.

12.7.7 Water

i. Water shall not contain more than 2 parts per thousand of suspended colloidal solids and no particles larger in size than the cement particles. It shall not be

aggressive. The chloride content shall be less than 50 mg per liter and the sulphate content less than 100 mg per liter.

ii. The temperature of water used for the preparation of grout shall not exceed 25^0c.

12.7.8 Admixtures

i. Admixtures shall be added to grout mixes to optimize the strength, viscosity, density, decantation, setting time and shrinkage.

ii. Only admixtures proved by testing prior to the start for grouting shall be used. Manufacturer's certificates or guarantees will not be accepted as relieving the Contractor of his responsibility for the suitability of any admixture. Admixtures shall conform to the relevant IS code.

iii. Liquid accelerators shall be alkali free and if required shall be added only through dedicated nozzle into the grout line at the face (1-2% by weight of cement).

iv. Super plasticizers shall be PC based only (minimum 1.5% by weight of cement).

v. Micro silica/Silica fume shall be added 1-2% by weight of cement if required.

12.7.9 Polyurethane (PU)

i. The products used in chemical grouting should be non-toxic, solvent free, eco-friendly and present low viscosity. Polyurethane foam resins, polyurethane resins and silicate foam resins can be used depending on the purpose and aim of the grouting.

ii. Polyurethane (combined systems) shall be used for consolidation of the sheared or disturbed rock, loose material, or for making the ground impermeable against water inflow even under high pressure. PU is two component system having high fire resistance, low flammability and extremely fast curing. The system should be capable of being designed to behave as foaming or non-foaming in the presence or absence of water.

iii. For consolidation grouting: A polyurethane resin with low viscosity, a large penetration factor and high compressive strength should be used. Foam factor should be less than 4 (4 times its original size).

iv. For waterproofing and control of high ingress of groundwater: A polyurethane foam resin with low viscosity and a large foam factor (approx. 40) with a fast reaction in contact with water should be used.

v. Accelerators should be used. The ratio accelerator/resin should be tested and calibrated in a trial test to optimize the penetration rate according to the needed depth of the treatment.

vi. It is advised to test the optimized mix for a situation where a weak sheared/fault zone is bearing high inflow and a quick stoppage of the water is required at the same time that a consolidation of the rock. A high foam factor reacts rapidly with the water but reduces compressive strength and decreases penetration capacity.

Thus, a trial test should be carried out to define the best combination for each situation.

vii. The results of these tests should be confirmed with core drillings to evaluate the penetration capacity of the resins.

12.7.10 Other Chemicals

When other chemicals are required or proposed, they shall be accompanied by the manufacturer's certificates that they have been commercially used with satisfactory service in the similar type of work. The storage, handling and usage shall be strictly with the manufacture's printed instructions.

12.8 GROUT MIXTURES

12.8.1 The type of grout and proportions of various constituents in the grout mixtures shall be as directed by Engineer and shall be constantly adapted to the conditions on the site as the Engineer may direct.

12.8.2 Any grout mixture not used within one hour after mixing shall be rejected.

12.9 DRILLING AND GROUTING EQUIPMENT

12.9.1 General

i. Only modern, properly operating drilling and grouting equipment approved by the Engineer and operated by trained and experienced crew shall be used for the performance of the work.

ii. Drilling equipment of the rotary or percussion type shall be used to perform the drilling as specified herein and as required by the Engineer.

iii. Percussion type drilling equipment shall be equipped for continuous washing of holes during drilling.

iv. All Drill booms on jumbo shall be equipped with sensors to record measurements while drilling (MWD) to record the drilling data.

v. The washing and water pressure testing plant shall include pumps, gauges, valves and all other accessories necessary to complete the works as specified. The pumps shall be of the gear, centrifugal or other acceptable types and shall be capable of maintaining constant pressure. The Contractor shall supply water storage tanks sufficient for the pumps in addition to flow meters and pressure gauges for calibration and checking purposes. The arrangement of injection equipment must include a return circuit, conveniently designed so that the grout or mortar can circulate continuously along the pipe, in order to avoid clogging and concurrently allowing an accurate pressure control into the hole. During grouting process, grout should always remain agitated. The distance between the injection pump and the injection hole should not be more than 50 meters. All the grout or mortar dosing and injection equipment must always be kept in optimal operating conditions and calibrated periodically. The entire circuit should be

prepared to be washed in case of clogging by means of "T" fittings and water connections.

vi. Grouting equipment shall consist of grout pumps, weighing scale for additives and cement, grout mixers water meters, agitator sumps, pressure gauges, packers, pipelines and fittings, and miscellaneous tools, and shall be specifically designed for grouting purposes.

vii. Grouting equipment shall be capable of effectively mixing and stirring the grout and forcing it into the grout holes or grout convections in a continuous, uninterrupted flow at any specified pressure up to maximum of 100 bar, accurately measuring the grout intake, and maintaining the specified pressure for at least 5 minutes after the hole refuses to accept further grout. The equipment shall be capable of accurately controlling grout flows and pressures and shall be suitable for neat cement, cement sand, and chemical grouts.

viii. Spare gauges, valves and fittings shall be kept available on the Site, and a two-way communication system between the mixing plant and place of grouting shall be provided if the distance exceeds 60 m.

ix. Standby equipment, which can be activated immediately, shall be furnished to ensure continuity of work in the event of main equipment breakdown. The standby equipment shall be able to operate at pressures up to 100 bar.

x. Prior to commencement of the work, during the work as specified or as requested by the Engineer, and at the end of the work, all pressure gauges, recorders and discharge meters shall be checked and calibrated.

xi. The grouting equipment shall be maintained to the satisfaction of the Engineer in order to guarantee continued and efficient performance during grouting work.

12.9.2 Deleted.

12.9.3 Recording of data for grouting

i. Recording of data shall be automatic through an electronic data logger (a PC), which shall have facility to actively control the entire process.

ii. Control parameters such as maximum allowed injection pressure, maximum and minimum flow rate and maximum quantity of grout per injected hole shall be entered into the PC.

iii. PC shall then record the process automatically, and also stop the pump when any of the stop criteria have been reached. When injecting on several holes simultaneously (with one pump per line) this equipment is a great help in keeping things under control and receiving accurate recordings, without the need for more staff.

iv. It should be possible to see the cumulative grout volumes and grout material weights injected inside the hole under grouting operation.

v. Pressure transducer and an inductive flow meter shall be coupled into the grouting line.

vi. Print out of grouting rig log shall me submitted with grouting reports after each grouting operation.

12.9.4 Grout Mixers and Agitator sumps

i. Grout mixers for mixing the stable mixtures shall be of the mechanically operated, high speed colloidal type of sufficient size, and operating at 1500 to 2000 rpm with electric or pneumatic drive to ensure complete dispersion and activation of the mix.

ii. Hand powered mixers or concrete mixers shall not be permitted for preparation of grout mixtures.

iii. Mix shall be weighing batched and mixers shall be provided with equipment for measuring weight and volume of mix components with an accuracy of 2 % and a water meter calibrated in liters with a reset switch for zeroing after each delivery.

iv. After mixing, the grout shall be discharged through a 5 mm mesh screen into an agitator sump equipped with stirring paddle to prevent settling and to remove any air bubbles from the mix. The stirring paddle shall be of such arrangement to guarantee a complete circulation of the entire sump content. The agitator sump shall have double the capacity as of the mixer so that one batch of grout can be pumped while the next batch is being mixed.

v. Grouting rig shall be equipped with computerized controls and automatic logging of entire grouting operations (volume of different recipies injected in each hole, pressure at which the injection took place, pressure build up/loss as the grout is run, start and stop time for different mixtures).

12.9.5 Grout Pump

i. Grout pump should be able to inject grout at upto 80 bars steady pumping pressure for upto 20 L/min of constant flow, simultaneously into 2 holes at the same time.

ii. Pumps shall be of the duplex double acting piston type. The pump body shall be of high wear and shock resistant material. The plunger unit shall be of stainless steel, highly resistant to abrasion.

iii. The pump shall have hydraulic drive.

iv. The pumps shall be equipped with precise pressure and capacity control valves, which allow the setting of both, the maximum pressure and the flow independently. The pump shall automatically stop whenever the preset pressure is reached and shall maintain the pressure without fluctuation.

v. For works requiring a small volume of grout such as crack grouting or rock bolts grouting, the Contractor may use hand operated grout pumps approved by the Engineer. These pumps shall be able to achieve a pressure of up to 25 bar.

12.9.6 Pressure Gauges

i. The Contractor shall provide pressure gauges for both low and high-pressure ranges (0- 20 bar and 20 -100 bar). Two gauges of the appropriate range shall be provided in each grout line, one at the pump for the use of the pump operator, the other at the hook up connection directly at the collar of the hole. The required pressure for each particular hole shall be measured on the hook up pressure gauge, not at the pump.

ii. Pressure gauges shall have an accuracy of 3%. A minimum of two standardized pressure gauges for each range shall be calibrated and certified by an independent laboratory prior to the commencement of grouting works. One gauge for each range shall remain at the disposal of the Engineer, and the other shall be, used by the Contractor for checking and calibration of working gauges. Working gauges shall be used for no longer than 2 shifts before being cleaned and recalibrated. All working gauges shall have reference number for identification, which shall be quoted in the grouting reports to be submitted to the Engineer.

12.9.7 Connections to Grout Holes and Packers

i. Supply and return lines equipped with quick release couplings shall be able to withstand an internal pressure greater than the maximum produced by the pump. The internal diameter of the lines shall be such that no appreciable settlement of grout takes place when pumping at the minimum discharge capacity of the pump.

ii. Valves shall be provided at the pump, in supply line and at the collar of the hole being, grouted. Suitable screens shall be incorporated in the supply line for removing oversize particles and foreign matter before injection into the grout hole.

iii. Packers shall be the same as used for water pressure testing and shall be of the mechanical rubbing ring or pneumatically expandable rubber types. These shall be capable of sealing holes without leakage. These packers shall be capable of being used either single or double. Double packers shall be separated by up to 3 m of perforated pipe. The diameter of pipes used for separating and placing the packers in holes shall be the maximum possible for the size of the holes.

12.9.8 Embedded Pipes and Fittings for Grouting

i. Whenever pipes are required to be installed, Standard mild steel pipes and fittings for grouting shall be set in the rock and concrete as directed by the Engineer. The pipes and fittings embedded in concrete shall be cleaned thoroughly of all dirt, grease, grout and mortar immediately before embedment and shall be firmly held in position and protected from damage of displacement while the concrete is being placed. The size of the pipes embedded in concrete lining for drilling holes for grouting shall be of a suitable internal diameter. A standard coupling and nipple wrapped to facilitate eventual removal shall be attached to the grout pipe where embedded in concrete. No portion of the pipe

shall be allowed to remain within 50 mm of the concrete surface and the resulting recess, after removal of the pipe or fitting, shall be filled with dry pack mortar.

ii. Care shall be taken to avoid premature blockage of pipes. Any pipe that becomes blocked before completion of operations shall be cleaned in a satisfactory manner or replaced by the Contractor

12.9.9 Maintenance routine

i. Thorough cleanup must be performed to prevent cement from hardening in production apparatus and in the grouting rig. Such maintenance must be facilitated by ensuring that a high-pressure washer and a work bench are available in the vicinity of the grouting rig. Following is the advisory schedule which may be followed: -

Component	Maintenance frequency	Comments
Hoppers	Feed screws should be checked regularly and cleaned when necessary. Hoppers must be emptied in the event a prolonged stoppage.	The screw can be checked when the hopper is run to empty.
High-speed mixer	Cleaning after each round of grouting. Impeller/paddles should be replaced every other year.	Thorough cleaning is vital. Inadequate cleaning may result in set cement falling into the cement being mixed and causing operating problems during grouting. Impeller/paddles/knives will become worn and gradually give poorer mixing results. They should be replaced when they no longer give the same shear force in the mixing process.
Stirrer (agitator)	After each round of grouting.	Thorough cleaning will prevent a buildup of cement, also at the top of the mixer. All surfaces must be checked.

Component	Maintenance frequency	Comments
Grouting pump	After each round of grouting.	Must be dismantled, cleaned and lubricated internally with acid-free vaseline.
	After each round of grouting.	Check of wear on connecting pieces, threads and split pins.
	After each round of grouting.	Check for wear and damage. Damaged hoses must be replaced.
Grouting rods	After each hole.	Thorough cleaning and lubrication of threads.
Packers	Check the packers that are going to be used before each round of grouting.	Check there are no production faults in the locking mechanism.
Taps/Ball valves	After each hole and during grouting. When grout takes are large, functionality should be checked by opening the tap.	Important to check functionality, particularly of pressure relief valves.
Grouting rig	Regular cleaning/lubrication, at a minimum after each round of grouting.	Anti-seize oil should be applied after rig has been washed. It is advantageous if the rig is equipped with a high-pressure washer for continuous cleaning during the grouting process.
Scales	Every other month, or after 200 tonne.	Measuring cells should be checked.

12.10 DRILLING OF HOLES

12.10.1 General

i. The number of holes to be drilled, their location, sequence, orientation, inclination and the depth shall be as per approved methodology.

ii. All holes shall be established within 0.10 m of the specified location. Maximum deviation for holes shall be 2^0 (degree) from the proposed values.

iii. If for any reason, the drill hole deviates in inclination or orientation in such a way that it does not satisfy the purpose for which it was intended, the Contractor shall correct the deviation or shall drill another hole to the satisfaction of the Engineer.

iv. Hole size for probing and consolidation grouting holes (Drilled in the face) shall be kept same.

12.10.2 Drilling of Holes for Rock bolts, Exploration and Instrumentation and other than Grouting, etc.

i. The minimum diameter of holes shall be 38 mm or as directed by the Engineer.

ii. Holes shall be drilled either directly into the rock or through the concrete lining and then into rock as directed by the Engineer.

iii. The holes shall be drilled in a direction normal/inclined to the surface of the underground excavation / concrete lining as the case may be or as directed by the Engineer.

iv. While drilling the holes, utmost care shall be taken to ensure that the reinforcement or structural ribs, if any, in the concrete lining, shall not be cut through. The position of steel ribs shall be recorded and marked on the finished concrete lining. If the reinforcement or steel ribs are encountered during drilling of any holes in concrete, drilling shall be discontinued immediately, and a new hole shall be drilled nearby. The holes so abandoned shall be backfilled with concrete as direct by the Engineer and the surface of concrete shall be repaired.

v. Each hole shall be protected from becoming clogged or obstructed by a grout connection pipe fixed suitable into the holes and the holes shall be suitably capped or otherwise protected until these are grouted. Any hole that becomes obstructed before being grouted shall be cleaned out in a satisfactory manner.

vi. The use of rod dope, grease or other lubricants on drill rods shall not be permitted and no drilling water additives of any kind shall be used without the approval of the Engineer.

vii. Whenever the drilled water is lost or artesian flow is encountered, drilling operations shall be stopped, and the hole shall be grouted before drilling operations are resumed. The Contractor shall record the location, flow and the pressure of any artesian conditions encountered in any drill hole.

12.11 FLUSHING OF HOLES

12.11.1 On completion of drilling, all holes shall be thoroughly flushed to remove any accumulation of fines, sludge, or foreign materials. Holes shall be flushed out by water at pressure of 10 bar, combined with some compressed air injected through a stiff plastic hose starting at the bottom of the holes. Contractor shall continue flushing for two minutes after the return water becomes clear.

12.11.2 For grout holes, flushing will also be required immediately before water testing/high pressure grouting. A custom designed diesel-powered piece of equipment shall be used to provide a water jet pressure of upto 100 bar. The high-pressure water hose shall have nozzle arrangement so that some water jets pointing 45° back along the hose and others at 90° radially. With this configuration, the nozzle is self-propelled forward into the hole and can be removed by just pulling the flexible hose.

12.11.3 If there are zones in the borehole that may collapse if soaked in water, or will be excavated by the flushing jet, or if the water yield from the hole is more than 10 l/min, the flushing may be omitted.

12.11.4 Flushing of boreholes for grouting should be done as specified as a routine matter and any necessary deviations should be decided on and recorded by the supervisor, based on the borehole records.

12.12 GROUTING OPERATIONS

12.12.1 General

i. All pressure grouting operations shall be performed in the presence of the Engineer.

ii. In the underground works, the grouting works, and other operations shall be carried out as per approved working methodology or directed by the Engineer.

a. Consolidation grouting and impermeabilization of the rock ahead and around the heading face as needed before further advance.

b. Fill grouting of exploratory and drain holes, which may be required during underground excavation, prior to placing of concrete lining.

c. Contact grouting in the crown of the tunnel and cavern after placing of concrete lining.

d. Fill grouting of drainage conduits and sump pits.

e. Depending on the rock conditions, the Engineer may direct to carry out Consolidation grouting.

f. Control grouting.

g. Installation of one-way checks valves.

h. Crack grouting as directed.

iii. The above sequence is not exhaustive, and the Contractor shall plan his operations in such a way that he is flexible to adapt to the conditions encountered.

iv. The utmost care and precautions shall be taken to ensure that the concrete does not get damaged during the grouting operations.

v. If the Engineer considers necessary to carry out an additional grouting in any section of the works, the Contractor shall reinstall the necessary equipment and perform the grouting to the satisfaction of the Engineer.

12.12.2 Contact Grouting between Concrete and Rock where concrete lining is required to be installed

i. Low pressure contact grouting shall be carried out between concrete and rock over the entire length of the tunnel to fill voids between the rock surface and the following:

a. Structural concrete in the crown of the tunnel and cavern and in the concrete plug in the tunnels.

b. Concrete in any other zones within the underground works where conditions so require and as the Engineer may direct.

ii. Contact grouting shall normally be performed from holes drilled in the crown of the tunnel, shaft and cavern and shall be carried out in advance of consolidation grouting operation.

iii. Contact grouting in the completed concrete plug in access and it shall be performed through the pipe system cast into the body of the plug as specified in Section of "Cement Concrete".

iv. Water pressure testing will not be required prior to contact grouting.

v. In any section of the underground structure, the concrete lining within 100 m of that section shall have been in place for at least 21 days before grouting commences.

vi. Contact grouting shall be carried out at low pressure (not exceeding 5 kg/sq.cm) using a cement-sand grout and shall continue until all voids are filled. Vent pipes for the release of air and water during grouting shall be provided in locations as shown in the drawings, as directed or approved by the Engineer.

vii. After the grouting of any hole is completed, the pressure shall be maintained, by means of stopcock or other suitable device, until the grout has set.

viii. Control grouting shall be carried out, where directed by the Engineer, to verify that voids have been completely filled with grout. Grouting will be regarded as being satisfactory if the pressure can be maintained for at least 5 minutes without grout intake.

12.12.3 Closure of Holes and Clean-up

Upon completion of grouting work, each hole shall be filled with thick grout and connections not embedded in the concrete shall be removed. The drilled holes in the concrete lining shall be reamed or redrilled to a depth corresponding to the ⅔ rd of

theoretical concrete lining thickness and filled with dry pack mortar, as stipulated in Section of "Cement concrete", flush with the concrete surface.

12.12.4 Crack Grouting

i. Crack grouting shall be performed to seal the cold joints, construction joints, shrinkage cracks, honeycombs, poorly closed grout holes etc., in the structural concrete lining of underground structure as directed by the Engineer and as stipulated in Section of "Cement Concrete".

ii. Crack grouting shall consist of injecting a stable, cement water mix with admixture through holes specially drilled into cracks or joints.

iii. Preventive measures shall be taken by plugging the joint with wooden wedges, cardboard; cement-gypsum mortar or other suitable mean to prevent the grout from flowing out of the crack.

12.12.5 Curtain Grouting

i. Curtain grouting shall not be started until consolidation grouting has been completed within 60 m radius around the curtain holes to be grouted.

ii. Drill holes for curtain grouting shall be drilled and grouted in three stages consisting of Primary, Secondary and Tertiary holes. Primary holes shall be drilled, washed, subjected to water pressure testing, when required by the Engineer, and grouted before proceeding to execute the secondary holes. The depth of holes and spacing between them shall be as shown on the drawings or as approved by the Engineer.

iii. Unless otherwise specified by the Engineer, curtain grouting shall be done in stages of 5 m each.

iv. If grout absorption in any 5-meter stage, which is not caused by leakage at the surface, is found to be excessive in adjacent primary and secondary holes, the Engineer may require the Contractor to drill and grout additional holes (tertiary holes) between the primary and secondary holes.

12.12.6 Water Pressure Testing

i. Water pressure tests with double packer apparatus having a perforated pipe not less than 1.5 m shall be carried out on the grout holes when directed by the Engineer. The actual spacing will be determined by the Engineer. Water pressure shall than be applied to the test section for a minimum period of 5 minutes.

ii. The maximum pressure for water testing shall correspond to the pressure specified for grouting. Water loss shall be measured in liters.

iii. Based on the results of the water pressure tests, the Engineer may require additional grouting. Such grouting shall be, carried out by the Contractor at the pressure specified by the Engineer.

Chapter 13

Earthwork in Formation

13.1 FORMATION IN EMBANKMENT/CUTTING

Earthwork in formation and blanketing shall be carried out as per RDSO specification No. RDSO/2020/GE: IRS-004 September 2020 "Comprehensive Guidelines and Specifications for Railway Formation" and in accordance with the approved drawings.

The Contractor shall utilise excavated earth/rock from tunnel/cutting for formation in the stretch from Ch. 12000 m to Ch. 18000 m. For the balance earthwork, the Contractor shall arrange suitable borrow areas at his own cost and get them approved from the Engineer before using soil from such borrow areas.

Soils mentioned in Clause 3.7 (a) of the RDSO Guidelines shall not be used.

SQ-1 type of soils shall not be used in prepared subgrade and top layer of subgrade.

MDD in laboratory shall be determined by using Heavy Proctor test as per IS 2720 Part-16.

MDD achieved in the field compaction trial shall not be less than 98% of the MDD achieved in laboratory.

Degree of compaction of soil in prepared subgrade/top layer of subgrade shall not be less than 98% of MDD achieved in field as a result of Field Compaction Trial.

After completion of earthwork slope shall be dressed in final profile by cutting the extra earth and compacted with vibratory rollers of approved capacity and make as per RDSO guidelines.

Blanketing material shall be as per RDSO Guidelines.

The type of test, frequency and acceptance criteria for quality check of earthwork and blanketing shall be as given in Chapter 7 of RDSO Guidelines.

Before laying the coir netting for slope protection, the slope shall be levelled, fertilised and a dose of seed broadcasting of locally available suitable type of grasses shall be done. Thereafter, coir netting shall be laid on the prepared slope surface firmly in the direction of water flow and flushed to the ground ensuring that the runoff would flow over the nettings. The netting shall be secured against displacement by an overlapping of 5 cm to 8 cm and stitched or pegged down with 15 cm long steel nails about 1 .0 m apart. The top and bottom ends of the fully stretched coir netting shall be fixed/anchored in trenches of 50 cm depth. Afterwards, another dose of seed broadcasting or dibbling of locally available grasses 15 to 20 cm apart, in rows shall be carried out.

NP-4 pipe of 450mm diameter, conforming to IS 458, shall be provided at about 500m interval throughout the alignment in embankments having fill heights upto 5m *including ballast cushion of 350mm*. In embankments having fill heights more than 5m *including ballast cushion of 350mm* precast RCC box of 500mmx500mm clear size shall be provided for the purpose of future utilities. Installation conditions for the pipe shall be designed as per the IS-783, according to the fill height.

Site drains, catchwater drains, drains on berms, chutes on slopes of banks/cuttings, sumps shall be constructed as per approved drawings in accordance with the ***Annexures OCS-1 and OCS-2.***

Chapter 14

BRIDGES

14.1 General

14.1.1 Scope of Specifications

This specification shall be applicable for carrying out bridge works.

14.1.2 Applicable Standards

The applicable standards shall be as follows:

a) Indian Railway Standard Codes and Specifications (IRS)

i. Bridge Rules
ii. Concrete Bridge Code
iii. Steel Bridge Code
iv. Well and Pile Foundation Code
v. Fabrication Specification No. B1-2001
vi. Specification No. B-2 for Steel Structures (other than Girder Bridges)-Part 3.
vii. Welded Bridge Code
viii. Bridge Sub-structure & Foundation Code
ix. Specification No.M-28, Classification, testing and approval of metal arc welding electrodes for use-Indian Railway
x. Specification No.M-29, Classification, testing and approval of submerged arc welding with flame combination
xi. Indian Railways Unified Standard Schedule of Rates - 2019
xii. Indian Railways Unified Standard Specification (Formation Works, Bridge Works & P.Way Works) - 2019
xiii. Indian Railways Permanent Way Manual (IRPWM)
xiv. Indian Railways Works Manual (IRWM)
xv. Indian Railways Bridge Manual (IRBM)
xvi. Indian Railways Engineering Code
xvii. Manual on the design and construction of Well and Pile foundations
xviii. Indian Railways Schedule of Dimensions (BG)
xix. IRS Seismic code for Earthquake Resistant Design of Railway bridges.

b) RDSO Guidelines

i. BS-113 Guidelines for providing Arrangements for Bridge Inspection
ii. Comprehensive Guidelines and Specifications for Railway Formation:

RDSO/2020/GE: IRS 0004.

iii. Report No. GE: R-50: Transitional System on approaches of bridges

iv. Report No. BS-111: Guidelines for use of High Strength Friction Grip (HSFG) bolts on bridges on Indian Railways

v. Guidelines for design of Spherical and Cylindrical bearings (in case of Steel Bridges).- RDSO/CBS/Bearing dated 22-06-2011

vi. RDSO drawings for H-beam sleepers

vii. Report No. BS 115 : Guidelines for Composite Construction Including Stud Shear Connectors

c) Indian Standards Codes and Specifications (IS)

i. IS: 456 Plain and reinforced concrete - code of practice

ii. IS: 800 Code of practice for General Construction Steel

iii. IS: 875 Code of Practice for Design Loads Part 1, 2 3, 4& 5 (Other than Earthquake)

iv. IS: 1080 Design and construction of shallow foundations in soils (other than raft ring and shell)

v. IS: 1367 Technical Supply Conditions for Threaded Steel Fasteners

vi. IS: 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces code of practice

vii. IS: 1489 Specification for Portland pozzolana cement (Fly ash based)

viii. IS: 1786 High strength deformed steel bars and wires for concrete reinforcement

ix. IS: 1904 Design and construction of Foundations in soils: general requirements.

x. IS: 2062 Specifications for weldable Structural steel

xi. IS: 2502 Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement

xii. IS: 2911 Design and Construction of Pile Foundation - Code of practice Part1 Concrete Pile- Section 2 Bored Cast-in-situ-piles

xiii. IS: 2911 Design and Construction of Pile Foundation- Code of practice Part1 Concrete Pile- Section 4 Precast Concrete Piles in Prebored Holes

xiv. IS 2911 Design and Construction of Pile Foundation- Code of practice Part 4 Load test on piles

xv. IS: 2950 Design and construction of raft foundations

xvi. IS: 3935 Code of Practice for Composite Construction

xvii. IS: 4923 Hollow steel sections for structural use -specification

xviii. IS: 1161 Steel Tubes for Structural Purposes- specifications

xix. IS: 8009 Calculation of settlements of shallow foundations

xx. IS: 269 Specifications of OPC cement

xxi. IS: 9103 Specifications of Concrete admixtures

xxii. IS: 12070 Code of practice for Design and construction of shallow foundation on Rocks

xxiii. IS: 14593 Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks.

xxiv. IS 455 Specifications for portland slag cement

d) Other Standards

i. CPWD specifications, (Vol 1 & 2) -2019

ii. Delhi Schedule of Rates, (Vol 1 & 2) - 2021

iii. UIC Code 772-2 (R) Code for the use of rubber bearings for rail bridges

iv. IRC:83-2018 (Pt. II) - Standard Specifications and Code of Practice for Road Bridges (Section – IX) Bearings (Elastomeric Bearings)

v. IRC:83-2014 (Pt. IV) - Standard Specifications and Code of Practice for Road Bridges (Section – IX) Bearings (Spherical and Cylindrical)

vi. ISO 6892 – Tensile Testing of Metallic Materials

vii. ISO 13918-2008 – Welding- Studs and Ceramic Ferrules for Arc Stud Welding

14.2 Bridge Works: Substructure

14.2.1 GENERAL

a) Coverage

The Specifications given in this chapter deal with items pertaining to all types of foundations for bridges and bridge superstructure viz., Piers, abutments, wing walls, bed blocks and ballast walls / dirt walls.

14.2.2 Setting out for foundations

a) Setting out for Minor Bridges and Culverts

shall be carried out by a competent / qualified engineer, employed by the Contractor and checked by the Engineer's representative for all bridges and culverts. Contractor shall provide necessary instruments, linear tapes, pegs etc.

The setting out for foundations and sub-structure shall be carried out with a theodolite and steel tapes / Invar tapes in case of works not involving deep foundations or standing water. All levels will be measured using a precise

levelling instrument. Errors in location of piers / abutments and fixing levels shall be within following limits:

Linear Measurements	±5 mm
Levels	±3 mm

b) Setting out for Major Bridges

i. Locations of piers and abutments along with the centre line of the bridge should be accurately laid out by establishing one or more base lines as directed and a system of pegs and posts. Also sufficient reference pegs and pillars should be established for checking the positions with ease during progress of work. Reference Bench Marks for levelling should be established nearby on a permanent structure or on a pillar to be built up in vicinity.

ii. The principal reference lines and level pegs should be established at easily accessible locations. They include-

1) Longitudinal Centre line

2) Transverse Centre lines of abutments and piers

3) Tangent points of the curve at either end, if alignment is on a curve.

iii. For Bridge Works involving deep excavations, pile driving or well sinking and / or where there is standing water, use of base line is obligatory. They should be preferably at right angle to centre line of bridge, with one on either end on high bank in case of long bridges or on one side bank of bridge for shorter ones.

iv. In case of bridges of length exceeding 1000 Metres, base lines and reference towers will have to be established. Provision of all assistance in form of measuring instruments, linear tapes as may be required by the surveyor, technical and skilled staff and labour required to assist them, fixing pegs, pillars and towers including all building materials and maintaining and guarding them including supply of all materials, tools and plant shall be done by the Contractor at his cost. Nothing extra will be payable to them on this account. Important points to be observed in this activity are:

1) Linear Measurement shall be carried out with invar tape or electronic distance measuring instruments

2) Spring balances shall be used for giving specified tension to the tape. Tape readings shall be corrected for tension, temperature and slope.

3) Concrete pillars with steel plates fixed over them shall be located at intermediate points (at tape lengths) and ends.

4) Reference pillars at pier and abutment position along centre lines and reference pillars on base lines shall be to standards to be prescribed by the Engineer. During construction, since centre line pillars at abutment

/ pier locations will be disturbed, reference pillars and lines shall be fixed around each structure by the Contractor under Site Engineer's supervision. Reference diagrams at Annexures 4/1 and 4/2 and Clause 401 of IRBM shall be referred to for more details.

14.3 Soil Exploration

Soil exploration and test shall be carried out conforming to Indian Railways Codes and Specifications according to soil type, foundation type and site requirement.

14.4 Earthwork in excavation

Excavation shall be made only to the exact depth as shown on the drawings. In the event of excavation having been made deeper than that shown on the drawing or as ordered by the Engineer, the extra depth shall be made up with M10 concrete in case of foundation resting on soil and with concrete of the same grade as that of the foundation, in case of foundation resting on rock.

14.5 Method Statement

The Contractor shall submit Method Statement for carrying out the work of excavation in foundations and flooring etc. suiting to local ground conditions and safety measures conforming to IS: 3764 (Excavation Work- Code of Safety) to the Engineer for approval. The work shall be carried out strictly in accordance with the approved Method Statement and drawings.

14.6 Site Clearance

Site clearance shall be done as per the Contract.

14.6.1 Setting Out

After the site has been cleared, the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the drawings or as directed by the Engineer. The Contractor shall be responsible for the setting out of works and the establishment and maintenance of benchmarks, other marks & stakes as long as in the opinion of the Engineer, they are required for the work.

a) Excavation shall be carried out in all types of soil encountered at site and to the lines, levels and profiles shown on the drawings that have NONO from the Engineer. The Work shall be carried out by the Contractor in such a way as to avoid soil erosion and groundwater pollution, accidents in habitational or frequented places, disturbance to the surrounding ground or structures, accident to workmen and any other untoward incident. Fencing, caution signages with red lights and other safety measures shall be employed to avoid accidents. Where necessary, signal men shall be employed to guide the movement of people, vehicles and equipment.

b) The work shall be carried out in a careful manner to ensure that the exposed surfaces are as sound as the nature of the material permits and that no point shall protrude inside the lines shown on the Drawings.

c) The Contractor shall be responsible for the safety and stability of all excavations performed by him or under his control. In case of any slips or blows in the excavation, the same shall be cleared by the Contractor at his own cost.

d) The Contractor shall notify the Engineer without delay of any permeable strata, joints, faults, fissures or unusual ground conditions encountered during excavation and any excavation instability and/or collapse.

e) The Contractor shall ensure that no air pollution takes place during excavation, storage and transportation of earth/spoil by providing suitable measures such as appropriate cover and the like.

f) The Contractor shall carry out ground stabilization measures without delay before and/or after excavation, if required.

g) The Contractor shall make provision for all shoring, de-watering, dredging, bailing out or draining water whether subsoil or rain or other water and the excavation shall be kept free of water while concrete work is in progress until the Engineer considers the work well set. The sides of trenches shall be kept vertical and the bottom level throughout or properly stepped as directed by the Engineer. No extra payment shall be made on this account.

h) De-watering shall be carried out by suitable means with adequate stand-by arrangements as may be approved by the Engineer. The Contractor shall be deemed to have satisfied himself with regard to feasibility of all aspects of de-watering including site constraints due to existing structures. Though the method of de-watering is left to the Contractor, he shall be required to submit method statement of de-watering scheme including requisite justifications to obtain approval from the Engineer.

i) Approval of the Engineer, however, shall not relieve the Contractor of the responsibility of adequacy and appropriateness of de-watering and protection arrangements for the quality and safety of the work.

j) The Contractor shall erect and maintain during progress of works temporary fences/ barricading around the work area with all safety measures as shown in Reference Information/Reports. The excavations near habitations, public movement areas and all works along the roads shall be provided with proper caution signs and marked with red lights, reflectors at night to avoid accidents. The Contractor shall take all adequate protective measures to see that excavation operations do not affect or damage adjoining structures.

k) Disposal of muck: The surplus excavated material (that cannot be used in the Works), shall be treated as Contractor's property. The Contractor shall be free to take away and make use of this surplus excavated material in the manner he wishes to, including disposal in spoil dumps or elsewhere as approved by the Engineer/concerned parties and regulating authorities. The Employer takes no responsibility for the arrangement of dumping areas and these will have to be arranged by the Contractor at his own cost. The Contractor is required to carry out detailed survey to identify dumping areas, clearances required, leads

involved etc. The quoted rates shall be deemed to have taken all these factors into account. The excavated material that can be used in the Works, shall be temporarily stockpiled, if required, in a dump site as proposed by the Contractor and agreed by the Engineer and the concerned regulating authorities. Any royalty, if to be paid to local authorities on the excavated material, is to be borne by the Contractor at his own cost irrespective of whether the excavated material is used for the Works or being used for any other purpose or being disposed off as surplus. Truck drivers shall be trained and educated by the Contractor to follow the traffic rules.

l) The Contractor shall ensure that traffic management on roads and railways is carried out in accordance with the *Employer's Requirements*.

14.6.2 Excavation beyond True Lines and Levels

If due to any cause whatsoever excavations are carried out beyond their true line and level, the Contractor shall make good excavation at his own cost to the required line and level with the appropriate grade of filling or with concrete subject to the NONO from the Engineer.

14.6.3 Backfill to Structures

a) Prior to commencement of backfill, the Contractor shall submit Method Statement for carrying out work such that the optimum use may be made of excavated material and obtain approval from the Engineer. The proposals shall include details of the compaction plant and methods for adjusting the moisture content of the material.

b) No filling shall commence until approval has been received from the Engineer.

c) The Contractor shall not backfill around structures until the structural elements have attained adequate strength.

d) The backfill material shall be selected excavated material, thoroughly compacted mechanically in layers not exceeding 300mm loose thickness to achieve a density of at least 90% of the maximum dry density.

14.6.4 Tolerance

Permissible Tolerance for excavation

Item	Standard value (mm)
Finished depth of excavation	±25
length/width	0 to +50

14.7 Bored cast in-situ Piling

Piling shall be carried out by hydraulic piling rig.

14.7.1 Method Statement

The Contractor shall submit Method Statement for carrying out the work of piling. The work shall be carried out strictly in accordance with the approved Method Statement, Manual on the design and construction of Well and Pile foundations, the Specification and the Drawings.

14.7.2 Materials

a) **Concrete**

Piles shall be constructed in accordance with the details shown in the drawings using the grade of concrete indicated, produced and placed in accordance with provisions of Annexure OCS-1 of these specifications.

b) **Reinforcement Steel**

Reinforcement steel shall comply with the provisions of **Annexure OCS-2** of these specifications.

c) **Temporary Casings**

Temporary casings, as approved by the Engineer, shall be used to maintain the stability of pile bore hole. Temporary casings shall be free of distortion and shall be of uniform cross-section throughout each continuous length. During concreting, they shall be free of internal projections and encrusted concrete which may prevent proper formation of the pile.

d) **Stabilizing Material**

The stabilizing material to maintain the sides of pile bores shall preferably be natural drilling mud. If natural mud is not available, then stabilizing fluid having bentonite, controlled with a polymer like CMC (Carboxyl Methyl Cellulose), shall be used. The stabilizing material shall be approved by the Engineer. Bentonite, when used, shall conform to IS 2911 (Part 1/ Section 4).

14.7.3 Pile Installation

a) **General**

i. Bored cast-in-situ concrete piles shall conform to IS 2911 (Part 1/ Section 2), where not contravening to the following provisions. Based on borehole reports and drawings, installation of piles shall be carried out as per pile layout drawings, installation criteria, approved Method Statement and instructions of the Engineer. Any changes to the pile design, based on test-piles results, bore-hole data or soil conditions encountered during boring, shall be as instructed by the Engineer.

ii. The equipment and accessories for installation of piles shall be selected giving the due consideration to the sub-soil conditions, ground water conditions and type of founding material. These shall be of standard type and shall have been approved by the Engineer.

iii. Before installing the initial test pile, the Contractor shall finalise the pile

testing arrangement and obtain approval of the Engineer.

iv. It is envisaged that the working piles shall be installed after the successful completion of the initial pile load test.

v. In case the Contractor desires to install the working pile, pending successful completion of initial pile load test, he may be permitted to do so, provided he gives undertaking to the Engineer to bear all associated risks and costs involved to make up for the short falls in the pile capacity, in the event of the failure of the initial pile load tests to establish specified 'Design Ultimate Load' carrying capacity of initial test pile.

vi. The Engineer reserves the right to reject any pile which in his opinion is defective on account of less carrying capacity, structural integrity, position, alignment, concrete quality etc. Piles that are defective shall be pulled out or left in place as judged convenient by the Engineer, without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles, as per the directions of the Engineer, at no additional cost to the Employer. Further, the cost of additional piles and increase in the pile cap size, if any, on account of additional piles, shall be borne by the Contractor.

vii. Each pile shall be identified with a reference number and shall be as shown in the Drawings. The convenience of installation may be considered while scheduling the sequence of piling in a group.

viii. In a pile group, the sequence of installation of piles shall normally be from the center to the periphery of the group or from one side to the other.

ix. Level marks shall be accurately painted on each pile immediately after its installation. Subsequently, if any pile displays any tendency to heave up due to installation of other piles or due to any other reasons, the same shall be reinstalled firmly as per the directions of the Engineer without any additional cost.

x. The Contractor shall record all the information during installation of piles, including pile-bore observations before concreting each pile. The data sheet for recording pile data shall be as approved by the Engineer. On completion of each pile installation, pile record shall be submitted to the Engineer within two days of completion of concreting of the pile.

b) **Control of Position and Alignment**

Piles shall be installed as accurately vertical as possible. The permissible tolerances with respect to position and inclination/alignment are as shown below:

Tolerances

No	Item	Permissible	Figure
1	Level of top i.e. Cut-off-Level (m)	-25mm to 25mm	
2	Position of the head in plan at Cut-off-Level (d)	75mm or less	
3	Embedded depth in bearing stratum (l)	Design value or more	
4	Diameter of the pile (D)	Design value or more	
5	Variation from vertical at Cut-off-Level (v)	1.5% or less	

c) **Pile Boring**

i. Boring Operation:

i) Boring operations shall be done by rotary hydraulic feed drilling rigs with reverse mud circulation or other suitable boring methods that have been approved by the Engineer. The boring or drilling equipment shall have suitable and adequate accessories for boring or drilling through all types of strata expected at site.

ii) The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm. However, the pile bore shall be of the specified size.

iii) The boring centre shall be aligned with the pile centre and the boring machine shall be installed so as not to move or incline. The sides of the bore-hole shall be stable throughout.

iv) Working level shall be above the Cut-off-Level. After the initial boring of about 1.0 m, temporary guide casing of suitable length shall be lowered in the pile bore for vertical pile. The diameter of guide casing shall be such as to give the necessary finished diameter of the concrete pile. The centre line of the guide casing shall be checked before continuing further boring. Guide casing shall be minimum of 1.0 m length. Additional length of casing may be used depending on the condition of the strata, ground water level etc.

v) The temporary guide casing (if provided) shall be withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing, concrete shall not be disturbed.

vi) For providing permanent MS liner, Clause 709.1.4 of IRC:78 shall be complied with. Whenever stricter provision has been given in the drawings, the same shall be followed.

vii) If boring operation becomes difficult before reaching the predetermined depth, further plan of action shall be submitted by the Contractor and approval shall be obtained from the Engineer for the same. The piles shall be founded on rock or other suitable strata as approved by the Engineer.

ii. Maintaining the bore hole:

i) For maintaining bore hole wall while boring, a stabilizing material, according to the soil shall be used and the level of the stabilizing fluid shall be maintained at not less than 2.0 m above the ground water level or at such other level as will ensure that the fluid pressure is at all times in excess of pressures exerted by the soils and external groundwater. The stabilizing fluid shall be under constant circulation till start of concreting. The level of stabilizing fluid for all piles shall be recorded by the Contractor and reported to the Engineer, including the confirmation of the bore-hole wall shape after boring. Where temporary casings or an alternative method for maintaining stability of a boring are used, these shall be subject to the Engineer's approval.

ii) Consistency of the stabilizing material suspension shall be controlled throughout concreting operations in order to keep the bore stabilized, as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

iii) When the boring is done by rotary drilling rigs, the verticality of Kelly bar shall always be maintained. In the soil layer such as sandy soil layer where the bore hole tends to collapse, care shall be taken to ensure the drilling bucket does not hit the hole wall. While boring in the founding soil layer, the drilling bucket shall be raised at appropriate speed to prevent loosening of the soil by suction.

iii. Stabilizing material management:

In addition to the requirements that are already stated, the following shall be considered:

i) The stabilizing material shall be controlled so as to prevent pile-bore wall collapse and ensure the quality and shape of the concrete.

ii) While boring, the Contractor shall periodically check the properties of the stabilizing material and control the management items (specific gravity, marsh funnel viscosity, pH, etc.) to be within the values set in the Method Statement that has been approved by the Engineer.

iii) Stabilizing fluid shall comprise of bentonite, complying with the specifications of IS 2720, IS 2911 (Part 1/ Sec2; ANNEX D) or

otherwise approved by the Engineer, thoroughly mixed with clean fresh water along with the required Polymer like CMC, to form a suspension meeting the specification requirements as submitted to and consented by the Engineer.

iv) The Contractor shall obtain manufacturers' certificates of the bentonite powder consigned to the Site giving properties of each consignment and shall submit them to the Engineer prior to commencing the work and whenever required.

v) The frequency of testing stabilizing material and the method and procedure of sampling shall be proposed by the Contractor and approved by the Engineer prior to the commencement of piling work. Such control tests on the bentonite suspension as required or as approved by the Engineer shall be carried out during the piling work.

vi) Prior to concreting a pile, the Contractor shall take measures to remove any heavily contaminated stabilizing material which could impair the free flow of concrete from the tremie pipe. Placing of concrete shall proceed only with due modification as per consent of the Engineer.

vii) All reasonable steps shall be taken to prevent the spillage of bentonite suspension in the Site in areas outside the immediate vicinity of boring.

iv. Confirmation of bearing stratum for termination level:

i) Confirmation of the support layer shall be carried out by boring depth and comparing excavated soil and soil survey material. Also, the pile designated as per approved Method Statement or by the Engineer shall receive necessary confirmation.

ii) The boring depth shall be measured at two or more places to the bottom of the hole immediately after completion of boring operations. The results shall be reported promptly.

iii) A protocol shall be maintained regarding the strata at the founding level, Standard Penetration Test (SPT) value, percent core recovery, Unconfined Compressive Strength (UCS) from the nearest borehole, socketing horizon, flushing of pile bore, time interval between end of boring and start of concreting, bentonite density prior to the commencement of concreting.

v. Cleaning of pile bore just after boring:

i) After completion of the pile bore up to the required depth, the pile bore shall be cleaned of loose, disturbed or re-moulded soil from the base of the pile.

ii) The cleaning shall preferably be achieved by three stages flushing of slurry using airlift technique, as per approved Method Statement. The bottom of the pile bore shall be thoroughly cleaned by airlift technique. Cleaning shall ensure that the pile bore is completely free of sludge or bored material, debris of rock or boulder etc. Necessary checks shall be made to ensure the thorough cleaning of the pile bore.

iii) Concreting operations shall not proceed if the contaminated stabilizing material at the bottom of the pile bore possesses a density of more than 1.12 g/ml. The stabilizing material sample shall be collected from the bottom of pile bore. For this a solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage, while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

iv) When the boring is done by rotary drilling rigs, cleaning-bucket attached to the Kelly shall be used for cleaning the bore. Wherever stabilizing material is used, after using the cleaning-bucket, the bore shall be flushed with fresh slurry.

v) The Contractor shall measure the final depth after this cleaning and confirm its effect by comparing with the depth at the end of boring.

vi. Cleaning of pile bore just before concreting:

i) Pile bore shall be cleaned by fresh stabilizing material through tremie pipe or as specified in the Method Statement, before (in case delay in concreting after the completion of bore) and after placing the reinforcement cage and just before the start of concreting. Pile boring shall be inspected and approved by the Engineer, in accordance with approved Method Statement, before concreting.

ii) The Contractor shall measure the final depth after this cleaning, when there is a delay in concreting after completion of the bore, for knowing the casting pile length, and confirm its effect by comparing with the depth at the end of boring.

vii. Other relevant considerations for pile boring:

i) Care shall be taken not to harm a recently concreted pile due to driving the casing nearby before the concrete has sufficiently set in that pile. The danger of doing harm is greater in compact soils than in loose soils.

ii) For bored holes, the finishing and cleaning of the bore, lowering of reinforcement cage and concreting of the pile for full height must be accomplished in one continuous operation without any stoppage.

iii) Pumping from a boring shall not be permitted unless approval has been issued by the Engineer.

iv) A pile excavation shall be backfilled without delay where a rapid loss of drilling fluid occurs and no further excavation at the location of that pile shall be carried out until the Engineer's approval is obtained.

v) After each pile has been cast, any empty bore which may remain shall be protected and carefully backfilled as soon as possible to the satisfaction of the Engineer.

vi) Carriage and Disposal: The bored spoil material and contaminated mud and bentonite slurry shall be disposed at the designated areas identified by the Contractor and as per the procedure approved by the Engineer and as mandated by other relevant Contract provisions.

d) **Concreting**

i. Cast-in-Situ pile concreting shall conform to provisions of **Annexure OCS-1** of these Specifications and the relevant provisions of IS 2911 (Part 1/ Sec 2), where not in contravention to the following provisions.

ii. Concreting shall not be done until the Engineer is satisfied that the termination level of pile, is as per the installation criteria and the Method Statement that has been approved by the Engineer.

iii. Concrete in the pile shall be coherent, rich in cement with high slump and restricted water cement ratio. The slump of concrete shall vary between 150 mm to 180 mm for bored piles. For long or large diameter piles, use of retarding plasticiser in concrete is desirable.

iv. The time interval between the completion of boring and placement of concrete in pile bore shall not exceed 6 hours. In case the time interval exceeds 6 hours, the pile bore shall be abandoned. However, the Engineer may allow concreting provided the Contractor extends the pile bore by 0.5 m beyond the termination level and clean the pile bore. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

v. The concrete shall be properly graded, self-compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silty clays and other soils which have the tendency to squeeze into the newly deposited concrete and cause necking. Adequate head of green concrete shall be maintained to prevent inflow of soil or water into the concrete.

vi. Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS 2911 (Part 1/ Sec 2). Stabilizing material shall be maintained sufficiently above the ground water level, as specified elsewhere in this Specifications.

vii. Concreting by tremie shall continue to allow the initial pours of concrete,

mixed with stabilizing fluid, sludge and cut spoils from the bore to overflow and the consistency and quality of the overflowing concrete is comparable to that of design mix. The length of overflow shall be decided by the Engineer.

viii. It shall be ensured that the volume of concrete poured is at least equal to the theoretically computed volume of the pile shaft being cast.

ix. The tremie shall have uniform and smooth cross-section inside. The tremie shall be water-tight throughout its length and have a hopper attached at its head by a water-tight connection. All tremie tubes shall be scrupulously cleaned before and after use.

x. While concreting the tremie shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal.

xi. An adequate quantity of concrete within the pipe shall be maintained at all times to ensure that the pressure from it exceeds that from the water or drilling fluid.

xii. The tremie pipe shall be lowered to the bottom of the bore-hole, allowing water or stabilizing material to rise inside it before pouring concrete. The tip of the tremie pipe shall not be separated from the bottom of the hole more than necessary (when plunger is used, it is about 0.2 m or less from the hole bottom)

xiii. The tremie pipe shall always be kept full of concrete and shall penetrate well into the concrete in the borehole, at least 2 m or more, with adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

xiv. During concreting, the cycle time of concreting, concreting volume, concrete placement height and the height of the tremie pipe tip in concrete shall be checked for all the piles and reported in a format that has been approved by the Engineer.

xv. To prevent the reinforcement cage from floating during placement of concrete, appropriate countermeasures shall be made in advance, as per the Method Statement that has been approved by the Engineer. The same shall be monitored for all piles and reported.

xvi. Temporary casings, when used, shall be extracted carefully to the satisfaction of the Engineer, whilst the concrete is sufficiently workable to ensure it is not disturbed or lifted, and the reinforcement cage does not get disturbed. During extraction, sufficient quantity of concrete shall be maintained inside the casing to overcome the pressure from external water, soil or stabilizing material and to ensure that no reduction in section by way of necking or shearing of concrete and contamination of the pile takes place.

xvii. Segregation of the ingredients shall be prevented. The displacement or distortion of reinforcement during concreting shall be avoided. If the concrete is placed inside precast concrete tubes or consists of precast sections, subject

to the approval of the Engineer, these shall be free of cracks or other damage before being installed.

xviii. While concreting uncased piles, voids in concrete shall be avoided and adequate head of concrete shall be maintained to prevent inflow of soil or water into the concrete. It is also necessary to take precautions during concreting to minimise the softening of the soil by excess water. Uncased cast- in-situ piles shall not be allowed where mudflow conditions exist.

xix. Where concrete is placed in dry borings, measures, subject to approval of the Engineer, shall be taken to avoid segregation and bleeding and to ensure that the concrete at the bottom of the pile is not deficient in grout.

xx. Where enlarged bases are required, as per site conditions and as approved by the Engineer, these shall be mechanically formed and shall be concentric with the pile shaft within a tolerance of 10% of the shaft diameter and shall not be smaller than the required dimension. The sloping surface of the frustum forming the enlargement shall make an angle of not less than 55° to the horizontal.

xxi. Grouting at base of pile shall be done wherever the results of proof coring (in case of rock), sonic logging and/or loading test etc. confirm that there is a void/ sludge at the pile base. The grouting shall be done with cement slurry under suitable pressure after concrete in the pile attains the desired strength, if required by the Engineer. For this purpose, conduit pipes with easily removable plugs at the bottom end shall be placed in the bore along with reinforcement cage before concreting

14.7.4 Top of Concrete in Pile, Cut-off-Level (COL):

a) Cut-off-Level of piles shall be as indicated in the drawings.

b) The top of concrete in pile cast shall be above the Cut-off-Level by 1.0 m (minimum) and as per the Method Statement, to remove all laitance and weak concrete and to ensure good concrete at Cut-off-Level, for the proper embedment into the pile cap. Any exceptions, due to contingent situation, will be subject to the approval of the Engineer.

c) Preparation of pile head: The area surrounding the piles shall be excavated up to the bottom of the pile caps. After seven days of concreting of pile, the exposed part of concrete above the COL shall be removed or chipped off and made rough at COL. In case a part of extra-pile concrete before curing is handled, the Contractor shall obtain prior approval from the Engineer. The projected reinforcement above COL shall be properly cleaned and bent carefully, only where required, to the required shape and level to be anchored into the pile cap as per the drawing. While finishing the pile head, care shall be taken to ensure no harmful damage, such as cracks, occurs in the concrete. The pile top shall be embedded into the pile cap by 150 mm as per the Drawings and as agreed by the Engineer. All loose material on the top of pile head after chipping to the desired level shall be removed and disposed as per contractual procedure and as directed by the Engineer.

14.7.5 Reinforcement Steel

a) Reinforcement steel, along with its inspection and testing shall conform to Annexure – OCS-2 of these Specifications, along with IS 2911 (Part 1/ Sec 2) and used as per the drawings.

b) The reinforcement shall be assembled before placing in the moulds and all hoops and links shall be of uniform length firmly wired into position. Ends of helical reinforcement, if used, shall be firmly secured. Diagonal fork spacers shall be of a pattern that has been approved by the Engineer.

c) Lap joints in main longitudinal bars will be permitted only when, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided at agreed centres, designed to develop the full strength of the bar across the joint, provided with adequate links or stirrups and staggered in position from those of adjacent longitudinal bars or as indicated in the drawings, subject to the approval of the Engineer.

d) The 'L' bends in the reinforcements at the bottom of the piles shall not be provided to avoid the formation of soft toe.

e) Jointing of Reinforcement Steel for Piles: Only lap joints shall be provided as shown in the drawings.

f) Lowering of the reinforcement cage:

   i. The reinforcement cage shall be properly aligned with the pile core and kept vertical without collapsing the hole wall. In lowering of the reinforcement cage, it shall avoid deformations, damages, etc. by using reinforcing material as necessary. In the lap joint part of the reinforcement cage, the upper and lower cages shall be in a straight line, with the joints tightly bound.

   ii. Proper cover to reinforcement and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers cast specifically for the purpose, as directed by the Engineer. The longitudinal reinforcement shall project above Cut-off-Level as indicated in the drawings.

   iii. After lowering of the reinforcement cage, the height of the top end of the reinforcement shall be measured and reported. The axes of the reinforcement cage and the pile core shall be matched, checked and reported.

14.7.6 Breaking off of Piles

If any pile already cast requires breaking due to subsequent change of Cut-off-Level, then the same shall be carried out, not before seven days of casting without affecting the quality of existing pile, such as loosening, cracking etc., and to the satisfaction of the Engineer.

14.7.7 **Pile** Caps

The ground shall be excavated, levelled, prepared and then layers of coarse aggregate and blinding concrete shall be constructed below pile cap. The pile cap shall then be cast as per the Drawings and conforming to Annexure OCS-1 and Annexure OCS-2 of these Specifications, subject to tolerances mentioned therein.

14.7.8 Tests on Piles

a) General

When preparing for conducting a pile test, the Contractor shall follow the requirements of the various acts, orders, regulations and other statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

b) Load Test on Piles

i. These Specifications covers the requirements for initial vertical load and routine vertical load tests on reinforced concrete single vertical piles of specified diameter to assess their vertical load carrying capacities. All pile load testing shall conform IS 2911 (Part 1/ Sec 4)

ii. Full details of the equipment proposed to be used, the test setup and pile testing scheme along with detailed design, drawings shall be submitted to the Engineer, before making arrangements to carry out the tests, for obtaining his approval. Approval of the Engineer shall also be obtained after the test setup is complete, prior to commencement of loading.

iii. The work shall include mobilization of all necessary equipment, kentledge, anchor piles and rock anchors, or combination of kentledge and anchor piles and rock anchors, providing necessary engineering supervision and technical personnel, skilled and unskilled labour as required, to carry out the complete pile testing and submission of test reports.

iv. In all cases, the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head the whole system will be stable up to the maximum load to be applied.

v. Necessary means shall be provided to enable dial gauges to be read from a position clear of the kentledge stack or test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure and so on might constitute a hazard to personnel.

vi. The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of one and a half times the maximum working pressure without leaking.

vii. The maximum test load or test pressure expressed as a reading on the gauge

in use shall be displayed and all operators shall be made aware of this limit.

viii. Where kentledge is used, the Contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structures in such a manner that there will not be differential settlement, bending or deflection of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it falling apart, or becoming unstable because of deflection of the supports. The weight of kentledge shall be greater than the maximum test load and if the weight is estimated from the density and volume of the constituent materials, an adequate factor of safety against error shall be allowed.

ix. It is essential that all the equipment and instruments are properly calibrated both at the commencement and immediately after the completion of tests, so that they represent true values. If the Engineer desires, the Contractor at his own cost shall arrange for calibration of the instruments in presence of the Engineer, at a laboratory having Engineer's approval, and the test report and calibration certificate shall be submitted to the Engineer.

x. The complete jacking system including the hydraulic jack, hydraulic pump and pressure gauge shall be calibrated as single unit. The complete unit shall be calibrated over its complete range of travel for increasing and decreasing loads same as that of test loads. The calibration certificate shall be submitted to the Engineer.

xi. The reaction load to be made available for the test shall be at least 25% greater than the maximum jacking force. The reaction system as relevant shall be designed for the total reaction load. All reaction loads shall be stable and balanced during all operations of testing. During testing, stability of reaction system shall be ensured.

xii. The vertical displacement of pile shall be measured using dial gauges having a least count of 0.01 mm.

xiii. Load test shall be conducted at pile Cut-off-Level (COL). If the water table is above the COL, the test pit shall be kept dry throughout the test period by suitable dewatering methods.

xiv. In case of initial vertical load test, where the water table level is higher than the COL, the Contractor may use anchor piles and rock anchors for testing purposes. The Engineer, at his discretion, may decide to raise the COL above water table.

xv. All operations in connection with pile load test shall be carried out in a safe manner to prevent exposure of the people to hazard and also to ensure the safety of manpower and material.

xvi. Test record and report for pile load tests shall be as per IS 2911 (Part 1/ Sec 2) and as approved by the Engineer. The reports shall be submitted to the

Engineer immediately on completion of each test.

xvii. Two fixed independent benchmarks shall be established as reference points at least 15 m from the test pile to monitor the settlements.

xviii. If any initial pile load test gets abandoned and is not successfully completed, then the Contractor shall install another test pile and repeat the initial test after correcting the fault, at his own cost.

xix. On completion of a test all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in further tests or removed from the Site.

c) Test Pile Installation

i. Piles shall be installed as per Sub-Clause 3.5.3 herein above.

ii. Pile installation data as applicable shall be furnished along with the load test results to the Engineer.

d) Types of Tests

i. Initial vertical (compression) load test and lateral load test shall be carried out on test piles, which are not to be incorporated in the work, to assess the 'Ultimate Load Capacity of Pile' before the commencement of the installation of working piles.

ii. The test piles shall have the same design details as of the working piles typically adopted in the predominant soil profile in that area.

iii. Routine vertical (compression) load test and lateral load test shall be conducted to verify the load carrying capacity of working pile.

iv. Pile integrity test shall be carried out on each pile by The Low Strain Method as per IS 14893 to verify the structural integrity, shape and continuity of pile

e) Number of Tests:

i. **Initial pile-load tests:** The number of load tests shall be as per IS 2911 (Part 4) depending upon the total number of piles but not less than two (2). Wherever the soil strata are erratic or there is change in structure type (such as river bridge, rigid frame), additional tests shall be required as directed by the Engineer.

ii. **Routine pile-load tests:** The number of tests may generally be 0.5 percent of the total number of piles required, but not less than one (1). The number may be increased up to 2% depending upon the nature, type of structure and sub-strata condition.

iii. Initial and routine tests may be suitably increased for important structures or cases with large variation in the subsurface strata as directed by the Engineer.

iv. Pile load tests shall be carried as per IS 2911 (Part 4).

f) Testing-Piles

i. The testing-piles for routine load test shall be identified by the Engineer. For initial load test, testing-pile shall be installed as a test-pile, separate from working piles, as directed by the Engineer.

ii. A minimum time period of four weeks shall be allowed between the time of pile casting and testing. Testing-pile head shall be prepared for testing purposes only, one week after casting the pile.

iii. Testing-piles shall be cut off at the proper level and provided with a proper cap, to provide a plane bearing surface for the test plate and for proper arrangements for seating of the jack and dial gauges.

g) Static Vertical Load Test

i. The tests shall conform to IS 2911 (Part 4).

ii. Equipment and Test Setup

i) A steel plate of adequate thickness and not less than 50 mm shall be centered on the pile cap to prevent it from getting crushed under applied load. The size of the circular test plate shall not be less than the pile size nor less than the area covered by the base of the hydraulic jack(s).

ii) The datum bars shall be supported on immovable supports, preferably of concrete pedestals or steel sections, placed sufficiently far away from the test pile. The distance shall not be less than 3 times the diameter of testing-pile and in no case less than 2 metres from the edge of testing-pile. These supports shall be placed at an adequate depth below ground to be unaffected by ground movements.

iii. Loading System

The test load on pile shall be applied by means of hydraulic jack(s) which obtain reaction in one of the ways mentioned in Cl.7.1.3 of IS 2911 (Part 4).

The measurement of strains for load monitoring may also be done by load cell connected to a digital read out unit.

iv. Test Procedure

i) Application of Load:- The test should be carried out by applying a series of vertical downward incremental load each increment being of about 20 percent of safe load on the pile. For testing of raker piles it is essential that loading is along the axis.

ii) This is applicable for both initial and routine test. In this method application of increment of test load and taking of measurement or displacement in each stage of loading is maintained till rate of movement of the pile top is not more than 0.2mm/h or until 2 h has

elapsed, whichever is earlier subject to a minimum of 1 h. The test load shall be maintained for 24 h.

iii) Duration of vertical loading shall be as per Cl. 7.2 of IS 2911 (Part 4)

iv) Settlement:- Settlement shall be recorded as per Cl. 7.1.4 of IS 2911 (Part 4).

v) The safe vertical load on single pile for the initial test shall be as per Cl. 7.1.5 of IS 2911 (Part 4).

vi) Items to be measured:

The following items shall be measured:

- Time;
- Applied pressure;
- Applied load;
- Displacement at the pile head;
- Movement of reaction devices;
- Others, as decided by the Engineer.

vii) Commencement, interruption and completion of the test:

- The test shall be commenced after ensuring the conditions surrounding the site, preparations of all equipment and the suitability of the weather condition.
- If any abnormal conditions are noticed during the test, the test shall be interrupted promptly. The test can only be resumed when the cause of the abnormal condition has been detected and rectified.
- The test shall be completed when the objectives of the test shall have been achieved, or when it is judged that abnormal conditions make it impossible to continue the test.

viii) Loading on the pile shall be continued till as given in IS 2911 (Part 4).

h) Lateral load tests – Lateral load tests shall be carried out on test pile as well as on working pile safe load capacity determined as per Clause 8 of IS 2911 (Part 4).

i) Pile Integrity Test on Working Piles (other than piles subjected to routine load test):

i. Pile integrity test shall be carried out on each pile by The Low Strain Method as per IS 14893:2001. In case of large diameter piles, the tests shall be conducted at 5-6 places to cover the entire section of the pile.

ii. The tests shall be conducted on piles whose length is correctly recorded or on test piles where available, to determine the value of stress wave velocity and characteristic or reference signal for comparing the signals for testing subsequent piles.

iii. The area surrounding the pile should be free from standing water and kept dewatered during the tests. The pile head should be accessible.

iv. Testing should be free of work likely to cause disturbance. The cast-in-situ piles should not be tested normally before 14 days of casting.

v. The test piles, if available at site, can be used to determine the pulse velocity and characteristic or reference signal generated. Where no test pile is available information can be obtained from cast piles whose length is accurately recorded.

vi. Methodology for Low Strain Integrity test:

i) This is a system of assessing the integrity of piles by the use of low stress wave imparted to the pile shaft and is also known as Sonic Integrity or Sonic Echo Test. A small metal/hard rubber hammer is used to produce a light tap on top of the pile. The shock traveling down the length of the pile is reflected back from the toe of the pile and recorded through a suitable transducer/accelerometre (also held on top of the pile close to the point of impact) in a computer disk or diskette for subsequent analysis. The primary shock wave which travels down the length of the shaft is reflected from the toe by the change in density between the concrete and sub-strata. However, if the pile has any imperfections or discontinuities within its length these will set up secondary reflections which will be added to the return signal.

ii) The reflected stress wave can be monitored using either processing technique, the observed signals are amplified and converted into digital display as velocity versus length or frequency versus mobility records, providing information on structural integrity of piles. The stress wave velocity and approximate pile lengths are provided as input for the integrity testing. The stress wave velocity is dependent on the Young's modulus and mass density of pile concrete. This value generally lies between 3000-4000 metre per second depending on the grade of concrete used (M15-M25).

j) Sampling, Testing, Inspection, and Acceptance Criteria Including Construction Tolerances of Piles

i. Frequency of sampling, testing and quality assurance including the method of conducting the tests, acceptance criteria and construction tolerances shall be as mentioned herein above and included in the Method Statement that has been approved by the Engineer. The tests shall be performed and reported as per the Method Statement that has been approved by the Engineer.

ii. Forcible corrections for any deviations shall not be made to concrete piles.

iii. Data Reporting and processing

i) The assessment of structural integrity is based on two equally important aspects:

- Quality of signals, and
- Accurate analysis and interpretation of signal.

ii) Piles requiring remedial measures should be so marked immediately on completion of the field integrity testing and rectification measures selected.

iii) The final report should include signals of each integrity test and structural condition of piles.

iv. Submission of Results: Immediately after testing, a signed copy of all the raw data of a pile shall be given to the Engineer. A test report shall be submitted to the Engineer within 3 days after testing.

14.7.9 Safety

The Contractor shall adopt appropriate method and practice conforming to IS 5121 (Piling and other deep foundation - Code of Safety) suiting to local ground characteristics.

14.8 Formwork

Form work for bridge foundations, sub structure and superstructures shall be as per IS-3696, IS-4014 and Annexure OCS-1. It includes all temporary or permanent forms required for forming the concrete of the shape, dimensions and surface finish as shown on the drawing or as directed by the Engineer, together with all props, staging, centering, scaffolding and temporary construction required for their support.

14.9 Substructure

14.9.1 Piers and Abutments

a) Concrete and reinforcement for piers and abutments shall conform to relevant sections of these specifications and drawings. In case of concrete piers, minimum grade will be M 20 unless otherwise specified / approved. The number of horizontal construction joints shall be kept to a minimum. Construction joints shall be avoided in splash zones unless specifically permitted by the Engineer and provided they are treated in accordance with special provisions. No vertical construction joint shall be provided. Shear connectors in the form of vertical plumbs, dowels, bond bars or rail cut pieces shall be provided at all horizontal joints as directed by Engineer. The work shall conform strictly to the drawings or as directed by the Engineer.

b) In case of tall piers and abutments, use of slipform shall be preferred. The design, erection and raising of slip form shall be subject to special specifications which will be furnished by the Contractor. The concrete shall also be of higher grade and subject to additional specifications as necessary. All specifications and arrangements shall be subject to the approval of the Engineer.

c) The surface of foundation / well cap / pile cap shall be scraped with wire brush and all loose materials removed. In case reinforcing bars projecting from foundations are coated with cement slurry, the same shall be removed by tapping, hammering or wire brushing. Care shall be taken to remove all loose materials around reinforcements. Just before commencing masonry or concrete work, the surface shall be thoroughly wetted.

d) In case of solid (non-spill through type) abutments, weep holes as shown on the drawings or as directed by the Engineer, shall be provided.

e) The surface finish shall be smooth, except the earth face of abutments which shall be rough finished or left as form finished.

f) In case of abutments likely to experience considerable movement on account of backfill of approaches and settlement of foundations, the construction of the abutment shall be followed by filling up of embankment in layers simultaneously with filter backing behind to the full height to allow for the anticipated movement during construction period before casting of superstructure.

g) *Transitional system on approach road bridges as per guidelines of RDSO Report No. GE: R-50 shall be provided in bridge approaches of ballasted and non ballasted deck bridges having span equal to or more than 12.2m.*

14.9.2 Pier Cap and Abutment Cap (Bed Blocks)

a) Form work, Concrete and reinforcement shall conform to relevant paras of Concrete work & RCC of these specifications and the Drawings. Unless otherwise specified, minimum grade of concrete mix shall be M 35.

b) The locations and levels of pier cap / abutment cap / pedestals and bolts for fixing bearings shall be checked carefully to ensure alignment in accordance with the drawings of the bridge.

c) The surface of cap shall be finished smooth and shall have a slope for draining of water as shown on the drawings or as directed by the Engineer. For short span slab bridges with continuous support on pier caps, the surface shall be cast horizontal. The top surface of the pedestal on which bearings are to be placed shall also be cast horizontal.

d) The surface on which elastomeric bearings are to be placed shall be wood float finished to a level plane which shall not vary more than 1.5mm from straight edge placed in any direction across the area. The surface on which other bearings (steel bearings, pot bearings) are to be placed shall be cast about 25mm below the bottom level of bearings and as indicated on the drawings. Specified rich levelling mortar shall be provided over this at the time of placing of bearing.

14.9.3 Dirt / Ballast Wall, Return Wall and Wing wall

a) Dirt / ballast walls ,return wall & wing walls shall be in RCC. Minimum grade of concrete will be M35 unless otherwise specified. In case of cantilever return walls,

no construction joint shall generally be permitted. Wherever feasible, the concreting in cantilever return walls shall be carried out in continuation of the ballast wall.

b) For concrete return and wing wall, the surface of foundation shall be prepared in the same manner as prescribed for construction of abutment. No horizontal construction joint shall be provided. If shown on drawing or directed by the Engineer, vertical construction joint may be provided. Vertical expansion gap of 20mm shall be provided in return wall / wing wall at every 10 metre intervals or as directed by the Engineer. Weep holes shall be provided as prescribed for abutments or as shown on the drawings.

c) Form work, reinforcement and concrete in dirt / ballast wall shall conform to relevant sections of these specifications.

d) The finish of the surface on the earth side shall be rough/form finish while the front face shall be smooth finished.

e) Architectural coping for wing wall / return wall in brick masonry shall conform to Drawings.

14.9.4 Tests and Standards of Acceptance

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

14.9.5 Tolerances in Concrete elements

a) Variation in cross-sectional dimensions: + 10mm, -5mm

b) Misplacement from specified position in plan: + 10mm

c) Variation of levels at the top: + 10mm

d) Variations of reduced levels of bearing areas: + 5mm

e) Variations from plumb over full height: + 10mm

f) Surface irregularities measured with 3m straight edge

   i) All surfaces except bearing areas: 5mm

   ii) Bearing areas: 3 mm

14.9.6 For construction of Br Nos. 150 and 153 temporary diversion of existing roads will be required first. Then existing roads will be lowered by about 1.90 m at the site of the bridges and regraded to join the existing roads. Thereafter Br Nos. 150 and 153 will be constructed.

14.9.7 ***Well Foundation***

Well Foundation shall be constructed as per IRS Bridge Substructure & Foundation Code/ IRC: 78, IRS-CBC, Manual on the design and construction of well foundation.

14.10 Bridge Work : Superstructure

14.10.1 GENERAL

a) Coverage

This chapter covers specifications for the following types of superstructures:

i. RCC Box

ii. Prestressed concrete girders and slabs

iii. Steel- Open Web Girders (OWG) and Composite Girders

14.10.2 RCC BOX

All concrete works for RCC box shall conform to **Annexures OCS-1 & 2.**

14.10.3 STEEL Open Web Girders (OWG) and Composite Girders

Fabrication and erection of steel girders shall conform to **Annexure OCS-3**.

Concrete and reinforcement for composite girders shall conform to **Annexures OCS-1 & 2**.

14.10.4 PRE-STRESSED CONCRETE GIRDERS AND SLABS

All prestressed works for bridges shall be carried out in accordance with **Annexures OCS-1 to 4**. PSC slabs of 12.2 m span shall be cast on a prepared casting bed and shall thereafter be launched in position after prestressing using suitable capacity crane.

Chapter 15

BALLASTLESS TRACK

15.1 GENERAL

a) BLT in tunnel has to be laid over the tunnel invert concrete base.

b) Electrical Interface: The plinth electrical continuity is essential, for which purpose the Contractor shall supply and install suitable connection.

c) The opposite electrical continuity between rail bases shall be checked by means of a low resistance continuity apparatus (10V-100 amp) in presence of the Engineer.

d) Detailed specification for RCC to be used *in construction* shall be as per *Annexure OCS-1 & Annexure OCS-2*

15.2 BALLASTLESS TRACK INSTALLATION

15.2.1 GENERAL

i. The track gauge throughout shall be 1673 mm (nominal) measured between the running edge gauge point of each rail and normal to the Centre line of the track 14 mm below top of rail.

ii. All main line track shall be laid with 1:20 inward rail slope.

15.2.2 RAIL JOINTING

i. All rail joints throughout the main lines glued insulated joints, switch expansion joints etc. shall be welded.

ii. The welding of nominal rail lengths into long welded rail panels for main lines shall be done with Mobile Flash butt welding machine approved by RDSO. Wherever the Mobile Flash Butt welding is practically not possible the Alumino-thermit welding can be done in accordance with RDSO specification.

15.2.3 RAIL EXPANSION JOINTS

i. Particular attention shall be given to ensure that rail expansion joints are assembled and installed in accordance with the Drawings and correctly located with relation to the type of Rail Expansion joint and the direction of traffic.

ii. Immediately prior to completion of a section, all sliding surfaces of rail expansion joint shall be cleaned and greased.

15.2.4 RAIL TEMPERATURE

Rail temperatures shall be measured using appropriate dial type magnetic thermometers placed on the web of the rail on the shaded side. A minimum number of thermometers required to be used per rail for measuring average rail temperature of a segment of track shall have the prior approval of Engineer.

15.2.5 CLEANING OF TRACK

The track from structure (including the rail surface) as installed shall be thoroughly cleaned to an acceptable standard as approval by the Engineer immediately after

installation and as required thereafter maintaining the standard until the arrangement of service trails so as to provide adequate levels of electric insulation and rail surface quality for correct performance of train control and signaling equipment under prevailing climate and environment conditions.

15.2.6 RAIL INSULATION

The track as installed shall be thoroughly cleaned immediately after insulation. This shall be necessary to provide adequate levels of electrical insulation for the correct performance of the signaling and traction equipment under the prevailing climatic and environment condition.

15.2.7 CUTTING OF RAILS

i. Rails shall only be cut by using abrasive rail cutting machines. The proposed method and equipment for the cutting of rails shall have the prior approval of the Engineer.

ii. Rails required to be cut shall be cold sawn square and vertical across the rail. A deviation from square or vertical of more than 0.5mm measured about the rail head, shall not be permitted. All burrs shall be removed from the rail ends.

iii. Quality of cutting shall be such as to ensure tolerances *specified* in Alumino-thermit welding manual.

15.2.8 STAGES OF REQUEST FOR INSPECTION DURING CONSTRUCTION OF SLAB TRACK.

A. The ballastless track system consists of:

i. Support structure done as a part of tunnel civil works

ii. Reinforced concrete slab track

iii. Rail fastening system (design and drawing shall be submitted by the bidder/contractor for approval).

"Request for inspection" shall be submitted to the Engineer, Complete with all necessary information to allow assessment, after the following activities and approval must be received prior to the commencement of any follow-on activity.

a) Acceptance of support structure including specified surface treatment

b) Acceptance of the slab track reinforcement

c) Acceptance of temporary/false works shuttering, jigs, fixtures and supporting arrangements

d) Acceptance of the track for concreting

e) Acceptance of the track for the movement of construction of plant equipments and machinery

f) Acceptance of the track for in-situ welding

g) Acceptance of the track for destressing

B. *All third party (RDSO/RITES/Any other nominated agency) inspection charges, if any, for Ballastless Track system shall be paid by the Employer.*

15.2.9 REINFORCED CONCRETE SLAB TRACK

a) The ballastless tracks shall be laid with reinforced concrete slab track on supporting structures.

b) The ballastless track shall be constructed by Top down method of construction. The laying tolerance for various parameters for the installed Ballastless track shall be strictly achieved in accordance with the relevant clauses in these specifications. For achieving these tolerances the tenderer may propose the method/scheme of construction of ballastless track along with the tender submission. However, the sole responsibility of achieving the stipulated track laying tolerances lies with the Contractor.

c) The Contractor shall be responsible to calculate the height of the slab track at each location to maintain the desired rail level as shown in the relevant drawings and submit the same for the approval of the Engineer. The reinforced concrete slab track shall be laid on the tunnel invert duly making the provision for cant and vertical curves.

d) Suitable construction joints shall be provided for the slab track in tunnel. Location of the joints shall be in conformity with the location of other joints in the tunnel structure.

e) The handling and transport arrangement of rails shall ensure no damage to the rails.

f) Resilient pads placed under the metal base plates shall be coated with silicon or any suitable product, on their underside and lateral side, to stop them adhering to the slab track concrete, as approved by Engineer.

g) During the concreting phase, the track fastening device, the running rails and the expansion joints templates shall be protected by movable covers against possible splattering of concrete.

h) Conduits required for crossing of signaling wires shall be have to be provided before concreting as directed by the Engineer.

i) Immediately after concreting of slab track the assembly consisting of the rails and the plinth segments shall be covered by wet cloths to prevent damage due to rise in temperature.

j) These cloths shall be damped constantly for 8 hours from the time of pouring the concrete.

k) The rail fastening between the metal base plates and running rails base shall then be removed to authorize differential movement in the longitudinal direction between the rails and structures.

l) Twenty-four (24) hours after pouring of the slab track concrete, the formwork shall be removed.

m) The concreted surfaces of the slab track below the base plates shall be smooth, devoid of any inclusions, roughness cracks and without showing any aggregate at the surface.

n) Temporary rails shall not be used for constructions, slab track shall be constructed using the permanent rail to be finally fastened.

15.3 TEST FOR RAIL FASTENING SYSTEM COMPONENTS

The following tests are required to be conducted for fastening system-

a) Pull out strength test of anchor bolts.

b) Longitudinal creep resistance test of rail seat assembly.

c) Fatigue test of tension clamp.

d) Fatigue test of helical spring.

e) Stiffness test (static & dynamic) of elastic base plate pad & the ratio of dynamic to static stiffness at various frequencies.

f) Fatigue tests of assembly as a whole. These tests shall cover as minimum heat generated in pads in terms of temperature, records of gauge, rotation of rail head, slippage of rail foot, and lateral & vertical movement of base plate and vertical deflection of rail head.

g) Installation procedure tests.

15.4 RAIL INSULATION TO EARTH TEST

a) All track work shall be subjected to a rail insulation to earth test. The track shall have a minimum rail to earth value of 40 Ω/km of single track for ballastless tracks.

b) The rail to earth test shall be undertaken after the track has been completed and cleaned but before it is finally formed into a continuously welded system and before all the bonding is installed.

c) Junctions shall be isolated and tested prior to their final connection into the track.

d) The test shall be undertaken on rail lengths up to maximum lengths of 1000 m. The tracks shall not be finally formed into a continuous length, nor shall the junctions be joined to the adjacent tracks, until the rail insulation to earth tests have been undertaken and approved.

15.5 BALLASTLESS TRACK BASE RESISTANCE TESTS

a) A ballastless track base resistance test shall be undertaken on all track lengths over 50 meters as a check of the leakage of current through the track base and rail fastening system from one rail to the other.

b) The ballastless track base resistance test shall be undertaken after the track has been complete and cleaned but before it is finally formed into a continuous length and all the bonds are attached.

c) The testing procedure and the minimum resistance shall comply with the

requirements proposed by the engineer.

15.6 RAIL INCLINATION INSPECTION

a) Both rails of all ballastless running line tracks shall be checked, at maximum 10m intervals, for inclination using an approved equipment/method in the presence of the engineer.

b) Should any reading show the inclination to be outside the specification limits every alternate fastening assembly shall be further checked either side of the non-compliant reading until compliant readings are consistently obtained.

15.7 RAIL WELDING:

a) The main line track shall be welded into LWR/CWR using mobile flash butt welding machine approved by RDSO. Wherever the mobile flash butt welding is practically not possible the Alumino-thermit SKV process welding shall be done with the approval of the Engineer through agencies approved by RDSO and as per provision of manual for fusion welding of rails by the Alumino-thermit process supply of portion must be and procurement is from sources approved by RDSO.

b) Welding shall be supervised by trained welding supervisor and carried out by trained welder having competency certificate from RDSO/Lucknow in his possession.

c) The preparation of rail ends to be ensured before welding.

d) The Contractor shall arrange for test welds and their testing done as per manual.

e) The welds shall be finished to final profile by grinding and the finished weld shall be within the specified tolerance.

f) Each joint shall have distinctive marks as per details in the manual.

g) Weld collar shall be painted against corrosion as per specification given in manual.

h) All the recorded welds shall meet the acceptance tests including ultra-sonic test.

i) Rail joints welded by the Contractor shall be guaranteed against failure for a period of 2 years from date of welding the joints in track or from date such welded joints made in cess are inserted in the track. Any such welded joint which fails within guarantee, the joints shall be rewelded free of cost.

j) In case of failure of sample test joint, the period of guarantee for 100 joints represented by the sample joint shall be extended for a further period of 1 year. In case of failure of joints exhibiting sign of failure by cracking within extended period of guarantee, the joints shall be rewelded free of cost.

k) When one bad joint is required to be replaced by two new joints, the entire cost of both the joints shall be borne by the Contractor.

l) Drilling of holes in the 60kg rails is strictly not permitted.

15.8 DESTRESSING OF CWR:

a) Destressing must be done as per provisions of Indian Railway Permanent Way

Manual.

b) Destressing of rails shall not be undertaken until it has been demonstrated to Engineer's satisfaction that the track has been completed to the specified standard specifications and the method of working for destressing of the relevant track has been approved by the Engineer.

c) Destressing must be done in accordance with temperature conditions stated in the Railway Manual.

d) The stress free temperature condition of LWR shall be achieved naturally or artificially by the use of hydraulic rail tensors as approved by the Engineer.

15.9 CONSTRUCTION PROCESS

Tenderers are advised to visit local sites location as specified in tender to get familiar with typical local environment like drainage system/extent of tunnel and water flooding during monsoon period in tunnel area etc.

Procedure of construction process of BLT should be mentioned in details suitable to local site conditions including necessary ground improvement. Removal of earth to required level followed by filling of coarse grained material in layer along with COMPACTION by vibratory process & system offered should be easy in construction suitable to condition prevailing on specified tunnel section in tender, clearly demonstrating how it can be constructed & installed within a reasonable time frame.

15.10 MAINTENANCE AND PERFORMANCE MONITORING

a) The *Defects Notification Period (DNP)* will be for 3 years from the date opening of traffic.

b) After Construction of Ballastless track, HRIDC will monitor the performance jointly with the Contractor on quarterly basis & for 3 years. The performance monitoring will be based broadly upon following parameters:

c) Efficacy of fastening: Fastening system should be able to maintain track geometry (gauge, cross level, loose fitting etc.) at all times within track tolerances during service without any components breakage, excessive wear & tear.

d) Track tolerances to be maintained at the time of construction & during trial/services should be as per Section VII-5 Outline Design Specification (ODS) - Civil.

e) Any track settlement which impairs the functionality of ballastless track.

f) Any visible crack of width more than 0.1 mm in concrete/RCC portion of slab which impairs the functionality of ballastless track.

g) Efficacy of drainage system e.g. the slope and drains constructed should function properly during Monsoon period.

h) Any special observation.

i) The decision of HRIDC about performance of the ballastless track after monitoring period shall be final.

Chapter 16

OPEN EXCAVATION

16.1. SCOPE OF WORK

16.1.1. The specifications described herein under relate to the work of open excavation for various structures and shall include all labour, tools, plants, Constructional Plant and services, necessary to carry out the excavation of different type of materials, geological mapping of excavated surfaces, dewatering, temporary slope stabilization measures required to facilitate excavation, transportation and stockpiling / disposal of all excavated materials into stockpiles / dumping areas as shown on the drawings or as approved by the Engineer.

16.1.2. Excavation shall be made to the lines, grades and dimensions shown on the drawings or as otherwise directed by the Engineer, which shall be required to be backfilled with acceptable material and compacted by contractor in a manner acceptable to the engineer.

16.1.3. The Contractor shall maintain the excavated slopes, drainage and trenches and prepare foundations as shown in the drawings or as required by the Engineer. The Contractor must ensure slope protection measures for riverbank and non- dumping station areas ensuring environmental mitigation measures as per the approved environmental mitigation plan.

16.1.4. The area of open excavation shall, where, in the opinion of the Engineer, clearing is necessary, be cleared of all trees, bushes, rubbish and other objectionable matter and the materials so removed, shall be disposed off suitably or as directed by the Engineer

16.1.5. When additional excavation outside the lines and grades shown on the drawings is required by the Contractor for his own convenience, such additional excavation shall be required to be backfilled with acceptable material and compacted by the Contractor in a manner satisfactory to the Engineer. The Contractor shall submit his plans for such proposed work in writing for the Engineer's acceptance prior to the commencement of the work.

16.1.6. The removal of mud and slush resulting from heavy rains or flooding of the sites, when necessary to ensure the safe and effective performance of the work shall be performed by the Contractor. For this purpose, Perimetric drains will also be required to be provided at a suitable distance from the edge of the cutting around the slopes to ensure the safe drainage of superficial water, avoiding slope erosion.

16.1.7. At all times during construction, the Contractor shall adopt such excavation procedures that at no time the stability of any slope be impaired. For the excavation in intake area special care shall be exercised and the Contractor shall adopt modern controlled blasting techniques.

16.1.8. The approval given by the Engineer to the Contractor's methods and equipment shall not relieve the Contractor of his full responsibility for a proper and safe execution of excavation, or of liability for injuries to, or death of person(s), or any obligations under this Contract.

16.1.9. The Contractor shall comply with all safety procedures and requirements as stipulated elsewhere in the Tender Documents.

16.2. SUBMITTALS

16.2.1. At least 4 (four) weeks prior to the commencement of excavation, the Contractor shall submit details of his excavation methods and sequences for all open excavation Works including the schedule of deploying equipment.

16.2.2. The description of drilling and blasting procedures shall include the following:

i. Diameter, burden, spacing, depth, pattern and orientation of blast holes

ii. Type, strength, amount (kg of explosive/hole) and distribution of explosives to be used, per hole.

iii. Description and purpose of any special method to be adopted by the Contractor.

iv. Sequence of various activities of the excavation work with an indication of corresponding time requirements.

16.2.3. At least 4 (Four) weeks prior to dumping or stockpiling of any excavated material, the Contractor shall submit the layout of the spoil and stockpile area. All data pertinent to working methods and provisions for the security, stability and temporary and permanent drainage of the work areas shall be included along with details of volumes, material types, heights and grade provided. To prevent spillage of muck, R. R. masonry/ Gabion retaining walls with adequate arrangement shall be provided in disposal area.

16.2.4. To enable the Engineer to verify all necessary setting out and elevations carried out by the Contractor, the latter shall notify the Engineer in writing, giving at least 1(one) week notice of his intention to start excavation.

16.2.5. The Engineer reserves the right to require any additional information deemed necessary to be included in the submitted documents

16.3. CLASSIFICATION OF EXCAVATION

16.3.1. Open excavation shall comprise of the following types of excavation:

16.3.2. Soil excluding Rock (Seismic velocity Vp <1000 m/s)

i. Loose excavation shall include all types of soil and such other material, which can be excavated manually by ordinary pick and shovel or barring and wedging or by mechanical equipment such as dozer blade, Ripper, power shovel and dragline but without resorting to blasting. It shall also include embedded boulder not bigger than 1-meter size in anyone direction. The Contractor will endeavor to provide proper excavation method in such so as not to over excavate the soil beyond the final design line. It will be necessary to provide the details of competence level of the shovel operator to excavate such areas as per the design.

16.3.3. Rock not requiring blasting (Seismic velocity> 1200 m/s to 2000 m/s).

i. This shall include excavation of all rock, which can be excavated by mechanical equipment such as dozer blade, Ripper, power shovel and dragline but without resorting to blasting to loosen the same. The Contractor will endeavor to provide proper excavation method in such so as not to over excavate the soil beyond the final design line. It will be necessary to provide the details of competence level of the shovel operator to excavate such areas as per the design.

ii. This shall also include boulders and detached rock blocks of size larger than one meter in any direction. It shall also include the removal of softer materials lying between layers of rock.

16.3.4. Hard Rock requiring controlled blasting (Seismic velocity >2000 m/s)

i. This shall include excavation of all rock, which cannot be excavated without prior blasting to loosen the same.

ii. The term rock shall include boulders and detached rock blocks of size larger than one meter in any direction which requires blasting for removal. It shall also include the removal of softer materials lying between layers of rock.

16.3.5. Hard Rock requiring blasting but blasting not permitted

i. This shall include excavation of all hard rock, which cannot be excavated without blasting but due to restriction imposed at site by employer, the same is required to be excavated by chiseling or Rock breaker, vibratory rock rippers, and rotary drum cutters. Alternatively, propellants (non-detonating silent explosives e.g. NONEX, ROYAX or plasma blasting).

Table 1. Comparison of various non-explosive blasting characteristics

Types		Economy	Application scope	advantage	Disadvantages
Mechanical broken	Hydraulic splitting machine	normal	Mines, precious stones and so on	Safe, weak vibration, environmental protection	Mechanical wear, low efficiency
	Hydraulic breaker	normal	Municipal engineering, mountain, ice, demolition and so on	Safe, environmentally friendly	Mechanical wear, medium hard rock should not be used
	Boring machine	Higher	Coal mines, tunnels and so on	Safety, environmental protection, into Lane efficient and good quality	Mechanical wear, complex structure, maintenance difficulties
Physical Chemistry acting	Static expansion agent	low	Quarries, concrete and so on	No fly stone, no vibration, environmental protection	Lithology and climate impact, low efficiency,
	Carbon dioxide cracker	low	Quarries, coal mines, concrete and so on	High safety, small vibration	Lack of standardization, there is a certain security risk
	Metal burners	Higher	Precious stone mining	No throwing, no toxic gas	Waste metal, lively metal prone to danger
Electrical Equipment	Plasma blasting	normal	Dismantling Municipal engineering	High safety, small vibration, no throwing	Equipment requirements are high, broken rock volume is small
	Heat splitting rock	normal	Auxiliary rock breaking	Hard rock effect is significant	Only applies to auxiliary rock breaking

Ref: https://iopscience.iop.org/article/10.1088/1757-899X/322/2/022014/pdf

ii. The term rock shall include boulders and detached rock blocks of size larger than one meter in any direction which requires blasting for removal. It shall

also include the removal of softer materials lying between layers of rock.

16.3.6. Removal of Slip

Unavoidable slips, which may occur in the excavated slopes, shall be removed by loading, hauling, dumping of the material and the surface cleaned.

16.3.7. Dental Excavation

i. Dental excavation shall include the removal of unsuitable material from shear zones, clay seams, pockets, joints, or from spaces between boulders beyond the lines of excavation shown on the Construction Drawings or established in the field, which are too small to be excavated by common earth moving equipment.

ii. Dental excavation, depending on its extent will require the use of a backhoe, hand tools, or other small excavating equipment, as well as the use of a high velocity air-water jet. The methods employed shall be such as to avoid fracturing of the rock adjacent to the material being removed.

iii. Dental excavation shall be performed where directed. The extent, to which such material shall be removed, including the depth, direction, and dimensions of the work, will be determined by the Engineer. Such excavation shall be backfilled with concrete or shotcrete. No blasting will be permitted.

16.4. REMOVING BLUFFS AND LOOSE ROCK

16.4.1. All loose boulders, semi-detached rocks (along with the earthy stuff which might move therewith) not directly in excavation but so close to the area to .be excavated as to be liable in the opinion of the Engineer, to fall or otherwise endanger the workmen, equipment of the Work, shall be stripped and removed from the areas of excavation. The methods used shall be such as not to shatter or render unstable or unsafe any rock that was originally sound and safe. Any material not requiring removal as contemplated in the Work but which, in the opinion of the Engineer is likely to become loosened or unstable later on shall also be promptly and satisfactorily removed as directed by the Engineer.

16.5. EXCAVATION IN OPEN CUTS

16.5.1. The side slopes of the excavation shall be as shown on the drawings or as directed by the Engineer.

16.5.2. Any changes in the slopes as shown on the drawings on account of siteconditions shall be subject to the approval of the Engineer.

16.5.3. Every precaution shall be taken to prevent slips. In case slips occur, the slipped material shall be removed to the designed / modified slope.

16.5.4. Suitable berms shall be left at appropriate places with necessary approach, ramps and sump pits for installation of dewatering pumps or other purpose, as required by the Engineer. This may warrant use of line drilling along the final line of excavation. Excavation should be conducted in a manner to expose half holes of such line drilled holes. All excavation shall be carried out finished to lines and grades shown on the drawings and to the satisfaction of the Engineer.

16.5.5. In case of loose excavation where the surface is left as excavated or is to be covered by pitching formation of rain cuts and gullies shall be avoided by proper drainages. Any gullies formed shall be "made good" by properly packing excavated rock spoil in them. All holes left by removing boulders shall also tie filled in with rock spoil and stablized.

16.5.6. Where plain surfaces are required, such faces of excavation shall be formed in such a manner that would least shatter the rock mass. Only light blasting or ream holes or similar methods shall be allowed in areas adjacent to such faces.

16.5.7. In special locations (only in rock) where specifically indicated or ordered by the Engineer, the use of explosives shall be discarded and excavation completed by the drilling, wedging or barring or other suitable method approved by the Engineer.

16.5.8. All excavations, done beyond the lines and dimensions shown on the drawings, which are to be covered by concrete shall be filled back with the concrete of the same grade and quality or as directed by the Engineer.

16.5.9. Blasting within 30 m of concrete works or grouted area shall be permitted preferably after concrete or grout is 7 days old and only after the submission by the Contractor and approval by the Engineer of a plan showing the relative positions of structures or grouted area and the areas to be blasted, Contractor's proposed drilling and blasting plan together with an outline of precautions to be taken.

16.5.10. All concrete works and other completed works within 30m of blasting shall be protected by limiting the charges / size of blasts to ensure that the maximum displacement velocity of particles at nearby structures is not more than 50 mm per second. For concrete or grout less than seven days old, this velocity shall not be more than 10 mm per second.

16.5.11. No blasting shall be permitted within 15 m radius of concrete works or grouted area.

16.5.12. The open cut excavation shall be done by benching with individual bench height not exceeding 2 m.

16.5.13. The Contractor shall carry out the excavation of open cut rock slopes utilizing controlled blasting techniques including line drilling and presplit blasting as per relevant codal provisions.

16.5.14. Where depth of open rock excavation is more than 10 m, the excavation shall be carried out in a descending way, from horizontal berms, by benching.

16.5.15. Immediately after excavation and scaling to the satisfaction of Engineer and prior to the excavation of next bench, the Contractor shall install rock bolts, provide wire mesh, shotcrete and temporary relief holes if considered necessary, as shown on the drawings or as required by the Engineer.

16.5.16. All blasted rock shall be removed from the bench toe before undertaking further work.

All other specifications pertaining to blasting and scaling etc. relevant to open excavation shall be as per stipulations of Section of Explosive and Blasting.

16.5.17. In all cases where blasting is to be conducted, the attenuation equation based on trials arranged by the Contractor should be used to define the maximum charge per delay to control the vibrations within the stipulated limits (as per DGMS Guidelines). The field

constants and the maximum charge per delay will be scrutinized by CSIR-CIMFR and approved by the engineer and practiced in all such cases by the Contractor.

16.5.18. In case of blasting being conducted near a dam, CSIR-CIMFR will conduct the blast trails, work out the attenuation equation and hence maximum charge per delay and continuously monitor the ground vibration at few places on the dam as per requirements. Contractor will have to adhere to the recommendations of CSIR-CIMFR and engineer.

16.6. EXCAVATION FOR FOUNDATIONS OF STRUCTURE

16.6.1. While carrying out excavation for the foundations of the structure, if it is considered necessary for a Work and if approved by the Engineer, the sides of the loose excavation shall be shored and strutted to the satisfaction of the Engineer.

16.6.2. After completion of the loose excavation, the rock excavation in foundations of the Structures shall be carried out to the depths as shown on the drawings. At all stages of excavation, precautions shall be taken to preserve the rock beyond the lines of required excavation. The quantity and strength of explosives used in the foundation excavation in rock in various locations shall be such as will neither damage nor crack the rock outside the limits of excavations.

16.6.3. As the excavation approaches its final lines and is within 300 mm to 600 mm of the specified foundation levels, the depth of the holes and the strength and quantity of explosives shall be progressively and suitably reduced so as to ensure that the rock profile beyond the lines and levels specified on the drawings shall remain undisturbed. If so, directed by the Engineer, this excavation shall be carried out by the line drilling.

16.6.4. Final excavated surface shall have no abrupt changes in slope and sharp projection greater than 500 mm. Projections in excess of 500 mm shall be treated where necessary by supplementary excavation as determined by the Engineer to produce the desired surface of contact between concrete and rock.

16.6.5. All excavations done beyond the lines and the dimensions shown on the drawings shall be back filled with concrete of the same grade and quality as that of the foundation or as directed by the Engineer.

16.6.6. Acceptance criteria for important foundations: Important structures shall be founded on sound and competent rock and suitable for taking up the load of the super structure without undergoing deformation beyond the acceptable limits as per the directions of Engineer. After excavation up to fresh rock level, further excavation shall be done up to one meter by wedging and barring to remove all the loose and soft, weathered rock, sheared material etc. All sheared portion shall be excavated to a desired depth and filled with concrete with steel reinforcements as per approved design and drawings. Concreting shall be taken up only after getting written approval of the Engineer.

16.6.7. Stable slopes shall be provided in open excavations along with berms of specified width as per approved design & drawings.

16.6.8. All permanent rock slopes shall be stabilized by suitable treatments such as shotcrete

with chain link mesh, rock anchors, spot rock bolts, perforated drainage pipes, berms with drains etc., as per approved design and drawings. The width of the berms shall not be less than 4 m. The slope to be provided in various types of rock as per weathering condition shall depend upon slope stability calculations and as per design drawings & IRPWM. If not available in design drawings & IRPWM it shall be as below.

i.	Fresh rock	0.20-0.25 (H): 1 (V).
ii.	Moderately weathered rock	0.33-0.50 (H): 1 (V).
iii.	Highly weathered rock	0.67-1.00 (H): 1 (V).
iv.	Overburden	1.25 (H): 1 (V) to 1.50 (H): 1 (V).

16.6.9. The cut slopes in overburden shall be treated with dry rock stone masonry with horizontal and vertical bunds of course rubble masonry in cement mortar 1:4 of 1 meter width as per approved design & drawings.

16.6.10. Surface Preparation of Foundations

i. After completion of excavation of foundations, trimming for the final removal of all dummy rock or loosened mass, shall be done by chiseling, barring and wedging as directed by the Engineer.

ii. Any weathered or decomposed rock remaining shall be removed. Open fissures joints; crevices and any other doubtful areas shall be cleaned to a suitable depth up to firm rock and backfill with the concrete/mortar of the same grade as that of the main structure and contact grouting as specified.

iii. Consolidation grouting of the foundation rock shall be carried out upto the specified depth before the placement of concrete.

iv. Contractor shall wash all rock surfaces of the excavations. This washing shall be carried out initially for inspections when required by the Engineer.

v. Final washing of any section of the work prior to concreting or application of shotcrete shall be carried out only when the blasting for the excavation and removal of projections inside the neat lines has been completed.

vi. Final washing prior to concreting shall be done by directing a stream of water at a pressure of about 8 to 10 bars on the rock surfaces from a distance of 1.5 meter through a nozzle of 18 mm diameter so as to remove all loose rock, fragments, dust and debris from the surfaces.

16.7. DISPOSAL OF EXCAVATED MATERIALS

16.7.1. All the excavated material shall be the property of the Contractor. The Contractor has to make his own arrangements for land required for dumping areas outside of HORC limit (at sufficient distance as per relevant provisions) for disposal of excavated materials. The technical specifications for developing and rehabilitating the muck disposal sites shall be as submitted by contractor and agreed by the Engineer.

16.7.2. The Contractor shall make necessary arrangements for the management of muck disposal so that it meets all the environment guidelines / conditions imposed for the

construction of project by MoEF&CC / Govt. bodies / State Pollution control board and/or other statutory bodies.

16.7.3. Surfaces of material so disposed off shall be trimmed to regular lines and grades satisfactory to the Engineer. Disposal of all material shall be such that it will not interfere with natural drainage and is as per the regulations for environmental protection or with Engineer's acceptance. The Contractor must ensure muck management as per the approved environmental mitigation plan with proper turfing and plantation at dumping sites. Nothing extra shall be paid for it.

16.7.4. The Contractor shall ensure that no excavated materials are disposed off in the streams or at locations where these are liable to be washed away by the floods or may block the water way of streams.

16.7.5. The plan of muck dump yard fill, berms and provision of retaining walls, slope of fill etc. will be as per site requirements and the same shall be got approved by the Contractor from ENGINEER before start of such works.

16.8. DRAINAGE

16.8.1. Seepage water from springs or rainwater shall be suitably collected and drained away from work area by gravity, wherever it is possible to do so. Where, however, drainage by gravity is not feasible, pumping could be resorted to all stipulations laid down in Section of "Dewatering, Drainage, Pumping *and Dewatering*" shall be followed.

16.9. BACKFILL

16.9.1. Backfill shall consist of materials as approved by the ENGINEER and shall be placed in locations as directed by the ENGINEER.

16.9.2. Only suitable materials obtained from excavation, if practicable, shall be used for backfilling.

16.9.3. Material to be used in backfill shall be free drainage type.

16.10. CUT & COVER TUNNEL

16.10.1. *Construction of Cut & Cover tunnel shall be done as per **Annexure OCS-1 and Annexure OCS-2**. Before taking up actual construction, the Contractor shall construct a 2 m long mock up, Cut & Cover tunnel section including drainage, waterproofing etc. completed at a location approved by the Engineer.*

16.11. MEASUREMENT AND PAYMENTS

16.11.1. General

i. This is a lump sum contract hence no separate payment will be made for any of the items separately. Tenderer shall consider all expenditures in their total offered cost. However, all detailed measurement shall be recorded for all the works executed for the purpose of quality check, preparation of completion/

as built drawings and future operation & maintenance.

ii. The Contractor is assumed to have included the entire scope but not limited to the following:

A. Provision of all labour, equipment and materials required for open excavation in various locations including drilling holes for blasting, developing and improving controlled blasting methods, performance of blasting, cleaning, washing protection and maintaining excavated surfaces in satisfactory conditions and additional excavations if any, required by the Contractor for his construction methods.

B. Geological mapping of the excavated area and the temporary stabilization measures adopted for facilitating the open excavation work.

C. Provision for loading, handling and dumping the excavated material on stockpiles, contractor's dumping area outside railway limit, shaping and trimming of the excavated materials in the dumping area, cleaning of the stockpile area, formation and maintenance of stockpiles, rehandling of suitable materials including segregating; grading, draining and drying of materials suitable for use in embankment construction or as backfill.

D. Deleted.

E. Deleted.

F. Complying with all requirements of statutory laws and regulations relating to the works and any restrictions resulting from obtaining all necessary permits and licenses for the purchase, use storage and transport of explosives and other materials.

G. Surveying, setting out, checking of excavated profile, layouts and any subsequent rectification works resulting from unable or incorrect surveys, provision of suitable equipment for and delays due to carrying out this work.

H. Furnishing, installation, operation, maintenance and removal of Communication and illumination systems and observing safety precautions.

I. Recording and preparation of reports related to excavation progress and procedures.

J. All work involved with and any partial or short interruptions or inconveniences caused by the check surveys, performance of the rock mechanics tests, installation and monitoring of instruments and geological mapping, for which no separate payment is provided elsewhere in these specifications.

Seepage water or rainwater suitably collected and drained away by gravity including provision of catch drains, diversion of nallah etc.

K. Dewatering by pumping in the open excavation area due to any reason whatsoever.

L. The compensation for removal of mud and slush resulting from heavy rains/flooding of the sites, if necessary, to ensure the safe and effective performance of the work shall be deemed to be included in the overall quoted amount for complete work in this contract.

M. The payment towards the preparation of disposal area shall 'be deemed to be included in the overall quoted amount for complete work in this contract".

N. Excavation for drainage trenches will not be paid separately.

O. All taxes duties.

P. Clearing of all trees, bushes, rubbish and any other objectionable materials and their removal and disposal.

Q. Over excavation beyond the excavation lines shown on the drawings, removal of material or backfilling with acceptable material where and when as required by the Engineer.

R. Replacement of survey points fixed by the Engineer, which are damaged by Contractor's negligence, and fixing of additional survey points near working area.

S. Methods adopted for specially controlled excavation at foundation level or near the faces where plain surfaces are required.

T. Formation of berms or ramps sump pits for installation of dewatering pumps at places, which fall beyond the specified excavation lines.

U. Replacement or repair of concrete or other works damaged by blasting.

V. Over-excavation required for contractor's convenience. The concrete required to fill such excavation shall also be at the Contractor's expense.

W. Draining, shaping and trimming of the dumped materials in waste disposal area to the lines and grades as directed or approved by the Engineer.

X. Provision of catch drain, nallah diversions etc. to avoid flow of water to working area.

16.11.2. Open Excavation

i. This is a lump sum contract hence no separate payment will be made for any of items separately. Bidders shall consider all expenditures in their total offered cost. However, all detailed measurements shall be recorded for all the works executed for the purpose of quality check, Preparation of completion/ as built drawings and future operation & maintenance.

Measurement of excavation will be of the in-situ volume defined by the excavation lines as shown on the drawings, and shall be worked out on the basis of solid volume, worked out from the initial, intermediate, and final ground cross sections recorded or as per direction by the Engineer.

ii. Cross sections will be taken normal to the center line at as close intervals as practicable but, in any case, not more than 5 meters and 3 meters apart in loose excavation and rock respectively, prior to the starting of excavation in each class of material, unless some other method is acceptable to the Engineer in any particular location of the work.

iii. This includes entire cost of

A. Drilling holes for blasting

B. Developing and improving controlled blasting methods

C. Blasting tests, explosives and performance of blasting

iv. Payment for removal of bluffs and loose rock close to the areas to be excavated shall be deemed to have been included in the overall quoted amount for complete work in this contract.

v. Payment for removal of *all avoidable and* unavoidable slips, which may occur in the excavated slopes, will be deemed to have been included in the overall quoted amount for complete work in this contract.

16.11.3. Shoring and Strutting

The rates for shoring and strutting shall be included in the overall quoted amount for complete work in this contract.

16.11.4. Dental Excavation:

If measurement by volume proves impracticable, the surface area of seams and cracks to be cleaned may be equated, as the conditions dictate, to a volume mutually agreed upon by the Contractor and the Engineer.

16.11.5. Royalties.

Soil or rock spoils such as stones, boulder, pebbles, gravels etc. available from excavation, if are found suitable for use in works as per required specifications, can be used free of cost but the legally payable royalty and taxes are to be paid by contractor to the concerned authorities. Necessary proofs to be submitted by contractor in this regard.

Annexure OCS-1

PLAIN AND REINFORCED CEMENT CONCRETE

1 MATERIALS

a) Before bringing to the site, all materials for concrete shall be approved by the Engineer. All approved samples shall be deposited in the office of the Engineer before placing orders for the materials with suppliers. The materials brought on to the works shall conform in every respect to their approved samples.

b) Fresh samples shall be deposited with Engineer whenever type or source of any material changes. The Contractor shall check fresh consignment of materials as it is brought on to the works to ensure that they conform to the specifications and/or approved samples.

c) The Engineer shall have the option to have any of the materials tested to find whether they are in accordance with specifications at the Contractor's expense. All bills vouchers and test certificates which in the opinion of the Engineer are necessary to convince him as to the quality of materials or their suitability shall be produced for his inspection when required.

d) If fly ash is used in concrete, the Contractor shall demonstrate the quality control procedure including source of fly ash, its properties, handling as per the relevant IS & international codes etc. and shall use in slabs and walls only after "no objection" to the same has been obtained from the Engineer.

e) Any materials which have not been found to conform to the specifications and not approved by the Engineer shall be rejected forthwith and shall be removed from the site by the Contractor at his own cost within the time stipulated by the Engineer. The Engineer shall have the powers to cause the Contractors to purchase and use materials from any particular source, as may in his opinion be necessary for the proper execution of work.

f) Contractor shall also ensure that all constituents of exposed concrete shall be taken from same sources to achieve a uniform colour and texture.

g) Approved list of Manufacturer's/Suppliers is given in Section VII- 8:Tender Drawings and Documents. In case the Contractor desired to procure the material from any other supplier, it shall be got approved by the Engineer.

2 Cement

2.1 Product and Materials for Cement

a) Cement to be used in the works shall conform to 53-grade OPC (IS 269:2015) or blended cement such as Portland Pozzolana Cement (IS 1489:2015) or Portland Slag Cement (IS 455:2015).

b) The Contractor shall submit to the Engineer the Manufacturer's Certificate to affirm that the cement complies with the relevant standards.

c) Samples of the proposed cement shall be taken and forwarded to an independent laboratory for analysis before the source is approved.

d) Prior to ordering cement, the Contractor shall submit details of the proposed supplier or manufacturer and information on the proposed methods of transport, storage and certification for the Engineer's approval and show that the quantity and quality required can be attained and maintained throughout the construction period. In exposed concrete elements, the cement used in the concrete for entire element shall preferably be from a single manufacturer to ensure uniform colour.

e) Subsequent to obtaining the Engineer's approval, the Contractor shall not change the agreed arrangements without the prior approval from the Engineer. Each delivery of cement shall be accompanied by a certificate which shall be submitted to the Engineer immediately after the delivery showing the place of manufacture and the results of standard tests carried out by the manufacturer.

2.2 Testing for Cement

a) Samples shall be tested from every batch of cement delivered on site or once for every 1000 bags whichever is more frequent. The sampling from bulker shall be increased as decided by the Engineer.

b) Samples shall be taken immediately on receipt of cement at site. The methods and procedures for sampling shall be in accordance with IS: 3535.

c) Tests shall be carried out as per IS4031 for physical analysis as fineness, initial and final setting time and compressive strength and results approved by the Engineer before use. The Contractor shall provide complete facilities at site for carrying out the following tests:

   i. Setting time by vicat's apparatus as per IS:5513 and IS:4031.

   ii. Compressive strength of cement as per IS: 4031, IS:650, IS:10080.

d) The Engineer may require any other form of sampling and tests including chemical analysis. Total chloride content in cement and total sulphur content calculated shall in no case exceed the requirements of Table 2 of IS 269. In case the cement supplied is of doubtful quality, tests shall be done in accordance with IS 4032. The costs of such additional tests shall be borne by the Contractor.

3 Aggregates

3.1 General

Aggregates shall conform to the provisions specified in IS 383:2016. The Contractor shall submit to the Engineer certificates of grading and compliance for all consignments of aggregate. In addition, at site from time to time, the Contractor shall allow for carrying out tests and for supplying test records to the Engineer. Prior to commencing any concrete work, the Contractor shall obtain the Engineer's approval of the proposed types and sources of aggregate.

For fair faced concrete, the Contractor shall ensure that aggregates are free from iron pyrites and impurities, which may cause discoloration. Aggregates shall be stored on paved areas in different compartments according to their nominal size.

Sampling of aggregates shall be as per IS 2430.

3.2 Fine Aggregates (Sand)

a) The grading of the sand shall conform to IS:2386(Part1). The grading of fine aggregate shall be within the grading zones I, II, III. Sand, if found too coarse, shall be suitably blended with finer sand obtained from approved sources to obtain the desired grading. The provision of two types of sand, their separate stacking and their mixing in the specified proportions shall be at the Contractor's own cost.

b) The sand shall not contain silt, shale, clay and other weak particles for more than a total of 3% by weight. In case of sand containing excess silt, clay and chlorides, the sand shall be washed in screw type mechanical washers in potable water to remove the same. The screening and washing of sand shall be completed at least one day before using it in concrete. The washed sand shall be stored on a sloping platform while ensuring that contamination is avoided.

c) Water absorption shall be less than 3% by weight (ASTM C 117)

d) The sand shall be screened on a 4.75 mm size screen to eliminate oversized particles. The Contractor shall carry out the following tests at Site and ensure that the appropriate provisions of Indian or other standards, as may be applicable, are complied with:

   i. Proportion of clay, silt and fine dust by sedimentation method as per IS 383:2016 and IS 2386 (Part II)

   ii. Moisture content in fine aggregate as per IS 2386(Part III)

   iii. Water absorption shall be worked out as per IS 2386(Part III)

   iv. Bulk Density or bulkage as per IS 2386(Part III)

   v. Grading of fine aggregate asper IS 383:2016 and IS 2386(Part I)

3.3 Coarse Aggregates

a) All coarse aggregate shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386, Parts I to VIII.

b) The maximum size of coarse aggregate shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. The grading of coarse aggregate shall be such that not more than 5% shall be larger than the maximum size and not more than 10% shall be smaller than the smallest size. Between these sizes the coarse aggregate shall be well graded. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20 mm.

c) Water absorption shall be less than 3% by weight (ASTM C 117)

d) Coarse aggregates used for the Works shall be crushed stone conforming to IS 383, obtained from approved sources by the Engineer. Only quarries having jaw crushers

with choke feeding arrangements producing aggregates of nearly cubical shape shall be applied.

e) Coarse aggregate containing flat or flaky pieces or mica shall be rejected.

f) The Contractor shall carry out the following tests at site and ensure that the appropriate provisions of following Indian standards as may be applicable are complied with:

i. Moisture content in coarse aggregate asper IS 2386(Part III)

ii. Water absorption shall be worked out as per IS 2386(Part III)

iii. Bulk density and voids asper IS 2386(Part III)

iv. Grading of coarse aggregate as per IS 383:2016 and IS 2386(Part I)

4 Water

Water used in the works shall be potable water and free from deleterious materials. Water used for mixing and curing concrete as well as for cooling and/or washing aggregate shall be fresh and clean free from injurious amounts of oil, salts, acids, alkali, sugar other chemicals and organic matter. Mixing and curing with seawater shall not be permitted.

Water shall be from the source approved by the Engineer and shall be in accordance with IRS: CBC(Cl.4.3), IS: 456 (Cl. 5.4) and/or BS 3148.

Water samples from the intended source of supply shall be taken for analysis before any concrete work commences, and at regular intervals throughout the duration of the Works, as approved by the Engineer. Whenever the source of water changes, the water shall be tested for its chemical and other properties or impurities to ascertain its suitability for use in concrete, subject to the approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such tests shall be borne by the Contractor.

5 Chloride Content

The chloride content of aggregates shall be within the recommended limits stated in IS: 383 or BS 882 and the chloride content of the concrete mix shall be within the recommended limit of IS: 456 or BS 8110. Chloride levels shall be determined daily in accordance with the methods described in BS 812.

6 Alkali-Silica Reactivity

If aggregates contain any materials which are reactive with alkalis in any of the constituents of the concrete, or in water which will be in contact with the finished work, then the Contractor shall take samples of these materials every week. The Contractor shall ensure that the concrete mix complies with the requirements of this Specification regarding "Minimising risk of alkali-silica reaction in concrete". The results of the Contractor's weekly monitoring tests shall be submitted in writing to the Engineer-in-charge.

7 Sulphate Content

The total acid soluble sulphate content of the concrete mix, expressed as SO3, shall not exceed the recommended limit in IS: 456 or BS 8110.

8 Reinforcement Steel

The Contractor shall refer to **Annexure - C** of these Technical Specifications.

9 Binding Wire

GI wires of 1.6mm diameter shall be used for binding of reinforcements. It shall conform to the provisions laid down in IS 280.

10 Concrete Admixtures

a) Admixtures shall conform to the provision laid down in IRS: CBC (Cl. 4.4).

b) Concrete admixtures are proprietary items of the manufacturer and shall be obtained only from established manufacturers with proven track record, quality assurance and full- fledged laboratory facilities for the manufacture and testing of concrete. Naphthalene or melamine-based admixtures that are approved by the Engineer only shall be used in the Works. The admixture shall be non-air entraining type. The Contractor shall provide the following information concerning each admixture after obtaining the same from the manufacturer:

   i. Normal dosage and detrimental effects, if any, of under dosage and over dosage.

   ii. The chemical names of the main ingredients in the admixtures.

   iii. The chloride content, if any, expressed as a percentage by weight of the admixture.

   iv. Values of dry material content, ash content and relative density of the admixture which can be used for uniformity tests.

   v. Whether or not the admixture leads to the entrainment of air when used as per the manufacturer's recommended dosage, and if so, to what extent.

   vi. Where two or more admixtures are proposed to be used in any one mix, confirmation of their compatibility.

   vii. Whether or not there would be an increase in risk of corrosion of the reinforcement or other embodiments as a result of using the admixture.

   viii. Retardation achieved in initial setting time.

c) Physical and chemical requirements of admixtures shall conform to IS 9103. In addition, the following conditions shall be satisfied:

   i. Plasticizers and superplasticizers shall meet the requirements indicated for "Water reducing Admixture".

   ii. The air content of freshly mixed concrete, in accordance with the pressure method given in IS 1199, shall not be more than 1% higher than that of the corresponding control mix.

   iii. There shall be no chloride content in admixture when tested in accordance with IS 6925.

iv. Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times.

v. All tests relating to the concrete admixtures shall be conducted periodically at an independent laboratory and compared with the data given by the manufacturer.

vi. While qualifying the admixture, the infrared spectrograph plot shall be given. Each batch of the supply shall be tested for IR spectrograph and prove the consistency of supply.

11 Minimising the Risk of Alkali-Silica Reaction (ASR) in Concrete

a) Precautions against ASR in Concrete

Concrete mixes for use in the Permanent Works shall comply with one of the Subsections (b), (c) or (d). The Contractor shall notify the Engineer of his proposals for complying with this requirement.

b) The cementitious material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested in accordance with Subsections 3.3.1 ((e) to (k) inclusive).

To combat the ASR, Microsilica shall be used in minimum 5% cement and shall not exceed 10% by the wt of cement in order to bind free alkalis early in plastic concrete and to reduce the permeability of concrete to prevent the moisture and external alkalis penetration.

OR

c) The total mass of reactive alkali in the concrete mix shall not exceed 3.0 kg/m3 of concrete when defined, tested and calculated in accordance with Subsections 3.3.1 ((e) to (k) inclusive) and 3.3.1 ((l) to (o) inclusive).

OR

d) The aggregate shall be classed as non-reactive in accordance with the definition in Subsection (n).

e) Cementitious Material (Hydraulic and Latent Hydraulic Binders):

f) The term alkali refers to the alkali metals sodium and potassium expressed as their oxides. The reactive alkali content of Portland cements shall be defined as the percentage by mass of equivalent sodium oxide (Na_2O) calculated from:- % equivalent Na_2O = % acid soluble Na_2O + 0.658 x (% acid soluble K_2O)

g) The method used in determining the acid soluble alkali content of the materials shall be in accordance with BS 4550: Part 2: Subsection 16.2.

h) The Contractor shall make available the certified average acid soluble alkali content of Portland cement on a weekly basis.

i) The Contractor shall give immediate notice of any change which may increase the certified average acid soluble alkali content above the level used in the mix design

for the concrete. A revised mix design for any concrete which would be affected by the increased alkali content shall be submitted for consent with notification of the change.

j) Minimising the Risk by Using Cementitious material Containing less than 0.6% Reactive Alkali

The requirements of Subsection (b) will be met by Subsection (k) provided that the contribution of alkalis from other sources does not exceed 0.2 kg/m3 (see Subsections and (u)). Where alkalis exceed 0.2 kg/m3 the requirements of Subsections (l) to (o) shall apply.

k) The cementitious material shall be Portland cement complying with Indian Standard and shall have additionally a certified maximum acid soluble alkali content not exceeding 0.6%.

l) The Contractor shall provide on request weekly certificates which name the source of the cement and confirm compliance with the Specification.

Minimising the Risk by Limiting the Reactive Alkali content of the concrete to 3.0 kg/m3. The requirements of Subsection (c) will be met provided that Subsections (m), (n) and are satisfied.

m) The reactive alkali content of the concrete contributed by the Portland cement to the concrete shall be calculated from:

Portland cement

$$A = \frac{C \times a}{100}$$

Where,

A = reactive alkali content of the concrete to the nearest 0.1 (kg/m3)
C = target mean Portland cement content of the concrete (kg/m3)

a = certified average acid soluble alkali content of the Portland cement (%).

n) Where reactive alkalis in excess of 0.2kg/m^3 are contributed to the concrete from sources other than the cementitious material the limit of 3.0 kg/m^3 from the cementitious material shall be reduced by the total amount so contributed.

The reactive alkali contributed by sodium chloride contamination of aggregates shall be calculated from:

$$H = 0.76 \times \frac{(NF \times MF)+(NC \times MC)}{100} \text{ (kg/m3)}$$

Where,

H = equivalent alkali contribution made to the concrete by the sodium chloride

NF = chloride ion content of the fine aggregate as a percentage by mass of dry aggregates and measured according to BS 812: Part 4

MF = fine aggregate content (kg/m3)

NC = chloride ion content of the coarse aggregate as a percentage by mass of dry aggregate and measured according to BS 812: Part 4: 1976 (now in draft as Part 117)

MC = coarse aggregate content (kg/m3).

The factor 0.76 is obtained from a consideration of the composition of sea water.

The chloride ion content of aggregate sources containing 0.01% of chloride ion by mass or more shall be determined weekly in accordance with BS 812 or another approved method. When the chloride ion level is less than 0.01% it shall be regarded as nil.

o) The Contractor shall provide certificates on request confirming compliance with the Specification and stating:

i. The target mean cementitious material content of the concrete.

ii. The names of the works manufacturing the cement.

iii. A weekly report of the cement alkali determinations in accordance with Subsection (f).

iv. The certified average acid soluble alkali content of the Portland cement.

p) Minimising the Risk by Using Selected Aggregates

Fine and coarse aggregate material shall comply with the requirements of IS:383 (and/or AASHTO Standard Specifications M6 and M80 respectively) to be taken out to conform to 512(2).

q) Water

r) Water for use in the manufacture of concrete shall be obtained from a public utility undertaking supply or from a source approved by Engineer and shall be of potable quality, and comply with the requirement of IS:456 and or BS 3148

s) Where a potable mains supply is not available the Contractor shall obtain confirmation of the quality and reliability of the proposed source from the appropriate water authority and shall thereafter seek consent from the Engineer to use the proposed source.

t) Water other than from a public utility undertaking supply shall be sampled at a frequency to be determined by the Engineer and tested in accordance with the relevant provisions of IS:3025 or BS 3148. The sodium oxide and potassium oxide content shall be declared and expressed as equivalent Na_2O and shall be taken into account when calculating the total reactive alkali content of the concrete mix.

u) Admixtures and Pigments

Admixtures and pigments shall comply with the requirements of IS 9103 and IS:6925 or BS 5075 and BS 1014. The manufacturer's declared equivalent acid soluble alkali content and the dosage rate of any admixture or pigment to be incorporated shall be included with details of all concrete mixes submitted for consent.

v) The alkali content of admixtures shall be taken into account when determining the total equivalent alkali content of the concrete mix.

w) Micro silica (silica fume) shall be used in 5% by the weight of cement and shall not exceed 15% by the weight of cement.

12 Storage of Materials

12.1 General

a) Handling and storage of all material shall be as per IS 4082.

b) All materials shall be stored at proper places to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space shall also permit easy inspection, removal and restoring of the materials. All such materials even though stored in approved storage places, will be subjected to acceptance test prior to their immediate use.

c) The procedures to be adopted for transportation and storage of the materials shall obtain prior approval from the Engineer.

12.2 Cement

a) Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and watertight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used, it shall be ensured that their capacity is adequate to cater to the requirement at Site and they are cleaned at least once every 3 months. Cement older than 3 months from the date of manufacture shall not be used.

b) Each consignment shall be stored separately so that it may be readily identified and inspected, and cement shall be used in the sequence in which it is delivered at Site. Any consignment or part of a consignment of cement which had deteriorated of any sort during storage, shall not be used in the Works and shall be removed from the Site by the Contractor, without adding any costs to the Employer.

c) The Contractor shall prepare and maintain proper records on site regarding delivery, handling, storage and use of cement. These records shall be available for inspection by the Engineer at all times.

d) The Contractor shall make a monthly return to the Engineer on the date corresponding to the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

12.3 Aggregates

a) Storage areas for aggregates have to be covered, protected against any kind of contamination, avoid the possibility of mix among aggregates and protected also against any water inflow. The floor of the storage for aggregates has to be in concrete and has to be drained. Storage areas for different size of aggregates have to be independent to avoid any possibility of mix.

b) During rainy and cold weather periods, the aggregates shall be stored undercover for at least 48 hours before being used and kept sufficiently dry.

c) The stockpiling of the processed aggregate and drawl there from shall be such as to ensure that the variation in the free moisture in the aggregate during anyone shift of working, does not exceed 1 percent.

d) The coarse aggregates shall, be stored as per the procedure of relevant IS: codes.

e) Care shall be taken in screening and stocking of the coarse aggregates so as to avoid intermixture of different gauge materials and inclusion of any foreign materials.

f) The stockpiles shall be built up in horizontal or gently sloping layers.

g) Trucks and bulldozers shall be kept off the stockpiles to prevent breakage and impairing the cleanliness of aggregate.

h) A hard base shall be provided to prevent contamination from underlying materials in storage areas in continuous use.

i) Overlap of different sizes of materials shall be prevented with suitable walls or by ample distance between storage piles.

j) Arrangement shall be made to store natural and manufactured sand in a way that shall protect it from being contaminated with dust, organic matter or other deleterious substances.

13 Design Mix Concrete

13.1 General

a) For all items of concrete, only design mix shall be used. Prior to the commencement of construction, the Contractor shall design the mix and submit the proportions of materials, including admixtures to be used to the Engineer for obtaining approval. Suitable water reducing admixtures or super-plasticizing admixtures shall be used for achieving desired workability and strength of the concrete only after obtaining prior approval from the Engineer. No extra payment shall be made for such admixtures.

b) Mix design shall conform to the provisions under IRS: CBC (Cl. 5.5 and 8.7) and IS 10262.

c) Drying shrinkage of concrete shall be 0.03% or less. Drying shrinkage of concrete shall be tested in accordance with IS 1199.

d) When non-bleeding high flow concrete is used, it shall be confirmed that no bleeding occurs under Concrete Bleeding Test specified in IS 9103. The Contractor shall submit

the test results to the Engineer prior to the commencement of concrete works for obtaining approval.

e) Mix design, once approved, must not be altered without obtaining prior approval of the Engineer. However, if the Contractor anticipates any change in quality and/or change in source of future supply of materials than that used for earlier mix design, the Contractor shall inform the Engineer well in advance and bring fresh samples sufficiently in advance, to carry out fresh trial mixes.

f) The total chloride content of all constituents of concrete in mix shall be limited to 0.43 kg/m3 for reinforced concrete works and prestressed concrete works as per IS:14959.

13.2 Workability of Concrete

a) The mix shall have the consistency which allows proper placement and consolidation in the required position. It shall be ensured that uniform consistency is maintained.

b) Workability of concrete shall conform to the provisions of IRS: CBC(Cl.5.3).

13.3 Durability of Concrete

a) Maximum water cement ratio for design mix shall conform to IRS: CBC(Clause5.4.3) as follows:

Plain Concrete	Reinforced Concrete
0.45	0.40

b) Minimum grade of concrete shall conform to IRS: CBC(Clause5.4.4) as follows:

Plain Concrete	Reinforced Concrete
M-20	M-35

c) Maximum and minimum permissible cementitious material shall conform to IRS: CBCClause5.4.5) as follows:

Minimum(kg/cum)		Max
Plain Concrete	Reinforced Concrete	
250	350	500

13.4 Trial Mixes

a) The Contractor is entirely responsible for the design of the concrete mixes. However, the design shall have approval from the Engineer. At least 8 weeks before commencing any concreting in the Works, the Contractor shall make trial mixes using samples of coarse aggregates, sand, water, super plasticiser and cement, typical of those to be used

in the Works, and which have been tested in an approved laboratory. A clean dry mixer shall be used, and the first batch shall be discarded.

b) The mix shall be designed to produce the grade of concrete having the required workability, durability and a characteristic strength not less than appropriate value given in IRS: CBC (CL. 5.1, 5.3 & 5.4). Trial mixes shall be prepared under full-scale site conditions and tested in accordance with IS 10262.

c) Whenever there is a significant change in the quality of any of the ingredients for concrete, the Engineer, at his discretion, may order the carrying out of fresh trial mixes. All costs for trial mixes and tests shall be borne by the Contractor's and held to be included in the rates quoted in the priced Bill of Quantities.

d) Before commencing the Works, the Contractor shall submit full details of the preliminary trial mixes and tests to the Engineer for approval.

13.5 Size of Coarse Aggregate

The nominal size of coarse aggregates for concrete shall be as per the Drawings. The proportions of the various individual size of aggregates shall be so adjusted that the grading produces densest mix and the grading curve corresponds to the maximum nominal size adopted for the concrete mix.

13.6 Mixing Concrete

13.6.1 General

a) Production and control of concrete shall conform to IRS: CBC(Cl.5.6).

b) Concrete shall be mixed in an automatic batching and mixing plant as per this Technical Specifications. Hand mixing shall not be permitted. The mixer or the plant shall be at an approved location that shall be selected considering the properties of the mixes and the transportation arrangements available with the Contractor. The mixer or the plant shall be approved by the Engineer. Unless permitted by the Engineer, all concrete shall be produced in computerised automatic weigh batching plant having printing facilities to printout records of each batch and installed at the Site.

c) Mixingshallbecontinuedtillmaterialsareuniformlydistributedandauniform colour of the entire mass is obtained, and each individual particle of the coarse aggregate shows complete coating of mortar containing its proportionate amount of cement.

d) Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch. Unless otherwise agreed by the Engineer, the first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregate for cleaning purpose only, and the same shall not be used for concreting purpose. Mixing plant shall be thoroughly cleaned before changing from one type of mix to another.

13.6.2 Batching on site

a) Batching of concrete shall conform to the provision of IRS: CBC (Cl. 5.6.2) and IS 4925.

b) All weighing and measuring equipment shall be tested and calibrated as per IS 4926.The results of these tests and calibration shall be submitted to the Engineer.

c) Addition of water to compensate for slump loss shall not be resorted to nor shall the design maximum water content and maximum water-cement ratio be exceeded. If permitted by the Engineer, additional dose of retarder shall be used to compensate the loss of slump at the Contractor's cost. Re-tempering water shall not be allowed to be added to mixed batches to obtain desired slump.

13.6.3 Ready Mixed Concrete

The Contractor can use RMC, if approved by the Engineer. The source batching plant of RMC shall not change during the course of work. If RMC is used, it shall conform to the provisions laid down in IRS: CBC (CL. 5.7). The batching plant shall have consent to establish and consent to operate permit from Pollution Control Authority. The batching plant shall be operated by trained staff. The batching plant shall have suitable motorable road and a traffic plan to ensure free and safe passage of all vehicles. Waste water and sludge from batching plant shall be at the designated points.

A. Transporting, Placing and Compaction of Concrete

Transporting, placing, compacting and curing of concrete shall be in accordance with IRS: CBC(Cl.8), IS 456 and IS 5892.

i. Transporting

The method of transporting and placing concrete shall have approval from the Engineer. Transportation of concrete shall conform to IRS: CBC (Cl. 8.1, 5.7), if not in contravention to the following provisions.

The mix shall be transported by agitating transit mixers, buckets, pumps etc. or asper approval by the Engineer, without causing segregation and loss of cement slurry and without altering its desired properties with respect to water content, water cement ratio, slump, air content, cohesion and homogeneity.

1m^3 of each mix shall be supplied to Site before it is required in the Works to enable the Contractor to carry out workability tests. Under no circumstances shall extra water be added to the concrete after the original mixing is completed.

ii. Pumping

Pumping of concrete shall conform to IRS: CBC (Cl.8.9), if not in contravention to the following provisions.

a) The type of concrete pump, the diameter of transporting pipe, the route of piping etc. shall be determined considering the pumpability of the concrete to obtain the required quality of concrete after pumping.

b) The type and the number of concrete pumps shall be determined in consideration of the pumping pressure, the discharge amount, the pumping rate per hour, the environmental conditions of construction site etc.

c) Prior to pumping design mix concrete, pumping of mortar with the same proportion as of design mix concrete shall be done to prevent loss of mortar in pump due to adherence.

d) The mortar pumped prior to the concrete pumping shall not discharge into the formwork.

iii. Placing

a) Placing General

i) Placing of concrete shall conform to the provisions laid down in IRS: CBC(Cl.8.2).

ii) Prior to concreting, detailed planning on the placing system, the arrangement and the number of pumping cars, the position of the inlet for concrete pump, lighting equipment and arrangements for power supply, the sequence and rate of placing, time interval between concrete lifts etc. shall be specified in the Method Statement and the same shall be submitted to the Engineer for approval. Due allowance shall be made to secure enough clear spacing of reinforcement bars which enables concrete to flow through the spaces between reinforcement bars.

iii) Concrete shall be transported by means which prevent contamination (by dust, rain etc.) segregation or loss of ingredients, and shall be transported and placed without delay.

iv) Concrete shall be placed directly in its final position without segregation or displacement of the reinforcement, embedded items and formwork. Concrete shall not be placed in water, except as specified. Concrete shall not be dropped through a height greater than 1.5 metres.

v) All formwork shall be thoroughly cleaned to remove debris etc. before concreting. In addition, the Engineer shall inspect that there is no debris etc. in the formwork before concrete is cast. It shall be examined that there is no abnormality in the formwork and falsework before and during concreting.

vi) No concrete shall be placed in any part of the structure until approval of the Engineer has been obtained. If concreting did not commence within 24 hours of issuance of approval, then it shall be obtained again from the Engineer. Concreting then shall proceed continuously over the area between the construction joints.

vii) Except where otherwise agreed by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth of not more than 300 mm.

viii) Concrete when delivered in the works shall be maintained at a

temperature of not more than 35°C as far as possible.

ix) Clear spacing between reinforcements shall be secured adequately and lighting equipment shall be arranged adequately in order to visually check the position of inlet of the concrete pump and the filling situation of the concrete during concreting works. In addition, suitable measures shall be taken so that the reinforcement bars do not move and clear cover to the reinforcement bars does not change.

x) The clear cover shall be uniform and as per the Drawings. Concrete cover blocks used shall be of the same concrete mix as the member and shall contain the binding wire to secure it to the reinforcement. All ends of binding wire shall be carefully turned inside so that they do not project out of concrete cover. Reinforcement bars shall be adequately secured by chairs/ties/hangers so that it maintains its position during casting and vibrating concrete. Ends of the wires used to tie bars shall be bent into the member.

xi) In case of concreting the horizontal member immediately after the concreting of vertical member is finished, the horizontal member shall be cast after any settlement of concrete of the vertical member ceases in order to prevent settling cracks.

xii) If bleeding water is present on the surface of concrete during concreting, the bleeding water shall be removed before the following concrete is placed.

xiii) The Contractor shall ensure that the place where concreting is to be done shall be free of water.

b) Extent of Pours

For piers and pier heads, portal columns the concreting is to be carried out in single stage i.e. in first stage concreting will be from kicker to just below pier head bottom and second stage of concreting will be pier head including shear key and cross girder (in station zone stages as given in drawings for all heights by using tremie/ pumps at the rate not more than 1.5m / hr or as approved by the Engineer.

Floors, roofs and ground slabs shall be placed in a sequence of pours to the approval of the Designer and the consent of the Engineer.

If the use of slip-forms or paving trains is permitted, these limits may be revised. The sequence of pours shall be arranged to minimise thermal and shrinkage strains.

c) Placing Equipment

Concrete shall generally be placed without segregation by pumping or bottom-opening skips. If chutes are used their slopes shall not cause

segregation and spouts or baffles shall be provided.

d) Time for Placing

Concrete and mortar must be placed and compacted within 30 minutes of water being added to the mix or otherwise included via damp aggregates, unless admixtures are in use. Partially-set concrete shall not be used in the Works.

e) Continuity of Placing

Placing in each section of work shall be continuous between construction joints. The Contractor shall make provision for standby equipment. If the placing of concrete is delayed due to breakdown then the Contractor shall erect vertical stop-ends and form a construction joint or remove the concrete already placed and restart after repair of the breakdown, as directed.

f) Placing in Inclement Weather

Placing shall not take place in the open during storms or heavy rains. If such conditions are likely to occur the Contractor shall provide protection for the materials, plant and formwork so that work may proceed. If strong winds are prevalent protection from driving rain and dust shall be provided.

g) Placing in High Temperature and Low Temperature

The temperature of concrete shall not exceed 32o nor below 5oC or the temperature stated in the table of Mixes whichever is the lower at the time of placing concrete. Also the maximum concrete temperature after placing shall not exceed temperature 50oC or 30oC above the concrete temperature at the time of placing whichever is the lower.

"Concrete in hot countries" published by FIP congress at New Delhi 1986 shall be complied with. The procedures the Contractor wishes to employ shall be subject to the Engineer consent

The Contractor shall supply suitable maximum/minimum thermometers and record the shade and sun temperatures at locations where concrete is being placed. Recommendations for cold weather concrete can be had from IS: 7861 (Part 2).

h) Placing at Night

If consent has been given for placing at night or in dark interiors, adequate lighting shall be provided where mixing, transportation and placing are in progress.

i) Placing Under Water

Underwater concrete shall be placed with minimum disturbance of the water. Running water and wave wash shall be controlled. The specified

concrete grade shall be used and the mix design shall provide for good flowing ability.

Tremie pipes, bottom-dump skips or other approved placing equipment shall be used. Segregation shall be avoided.

Placing shall be commenced in approved sections and continued to completion.

The tremie pipe shall be buried in the concrete for at least 1.5m and the pipe must not be emptied until the pour is complete. If a bottom-dump skip is used, the contents shall be covered by canvas or similar before lowering into the water. The doors shall be opened when the skip is resting on the bottom with no tension in the support cable, and the skip shall be lifted gradually so that the concrete flows out steadily.

j) Preparation Before Placing

Before placing concrete for reinforced work on the ground, the formation shall be compacted as specified and a screed of blinding concrete shall be applied to form a surface for construction.

Before placing concrete on or against rock, masonry, brickwork or old concrete, loose material shall be removed and the surface washed down; water seepage shall be stopped or channelled away from the work.

iv. Compaction

a) Compaction of concrete shall conform to the provisions laid down in IRS: CBC (Cl.8.3).

Additional vibrators in serviceable condition shall be kept at site so that they can be used in the event of breakdowns. Concrete shall be compacted before setting commences and shall not be subsequently disturbed.

b) Internal (needle) and surface (screed board) vibrators of approved make shall be used for compaction of concrete. Internal vibrators shall be inserted in an orderly manner. The distance between insertions shall be 500 mm or less. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.

c) Internal vibrators shall be used for compaction of concrete in foundations, columns, buttresses arch section, slabs etc, and if required surface vibrators shall also be used. Depending on the thickness of layer to be compacted, 25 mm, 40 mm, 60 mm and 75 mm dia internal vibrators will be used. The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until:

i) Air bubbles cease to come to surface.

ii) Resumption of steady frequency of vibrator after the initial short period of drop in the frequency, when the vibrator is first inserted.

The vibration shall be done till the tone of the vibrated concrete becomes uniform. To achieve an even and dense surface free of aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.

iii) Flattened, glistening surface, with coarse aggregates particles blended into it appears on the surface.

iv) Use of curing compounds may be permitted with specific approval of Engineer.

d) After the compaction is completed, the vibrator should be withdrawn slowly from the concrete so that concrete can flow in to the space previously occupied by the vibrator. To avoid segregation during vibration the vibrator shall not be dragged through the concrete nor used to spread the concrete. The vibrator shall be made to penetrate, into the layer of fresh concrete below if any for a depth of about 150mm. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.

i) To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.

ii) A sufficient number of spare vibrators shall be kept readily accessible to the place of deposition of concrete to assure adequate vibration in case of breakdown of those in use.

iii) Form vibrators whenever used shall be clamped to the sides of formwork and shall not be fixed more than 450 mm above the base of the new formwork and concrete shall be filled not higher than 230mm above the vibrator. The formwork must be made specially strong and watertight where this type of vibrator is used.

iv) Care must be taken to guard against over vibration especially where the workability of the concrete mix is high since this will encourage segregation of the concrete.

v) Plain concrete in foundations shall be placed in direct contact with the bottom of the excavation, the concrete being deposited in such a manner as not to be mixed with the earth. Plain concrete also shall be vibrated to achieve full compaction.

14 Construction Joints

a. Construction joints shall be avoided as far as possible and in no case the locations of such joints shall be changed or increased from those shown in the drawings, unless otherwise approved by the Engineer.

b. Where provision of construction joint is unavoidable, the location, direction and construction method of construction joint shall be determined in consideration of the structural strength, durability and appearance of the structure. Concreting shall be carried out continuously upto the construction joints. Construction joints shall conform to the provisions laid down in IRS: CBC (Cl. 8.5 and Annexure - B). The Contractor shall submit Method Statement on the construction joints which shall be subject to the consent of the Engineer prior to concreting works.

c. The location of the construction joints and their arrangement, procedure for surface preparation of construction joint and sequence of concreting shall be subject to the consent of the Engineer. Construction joints shall be located at locations where the shear force is minimum. The joints shall be provided in a direction perpendicular to the member axis. Sequencing of concrete placement shall be organized in such a way that cold joints are totally eliminated. Properly designed reinforcement shall be provided prior to casting of the next lift for transfer of full tensile stress across the joints.

15 Expansion, Contraction and Movement Joints

a. Expansion, contraction and other movement joints shall be incorporated in the works as shown on the Drawings.

b. Where shown on the Drawings approved, expansion joint fillers shall be supplied and installed. Filler material shall be stored flat on a dry surface adequately protected from rain or moisture in such a way that the material does not deteriorate. Filler material which has been damaged or has started to deteriorate shall not be incorporated in the works.

c. Movement joints shall be sealed with an approved sealant applied in strict accordance with the manufacturer's instructions to the dimensions shown on the Drawings. The surface of the concrete to which the sealant is to adhere shall be straight and cleaned of all filler material, dirt, oil, grease and other matter. The sealant shall be applied by methods recommended by the manufacturer so that the sealant is brought flush to the surface of structure and a smooth surface is achieved. Excess material and spillage shall be properly cleaned off and removed.

d. Dowel bars shall be installed and cast in across the movement joint where shown on the Drawings. The bars shall be straight with clean cut ends of the diameters and lengths as

e. shown on the Drawings or in the Schedules. Cutting and cleaning of the dowel bars shall comply with the requirements of this Specification.

f. The bars shall be firmly supported in the positions shown on the Drawings so that they remain accurately parallel and are not displaced during the casting of the concrete in the first part of the structure. After the concrete has hardened and the formwork removed, the projecting ends shall be cleaned of all concrete spillage and painted with two coats of an approved bituminous paint and caps shall be fitted to the free ends of the bars. Dowel bar end caps shall be of cardboard or other material, of correct diameter for the dowel bar and of sufficient length to allow the specified movement of the two adjacent concrete structures. They shall be manufactured

expressly for this purpose by an approved manufacturer.

g. The Contractor shall take care to protect the projecting ends of dowel bars from bending or other damage prior to concreting the succeeding bay. The bituminous paint shall be applied as soon as practicable, but end caps shall not be fitted until immediately prior to the succeeding concreting operations.

16 Bolts, Inserts and Openings

a. All fixing blocks, brackets, built in bolts, holes, chases, etc., shall be accurately set out and formed and carefully sealed prior to the concrete being placed. No cutting away of concrete for any of these items shall be done without the permission of the Engineer-in- Charge.

b. Bolts and other inserts to be cast into the concrete shall be securely fixed to the formwork in such a way that they are not displaced during the concreting operations, and that there is no loss of materials from the wet concrete through holes in the formwork.

c. Unless shown otherwise on the Drawings or the Engineer has given consent, reinforcement shall be locally moved so that the minimum specified cover is maintained at the locations of inserts, holes, chases, etc.

d. Temporary plugs shall be removed and the threads of cast in bolts shall be proved to be free and shall be greased before handing over any part of the Works. Construction joints in all concrete work shall be made as directed by the Engineer. Where vertical joints are required, these shall be shuttered as directed and not allowed to take the natural slope of the concrete.

17 Concreting under Special Conditions

Concreting under special conditions shall conform to the provisions laid down in IRS: CBC.

17.1 Concreting in Extreme Weather Conditions

Concreting in extreme weather conditions shall conform to the provisions laid down in IRS: CBC (Cl. 8.6.1).

17.2 Concreting under Water

a. Concreting underwater and seawater shall conform to the provisions laid down in IRS: CBC (Cl. 8.6.2 and Cl. 8.6.3), where not contravening to the following provisions.

b. When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of mix to be used shall obtain approval of the Engineer, prior to the commencement of any work.

c. Concrete shall not be placed in water having a temperature below 5°C. The temperature of the concrete, when deposited, shall neither be less than 16 °C nor more than 35°C.

d. All underwater concreting shall be carried out by tremie method as described in IRS: CBC (CL.8.6.2) only, using tremie of appropriate diameter. The number and spacing of the tremie shall be worked out to ensure proper concreting. The tremie concreting when

started shall continue without interruption for the full height of the member being concreted. The concrete production and placement equipment shall be adequate to enable the underwater concrete to be completed uninterrupted within the stipulated time. Necessary standby equipment shall be available for emergency situation.

e. In case of withdrawal of tremie out of the concrete either accidentally or to remove a choke in the tremie with the approval of the Engineer, the tremie shall be reintroduced in the following manner to prevent impregnation of laitance or scum lying on top of the concrete deposited in the bore. The tremie shall be gently lowered on to the old concrete with very little penetration initially. A vermiculite plug shall be introduced in the tremie. Fresh concrete of slump between 150 mm and 175 mm shall be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing the laitance or scum. The tremie shall be pushed further in steps making fresh concrete sweep away the laitance or scum in its way. When tremie is buried in for about 0.60m to1.0 m, concreting may be resumed.

f. In case of concreting through tremie or such pipes which are subsequently withdrawn, the concrete shall be placed in adequate quantity to ensure that during withdrawal of the tube, a sufficient head of concrete is maintained to prevent the inflow of soil and water or bentonite slurry.

g. No concrete shall be allowed to come in contact with seawater within 72 hours of casting.

17.3 Concreting under Aggressive Soils and Water

Concreting under aggressive soils and water shall conform to the provisions laid down in IRS: CBC (Cl. 8.6.4).

18 Curing of Concrete

18.1 General

a. Concreting operations shall not commence until adequate arrangements for curing of concrete have been made by the Contractor. Curing and protection of concrete shall commence after the concrete has set hard enough, to with stand stresses due to curing work and does not get damaged, in order to protect it from the following:

   i. Premature drying out, particularly by solar radiation and wind.

   ii. High internal thermal gradients.

   iii. Leaching out by rain and flowing water.

   iv. Rapid cooling during the first few days after placing.

   v. Low temperature.

   vi. Vibration and impact which may disrupt the concrete and interfere with its bond to there reinforcement.

b. Where members are of considerable size and length, with high cement content, accelerated curing methods may be applied, as approved by the Engineer.

18.2 Curing Procedure

a. In order to ensure the required quality of concrete in terms of parametres such as strength, durability and permeability, concrete shall be cured adequately, being kept at a temperature and humidity necessary to be hardened within a certain period of time after concreting, in order not to be affected by harmful effects such as low or high temperature, rapid temperature change, drying, loading and impact loading.

b. Curing of concrete shall conform to the provisions laid down in IRS: CBC (Cl.8.4). Approved curing compounds shall be used in lieu of moist curing, with the approval of the Engineer, particularly for all vertical faces and inaccessible areas, conforming to IRS: CBC (CL. 8.4.2).

18.3 Finishing

Finishing shall conform to the provisions laid down in IRS: CBC (Cl. 6.2.4), if not in contravention to the following provisions:

a. Immediately after removal of forms, exposed bars or bolt, if any, shall be cut inside the concrete member to a depth of at least 50 mm below the surface of the concrete and the resulting holes shall be filled with cement mortar of dry pack consistency.

b. All construction and expansion joints in the completed work shall be left carefully tooled and free of any mortar and concrete. Expansion joint filler shall be left exposed for its full length with clean and true edges.

c. The finished surfaces of concrete after removal of form work shall be such that no touching up is required. All finsca used by form joints, if any, shall be ground using electric sur face grinder.

d. Immediate Lyon removal of forms, before any defects are rectified, the concrete work shall be examined by the Engineer.

    i. Exposed concrete surfaces shall be smooth and even, originally as stripped, without any finishing or rendering. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made true to their sizes, shapes and positions. The work that has sagged or contains honeycombing to an extent which is detrimental to structural safety or architectural appearance shall be rejected. Honeycombed parts of the concrete, including other surface defects in the concrete, shall be removed by the Contractor as per the methods which do not affect the strength of adjoining concrete and as per approval of the Engineer. In the final finish, no honeycombing is allowed.

    ii. Part of defective concrete thus removed shall be recast using fresh concrete of same grade, as approved by the Engineer without any additional cost. For that purpose, the Contractor shall prepare a comprehensive work procedure and obtain approval of the Engineer. No additional payment shall be made for repair of the concrete. The Contractor shall ensure that no air bubbles are formed on the exposed surface. Concrete pouring sequence, vibration methodology etc. shall be planned to ensure that air bubbles are

not formed. All materials, sizes and layouts of formwork including the locations for their joints shall have approval from the Engineer prior to the commencement of the works.

iii. After the finishing works, cracks which occurred in the surface of concrete until the concrete starts to set shall be removed by refinishing or tamping.

e. The top face of a slab intended to be surfaced with other material shall be left with a spaded finish.

f. Chemical surface retarders, if approved by the Engineer, shall be used to produce an exposed aggregate finish, provided the Contractor demonstrates that the durability of the concrete surface is not reduced.

19 Inspection, Tests and Standards of Acceptance

a. The Contractor shall submit test certificates from the manufacturer or supplier of materials along with each batch of material(s) delivered to site.

b. The Contractor shall set up a field laboratory with necessary equipment for testing of all materials & finished products to be used in the construction. The laboratory must have riffle divider of adequate capacity as approved by the Engineer for preparation of lab sample for sieve analysis of aggregates.

c. The test in go falls the materials shall be carried out by the Contractor at the field laboratory or from the laboratory approved by the Engineer and in the presence of the Engineer. The Contractor shall make all the necessary arrangements and bear the entire cost for the same.

d. Tests which cannot be carried out in the field laboratory shall be done at the Contractor's cost at any recognized laboratory or testing establishments having NABL certification and duly approved by the Engineer.

e. If materials are brought from abroad, the cost of sampling or testing, whether in India or abroad, shall be borne by the Contractor. The Contractor shall provide and maintain on site, until the works are completed, at all times the equipment and staff required for carrying out these tests.

20 Quality Control of Concrete

a. The Contractor shall carry out the following tests for concrete, at the site of placing, and ensure that they comply with appropriate provisions of Indian and/or other standards, as may be applicable:

i. Slump test for concrete: The frequency of slump test shall be as follows:

ii. Case 1: If the site of placing is at the same area as the concrete plant installed, then it shall be conducted once in every hour, as per IS1199(Cl. 5.0) and IS7320.

iii. Case2: Other than Case1, it shall be conducted once in each delivery of transit mixer, asper IS 1199 (CL. 5.0) and IS 7320.

iv. Tolerance for slump shall conform to IS4926(Cl.6.2.1).

v. Compressive and Flexural strength of concrete: Sampling, Strength tests and Acceptance criteria of concrete shall conform to IRS: CBC (Cl. 8.7) according to the type of concrete grade.

vi. Chloride ion content test: It shall be conducted as per IS:15949 once a week. Chloride ion content shall be0.43kg/m3 or less.

vii. Relative Density and pH value of plasticizer (if used): The test shall conform to IS9103(Cl.7.1, Cl.10.0, Annexure-E) and the tolerances shall be as specified in IS9103(Cl. 9.0, Table-2).

viii. Temperature of concrete shall be verified once in each slump test.

ix. The concrete shall be verified for permeability and the test procedure along with tolerances shall conform to IRS: CBC (Cl. 5.4.2, Appendix - G). The frequency of test shall depend up on the change in design mix or change in source of material used in the work. However, the Engineer shall select random batches of concrete for examination at his discretion, and any time during concreting. Sampling shall generally be done at the point of discharge from the mixer and at placing point. The concrete shall pass the permeability test if it is properly compacted and the water penetration depth in the broken core is less than 25mm.

b. It is the complete responsibility of the Contractor to redesign the concrete mixes as per the standard methods that have been approved and to produce there in forced concrete conforming to the specifications. The Contractor shall have competent staff to carry out this work.

c. After the completion of the quality control checks of concrete, the Contractor shall immediately report the test results to the Engineer by submitting quality control records of the concrete.

21 Inspection of Concrete

a. Inspection shall be carried out by the Contractor, after the removal of form work. Also, additional inspection shall be carried out if instructed by the Engineer.

b. Inspection shall be carried out as per approval of the Engineer for the Method Statement, incorporating the test procedures specified in Table below:

Table: Inspection of Concrete Surface Condition

Measurement Items	Inspection Method	Place to be Inspected
Presence or absence of honey combing, cold joint, discoloration, and cracking	Visual inspection at point-blank range	All parts
Presence or absence of cavity, float, and cracking	Hammering Inspection	As per approved Method Statement,

Clear cover to the outermost reinforcement	Non-destructive test using a probe	and as directed by the Engineer

c. Additional non-destructive tests (NDT) on the hardened concrete in the structure as a whole or any finished part of the structure where necessary, or directed by the Engineer, shall be carried out as laid down in IRS: CBC (CL. 18.3).

d. The Contractor shall report the inspection results along with the location to the Engineer immediately after the inspection. The forms generated from the probes during the inspection shall be attached to the records.

e. If defects such as deleterious cracking, spalling, deformation and finishing defects or damages caused by the Contractor are noticed from the results of the inspection, no repair work shall be commenced without prior permission taken from the Engineer.

f. Counter measures against the defects shall be subject to approval of the Engineer. In this case, "repair work" refers to all actions which make alterations to the surface of concrete after the removal of formwork (including plastering etc.). If repair work is required, the Contract or shall submit Method Statement on the repair work and shall obtain approval of the Engineer for the same, prior to the commencement of repair work. During the repair work, the Contractor shall record about the work, and shall report to the Engineer on the results of the work immediately after the repair work has finished.

g. If cracks develop in concrete construction, which in the opinion of the Engineer may be detrimental to the strength of the construction, the Contractor, at his own cost, shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto.

h. If any cracks develop in the concrete construction, which in the opinion of the Engineer, are not detrimental to the stability of the construction, the Engineer shall decide whether such cracks are required to be grouted. The Contractor shall grout such cracks as decided by the Engineer with polymer cement grout of approved quality at his own risk and cost.

i. External crack width shall be restricted to 0.2mm or less on all concrete structures, unless otherwise specified in the Drawings/Design.

ADDITIONAL TESTS FOR CONCRETE:

As frequently as the Engineer may require, additional testing shall be carried out for concreting in addition to mandatory test specified in CPWD specifications 1996/2002 / relevant IS Code / MOST/MORTH Specifications.

22 Non-Destructive tests for concrete

a) Ultrasonic pulse velocity test

b) Rebound hammer test

In order to determine the following properties of concrete, non-destructive tests for concrete

(ultra-sonic pulse velocity test and rebound hammer test) in accordance with IS 13311(Part 1 and Part 2) shall be carried out.

i. the homogeneity of concrete

ii. the presence of cracks, voids and other imperfections

iii. changes in the structure of the concrete which may occur with time

iv. the quality of the concrete in relation to the standard requirements

v. the quality of one element of concrete in relation to the another, and

vi. the values of dynamic elastic modulus of the concrete

In view of the limitations of each method of the non destructive testing of the concrete, it is essential that the results of tests obtained by one method should be complemented by other tests and each method should be adopted very carefully.

23 Permeability test for Concrete:

The concrete will be verified for permeability by the following procedure and shall confirm to IS: 3085-1965 – „Permeability of Cement Mortar & Concrete", Section 1717.7.5 of MOST Specification and DIN 1048.

a) The Engineer shall select random batches of concrete for examination at his discretion and sampling will generally be done at the point of discharge from the mixer and at placing point.

b) From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.

c) All cylinders shall be made, cured, stored, transported and tested in accordance with clause 1717.7..5 of MOST Specifications. The tests shall be carried out in a laboratory approved by the Engineer.

d) At least two cylinders shall be made on each day"s concreting until 60 cylinders have been made for each grade of concrete. The cylinders will be tested as per the procedure, given in Clause (e) next.

e) Test Procedure:

The permeability of concrete will be verified by the following procedure:

i. Prepare a cylindrical test specimen 150 mm dia and 160mm high.

ii. After 28 days of curing, test specimen will be fitted in a machine such that the specimen can be placed in water under pressure up to 7 bars. The typical machine shall be similar to one shown in Appendix 1700/II of MOST.

iii. At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.

iv. After the passage of the above period, the specimen is taken out and split in the middle by compression applied on two round bars on opposite sides above and below.

v. The water penetration in the broken core is measured with scale and the depth of penetration assessed in mm (max permissible limit 25 mm).

f) Acceptability Criteria:

The concrete shall pass the permeability test if it is properly compacted and is not considered permeable when tested as per DIN, and the water penetration in the broken core is less than 25mm.

No extra payment shall be made for this test and cost of the same will be included in his rate for concrete work.

24 Chlorides in Concrete

The levels of equivalent acid-soluble chlorides as NaCl (Cl x 1.65 = NaCl) in the constituents of concrete as stated elsewhere are indicative and are subject to the over-riding limits for the mixes.

The total estimated content as a percentage by weight of the cement in the mix shall not exceed the following limits: -

(a) For reinforced concrete

0.5% if made with Ordinary Portland Cement (OPC)

0.1% if made with Sulphate Resistant Portland Cement (SRPC)

(b) For mass concrete

1.0% if made with OPC

0.1% if made with SRPC

The Contractor shall test the constituents of the concrete to establish these contents as provided for elsewhere in this Specification.

In addition, regular tests to BS 1881: Part 6 for chloride content shall be made on the hardened concrete. The following values are acceptable: -

(i) For reinforced concrete made with OPC

95% of the test results less than 0.40% NaCl by weight of cement and no result greater than 0.50% NaCl by weight of cement.

(ii) For reinforced concrete made with SRPC

95% of the test results less than 0.1% NaCl by weight of cement and no result greater than 0.14% NaCl by weight of cement.

(iii) For mass concrete made with OPC

95% of the test results less than 1.0% NaCl by weight of cement, and no result greater than 1.30% NaCl by weight of cement.

(iv) For mass concrete made with SRPC

95% of the test results less than 0.2% NaCl by weight of cement and no result

greater than 0.25% NaCl by weight of cement.

In the event that the SRPC used contains a proportion by weight of tri-calcium aluminate which approaches 4 - 8%, then consent may be sought for an appropriate adjustment of the relevant chloride content limits.

25 Sulphates in Concrete

The level of acid-soluble sulphates (SO3) in the mix shall be no greater than:

Coarse aggregate 0.4% by weight

Fine aggregate 0.4% by weight

Water 500 mg/l

The total estimated sulphate content (SO_3) of the mix including that present in the cement shall not exceed 3.7% by weight of cement in the mix.

In addition, regular tests to BS 1881: Part 6 shall be made on the hardened concrete to determine the total sulphate content, which shall not exceed 4% by weight of cement in the mix.

Permissible Level of Chloride and Sulphates

The permissible level of chlorides and sulphates quoted in the above Subsections shall not be considered as mean values for the whole of the Works, but shall apply to any concrete.

Concrete for water-retaining structures shall in addition be as per IS: 3370.

26 CRACKS:

If cracks, which in the opinion of the Engineer may be detrimental to the strength of the construction, develop in concrete construction, the Contractor at his own expense shall test the structure as specified in "Loading Tests" of these Specifications.

If under such test loads the cracks develop further, the Contractor shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto.

If any cracks develop in the concrete construction, which in the opinion of the Engineer-in-Charge, are not detrimental to the stability of the construction, the Contractor at his own expense shall grout the cracks with neat cement grout or with other composition as directed by Engineer-in-Charge and also at his own expense and risk shall make good to the satisfaction of the Engineer all other works such as plaster, moulding, surface finish, which in the opinion of the Engineer have suffered damage either in appearance or stability owing to such cracks. The Engineer's decision as to the extent of the liability of the Contractor in the above matter shall be final and binding.

External crack width shall be as per IRS: CBC with latest addendums.

27 DEFECTIVE CONCRETE:

Should any concrete be found honeycombed or in any way defective, such concrete shall be cut out partially or wholly by the Contractor and made good at his own expense. If

Engineer feels that repaired structure will not be having same strength or shape or uniformity with other exposed surface as original desired structure / original structure, the same shall be rejected by Engineer and required to be dismantled and disposed by contractor at his own cost as instructed by Engineer-in-Charge. Decision of the Engineer shall be final and binding in this regard.

28 EXPOSED FACES, HOLES AND FIXTURES:

On no account shall concrete surfaces be patched or covered up or damaged concrete rectified or replaced until the Engineer or his representative has inspected the works and issued written instructions for rectification. Failure to observe this procedure will render that portion of the works liable to rejection.

Holes for foundation or other bolts or for any other purposes shall be moulded, and steel angles, holdfasts or other fixtures shall be embedded, according to the drawing or as instructed by the Engineer.

29 FINISHES:

Unless otherwise instructed the face of exposed concrete placed against formwork shall be rubbed down immediately on removal of the formwork to remove irregularities. The face of concrete for which formwork is not provided other than slabs shall be smoothed with a float to give a finish equal to that of the rubbed down face, where formwork is provided. The top face of a slab which is not intended to be covered with other materials shall be leveled and floated to a smooth finish at the levels or falls shown on the drawings or as directed. The floating shall be done so as not to bring an excess of mortar to the surface of the concrete. The top face of a slab intended to be surfaced with other material shall be left with a spaded finish. Faces of concrete intended to be plastered shall be roughened by approved means to form key.

30 CONCRETE FOR FLOORING ON GRADE:

Concrete for flooring on grade shall be placed in alternate bays not exceeding more than 4m x 6m or as specified in the drawings including forming the joints or adjacent bays. The stiff mix shall be thoroughly vibrated and finished to receive the floor finish.

31 GROUTING OF BASE PLATES & BOLT HOLES:

a) Mixing :

Dry grout should be mixed in a mechanical mixer: the conventional 200/400-litre capacity concrete mixer can be used to mix four bags of dry grout; alternatively, paddle type mortar mixers can be used. The quantity of grout to be mixed at one time should not exceed that amount which can be placed in approximately 10 to 15 minutes.

b) Batching :

Batching of grout by fraction of a bag is not allowed. The quantity of mixing water should be the minimum commensurate with workability, compaction, and filling of the grout in all corners and crevices. Mixing should be done for a minimum of three minutes to obtain a fluid grout of uniform consistency.

c) Cleaning and preparation of the surface :

The base concrete should be clean and strong, and its surface should be properly hacked; all dust should be removed suction or compressed air. The surface should be thoroughly wetted with water for several hours. Before the grout is poured, all free water should be removed and the flat surfaces coated with a thin cement slurry.

d) Restraint :

Heavy back-up blocks of timber or concrete should be fixed on all sided of the base plate to prevent escape of the grout, when poured through the openings provided in the base plate. Adequate restraint must be ensured on all the sides for a period of 7 days to obtain effective expansion and shrinkage compensation.

e) Curing :

The grout should not dry out where external restraint is provided in the form of form- work, the top opening and all stray openings should be covered with wet sack for at least 7 days.

f) Placing and Compaction :

The grout should be placed quickly and continuously either through the holes in the base plates or from one side only to ensure complete filling without entrapment of air. Grout should be properly spread and compacted by rodding. Excessive vibration should be avoided.

Below the bed plates the grout should be compacted using long pieces of doubled-over flexible steel strapping or chains. The forward and backward movement of the strap or chain will assist in the flow of the grout into place. Steps must be taken to keep the grout in full contact with the underside of the bedplate until the grout sets; maintaining a small head of fresh grout in the forms.

g) Shrinkage Compensated Grout:

Shrinkage compensated grout or non-shrinkable grout of Associated Cement Companies Limited or any other approved manufacturer (Fosroc, Roff, Sikka) should be used. The batching shall be as per the manufacturer's specifications, other procedures being as above.

32 Tolerance

Tolerances for the finished concrete structures shall be as specified in the Contract.

33 *Mass Concrete*

a) Any concrete having minimum dimension of more than 1 m shall be considered mass concrete.

b) In mass concrete core temperature shall not exceed 750C and differential temperature between core and surface of concrete shall not exceed 200C.

c) For each grade of mass concrete mock up trial shall be carried out of size 2m x 2m x thickness of mass concrete. Mock up trial shall use thermocouples to measure concrete temperature both near surface and at the core. Thermocouples shall be located

centrally along the length and width of the mock up. Thermocouple shall be rigidly suspended so that they do not move out of position during casting. The Contractor shall monitor and document the conformance of the trial with the maximum allowable temperature requirement as given above. Result shall be automatically locked at the minimum of hourly intervals and logging shall continue for at least 72 hours or until the core reached ambient temperature, which ever is longer.

d) The scheme of mock up trial shall be submitted by the Contractor to the Engineer for approval. If there is change in brand/ factory of cement, mock up trial will be required again.

e) The Contractor shall carry out temperature monitoring of core temperature and surface temperature of 1st structure of mass concrete to confirm the results of mock up trial.

f) Ply shuttering will be preferred. However, if steel plate shuttering is used, insulation will be provided with thermocol.

g) No water curing should be carried out for 07 days. Concrete top surface shall be covered with plastic sheets after initial setting of concrete and insulation of plastic sheets by thermocol after final setting of concrete. Vertical shuttering shall remain intact till 07 days or as per directions of the Engineer.

h) Detailed report shall be submitted by the Contractor to the Engineer after mock up and 1st structure casting.

i) The Contractor shall submit pour plan to the Engineer for approval for each structure of mass concreting. The pour plan shall include pour sequence, infrastructure required (RMC plant, TM, Concrete pump, placing boom), logistic plan, manpower (duties and responsibilities), lab equipment. Mass concrete shall preferably use PPC to reduce core temperature. Concrete placement temperature shall be decided by the results of mock trial and the same shall be followed.

j) *Thermocouples shall be provided in permanent concrete structures having maximum thickness more than 1m at one location for each additional 500mm thickness above 1m. The scheme of providing thermocouple shall be submitted by the Contractor to the Engineer for approval.*

34 Precast Concrete

34.1 Manufacture Off-Site

a) Casting of members shall not begin until a NONO has been given by the Engineer to the shop drawings, required computation and method of manufacture.

b) When the drawings and method of manufacture have been noticed, no changes shall be made without NONO from the Engineer

c) The Contract or shall in form the Engineer in advance of the date of commencement of manufacture and casting of each type of member.

d) Concrete reinforcement and work man ship shall be asper IS: 456.

e) A copy of all cube test results for the precast concrete works shall be sent to the Engineer as soon as these are available.

f) No members to which the tests relate shall be dispatched to the Site until the tests have been satisfactorily completed and noticed by the Engineer.

34.2 Forms

The design and fabrication of the forms and false work as well as their construction shall be the responsibility of the Contractor. Forms shall be inspected prior to authorizing casting operations. Details shown on the Drawings shall be built into the forms. Worn, damaged, or otherwise unacceptable forms shall be repaired be forecasting of any member is authorized. The forms may be made either of steel or of plywood. If the Contractor elects to use plywood forms, it shall be high quality plywood, 19mm minimum thickness marine grade subject to NONO from the Engineer. Forms shall be structurally adequate to support the members within permissible tolerances. Forms shall be coated with a noticed form-release agent prior to use. Anchor devices may be cast into the concrete for later use in supporting forms provided the arrangement has Notice from the Engineer. Bottom/base should be true level without offsets and kinks of designed supports and shutterings over required PCC base with proper drainage arrangement for proper working and curing.

34.3 Curing

Steam curing with approved methodology can be adopted if required, for precast components subject to the approval of Engineer-in-Charge. No extra payment will be made for adopting steam curing. Before concrete products are subjected to any accelerated method of curing, the cement to be used shall be tested in accordance with accepted standards (relevant IS codes) especially for soundness, setting time and suitability for steam curing. In the case of elements manufactured by accelerated curing methods, concrete admixtures to reduce the water content may be allowed to be as permitted by applicable codes of practice subject to the approval of the Engineer-in-Charge. The normal aeration agents used to increase the workability of concrete shall not be allowed. The steam curing of concrete products shall take place under hoods, under chambers or in tunnels. Use of insulated tarpaulin may be permitted. The steam shall have a uniform quality throughout the length of the member. The precast elements shall be stacked with sufficient clearance between each other and the bounding enclosure, so as to allow proper circulation of steam. The surrounding walls, the top cover and the floor of steam curing chamber or tunnel or hood shall be so designed as not to allow more than 1 kcal/m2/h/ deg C. The inside face of the steam curing chamber, tunnel or hood shall have a damp-proof layer to maintain the humidity of steam. Moreover, proper slope shall be given to the floor and the roof to allow the condensed water to be easily drained away. At first, when steam is let into the curing chambers, the air inside shall be allowed to go out through openings provided in the hoods or side walls which shall be closed soon after moist steam is seen jetting out. Preferably, steam should be let in at the top of the chamber through perforated pipelines to allow uniform entry of steam throughout the chamber. In no case shall steam impinge directly on concrete products. The fresh concrete in the moulds shall be allowed to get the initial set before allowing the concrete to come into contact with steam. The regular heating up of

fresh concrete product from 20 °C to 35 °C shall start only after a waiting period ranging from 2 to 5 hours depending on the setting time of cement used. The second stage in steam curing process shall be to heat up the concrete elements, moulds and the surroundings in the chamber. The air-space around the member shall be heated up to a temperature maximum to 70°C at a gradual rate, not faster than 10° per hour. This process shall continue 1 1/2 to 2 1/2 hours depending upon the outside temperature. The third stage of steam curing shall be to maintain the uniform temperature and pressure for a duration depending upon thickness of the section. This may vary from 3 to 5 1/2 hours. The fourth stage of steam curing shall be the gradual cooling down of concrete products and surroundings in the chamber and normalization of the pressure to bring it at par with the outside air. The maximum cooling rate, which is dependent on the thickness of the member, shall not exceed 30° per hour. In all these cases, the difference between the temperature of the concrete product and the outside temperature shall not be more than 60°C for concrete up to M 30 and 75°C for concrete greater than M 45. In the case of light weight concrete, the difference in temperature shall not be more than 60°C for concrete less than M 25. For concrete greater than M 50, the temperature differences may go up to 75°C. After the steam curing is completed, the elements shall be further water cured for about 3 to 7 days.

The curing shall be carried out as per approved Method Statement.

34.4 Storage

When members are stored, they shall be firmly supported only at the points specified.

a. The accumulation of trapped water and deleterious matter in the units shall be prevented.

b. Care shall be taken to avoid rust staining and efflorescence.

c. The area intended for the storage of pre-cast units should be surfaced in such a way that no unequal settlement can occur.

d. To prevent deformation of slender units, they should be provided with supports at fairly close intervals and should also be safeguarded against tilting. Lifting and hand ling positions should conform to the Engineer's directions and drawings. In addition, location and orientation marks shall be put on the members, as and where necessary.

34.5 Handling and Transport

a. Members shall be lifted or supported only at points specified or otherwise given a NONO from the Engineer and shall be handled and placed without impact.

b. The Contractor shall define the method of lifting, the type of equipment and transport to be used, and the minimum age of the members to be handled and shall submit to obtain approval from the Engineer.

34.6 Protection

At all stages of construction, pre-cast concrete units and other concrete associated there with shall be properly protected to prevent damage to permanently exposed concrete surfaces, specially arises and decorative features.

35 Falsework and Formwork

35.1 General

Falsework and formwork shall conform to the provisions laid down in IRS: CBC (CL. 6.1 to 6.4) and IRC: 87, if not in contravention to the following provisions:

a. Falsework shall be designed in consideration of appropriate raising (camber) against sinking and deformation due to the weight of the concrete during construction and after completion. Furthermore, the Contractor shall submit the plan of the camber to the Engineer prior to the commencement of works for obtaining approval.

b. Ties shall not be welded to the reinforcement bars. Clear cover to the end of the ties shall not be less than 25mm. Filling of tie locations after removal of form work shall be carried out with dry pack cement mortar.

c. The form work shall be of steel plates of proper thickness to give good finish.

35.2 Design of Formwork

a. The Contractor shall submit the design and drawing of complete formwork (i.e. the forms as well as their supports) to the Engineer, before any erection work commences. If proprietary system of formwork is used, the Contractor shall furnish detailed information to the Engineer. However, the Contractor shall be entirely responsible for the adequacy and safety for formwork.

b. The foundation of all supports shall be designed to suit the bearing capacity of soil to support the designed loads without settlement.

c. The Contractor shall prepare detailed shop drawing showing the arrangement of form work for structural members including shoring system, horizontal and diagonal bracing system, details of foundation etc. The sizes of individual members shall be as per the design calculations.

35.3 Finishing of Formwork

a. Finishing shall conform to IRS: CBC (Cl.6.2.4 and Cl.6.2.5).

b. Formwork shall be made to produce a finished concrete true to shape, line, levels and dimensions.

c. Chamfers shall be provided at all angles of the formwork to avoid sharp corners. The chamfers, bevelled edges and mouldings shall be made in the form work itself, conforming to the Drawings.

35.4 Cleaning and Treatment of Forms

Cleaning and treatment of forms shall conform to IRS: CBC(Cl.6.3).

35.5 Specialized Formwork

a. Specialized form work shall conform to the provisions laid down in IRC:87(Cl.10).

b. Specialized formwork may be required in the case of slip formwork, underwater concreting etc. Such specialized formwork shall be designed and detailed by competent agencies and a set of complete working drawings and installation

instructions shall be supplied to the Engineer. The site personnel shall be trained in the erection and dismantling as well as operation of such specialized formwork. If proprietary equipment is used, the supplier shall supply drawings, details, installation instructions, etc. in the form of manuals along with the formwork. Where specialized formwork is used, close coordination with the design of permanent structure is necessary.

c. For slip form, the rate of slipping the formwork shall be designed for each individual case considering various parametres including the grade of concrete, concrete strength, concrete temperature, ambient temperature and concreted mixtures.

d. In order to verify the time and sequence of striking or removal of specialized formwork, routine field tests for the consistency of concrete and strength development are mandatory and shall be carried out before adoption.

35.6 Inspection of Formwork

a. The Contractor shall inspect the formwork and shall submit inspection results by "Formwork Assembly Inspection Record" prior to concreting works.

"Formwork Assembly Inspection Record" describes the results of verification of inspection results of the formwork with design documents in which the shape and dimensions of the formwork, clear cover to the outermost reinforcement, effective height etc. are verified. The proposed form of "Formwork Assembly Inspection Record" shall be submitted by the Contractor for approval of the Engineer.

b. Concreting shall not be allowed unless approved for the formwork by the Engineer.

35.7 Stripping and Removal of Formwork

a. Stripping time shall conform to the provisions laid down in IRS: CBC(Cl.6.4).

b. The scheme for removal of formwork (i.e., de-shuttering and decentring) shall be planned in advance and submitted to the Engineer for scrutiny and approval. No form work or any part there of shall be removed without prior approval of the Engineer.

c. The formwork shall be removed in such a manner that does not cause any damage to concrete. Centring shall be gradually and uniformly lowered in such a manner that it permits the concrete to take stresses due to its own weight uniformly and gradually to avoid any shock or vibration.

d. Where the rear ere- entrant angles in the concrete sections, the formwork shall be removed at these sections as soon as possible after the concrete has set to avoid cracking due to shrinkage of concrete.

35.8 Reuse of Forms

The Contractor shall not be permitted reuse of timber facing formwork brought new on the works for more than 5 times for exposed concrete formwork and 8 times for ordinary formwork.5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. Use of different quality boards or the use of old and new boards in the same form work shall not be allowed. If any other type of special or proprietary form work is used, the number of times they can be used shall begiven a NONO from the Engineer.

Annexure OCS-2

REINFORCEMENT STEEL

1. General

a) High strength deformed steel bars for concrete reinforcement used in the works shall be Fe 500D TMT, conforming to IS 1786 and manufactured by SAIL/TATA STEEL /JSW STEEL/RINL/*JSPL*. No rerolled steel shall be used. The Contractor shall produce copy of original challan or voucher as a proof of having purchased the steel reinforcement from manufacturers or their authorized distributors having approval of the Engineer. Reinforcement steel shall be stored as per IS 4082.

b) Any steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications and shall be of tested quality under the ISI Certification Scheme.

c) All reinforcement work shall be executed in conformity with the drawings supplied and instructions given by the Engineer and shall generally be carried out in accordance with the relevant Indian Standard Specifications IS: 2502- Bending and Fixing of Bars for Concrete Reinforcement.

d) No work shall be commenced without the Engineer's approval for reinforcement bar bending schedule. The reinforcement bars shall be bent to conform to the dimensions and shape shown in the Drawings in a manner that will not damage the parent material. Bars shall be bent cold. Any reinforcement, which is bent, shall not be re-bent. However, when it is unavoidable to re-bend the reinforcement, the same shall have approval from the Engineer.

e) Placement of reinforcement shall conform to the provisions laid down in IRS: CBC (Cl. 7.1.3). Cover and spacing of steel shall be uniform and as specified in the specifications and as shown in the Drawings.

f) Uncoated reinforcement steel shall be protected from rusting or chloride contamination. Reinforcements shall be free of rust, mortar, loose mill scale, grease, oil or paint.

g) Procurement of reinforcement steel shall be so phased by the Contractor that the storage period before its actual use in the works is limited to the bare minimum as directed by the Engineer.

2. Transportation and Storage

a) Transportation and Storage shall be undertaken in such a manner that no damage is done to the steel.

b) Reinforcement steel shall be stored off the ground in separate groups according to size and length. Reinforcement steel, which has been cut and bent according to the schedules provided by the Contractor, shall be marked with bar number, as shown in the schedule, by using weatherproof tag or by placing in marked bins and shall be stored in such a manner as to be readily accessible when required and to facilitate inspection.

c) A hard base of PCC M 20 shall be provided for stacking of steel to avoid corrosion.

3. Inspection and Testing

a) Manufacturer's test certificate shall be submitted for each lot of supply brought at the Site by the Contractor. Physical tests shall conform to IS1387, IS1599, IS1608 and IS1786. Independent test on quality of steel from each lot shall be carried out as per IRS: CBC (Cl.4.5.2).

b) The frequency of tests on reinforcement consignments delivered at site from one manufacturer should be as per IS 1786:2008 (Cl. 11.1).

c) Specimens required for three tensile tests for each of the different size of bar for each consignment delivered shall be sampled and tested by the Contractor before use at Site. Test results shall be duly supported by graph with respect to stress and strain. If first test of three test samples does not give the specified results, two additional tests shall be carried out. Both retests shall conform to the requirements as specified in IS 1786. The steel shall be rejected otherwise.

d) Reinforcement steel shall be inspected prior to the commencement of works and assembly on Site. Defective, brittle, excessively rusted or burnt bar shall be discarded. Cracked ends of bars shall be cut out. All reinforcement steel shall be free of loose small scales, rust and coats of paint, oil, mud etc.

e) The Contractor shall inspect the reinforcement works and submit inspection results by "Reinforcement Assembly Inspection Record". "Reinforcement Assembly Inspection Record" describes the results of verification of inspection results of the reinforcement work with the Drawing in which the diameter, number and length of the reinforcements, position of splices and joints, position and interval of the bent reinforcement bar, type and disposition of cover blocks are verified. The form of "Reinforcement Assembly Inspection Record" shall be proposed by the Contractor for approval of the Engineer.

f) The Contractor shall obtain approval of the Engineer for reinforcement work prior to the commencement of concrete work.

4. Tolerances and Criteria

a) Unless otherwise specified by the engineer, reinforcement shall be placed within the following tolerances:

i. For overall depth 200 mm or less : ±10mm

ii. For overall depth more than 200mm : ±15mm

The cover shall, in no case, be reduced by more than one third of specified cover or 5mm whichever is less.

5. Lapping and Joints

a) Lapped Splices: No splicing of bars shall be permitted without prior approval of the Engineer. Lengths of splice, wherever required, shall be as indicated on the drawings

and approved by the Engineer. Lapped splices shall be staggered and located at points along the span where shear stresses are low.

b) Mechanical Joints: Mechanical coupler shall be used for jointing of reinforcement bars of diameter 25 mm and above. Mechanical coupler shall conform to laid down specification given in Clause 6 below. Mechanical couplers of threaded type with enlargement at connection by cold forging may be used at appropriate locations after prior approval of the Engineer.

c) Welded Joints: Not permitted

6. Coupler Specifications

a) Introduction

Only cold-forged, parallel threaded mechanical coupler system shall be used. All mechanical couplers shall be of Type 2 (or Class H as specified in IS-16172) and should be simple to install and which can be confirmed by quick visual inspection to have been correctly installed and to have achieved the required full strength connection. Any other types of mechanical coupler systems are not permitted.

The couplers shall be of standard parallel thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that root thread diameter is not lesser than the parent bar to be joined. The coupler shall be of TYPE – II and qualified/Certified as per UK CARES, IS code 16172:2014, ACI 318, ASME, Section III, and Div.2, Caltrans.

Couplers installed shall be strictly in accordance with the manufacturer's recommendations. Couplers shall be located away from high stress zones in the various structural elements and shall be staggered and shall conform to provision of IRS: CBC

All the couplers shall be manufactured in a factory which is ISO 9001:2008 (or higher revision) certified for "Manufacturing of Mechanical Steel Rebar Couplers & Accessories" and also be certified for "Site Management of Threading & Processing of Rebar including Sales and Distribution". All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties. The coupler manufacturer shall operate at least an ISO 9000 approved quality assurance programme or equivalent for the manufacture of couplers.

b) Threading of ends of the reinforcing bars:

The threading activity shall preferably be done at Site. The various stages involved in threading are as given below:

i. Cutting (Rebar End Preparation):

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plane surface perpendicular to the axis of the bar.

ii. Cold forging & threading:

After cutting the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done on threading machine. The threads shall be square parallel type to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic end caps before taking the bars out of the shop.

c) Quality control in making of threads:

Double forging of bars is not permitted. In case of improper cold forging the forged of the bar shall be square cut and fresh cold forging shall be undertaken. 100% threading at threaded rebars shall be checked with 'go' and 'no go' gauges for the correctness of the thread profile on the rebar. A proper record for same shall be maintained at site.

d) Qualification tests

The coupler shall be qualified as per IS code 16172:2014, ACI 318, ASME - Section III, and Div.2, Caltrans and must have conducted & qualified for the following tests:

i. Static tensile test

Mechanical connections shall be tested for all reinforcing rebar sizes. For each rebar size, a minimum of three connections (3 joints + 1 Parent bar) in each load direction shall be tested in accordance with ASTM A370 test method to meet code requirement. A tensile test on an unsliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength. The tensile strength of an individual splice system shall not be less than the 125% of the specified minimum yield strength (fy of rebar) of the spliced bar.

ii. Cyclic tension and compression test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for cyclic tension & compression test. Each specimen shall withstand cycles of stress variation of the specified minimum yield strength of the reinforcing bar. The test should be carried out as per the table mentioned below:

Loading Stages and Cycles per stage for cyclic load test

Stage	Tension	Compression	Cycles
1	0.95 fy	0.5 fy	20cycles
2	2 εy	0.5 fy	4cycles
3	5 εy	0.5 fy	4cycles

Note:

fy is specified yield strength of the reinforcing bar.

εy is the strength of reinforcing bar at actual yield stress

iii. **Cyclic tensile test**

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength (fy) of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return.

iv. **Low cycle fatigue test (for 10,000 cycles)**

Fatigue test shall be conducted on splice sample from +173 Mpa to -173 Mpa for 10,000 cycles. A sine wave form @ 0.5 Hz shall be followed for bar dia 36 mm & above and 0.35 Hz shall be followed for bar dia less than 36 mm. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. Past certificates for low cycle fatigue test shall be accepted. However these should not be more than 3 years old.

v. **High cycle fatigue test (for 2,000,000 cycles)**

In high cycle fatigue test, the test specimen is subjected to an axial tensile load which varies cyclically according to the sinusoidal wave form of constant frequency in the elastic range, as accordance with IS-16172. Past certificates for high cycle fatigue test shall be accepted. However these should not be more than 3 years old.

vi. **Slip test**

Slip Test Shall be performed on each diameter coupler specimen as per ASTM A 370 section 10. Test shall be conducted conforming to IS 16172:2014 & Caltrans specifications. Total slip shall not exceed the max value of 0.1 mm.

vii. **Proof loading test**

Every cold-forged, threaded bar end shall undergo a proof load test prior to leaving system supplier's workshop. Every threaded bar must be subjected to proof load testing to a minimum test loading of 75% of the characteristic strength (theoretical fy). The system supplier shall essentially install a proof load tester equipment within its threading workshop premises and ensure to test each and every threaded bar. A positive indication shall be marked on the rebar to indicate that this operation has been carried out.

Note: All three steps involved in the preparation of mechanical joints i.e end cutting of reinforcement, cold forging and threading shall be performed by the coupler manufacturer either at site or at supplier's workshop. Proof load testing of each threaded bar end shall also be performed by the

manufacturer at a NABL approved lab which will be witnessed by the Engineers Representative. Contractor shall submit the test certificates of joint strength issued by the manufacturer.

7. INSTALLATION OF COUPLERS IN THE FIELD:

The installation of couplers in the field, for joining reinforcing bars shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned just before installation. Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached, then the same to be cleaned before joining the next bar.

The Contractor shall arrange for a suitably qualified manufacturer's representative experienced in mechanically connecting reinforcement to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary. The threading workshop is to be fully supervised by the manufacturer's representative.

The Contractor shall submit to the Engineer, for his approval a method statement duly approved by the manufacturer for mechanically connecting the reinforcement and for the installation and verification in the field. All activities of manufacture of mechanical joint i.e. cutting, forging and threading shall be carried out under the overall guidance of the manufacturer at the rebar yard with necessary machines and equipment supplied by the manufacturer. The Contractor shall also submit certificate for satisfactory performance of the mechanical joint from the manufacturer for all the coupled bars. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

i) Requirements for cleanliness

ii) Equipment for threading bars

iii) Method of locking the connections on both rebars

iv) Method of verification of final rebars alignment and coupler integrity

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The Contractor shall retain inspection records and shall submit copies to the Engineer-in-Charge within 7 days. The Couplers that do not meet the acceptance shall be completely removed and the bars re-connected as required.

6. BAR BENDING AND BAR BENDING SCHEDULE:

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule and bent bars are not straightened for use in any manner that will injure the material.

Prior to starting bar bending work, the Contractor shall prepare bar bending schedule from the structural drawings supplied to him and get the same approved by Engineer. Any discrepancies and inaccuracies found by the Contractor in the drawings shall be immediately reported to the Engineer whose interpretation and decision there to, shall be accepted.

7. SPACING, SUPPORTING AND CLEANING:

a) All reinforcement shall be placed and maintained in the positions shown on the drawings to be prepared by contractor.

b) The Contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape and size, Chairs and spacer bars shall be used to ensure accurate positioning of reinforcement. Spacers or chairs should be placed at a maximum spacing of 1m and closer spacing sometime be necessary. Cover blocks of approved proprietary should be pre-packaged free flowing mortars (Conbextra HF of Fosroc or equivalent). Cover blocks of concrete (not sand cement mortar) should be of the same strength as that of the surrounding concrete and properly compacted and vibrated on a vibrating table. They shall be cured for a minimum period of 14days before they are used in the works. The cost of cover block shall be deemed to have been included in the rates.

c) Cover blocks shall be firmly placed at appropriate intervals to maintain specified concrete cover to the reinforcement. The number of cover blocks to be provided shall generally be about 4 pieces per m2 for the bottom surface of the member and about 2-4 pieces per m2 for the side surface of the member. Cover blocks shall be made of concrete or mortar having quality equal to or higher than that of the parent concrete.

d) Bars must be cleaned, before concreting commences, of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete. On no account shall the bars be oiled or painted nor shall mould oil used on the formwork be allowed to come in contact with the bars. Cement wash to bars will not be permitted.

e) Only Fe500D TMT bars complying to IS:1786 shall be provided.

f) 1.6mm dia. G.I. wire shall be used for binding reinforcement.

Annexure OCS-3

FABRICATION AND ERECTION OF STEEL BRIDGE GIRDER

1. General

Fabrication of all Steel Bridge Girders shall be performed within the plants and by fabricators having the experience, knowledge, trained manpower, quality controls, equipment and other facilities required to produce the steel work to desired quality. The plants where fabrication works are proposed to be performed shall be duly approved by RDSO for fabrication of OWG. The tenderer shall submit complete details of the plants along with his tender for the approval of the Engineer. Inspection and passing of fabricated elements/girder shall be done by the RDSO/Employer as per codal provisions and specifications.

Fabrication and erection of steel girder bridges shall be in accordance with IRS fabrication specifications (B1).

2. Material

a. Steel: Mild steel for welded/riveted bridge girders subjected to railway loading shall conform to IS: 2062, Quality "B0" Grade Designation E250, fully killed and with normalizing/ normalizing rolling/ controlled rolling. Plates less than 12mm thick need not be with normalizing/ normalizing rolling/ controlled rolling.

b. In case Rolled Steel Standard Sections conforming to IS:2062 Quality "B0" are not available in market, Engineer may permit use of steel conforming to IS:2062 Quality "BR" / "A" on case to case basis.

c. Steel shall have smooth and uniform finish and shall be free from rolling defects such as cracks, flaws, seams, laps, imperfect edges etc. and other defects such as loose mill scale, rust, pitting, or other defects affecting its strength and durability.

d. High Strength Friction Grip (HSFG) bolt assembly including Direct Tension Indicator (DTI)washers shall conform to EN: 14399 series.

e. All the steel sections used in the fabrication must have mill test certificate clearly indicating the specification to which the steel conforms and whether steel is killed and normalized.

f. The materials, on receipt, shall be carefully unloaded, examined for defects, checked, sorted, and stacked securely on a level bed, out of danger from flood or tide and out of contact with water or ground moisture. They will be supported on timber or concrete plinths so that they do not touch the ground.

3. Fabrication of steel work

a. The records of fabrication shall be maintained in the registers as per the formats given in the Appendix I of IRS: B1-2001.

b. The greatest accuracy shall be observed in the design, fabrication, and erection of every part of the work to ensure that all parts will fit accurately together on erection. Components of all the spans shall be fully interchangeable. Same jigs and assembly

fixtures duly approved shall be used. The tolerances in manufacture shall be in accordance with as shown in Appendix II of IRS: B1-2001.

c. There should be level, finished concrete floor of sufficient dimensions in the fabrication yard, on which the fabricator will precisely set out the outline of the structure (to full scale) as per drawings for the purpose of preparing templates. Only steel tapes shall be used for all measurements, and they will be held tight and level on the floor while measuring or marking.

d. Steel tapes used for marking out the work shall be calibrated at a temperature of 20° C.

e. The templates throughout the work shall be of steel bushed.

i. Flattening and straightening

All steel materials, plates, bars and rolled sections shall have straight edges, flat surfaces and be free from twist. If necessary, they shall be cold straightened or flattened by pressure before being worked or assembled unless they are required to be of curvilinear form.

ii. Cutting of Steel

Cutting of steel for fabrication may be done by shearing, sawing, or by gas using mechanically controlled torch/torches. All flame cut edges shall be ground to obtain reasonably clean square and true edges. Plasma-arc cutting method may also be employed. This process offers less heat input causing less distortion.

iii. Making of Holes

Marking and drilling of holes in members shall preferably be done with the use of templates/jigs. All bolt holes in members built up by welding shall be drilled after welding.

Holes for turned bolts, should be 1mm under drilled in shop and should be reamed at site to suit the diameter of turned bolt. Jigs shall be periodically checked for tolerances from master plates.

iv. Welding

Welded construction work shall be carried out generally in accordance with the provisions of Indian Railway Standard Welded Bridge Code and subject to further specifications as given below:

i) All welds shall be done by submerged arc welding process in shop. Site welding should not be undertaken except in special circumstances with the approval of the Engineer. Site welding should be confined to connections having low stresses, secondary members, bracings etc.

ii) Suitable jigs and fixtures shall be used to avoid distortion during welding. Components which are mass fabricated in the shop should be proved in master templates.

iii) Class and size of electrode for welding shall conform to IRS Specification M-28. For fabrication of steel bridge girder following class of electrode shall be used-

Class of Electrode as per IRS Specification No. M.28.66	Type of work to be welded	I.S. Specification No.	Code (as per IS:815- 66)
Class B2 (Moderately high ductility)	For welding of mild steel to IS:2062-1962 (Fusion welding quality) or equivalent, for service conditions where the weldment is rigid and subjected to relatively high dynamic stresses	814-63	M 110 to M 997-H, J, K or P.

Brand and make of electrode on approved list of M&C wing of RDSO should be used.

a) No welding operator shall be employed on the work until he has, in the presence of the Engineer, passed the appropriate tests laid down in relevant codes.

b) All main butt welds shall have complete penetration and shall comply with the requirements of IRS Welded Bridge Code. They shall be made between prepared fusion faces. Where possible they shall be welded from both sides. The ends of the welds shall have full throat thickness. This shall be obtained on all main welds by the use of extension pieces adequately secured on either side of the main plates. Additional metal remaining after the removal of the extension pieces shall be removed by machining, or by other approved means and the ends and surfaces of the welds shall be smoothly finished.

c) In the fabrication of built-up assemblies all butt welds in the component parts shall be complete before the final assembly.

d) A record of butt welds shall be kept to enable it to be identified with the welders responsible for the work but material shall not be marked by hard stamping for this purpose.

The welding techniques and sequence, quality, size of electrodes, voltage and current required shall be as prescribed by manufacturers of the material and welding equipment. The Contractor shall submit full details of welding procedure in proforma given at Appendix V of IRS: B1-2001 for approval of the Engineer.

v. Welding of Stud Shear Connectors:

a) The welding of stud shear connectors shall be done by "DRAWN ARC STUD WELDING WITH CERAMIC FERRULE" technique. The shear stud and ceramic ferrules shall conform to type SD1/UF as per BS EN ISO 13918-2008.

b) The stud and the surface to which studs are welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanized or cadmium plated prior to welding. Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during periods of strong winds unless the work and the welder are adequately protected. The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs. The procedural trial for welding the stud shall be carried out when specified by the Engineer.

vi. Testing of Stud Shear Connectors:

a) Appearance Test

i) The weld to a shear stud connector should form a complete collar around the shank and free from cracks, excessive splashes of weld material, free from injurious laps, fins, seams, twist, bends or other injurious defects.

ii) Weld material should have a 'steel blue' appearance.

b) Test to check the fixing of shear studs

i) Ring Test: Involves striking the side of the head of stud with a 2 kg hammer. A ringing tone achieved after striking indicates good fusion whereas dull tone indicates a lack of fusion (BS 5400-6) All studs shall be checked by Ring test.

ii) Bend Test: Test requires the head of a stud to be displaced laterally by approximate 25% of its height using 6kg hammer.

* The weld should then be checked for sign of cracking or lack of fusion.

* Stud should not be bent as back as this is likely to damage the weld.

* The testing rate should be 1 in 50 (BS 5400-6).

vii. Making of Joints

a) Joints shall normally be made by filling not less than 50 per cent of holes with service bolts and barrel drifts in the ratio 4:1. Only barrel drifts shall be used in erection. Drifts may be used for drawing light members in position; but their use on heavy members shall be restricted to securing them in their correct position. Any error in the shop fabrication or

deformation resulting from handling and transportation which prevents proper assembling and fitting up of parts shall be reported immediately to the Engineer. No reaming shall be undertaken without the written authority of the Engineer.

b) The erection of OWG shall be done in accordance with Appendix III of IRS: B1-2001. However, if the Contractor desires to adopt any other method of erection, they shall submit the scheme and obtain the approval of the Engineer. It shall be ensured that when in position, the girder has the camber as per drawing.

viii. High Strength Friction Grip (HSFG) bolting assembly

The HSFG bolting assembly shall conform to EN 14399 Series (High strength structural bolting assemblies for preloading):

a) EN 14399-1:2015- General requirements.

b) EN 14399-2:2015- Suitability for preloading.

c) EN 14399-3:2015- System HR- Hexagonal bolt and nut assemblies.

d) EN 14399-5:2015- Plain washers.

e) EN 14399-6:2015- Plain chamfered washers.

f) EN 14399-9:2009- Direct Tension Indicator for bolt and nut assembly.

HSFG bolting assemblies are very sensitive to differences in manufacture and lubrication. Therefore, complete HSFG bolting assembly (i.e. bolt, nut, washers & DTI) including galvanizing shall be procured from single manufacturer. Use of Direct Tension Indicator (DTI) washers shall be mandatory in the HSFG bolting assemblies.

Grade and size of bolts shall be as per the Drawings. The surface preparation, tightening procedures and other details for HSFG bolts shall be as per RDSO standard Drawing No. RDSO/B-11760/R1.

Table: Composition of high strength structural bolting assembly and its component marking

Type of bolting assembly		System HR	
General requirements		EN 14399-1	
Suitability for preloading		EN 14399--2 and, if any, additional testing specified in the product standard	
Bolt & Nut		EN 14399-3	
Marking	Bolt	HR8.8	HR10.9
	Nut	HR8 or HR10	HR10
Washers		EN 14399-5[a] or EN 14399-6	
Marking		H or HR[b]	
Direct tension indicator and nut face washer or bolt face washer		EN 14399-9	
Marking	Direct Tension Indicator	H8	H10
	Nut Face Washer	HN	
	Bolt Face Washer	HB	

[a] EN 14399–5 can only be used under the nut.
[b] At the choice of the manufacturer.

The bolt length shall be chosen such that after tightening the following requirements are met for bolt end protrusion beyond the nut face and the thread length:

i) the length of protrusion shall be at least the length of one thread pitch measured from the outer face of the nut to the end of bolt

ii) at least four full threads (in addition to the thread run out) shall remain clear between the bearing surface of the nut and unthreaded part of the shank.

Holes for HSFG bolts- The holes shall be made by drilling only. The actual diameter of hole shall be 1.5 mm more than the bolt diameter for less than 25mm diameter bolts and 2mm more than nominal diameters of HSFG bolts for diameters 25mm and above.

Surface preparation of steel interface before providing HSFG bolts– Wherever property class 8.8 bolts are used these should be hot dip galvanized as per ISO: 10684(latest version). Property class 10.9 bolts should not be hot dip galvanized since this may cause hydrogen embrittlement. So these bolts should be coated with zinc flakes as per ISO: 10683 (latest version). However, depending on the site conditions, locations of these bolts in the structure and corrosion proneness, use of zinc flake spray coating as per ISO: 10683(latest version) can be adopted even for property class 8.8 bolts as well.

Installation of HSFG bolting assembly- Installation /tightening of preloaded bolting assemblies shall be carried out as per clause 8.3 & 8.5 of EN 1090-2 and clause 5.2 of EN 14399-9. The following steps shall be followed for tightening of bolts:

i. The holes shall be brought in alignment by using drifts etc. such that bolt threads are not damaged/enlarged during insertion of bolts.

ii. The members being joined shall be held in position by insertion of few HSFG bolts (tightened to first stage only i.e. snug tight condition).

iii. After the alignment/geometry of members is verified to be correct as per drawings, balance bolts shall be inserted and tightened upto first stage of tightening. The drifts inserted as above shall also be replaced by HSFG bolts one by one.

iv. After first stage of tightening, the joint shall be checked to see if the plies are in close contact and clearances are not exceeded.

v. Second stage tightening shall be done with torque wrench. Bolts shall be tightened until indentation on the DTI indicate full tightening. In order to minimize loosening of already tight bolts, tightening in both the stages shall be done starting from the stiffest part to free edges.

vi. 100% bolts shall be checked for proper tightening using feeler gauge of 0.4/0.25 mm.

vii. Fully tensioned bolt, opened for any reason whatsoever, shall be rejected and removed from the site of work along with washers, nut and DTI.

4. Bearing and Expansion Gear

All bearings and expansion gears shall be procured from a reputed and experienced manufacturer qualified to undertake precision fabrication of this type and shall be approved by the Engineer.

5. Trial Shop erection

Trial shop erection shall be done in accordance with Cl.614 of IRBM.

6. Field erection

Field erection shall be done in accordance with Cl.616 of IRBM.

7. **Erection in contractor's Works**

The whole of the work shall be completely interchangeable. First span (of each type) shall be temporarily erected complete at the Contractor's Works for inspection by the Inspecting Officer to test the accuracy of the templates. Further spans or part span assemblies built from parts selected at random by the Inspecting Officer shall be erected from time to time to check the accuracy of the work as the Inspecting Officer may require.

8. Launching

Before *taking up launching, the Contractor shall prepare and submit launching scheme along with design and methodology of launching including details of equipment proposed to be used for the approval of the Engineer.*

a) Rail Flyovers (RFO)

After approval of the Engineer, launching scheme shall be got approved from Chief Bridge Engineer/Northern Railway. CRS application shall be prepared by the Contractor and submitted to the Commissioner of Railway Safety (CRS) through the

Engineer, HRIDC and CBE/NR. Work of launching shall be started only after receipt of sanction of CRS.

b) Road Under Bridges

After approval of the Engineer, launching scheme shall be got approved from concerned road authorities. Work of launching shall be started only after receipt of approval of concerned road authority.

During erection of plate/composite steel girder by crane special care shall be taken to support the girder by wooden blocks & temporary bracing to ensure stability against toppling till permanent bracings are provided.

9. Track work for OWG:

Track work for open web girder bridge on H-beam sleepers shall be done as per IRPWM, relevant RDSO drawings and codal provisions.

10. Camber

In order to eliminate secondary stresses in a span under loaded condition, the nominal length (i.e. the lengths which will give no camber) of member shall be increased or decreased by the amount shown on the camber diagram supplied by the Employer. Frequent checks shall be made of the camber of girders during erection and care taken to see that the camber as per drawing is obtained when the girder is completely assembled. When span is supported on ends and intermediate supports are removed the dead load camber shall be recorded and entered in bridge register. This will provide the reference to compare the camber checked during technical inspection to ascertain the loss of camber.

11. Test certificates & testing

All materials for the work shall pass Mechanical test, Charpy test, Chemical Analysis, etc. prescribed by the relevant IS specifications or such other equivalent specifications.

For all materials including HSFG bolts, the Contractor shall furnish copies of test certificates from the manufacturers including proof sheets, mill test certificates, etc. showing that the materials have been tested in accordance with the requirements of various specifications and codal provisions.

If any further testing of materials is required by Engineer in respect of these and other items, it shall be arranged for by the Contractor at a reputed laboratory/National test house as approved by Engineer. For this, nothing extra shall be payable.

Even satisfactory outcome of such tests or analysis shall in no way limit, dilute or interfere with the absolute right of the Engineer to reject the whole or part of such materials supplied, which in the judgement of the inspecting authority does not comply with the conditions of the contract. The decision of the Engineer in this regard shall be final, binding and conclusive for all purposes.

The Engineer shall be empowered, at his/her discretion to make or have made under the supervision, any of the tests specified in the specifications mentioned herein in addition to such other tests as he/she may consider necessary, at any time up to the completion of the contract and to such an extent as he/she may think necessary to determine the quality of all

materials used therein. In doing so, he/she shall be at liberty under any reasonable procedure, he/she may think fit to select, identify, have cut-off and take possession of test pieces from the material either before, during or after its being worked up into the finished product.

The Engineer shall also be empowered to call for a duly authenticated series of mechanical tests to be obtained from the maker for this materials used in the work and to accept the same in lieu of other tests to the extent he/she deems fit. The Contractor shall supply the material for the test pieces and shall also prepare the test pieces necessary.

The test shall be carried out by the Contractor, for which Contractor shall provide all facilities including supply of labour and plant. Engineer may at his/her discretion direct the Contractor to despatch such tests pieces as he/she may require to the National Test House or elsewhere as he/she may think fit for such testing purposes. The Engineer may at his/her discretion, check test results obtained at Contractor's work by independent tests at National Test House.

The Engineer shall at all times be empowered to examine and check the working of the Contractor's plant before and after using it. Should the Contractor's plant be found, in the Engineer's opinion, unreliable, he/she is empowered to cancel any tests already carried out in this contract and have these tests carried out at any National Test House or elsewhere, as he/she may think fit.

12. Fabrication drawings

The Contractor shall prepare detailed shop drawings including drawing office dispatch lists (DODL's) on the basis of design drawings supplied by Engineer in such size and in such details as may be specified by Engineer. The shop drawings shall be submitted to Engineer in triplicate.

No work of fabrication will be started without such approval being obtained. Contractor has to arrange the proof checking of the working fabrication drawings from the nominated Institution / Consultant. The cost will be borne by the Contractor.

13. Painting

a. Fabricated steel work shall not be painted over except to the extent specified in para (b) until it has been inspected and passed by the Engineer or his representative and any defect, pointed out by him has been rectified.

b. All surfaces which shall be in permanent contact and any others which will not be accessible for painting later on shall be cleaned thoroughly and given one coat of Zinc Chrome Red Oxide Priming to IS 2074 or other approved composition in the prescribed number of coats immediately prior to assembly.

c. Steel girders (including all components) shall be provided with protective coating by metalizing with sprayed aluminum as given in the Appendix-VII of IRS: B1-2001, followed by painting as per painting schedule given below-

    i. One coat of etch primer to IS:5666

ii. One coat of zinc chrome primer to IS: 104 with the additional proviso that zinc chrome to be used in the manufacture of primer shall conform to type 2 of IS:51.

iii. Two coats of aluminum paint to IS: 2339 brushing or spraying as required. One coat shall be applied before the fabricated steel work leaves the shop. After the steel work is erected at site, the second finishing coat shall be applied after touching up the primer and the finishing coat if damaged in transit.

14. All third Party (RDSO/RITES/Any other nominated agency) Inspections charges for Open Web Girders and Composite Girders etc. shall be paid by the Employer."

Annexure OCS-4

PRESTRESSING

1. GENERAL

The work shall be carried out in accordance with the drawing and these specifications or as approved by the Engineer.

Concrete and un-tensioned steel for the construction of prestressed concrete members shall conform to the requirements of respective sections so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

Contractor shall ensure that different components of prestressing such as jacks, bearing plates, wedges, anchorages, strands, and HDPE ducts etc. are compatible to each other and the same shall be exchanged in between all the suppliers to ensure the same.

2. MATERIALS

a. Sheathing

i. The sheathing ducts shall be of the spiral corrugated type. Unless otherwise specified, the material shall be Cold Rolled Cold Annealed (CRCA) Mild Steel conforming to IS: 513 intended for mechanical treatment and surface refining but not for quench hardening or tempering.

ii. The material shall normally be bright finished. However, where specified, as in case of use in aggressive environment, galvanized or lead-coated mild steel strips shall be used. The thickness of sheathing shall be as shown on the drawing, but shall nevertheless not be less than 0.3mm, 0.4mm and 0.5mm for sheathing ducts having internal diameter of 50mm, 75mm and 90 mm respectively. For larger diameter of ducts, thickness of sheathing shall be based on recommendations of prestressing system supplier or as directed by the Engineer.

iii. For major projects, the sheathing ducts should preferably be manufactured at the project site utilising appropriate machines. With such an arrangement, long lengths of sheathing ducts may be used with consequent reduction in the number of joints and couplers. Where sheathing duct joints are unavoidable, such joints shall be made slurry tight by the use of corrugated threaded sleeve couplers which may be tightly screwed onto the outer side of the sheathing ducts.

iv. The length of the coupler should not be less than 150mm but should be increased upto 200mm wherever practicable. The joints between the ends of the coupler and the duct shall be sealed with adhesive sealing tape to prevent penetration of cement slurry during concreting. The couplers of adjacent ducts should be staggered wherever practicable. As far as possible, couplers should not be located in curved zones. The corrugated sleeve couplers are being conveniently manufactured using the sheath making machine with the next higher size of die set.

v. The internal diameter of the sheathing duct shall be in accordance with the recommendations of the system manufacturer and shall be about three times the area of the tendons. In case of 6T13, 12T13 and 19T13 sizes of tendons

comprising 12/13mm dia strands, the inner diameter of the sheathing shall not be less than 50mm, 75mm and 90mm respectively or those shown in the drawing, whichever is greater.

b. Anchorages

i. Anchorages shall be procured from authorized manufacturers only. Anchorages shall conform to BS 4447. Test certificates from a laboratory fully equipped to carry out the tests shall be furnished to the Engineer. Such test certificates shall not be more than 12 months old at the time of making the proposal for adoption of a particular system for the project.

ii. No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar and loose rust and any other deleterious coating.

iii. Swages of prestressing strand and button heads of prestressing wire, where provided shall develop a strength of at least 95 per cent of the specified breaking load of the strand or wire as the case may be. Where swaging / button-heading is envisaged, the Contractor shall furnish details of his methodology and obtain approval of the Engineer, prior to his taking up the work.

c. Prestressing Steel

i. 12.7mm nominal dia stress relieved low relaxation high tensile steel strand (CLASS-II) conforming to IS: 14268 with ultimate tensile strength 1861 N/mm2 shall be used. Various test as recommended in IS: 14268 shall be conducted before transporting the lot to site. Apart from 1000 hrs relaxation test conducted by manufacturer, at least two such tests are required to be conducted by independent agency in the beginning of project.

d. Prestressing strands/Wires storage

i. All high tensile steel for prestressing work shall be stored about 30cm above the ground in a suitably covered and closed space to protect it from dampness. It shall also be invariably wrapped in gunny cloth or tar paper or any other suitable materials, as per approval of Engineer. Even if it is to be stored in an area at the site for short time during transit it shall be suitably covered. Protection during storage and repacking or application of washable protective coating to the H.T. steel shall be given by the Contractor at no extra cost if the packing of H. T. Strand/wire during unloading and storage / handling in the stores gets damaged.

ii. Stock piling of H. T. Steel on the work site shall not be allowed any time, especially before and during the monsoon.

iii. The Engineer or his authorized representative shall always have an easy access to the store-yard for inspecting the H. T. Wire/strands/Bars and satisfying themselves regarding the condition thereof. Any modifications regarding storage suggested by the Engineer shall scrupulously be followed by the Contractor.

During monsoon days, H.T wires/strands shall be kept in reasonable airtight store, if required by the Engineer, at no extra cost.

e. Testing of Prestressing steel and Anchorages

i. All materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

ii. All wire, strand or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be like-wise identified.

iii. All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll. The Contractor shall furnish samples of at least 5.0m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or types to be used, shall be furnished along with short lengths of strands as required.

3. WORKMANSHIP

a. Cleaning

i. Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance.

ii. Cleaning of the steel may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing carborandum powder. However, the tendons shall not be brought to a polished condition.

b. Straightening

i. High tensile steel wire and strand shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

ii. The packing of prestressing wire / strand shall be removed only just prior to making of cable for placement. Suitable stands shall be provided to facilitate uncoiling of wires / strands without damage to steel. Care shall be taken to avoid the possibility of steel coming into contact with the ground.

c. Positioning

i. Post-Tensioning

Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.

Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks.

The location of prestressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons.

Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars so that they do not get disturbed during concreting.

The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.

Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.

The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete which adheres to bearing or wedging surfaces shall be removed immediately.

d. Cutting

i. Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contract with other stressed steel. The location of flame cutting of wire or strand shall be kept beyond 75mm of where the tendon will be gripped by the anchorage or jacks.

ii. In post-tensioning the ends of prestressing steel projecting beyond the anchorages, shall be cut after the grout has set.

e. Protection of Prestressing steel

i. Prestressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer or specified in Contract Specifications.

f. Sheathing Joints and Couplings

i. Joints in sheathing shall, if so, instructed be sealed with a heat shrink tape.

ii. Special attention should be paid to its junction at the anchorage. It should tightly fit on the trumpet end of anchorage and the junction should be sealed, preferably, with heat shrink tape.

iii. The heat shrink tape is supplied in the form of bandage rolls which can be used for all diameters of sheathing ducts. The bandage is coated on the underside with a heat sensitive adhesive so that after heating the bandage material shrinks on the sheathing duct and ensures formation of a leak-proof joint. The heating is affected by means of a soft gas flame.

iv. The sheathing and all joints shall be watertight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent

entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

v. Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

g. Grout Vents

i. Grout vents of atleast 20mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacings of consecutive vents do not exceed 20m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0MPa without the loss of water, air pressure or grout.

h. Anchorages

i. All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning. Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the anchorage assembly.

ii. The anchorages shall be recessed from the concrete surface as per drawings.

iii. After the prestressing operations are completed and prestressing strands are cut, the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 microns per coat and entire recess shall be filled with concrete or non-shrink/pre-packaged mortar or epoxy concrete.

i. Handling and Storage

i. Care shall be taken to avoid mechanically damaging, work-hardening or heating prestressing tendons while handling. All prestressing tendons shall be stored clear of the ground and protected from the weather, from splashes from any other materials, and from splashes from the cutting operation of an oxy-acetylene torch, or arc-welding processes in the vicinity.

ii. In no circumstances shall prestressing tendons after manufacture be subjected to any welding operation, or 'on-site' heat treatment or metallic coating such as galvanizing. This does not preclude cutting as specified.

iii. All wires, strands or bars stressed in one operation shall be taken, where possible, from the same parcel. Each cable shall be tagged with its number from which the coil numbers of the steel used can be identified. Cables shall not be kinked or twisted. Individual wires and strands for which extensions are to be measured shall be readily identifiable at each end of the member. No strand that has become unraveled shall be used.

j. Supervision

i. All prestressing and grouting operations shall be undertaken by trained personnel only. A representative of supplier of the prestressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

4. Tensioning Equipment

All tensioning equipment shall be procured from authorized manufacturers only and be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements:

a. The means of attachments of the prestressing steel to the jack or any other tensioning apparatus shall be safe and secure.

b. Where two or more wires / strands constitute a tendon, a single multiple stressing jack shall be used which is capable of tensioning simultaneously all the wires / strands of the tendon. Suitable facilities for handling and attaching the multi-pull jack to the tendons shall be provided.

c. The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete; and

d. Means shall be provided for direct measurement of the force by use of dynamo metres or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the linear measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.

e. Any indication in the loss of strength in tendons during the tensioning operation shall be brought to the attention of the Engineer. Any corrective measures which may be required in procedures and/or material shall be approved by the Engineer.

f. When friction must be reduced, water soluble oil may be used subject to the approval of the Engineer. This oil may be flushed from the duct as soon as possible after stressing is completed by use of water pressure. These ducts shall be flushed again just prior to the grouting operations. Each time the ducts are flushed, they shall be immediately blown dry with oil-free air.

5. Testing by the Contractor

For the purpose of accurately determining the tendon elongations while stressing, the Contractor shall bench test two samples of each size and type of strand tendon to determine the modulus of elasticity prior to stressing the initial tendon. The bench should be at least 6metres long, with concrete anchorage blocks having a constant area end section of at least four times that of the anchorage assembly area. The tendon shall be straight and centered on the cross-sectional area of the bench. The test procedure shall consist of stressing the tendon at an anchor assembly with the dead end consisting of a load cell. The test specimen shall be

tensioned to 80 percent of ultimate in 10 increments. For each increment, the gauge pressure, elongation and load cell force shall be recorded. The data shall be furnished to the Engineer. The theoretical elongations shown on the post-tensioning working drawings shall be re-evaluated by the Contractor using the results of the tests and corrected as necessary. Revisions to the theoretical elongations shall be submitted to the Engineer for approval.

Apparatus and methods used to perform the tests shall be proposed by the Contractor and be subject to the approval of the Engineer. After the initial testing, five more tests shall be performed. These tests shall be spaced evenly throughout the duration of the Contract.

a. Post Tensioning Procedure

i. Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

ii. It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more.

iii. After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily so as to avoid shock to the prestressing steel or anchorage.

iv. The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo metres and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

v. The difference between calculated and observed tension and elongation during prestressing operations shall be regulated.

vi. **Grouting of Prestressed Tendons:** Grouting shall conform to provisions in **Annexure D** of "IRS Concrete Bridge Code: 1997". A record of grouting operations shall be maintained in a format given by Engineer.

6. Safety Precautions during Tensioning

These are applicable for both pre-tensioning and post tensioning operations.

a. Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

b. Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

c. No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

d. The operations of the jacks and the measurement of the elongation and associated operations shall be carried out in such a manner and from such a position that the safety of all concerned is ensured.

e. A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

f. During actual tensioning operation, warning sign shall be displayed at both ends of the tendon. No person will stand behind in line with jacks while tendon / wire are being stressed.

g. After prestressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without express approval of the Engineer.

h. No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon which has been affected by welding, weld spatter or heat shall be rejected.

7. Transportation and Storage of Units

a. Precast girders or elements shall be transported in an upright position. Points of support and the direction of reactions with respect to the girder shall approximately be the same during transportation, and storage as when the girder is placed in final position.

b. When members are to be stacked, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

c. Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being otherwise damaged. Units worked or damaged by improper storing or handling or transport shall be replaced by the Contractor at his expense.

8. Tolerances

a. Permissible tolerances for positional deviation of prestressing tendons shall be limited to the following:

i. Variation from the specified horizontal profile: 5 mm

ii. Variation from the specified vertical profile: 5 mm

iii. Variation from the specified position in member: 5 mm

Section VII: Employer's Requirements

Section VII-7: General Electrical Services

CHAPTER –1 SCOPE OF WORK

1.1 GENERAL

A general description of the broad scope of work, relating to works covered in this Tender under Schedule A, is given below. It shall, however, be clearly understood that the description is for the purpose of general guidance only and is not exhaustive. For complete appreciation of the Scope, the specifications, drawings and other relevant paragraphs of the Tender documents shall be referred to.

1.1.1 ITEMS OF WORK

The jobs **Tunnel** to be carried out by the Contractor under this contract comprises of but not limited to the following: -

ITEM . No.	Description of Work	Total Qty
1	Design, Supply, Erection, Testing & Commissioning of (11/ 0.433) kV Sub-station complete in all respect along with all protection system including 11kVA GIS HT Panel Board, (2x2000) kVA Dry Type Transformers (02 Nos transformer for each substation, Sub-station-1 (SS-1) at Centre of Tunnel and Sub-station-2 (SS-2) at Sonepat end of Tunnel), 3 ways 11 kV Ring Main Unit (RMU) comprising of 2 Nos load break switch, Battery Charger, APFC Panel, LT Distribution Panel, other necessary switchgears, Complete Earthing system & all associated works as per specification. GIS panels shall be operated and monitored through SCADA. This includes construction of sub-stations building complete in all respects as per specification and drawing.	**01 Job**
2.	Design, Supply, Testing & Commissioning of 11 kV HT/LT fire survival Copper cable (Power and Control) Network of adequate sizes including laying of cables in Air/HDPE pipe/DWC Pipe/ Trench of size 0.5 mts wide x 1.2 mts deep/ stainless steel cable tray/ cable ladders/ Stainless steel conduit on wall inside/outside of the tunnel as per site requirement, specification and standard. 1.Main HT Supply (Incoming supply) for SS-1 and SS-2 = 3x120 Sqmm Cu cable. 2. HT supply between SS-1 and SS-2 for Ring main system = 3x95 Sqmm Cu cable. 3. LT Distribution Network from SS-1 and SS-2 = 4x50,4x25 Sqmm and other size of copper cable as per specification. **Note: -** EPC Contractor shall ensure laying of spare cables of same size for each feeder as per Railway Board/RDSO Guidelines**.**	**01 Job**
3	Supply, Erection, Testing & Commissioning of 900 kVA / 910 kVA Advantage prime rating diesel generating set (11000 volts Alternator) along with powder coated acoustic enclosures at SS-1 and SS-2 suitable for outdoor application including AMF panel, *NGR & NIS Panel* Auto synchronizing panels, silencers, Earthing system, all civil work & associated arrangement as per CPCB norms and as per specification.	**01 Job**

ITEM . No.	Description of Work	Total Qty
4	Design, Supply, Erection, Testing and Commissioning of tunnel lighting system and its associated works by using of 4x25/4x16/4x10, 4x6/4x4 sqmm copper cable, energy efficient 20 watt LED fixtures, Lighting DB's, Lighting Panel, Junction Box with complete wiring of multi core 1.5/2.5/4/6 sqmm Cu conductor cable laying in stainless steel conduit of dia 12.5/25mm, necessary switch gears and surge protection equipment complete in all respect as per site requirement, standard and specification.	**01 Job**
5	Design, Supply, Installation, Testing and commissioning of Maintenance Power socket (1 Phase- 16/20 Amp, 3Pin and 3 Phase-16/20 Amp, 5Pin) system including MCB's, all accessories and Maintenance DB's with IP 65 protection complete in all respect as per site requirement, standard and specification.	**01 Job**
6	Design, Supply, Installation, Testing & Commissioning of Emergency power supply system including online UPS 20 kVA (minimum) capacity with Sealed Maintenance Free Heavy duty lead acid Batteries for 120 minutes backup along with UPS lighting DB's and other accessories, powder coated steel racks for placing batteries, interconnecting Copper PVC sleeved bus bars complete in all respect as per site requirement specification and standard. UPS Power Supply to be designed through DG set for providing Level-I illumination in the tunnel as per specification. One UPS at SS-1 and one UPS at SS-2 .	**01 Job**
7	Design, Supply, Installation, Testing and Commissioning of Programmable Illuminated Escape Route Orientation sign board, Programmable non illuminated Escape Route Orientation sign board controlled by SCADA and Fire Extinguisher glow signage board, other required Signage board, as per decision of Engineer and Visibility Sensors at adequate distance controlled & monitored through SCADA, complete in all respect as per site requirement, standard and specification.	**01 Job**
8	Supply, Installation, Testing and Commissioning of stainless steel cable Trays of size 150x50x2mm thickness ladder and Perforated type as per specification made of material no. 1.4404, throughout the tunnel, for HT/LT and lighting etc. Cu. Cable, wall mounted on hot dip galvanized heavy duty steel structure, continuously connected including horizontal and vertical bends, reducers, tees, coupling plate and *high-grade stainless-steel* anchor fasteners of material no. 1.4401 complete in all respect and as per site requirement	**01 Job**
9	Electrification of Sub-station and other service Building/Rooms with allied facilities including LED luminaries (Indore & 150-watt flood light fitting with all accessories, 1.5-ton capacity split Ac 5-star rating for control room, 150 ltrs water cooler and all other electrical accessories as per site requirement specification and guide line issued by RDSO/Railway Board.	**01 Job**

ITEM . No.	Description of Work	Total Qty
10	*Reliable Electrical Power Supply (3 phase, 11 kV) for both sub-stations (Separate feeder circuit for each substation) of tunnel and associated works including all liaison work from State DISCOM.. The Contractor shall assess the load requirement and connected load of each substation. after load calculation for each tunnel and obtain approval of the Engineer for the purpose of getting new connection for each substation.* *The cost Include (for each substation) copper cable laying/Overhead Line with H-pole from DISCOM substation to HRIDC HT panel, Metering arrangement, protection, earthing connection of DISCOM end and connection at HRIDC substation including payment for application fees, charges etc. for 2000kVA load of each substation Necessary clearance from statutory authorities.*	**01 Job**
11	**Design, Supply, Installation, Testing and Commissioning of Earthing System of following type: -**	**01 Job**
11 (a)	Supply, Installation, Testing and Commissioning of Earthing system with 3-meter-long, 50 mm dia, G.I. pipe class 'B' earth electrode, adding of charcoal or coke and salt, providing masonry enclosure. *(Brick with class designation not less than 7.5 and cement plaster 1:4)* and cover plate with lifting arrangement etc. including connections with 8 SWG G.I wire from earth electrode as per specification.	
11 (b)	Supply, Installation, Testing and Commissioning of Maintenance Free Earthing (chemical Earthing) as per specification	
11 (c)	Supply, Installation, testing & Commissioning of Copper Bonded Steel Earth Rod of 3-meter length, 17.2 mm dia with Exothermically welded busbar along with 50 kg Earth Enhancement Compound in each pit. pit covers made up of Poly Plastic and SITC of 10 mm Copper Clad Steel Round Conductor laid at 600mm below the ground, as per specification, requirement and code of practice.	
11 (d)	Supply, Installation, *Testing & commissioning* of Earth Grid for 11/0.433 KV Substations. It shall have a Copper Bonded steel rod & conductor of diameter 17.2 mm / 3 meters length. An earth rod shall have an earth enhancement compound 50 kg per pit. All the joints shall be exothermically welded. Dedicated riser of 50x6 & 25 x 6 mm copper coated steel strip shall be provided for Neutral & Body respectively with RCC Chambers. With Copper MET's shall be provided *Poly carbonate* (PC) enclosure. An Isolation spark gap shall be provided for equipotential bonding as per IEC 62561-3 & as per requirement and specification.	
12	**Design, Supply, Installation, Testing and Commissioning of Earthing and Potential equalization system for Inside throughout the tunnel with crossings by following material: -**	
12 (a)	Providing, excavating & laying of stainless steel main potential equalization 150 sq mm *conductor* to be laid inside the tunnel on both walls of the tunnel. It shall be available in a drum roll of minimum 1000	**01 Job**

ITEM . No.	Description of Work	Total Qty
	meters. Inclusive exothermic welded joints at the required intervals for connections to other elements of the earthing network and straight through joints.	
12 (b)	Providing & laying of stainless steel main potential equalization 25 sq. mm *conductor* for all required earth connections to MET to be laid at every crossing to interconnect busbar to the other equipment for equi-potential bonding along with all required fixing arrangements. *One end shall be connected to 150 sq mm conductor and other to any equipment as required.*	
12(c)	Providing & fixing of Isolation Spark Gaps for Equipotential Bonding as per IEC 62561- 3	
12 (d)	Supply, Design & Fixing of Stainless steel potential equalization Bus bar *(MET)* of size 500x50x6 mm with 8 holes for *electrical equipment and 400X25X3 for S&T equipment* provided on both sides of the tunnel at every 200 m along with all accessories to connected to earth grid with stainless steel main potential equalization 150 sq mm It shall be enclosed in an enclosure Poly cabinet (PC) box with transparent front cover and fixed to the wall with insulated fire resistant supports.	
12(e)	*Supply, Design & Fixing of two independent earth grids on each side of both the Tunnels (8 nos). Each earth grid shall have a copper bonded steel rod & conductor of diameter 17.2 mm/3 meters length. An earth rod shall have an earth enhancement compound 50 kg per pit. All the joints shall be exothermally welded. Dedicated riser of 50X6 & 25x6 mm copper coated steel strip shall be provided for OHE, Electrical equipment, Neutral & Body respectively with RCC chambers with copper METs shall be provided PC enclosure. An isolation spark gap shall be provided for equipotential bonding as per IEC 62561-3 & as per requirement and specification.* *Dedicated riser of 50X6 mm copper coated steel strip shall be provided for Telecom equipment in both tunnels separately. Contractor shall design the system as per relevant IEC, DIN, EN, IS standards.*	**01 Job**
13	*Supply of spares and tools & Tackles and measuring equipment.*	**01 Job**
14	*Routine Maintenance of Electrical items and Manning of both substations round the clock*	**01 Job**

NOTE: -

1) All the quantity, type, rating and size of equipment /material (Transformer, DG and HT/LT Panels etc.) in above table *are* indicative *and minimum rating* only. It may *increase* as per EPC contractor design, various guidelines & standard issued by RDSO/Railway Board and site condition.

2) *Deleted* .

3) *Deleted*.

4) *Contractor shall arrange all RDSO drawings*, documents, specification from RDSO at their own cost.

5) *No mild steel materials shall be used anywhere in the electrical system in project.*

6) *The zinc coating steel item shall be as per RDSO specification no. ETI/OHE/13(4/84) Latest or IS specification. Mild steel shall be hot dip galvanised to 610 g/sqm of zinc.*

7) *Unless otherwise specified in the tender document, all bolts, studs, Nits, Washers, and pins etc shall be of stainless steel or high-tension copper alloy for current carrying conductors for all other applications, galvanised steel shall be used.*

8) *The cable upto 16 sqmm size shall be copper conductor XLPE insulate only. Cables above 16 sqmm size may be of copper or aluminium as mentioned in the tender document or as submitted by contractor and approved by Engineer.*

9) Cables/Wiring shall be laid down in metallic/rigid fir resistant PVC conduits. PVC conduits shall be used in concealed wiring only.

10) During cable laying and on the bends radius of the cable shall be maintained as per IS standard.

11) All Electrical appliances/equipment viz LED lights, Fans, Exhaust Fan, Air conditioner, Water cooler, Transformers, shall carry highest star rating for energy efficiency as prescribed by Bureau of Energy Efficiency (BEE) as applicable.

12) The scope of work shall be read in conjunction with detailed specifications mentioned in tender document.

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CHAPTER 2 — DESIGN AND PERFORMANCE REQUIREMENTS

2.1 General

2.1.1 The design, supply, installation, testing and commissioning of General Services work including Power supply system and construction of sub-station buildings etc. shall meet the design and performance requirements within the design environments specified in this PS.

2.1.2 Design Environment

i. Adequate Margin shall be built in Design, particularly to take care of Climate Conditions/Operating Environment. Wherever the equipment is installed in open at the surface level or inside service buildings at surface level, the same shall be designed for working in the tropical conditions existing here and the ambient temperature and humidity levels pertaining to HORC Project area.

ii. Tunnel walls may be wet and seepage water will normally be present in the invert. The system design shall, therefore, take into consideration the effect of seepage and continue to operate in such wet and humid conditions.

iii. *Contractor shall interface with all agencies during design and execution stage of the project*.

2.2 Basic Design Philosophy and Requirements

2.2.1 Proven Design

i. The Contractor shall develop the design based on specification and on proven and reliable Engineering Practices. The design details shall be submitted with technical data and calculations to the Engineer for review.

ii. The contractor shall submit drawings in such a form as the Engineer will require them for approval, copies as required of all drawings, diagrams and details of all equipment in part or in whole. The contractor shall make any drawings available to the Engineer at all reasonable times. Wiring diagrams and other drawings as the Engineer deems shall not be finally settled until satisfactory installation and testing has been made, this shall be approved in principle.

iii. The contractor shall submit a schematic block diagram of the equipment showing the manner, in which the functional requirements of this specification shall work together. The contractor shall submit a schedule including details of numbering, categories and drawing registers / indexes for the production, submission and approval during the period of the contract of drawings and also of any information, required for the Engineer in connection with the design of the contract works.

iv. This schedule shall be suited to the requirements of manufacture, delivery and installation of the contract works to meet the requirements of the contract and shall allow reasonable time (approx. 8 weeks) for study and approval by the Engineer of all drawings, calculations and graphics submitted (and, as necessary, resubmitted) by the contractor. *Contractor shall undertake work only after obtaining No Objection for the work from Engineer.*

v. No approval by the Engineer of any drawing shall relieve the contractor of any of his obligations of liabilities under the contract or of his responsibility for ensuring that the work is satisfactory done and that all operational requirements shall be met.

vi. The contractor shall provide final drawings without undue delay, and in any case within twelve weeks of the award of the contract, these drawings shall include dimensions, capacity of equipment and complete power supply & lightning arrangements of tunnels with all associated items.

2.2.2 **The design philosophy should meet the following criteria**:

a) Application of state-of-the-art Technology
b) Service proven design
c) Design life *20* years. *(Individual components may have different design life.)*
d) Minimum life cycle cost
e) Low maintenance cost
f) Use of interchangeable, modular components
g) Extensive and prominent labelling of parts, cables and wires
h) High reliability
i) Low energy loss
j) System safety
k) Adequate redundancy in system
l) Fire and smoke protection
m) Use of fire retardant materials and fire survivals cables
n) Environment friendly
o) Adherence to operational performance requirements
p) Maximum utilization of indigenous materials and skills, subject to quality conformity.

Adequate margin shall be built into the design particularly to take care of the higher ambient temperatures, dusty conditions, and high seasonal humidity, etc. prevailing in HORC Project area.

2.3 AS-BUILT DRAWINGS

Preparation of the as-built drawings shall be part of these specifications. As-built drawings will be Final Design Drawings of the project showing the actual work done. The contractor shall provide the as-built drawings in one original and one reproducible negative produced from the original, with the names of the signature authorities of the Engineer and the contractor. After they are signed for approval, prints shall be taken from the signed original of each drawing. Also, *Hard Disc Drive (Min 1 TB size)*with all as-built drawings shall be handed over to the Engineer. Together with the as-built drawings, the contractor shall provide reduced size (e.g. A3 size) booklets of the as-built drawings as per the Engineer requirement.

All details, dimensions, texts, etc., on the reduced size drawings shall be clearly recognizable and readable. The contractor shall complete and obtain the Engineer's approval on the as-built drawings and make the final submission of the as-built drawings together with the A3 size booklets latest within three months following the date of the Certificate of Completion. All costs associated with the provisions mentioned above shall be deemed to be included in the contract price.

As-built drawings shall cover in general (but not limited to):

a) For mechanical equipment:

i. Construction drawings,
ii. Instruction drawings,
iii. Functional block diagrams with set-point range of process parameters depicted

thereon.

b) For electrical installation:

i. Installation drawings with circuit numbers and exact type-assignation of all installed equipment.
ii. Distribution diagrams with circuit numbers,
iii. Fault analysis and protection co-ordination settings the of protection system,
iv. Power consumption,
v. Precise type numbering
vi. Earthing systems

c) For distribution panels:

i. Construction drawings,
ii. Circuit drawings as operating diagrams,
iii. Additional current flow-charts where required,
iv. Accurate lists of any installed equipment with precise description of this equipment,
v. Adjustment tolerances of circuit-breakers, switches, etc.

d) For equipment:

i. Construction drawings,
ii. Circuit diagrams,
iii. Functional block diagrams with set-point range of process
iv. parameters depicted thereon,
v. List of quantities with detailed break-down of the bill of materials comprising the equipment.

e) For cabling:

i. Diagrams with dimensions, type of cables and power requirements with regular cross- section area and measured cable values shall be used for these diagrams.

2.4 System Requirements:

2.4.1 Conformity with Governing Specifications and other Statutory Requirements: -

The work shall be carried out in accordance with the following governing specifications and other statutory rules:

i. CEA Regulations 2010
ii. Indian Electricity Act 2003 with latest amendments.
iii. Central Safety regulations, 2010
iv. Regulations laid down by Chief Electrical Inspector to the Government.
v. Regulations laid down by EIG Indian Railways.
vi. Rules and Regulations prescribed by local authorities as applicable.
vii. Relevant, Indian Standards, IEC Standards, CENELEC, British Standards, Tunnel draft Manual of Indian Railways (as applicable) and other National/ International standards as applicable.
viii. The Contractor shall furnish information asked for by a statutory body (e.g., Government of India, Ministry of Railways, Commissioner of Railway Safety, Government of Haryana etc.) in particular format as directed by Engineer. Any documents, studies, test reports, compliances required for getting safety clearances from any authority shall be submitted by the contractor

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CHAPTER –3 INSTALLATION AND CONSTRUCTION

3.1 REQUIREMENTS

3.1.1.General Requirements

i. The Contractor shall comply with all Enactments in executing the Works, including but not limited to all statutory provisions on occupational health and safety.

ii. The Contractor shall co-ordinate with Other Contractors in the execution of the Works.

iii. The Contractor shall also co-operate with all Relevant Authorities in the execution of the Works.

iv. The installation of all equipment shall be undertaken at all times by suitably trained and competent employees of the Contractor, to the satisfaction of the Engineer.

v. Only appropriate tools, plant, equipment and vehicles shall be used.

vi. Installation of all equipment shall be in accordance with the Construction and Installation Plan described in the drawing/plans as approved by Engineer before commissioning of work.

vii. Installation of all equipment shall conform to the best industry practices.

viii. Precautions shall be undertaken to ensure the safety of personnel and equipment for all installation works.

ix. The Contractor shall, prior to starting any installation and construction work, identify any possible hazards, and implement measures of eliminating and/or controlling such potential hazards, in line with safe working practices.

x. The Contractor shall ensure that all areas of work are sufficiently illuminated for the works to be undertaken and that a safe system of work is employed for all activities.

xi. The Contractor shall operate a robust system for the control of persons entering or working upon the site.

xii. The Contractor shall co-operate, always, with the Engineer and Other Contractors to ensure that the Site is protected from unauthorised admission, either wilfully or otherwise.

xiii. The Contractor shall make due provision for the safe access and egress to the Site of Works for its staff and subcontractors.

xiv. This access shall be maintained such that it is free of all hazards and is in a safe condition throughout the duration of the Works.

xv. The EPC contractor shall set up at least one main store/ depot for receiving and storing materials & other equipment at his own cost.

3.1.2 Specific Requirements

The installation and construction work pertaining to this Contract shall include, but not be limited to the following: -

i. Finalisation of the Construction and Installation Programme provided by EPC contractor and duly approved by Engineer.

ii. Survey on Site and review the technical requirements shown in this Specification and the Engineer's Drawings (if any).

iii. Production of the calculation sheets and installation drawings for Site installation.

iv. Production of specific site designs and drawings based on typical designs and drawings supplied.
v. Installation in accordance with the finalised installation drawings.
vi. Co-ordination with Other Contractors.
vii. Submission of the installation reports and records.
viii. Testing and commissioning, as per finalised protocol and programme.

3.2 Construction and Installation Plan

The Contractor shall undertake installation work in stages as shown in the detailed installation programme. Installation, testing and commissioning of later stages shall not impact revenue operation of earlier stages.

As a minimum, the detailed Construction and Installation Plan shall include but not be limited to all the activities, installation details and methods of all activities, equipment and tools to be used for installation, safety issues, supervision, temporary land occupation needed and the vehicles to be used for installation.

3.2.1 *Material* Handling

To facilitate handling of equipment during installation and maintenance thereafter, the Contractor shall closely co-ordinate and interface with other contractors travelling hoists and unloading jib cranes for sub-stations. The entire material handling plan for movement of bulky item such as Transformers, Panels, DG sets, and cables etc. shall be carefully planned. Crane of adequate capacity with a jib of requisite length will be arranged by the EPC Contractor at his own cost. Road crane for handling heavy materials at the contractor's depot for loading and unloading of material will be arranged by the contractor who will also arrange his own crew for its operation and maintenance. All charges including pay and allowances of the crew and all running expenditure will be borne by the contractor.

3.3 Site Supervision/ Deployment of Technical Staff: -

3.3.1 The Contractor shall set up a Site supervision system, which shall be part of the overall safety, system assurance and quality management system.

i. The Contractor shall provide sufficient number of experienced Engineer, Supervisors and skilled workers to ensure progress and quality of the work at Site and in the Contractor's workshops (if any), are maintained to the satisfaction of the Engineer. The minimum number of Engineers required to be deployed is shown in table below: -

S.N	Post	Minimum Eligibility	Minimum Requirements in nos.
1	Sr. Engineer (overall in charge of all type of General Services work)	Graduate in Electrical Engineering with 7 or more- year experience in Electrical and E&M System.	1
2	Electrical Engineer (Site Engineer)	Graduate in Electrical Engineering with 5 or more-year experience in HT & LT works. **Or** Diploma in Electrical Engineer with 7 or more years experience in HT & LT works.	1

S.N	Post	Minimum Eligibility	Minimum Requirements in nos.
3	E&M Engineer (Site Engineer)	Graduate in Electrical /Mechanical Engineering with 2 or more-year experience in E&M system. **Or** Diploma in Electrical/ Mechanical Engineer with 3 or more-year experience in E&M system.	1

ii. The contractor shall submit to the Engineer, not later than 60 days from the date of award of contract, the organization chart showing following key positions, and CV's of the incumbents and the brief job descriptions. The Engineer shall issue Notice of "No-objection" or otherwise for the appointment of "key positions" within stipulated working days of such submission.

iii. The performance of personnel shall be under observation by Engineer. In case the performance of any personnel is not up to the mark, as decided by Engineer, . contractor shall be responsible for replacement of such personnel.

iv. In case the contractor fails to employ the technical staff as aforesaid to the satisfaction of the Engineer-in-charge, the recovery shall be as mentioned below per each calendar month or part thereof of default.

Sl. No.	Post	Amount to be recovered per person per each calendar month or part thereof of default. (Rs)
1	Sr. Engineer	1.0 Lakhs
2	Electrical Engineer	50,000 /-
3	E&M Engineer	40,000/-

v. Contractor is to abide by the provisions of Payment of Wages act & Minimum wage act.

vi. The Contractor's supervision system shall be responsible not only for the supervision of the concerned system installation but also for the supervision of the installation of the primary fixing system, earth mats and systems, etc. The supervisors shall work on a full-time basis during the entire installation process.

vii. The Contractor shall maintain a set of drawings at each system which accurately reflect the current status of field changes. The Contractor shall obtain letter of no objection from the Engineer for any such changes. The Contractor shall prepare final drawings showing the as built configuration. These drawings shall be developed in a logical format to facilitate routine system maintenance and troubleshooting. All drawings and details shall be endorsed by the Contractor.

viii. The Engineer reserves the right to undertake, at any time, checks on the proficiency of the Contractors staff, licensing and all associated documentation. If any of the Contractors

staff be found incompetent or unlicensed he shall be removed from the site until their Competency has been established.

3.4 Workmanship

All the installation shall be carried out according to the instructions shown in these specifications and Drawings (as approved).

All assemblies of equipment and their components and parts shall be completely interchangeable if they are of similar type

The style and procedure of the workmanship shall be consistent throughout the Works.

Unless otherwise specified, the Engineer shall decide the final colours for all paint work and other finishes to be applied to any part of the Works.

All parts, which are subject to, wear or damage by dust, shall be completely enclosed in dust proof housings.

3.4.1 Installation of Cables

The Contractor shall co-ordinate with the Civil Contractors wherever necessary, for the installation of cables in cable galleries, trenches, ducts, trays, risers and other locations.

The cable system shall, during installation, be fully protected from mechanical damage and be generally accessible at all points for inspection along its entire route. Suitable cable *route* markers shall be provided for covered cables upon completion of installation *Cable Route Marker size 200X150X3 mm thick GI plate for HT/LT electrical underground cables. The plate shall be provided with 250X50X6 mm GI flat whose one portion shall be welded to the route marker plate and another antiskid end shall be embedded suitably in 150X150X 150 mm M-20 grade concrete and concrete block shall be minimum 100 mm below the ground.*.

The maximum pulling force of any cable during installation shall not exceed the design force of cables.

All cables shall be installed in the formed cable trenches, shafts, hangers, trays and brackets.

The minimum recommended bending radius of the cables shall be adhered to during installation.

All materials used for termination, jointing and installation of cables in confined spaces shall have flame retardant, low smoke, halogen free characteristics.

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CHAPTER – 4 TESTING AND COMISSIONING

4.1 TESTING

This Chapter describes the testing & commissioning related to the Various General Services works in conformity with the requirements of RDSO/Railway Board Standards and standard Railway practices.

Testing constitutes an essential obligation to satisfy the Railway System.

4.2 Testing Conditions and Equipment Acceptance

The Contractor Shall carry out all the tests and checks required guaranteeing the Engineer of the good construction and the satisfactory operation of all power supply installation.

Also, the contractor shall co-ordinate & arranges testing equipment etc. required for testing facilities.

The various high, medium and low voltage equipment will be subjected to all the tests required under equipment test sheets, (lists are not exhaustive) as per the relevant IEC or other standards mentioned in the technical specification of each equipment or otherwise.

It is reminded that the contractor is totally entrusted with full responsibility of assembly and installation of all pieces of equipment mentioned in this specification, with supplying the maintenance equipment and the special tooling which shall be delivered as soon as equipment installation will be completed and with the various duties he is bound to regarding witnessing of tests at commissioning and supervision after energising.

4.2.1 In-plant testing: -

In plant *Type Test* , routine tests and factory acceptance test:

i. Type tests are tests performed on one or two of an equipment series
ii. Routine test are tests performed on each equipment
iii. Factory acceptance tests are tests on a sample size as per standards.
iv. These tests will enable checking the quality of the equipment and its compliance with the specifications.
v. Following equipment, if desired by the Engineer shall be tested at third-party (duly approved by the Engineer)/ RITES during Factory Acceptance Test.:
    1. DG sets
    2. Transformer of any capacity
    3. Switch gears
    4. Different size of cables (LT/HT)
    5. LED light fittings
    6. Different types of HT/LT panels, RMU and APFC panel etc.
    7. Earthing material

Once the equipment will have passed the in-plant acceptance tests, it shall be delivered and installed under the contractor responsibility.

Concerning some type tests, test certificates issued by recognised agencies will be able to be

supplied if the contractor cannot carry out these tests himself and if the test certificates are related to a similar equipment of same capacity and design. *These type test certification shall not be more than 7 years old from the date of issue of LOA (Letter Of Acceptance)*

The final factory tests will be carried out on the fully assembled equipment as specified. Thereafter, if required and permitted by the technical features of the equipment, the equipment may be dis-assembled for transportation purposes. The dis-assembly should not, however, cause any deterioration of the technical performance of the equipment.

These tests will be carried out by the contractor, under his responsibility and in the presence of the Engineer and of the consulting Engineer. The cost of Factory Inspection/Site Inspection/Lab Test/Documentations will be borne by contractor.

Each of these tests will be subjected to a certificate. Provisional acceptance will be granted only after execution of the both sets of tests.

NOTE: For type tests, the contractor can provide test reports performed according to the corresponding IEC standard, on similar equipment of same capacity and design.

4.2.2 Third Party Tests

i. During execution stage Engineer may conduct the Test on any type of equipment from third party independent lab at its own cost, to ensure the quality of material supplies. If any of the samples fail in the test, the cost of the Test along with the complete replacement of whole lot shall be borne by the Contractor.
ii. If contractor represents, two random samples from the failed Lot shall be collected by the contractor in the presence of Engineer duly sealing the samples and send to two different NABL accredited labs (as approved by Engineer) for conducting all those tests, which were conducted on the failed sample. Cost of the testing including the collection of sample and transportation of sample will be borne by the contractor.
iii. If both the samples pass all the Tests, the Lot will be deemed as accepted by HRIDC, but in the case of failure of any of the samples collected by the contractor, complete Lot will be deemed as rejected and contractor will replace the whole Lot.
iv. The delay, if any for the procurement of the material due to failure, shall be considered as non-compliance and applicable penalty shall be imposed on the contractor.

4.2.3 System Acceptance Tests

At least six weeks in advance of any particular site testing, the contractor shall submit details of tests and details for the teste equipment the proposes to use for that testing to the Engineer for his approval.

All tests for statutory requirements and insurances including arrangements for such tests, inspections by Authorized bodies, persons or insurers, as necessary and the provision of certificates in the prescribed and approved forms necessary to enable plant and equipment to be put into service, shall be made by the contractor.

If each section of plant is installed, commissioning tests for each section shall be carried out on site. At least six weeks in advance of any particular site testing, the contractor shall submit details of tests and details for the test equipment he proposes to use for that testing to the Engineer for his approval. As installation proceeds, the insulation resistance of cables shall be checked and recorded.

The identification of the cores shall be confirmed from end to end of each cable end, in the case of communication, alarm- and control-cabling, from end to end of each circuit. Tests on cables shall be completed and accepted by the Engineer before the testing of the associated equipment starts.

All tests for statutory requirements and insurances including arrangements for such tests, inspections by authorized bodies, persons or insurers, as necessary and the provision of certificates in the prescribed and approved forms necessary to enable plant and equipment to be put into service, shall be made by the contractor.

4.2.3.1 On-site commissioning tests being subject of acceptance by the Engineer shall include:

a) All equipment, cabling, distribution etc. is electrically and mechanically safe.
b) All interlocks, isolators and door and cover securing mechanisms shall be properly fitted and adjusted.
c) All exposed metal work is properly bonded and grounded and that all connections and points required to be grounded for a safe and satisfactory operation shall be properly grounded in accordance with the manufacturer's requirements.
d) All cables, cores and terminations shall be secure, properly fitted and correctly identified and coloured.
e) All phases, polarities, neutral and common connections shall be correctly switched / connected as required, so that the power is correctly available at all points and that the voltage and frequency at all equipment is correct and in accordance with the requirements for correct work.
f) All supplies shall be provided with proper fuse or otherwise protected, to give successfully discrimination and safe disconnection under fault conditions.
g) All contacts shall be properly aligned / adjusted and not subject to excessive wear or corrosion.
h) Batteries shall be correctly installed, connected and fitted and checked that the battery chargers are working correctly.
i) The insulation-resistance of all cabling and equipment shall not be less than specified.
j) During the commissioning of major item like GIS panel, Transformer, DG sets etc. the contractor shall arrange expert Engineer of OEM of such item at respective sites. The expenditure for charges for the same including transport, lodging, shall be borne by the contractor at no extra cost.
k) All instruments and meters shall be energized with correct polarity and working properly.
l) All fault indications and alarms shall be working correctly.
m) In addition to all operational tests, required for a successful hand-over, the operation of all interlocks, sequences and protections which are not utilized in normal operations shall be subject of acceptance by the engineer.
n) The on-site commissioning tests shall be conducted under the supervision of the engineer.

4.2.3.2 The final acceptance tests shall begin after all on-site commissioning tests have been successfully completed and all defects detected during those tests have been rectified / corrected, which is accepted by the Engineer. The tests shall include full operation tests on the works as a whole and selected technical tests on some or all of the equipment.

4.2.3.3 On completion of the site acceptance tests, the contractor shall forward the test results certified by him to the Engineer. When the Engineer has received the results and deems that the plant has successfully passed the tests, Engineer will write to the contractor to that effect. During the site acceptance tests the Engineer shall inform the contractor of minor faults detected and which of these minor faults shall be corrected before the beginning of the tests on completion.

4.2.3.4 *a) Type test shall be performed by the contractor and shall be witnessed by Employer's personnel/representative and/ or the Engineer.*

b) Factory Acceptance Test including stage inspection, if required, shall be performed by the contractor, and shall be witnessed by Employer's personnel/representative and/ or the Engineer.

c) The standard equipment which are serial, or bulk manufactured (branded, the manufacturer's type test certificate may be acceptable, subject to review by Engineer.

d) All material used for permanent work shall be as per specification and GTP (Guaranteed Technical Particulars).

e) Manufacturing and testing of various equipment and fitting shall be as per approved technical requirement GTP etc.

g) The contractor shall submit the engineer a request for a "Notice of No Objection" to supply for manufacture item along with manufacture test certificate, Inspection Certificate prior to shipping/Transporting.

4.2.4 TRIAL OPERATION

The trial operation shall occur with full responsibility of the contractor. The trial operation shall take place after finishing the tests on completion. For starting the trial operation, it is required, that all tests on completion are finished positive for the entire installation and shall occur within 21 days.

The trial operation shall show the evidence of a fully functional operation of the tunnel and that security is given during operation. Therefore, the trial operation shall occur without significant malfunctions. The contractor shall test different operation cases during the trial operation (e.g. loss of different equipment etc.).

The contractor shall make organizational measurements during the trial operation, so that malfunctions can be rectified as soon as possible (within max. 2 days).

The results of the different tests during trial operation shall be shown in a protocol. This protocol shall be signed by the contractor and the Engineer.

The cost of all consumables including water, electricity, fuel, lube oil etc. shall be borne by contractor.

4.2.5 Energization: -

The Contractor shall prepare operation safety rules and procedures for the review of the Engineer before Energization.

The Contractor shall carry out all necessary checks to ensure safe Energization.

All power equipment shall be subject to inspection by inspectors from the Electrical Inspectorate of Engineer before Energization. The Contractor shall ensure all Engineer requirements are met. Contractor shall be responsible for reliable operation of all Electrical equipment.

4.3 COMMISSIONING

4.3.1 General

The Commissioning description, based on the following frame, will have to be defined by the contractor and submitted to the Engineer.

Once the contractor has completed the above tests, and the various pieces of equipment installation, the assignment should include:

i. Putting into service tests
ii. After energising

The Engineer will be empowered to ask for any additional testing as deem necessary. The contractor will have to supply the testing installations and measuring apparatuses required to this effect in accordance with the stipulations, provisional acceptance will then take place, followed by final acceptance at the end of the guarantee time.

4.3.1.1 Putting into Service Tests

It should be performed at this stage the tests verifying that the different equipment is acting correctly when energised.

4.3.1.2 Integrated Testing and Commissioning

The general testing having shown proper operation, an overall integrated test of the installations, should be performed, after the first 15 days of operation, during which the various actuation and operation situation (putting into service, normal actuation, failure tripping) will be simulated.

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CHAPTER – 5 MAINTENANCE AND TRAINING

5.1 INTRODUCTION

This Chapter describes the maintenance philosophy and training of maintenance staff for Electrical system considering RDSO/ Railway board standards and Railway practices.

The Contractor shall provide comprehensive training and documentation to the Engineer *and Employer's* staff in accordance with the requirement of this chapter and the chapter of General Specifications.

This training shall enable all the installations, to be operated and maintained in the most efficient and safe manner, to achieve the maximum reliability and economy required by such System.

Note: - All type of Routine, Preventative and Schedule Maintenance work will be carried out at regular intervals, based on latest SMI's/ Instructions/Guidelines issued by RDSO/Railway Board and equipment manufacturers' recommendations.

5.1.1 Maintenance Management

The management of the maintenance process entails defining various levels of responsibility and enabling them to implement the strategic orientations defined by the directing authority:

i. By defining their respective missions,
ii. By setting objectives for each person,
iii. By translating these objectives into action plans,
iv. By implementing the means required to carry out action plans,
v. By diagnosing the causes of any deviation from the set objectives,
vi. By taking corrective measures concerning the action plans or the objectives.

This management process requires a global approach and helps to improve the performance of the maintenance work of different components with quality, on time and at low cost. It must be implemented at three levels:

i. At the level of human resources and management in the context of the scheduling of work, the allocation of human resources and the training of personnel.
ii. At the skills level to ensure quality, safety and suitable working conditions.
iii. At an economic and financial level to ensure responsible management of production, spare parts, purchasing and miscellaneous costs.

The quality of this management depends on the capability of those entrusted with operation and maintenance responsibilities:

i. To exploit the results of management within their field of responsibility.
ii. To react in the event of any deviation from the action plans defined with a view to achieving the set objectives.

Within the context of this approach, the management control function ensures timely advice to be given to those with operational and maintenance responsibility:

i. By placing at their disposal, the tools and information required for piloting and diagnosis.

ii. By participating in carrying out this diagnosis.

iii. By participating in the task of defining the objectives to be achieved.

In conclusion, the process of maintenance management must incorporate two major components:

i. the management of human resources and the study of the most suitable means of achieving the set objectives.
ii. This is one of the first guidelines of maintenance organisation in the various relevant centres.

5.1.2 Determining Requirements in Terms of Facilities and Tools

The achievement of the objectives assigned to the maintenance division about quality, safety and regularity for the lowest possible overall cost requires the implementation of a number of resources which must be perfectly tailored to the requirements.

The facilities and tools are part and parcel of the resources placed at the disposal of the maintenance division to achieve the set objectives.

Owing to the cost of these facilities, the number of maintenance centres to be equipped and the necessity of keeping the maintenance actions consistent and uniform, the main choices of facilities and tools are integral part of the System maintenance policy and program.

When determining these requirements, in-depth knowledge in the dedicated maintenance plan is needed while taking due account of the experience acquired in similar fixed installation which has been in service for several years.

5.2 SUPERVISION AND PLANNING OF MAINTENANCE

5.2.1 General

The following outlines the Engineer's maintenance strategy, various levels of maintenance, the Maintenance Management System and the arrangement for maintenance.

The Contractor shall make use of all relevant information to provide supervision of maintenance.

5.2.2 Engineer's Maintenance Strategy

According to the maintenance strategy, all equipment and infrastructure supplied for the 'Project' must be such as to ensure for minimum or no maintenance. Maintenance activities required must be capable of being performed with little or no impact on the train service. In addition, the maintenance work systems shall ensure safety of personnel and equipment.

The Contractor shall ensure that to supervise maintenance during the DNP (Defects Notification Period) personnel are always available with the relevant skills and level of competence.

The Contractor, upon noticing any defects, deficiency in quality and quantity of spares and materials shall without delay, arranges for alternative source of supply and submit his proposal to the Engineer for review.

5.2.3 Planned Maintenance

Routine preventative maintenance will be carried out at regular intervals based on condition, reliability, usage, and service history, SMI 's issued by Railway Board/ RDSO and equipment manufacturers' recommendations. The Operating and Maintenance Manual shall describe the different levels of planned maintenance.

5.2.4 Supervisory Staff

The Contractor shall provide supervisory Maintenance staff who are expert in all the different levels of fault finding, maintenance and repair of the various relevant systems supplied under the Contract:

i. Electrical system
ii. Switch gear/power supply arrangement
iii. Other works

5.2.5 Maintenance and Maintenance activity

Maintenance Management System (MMS) and Maintenance Arrangement:

The contractor will develop maintenance management system and get it approved from Engineer for schedule maintenance of Electrical system.

All type of maintenance activity of all Works will be conducted by the contractor staff under his supervision, till the **expiry of a period of 01 (One) year from taking over**. All type of Routine, preventative and schedule maintenance work will be carried out at regular intervals based on SMI's/ Instructions issued by RDSO/Railway Board and equipment manufacturers' recommendations. Under this, all the labour laws would be applicable, and contractor has to submit all the records (EPF/ESI and other certificates) to Engineer.

5.2.6 Competency of Personnel and Deployment of Maintenance staff *during DNP:*

During the One-year Maintenance, the Contractor shall support the Engineer with sufficient trained and competent personnel Such persons shall have their generic competence established and must demonstrate their specific competence and knowledge in the particular systems, environment and procedures. The competency certificates of such maintenance staff shall be issued by Engineer.

The detail of deploying staff is as under:

S. No	Personnel	Qualification	Total work experience (in year)	Required No of staff	Remark
1	Maintenance In-charge	Graduate Degree in Electrical Engineering	Min. 08 Years of working experience of any Electrical/E&M/Ventilation. Project.	01	Overall in charge of all type of Electrical work
2	Maintenance Engineer (Electrical and E&M)	Degree/ Diploma in Electrical Engineering	Min. *3 years for degree &5 Years for diploma holder* of working experience of any E&M/Electrical General	01	Required as Site Engineer for all type of Electrical General services

S. No	Personnel	Qualification	Total work experience (in year)	Required No of staff	Remark
			services project.		work
3	Maintenance Engineer (Electrical and E&M)	Degree/ Diploma in Electrical Engineering	Min. *2 years for degree & 3 Years for diploma holder* of working experience of E&M Project or E&M maintenance activity.	03	Required for Manning of 11 kV Substations/Control Room for round the clock (one person in each shift)
4	Skilled Staff for Manning Purpose	ITI in Electrical Trade	Min. 04 Years of working experience on any E&M /General power supply arrangement project	03	Required for Manning of 11 kV Substations/ control Room for round the clock(one person in each shift)
5	Skilled Staff for Maintenance activity	ITI in Electrical Trade	Min. 04 Years of working experience on any E&M /General power supply arrangement project	04	Required to perform day to day maintenance activity

The Contractor shall provide evidence of specific competence and knowledge, which shall include:

i. Assessment and certified training in particular software applications and operations.

ii. Receiving or in receipt of sufficient and current exposure to the area of work that the holder is licensed for.

In the event of a failure, the Contractor shall undertake the management and investigation necessary to identify and rectify the cause.

If the Engineer, during the DNP requires further investigations at other Sites throughout the system, the Engineer will formally request the Contractor to undertake such investigations.

5.2.7 Maintenance requirements

I. Testing and Re-commissioning of System and Equipment

In the event of a failure requiring modifications to the System, the Contractor shall undertake any testing and re-commissioning required.
Any such modification shall be submitted for Engineer review.

II. Temporary Alterations to Restore Service

The Contractor shall undertake any temporary modifications necessary to maintain service.
Any such modification shall be submitted for Engineer review.

III. Discrepancies between Installation and Design Records

Should the Contractor discover inconsistencies between the maintenance drawings and documentation and the installed equipment, the Contractor shall correct all such errors within two weeks.

IV. Communications

The Contractor shall ensure that adequate communication facilities are provided to its staff during the DNP and maintenance period as per approval of Engineer.

V. Location of Staff

The Contractor shall be responsible for locating staff such that the Contractor meets its contractual obligations and as per approval of Engineer.

VI. Maintenance Regimes

The Contractor shall provide documented maintenance regimes to be followed by the Engineer upon substantial completion of various components of the work until the end of the DNP.

The Contractor shall produce a maintenance regime for the equipment that shall comprise two constituent parts, corrective and routine/preventative maintenance.

Routine/preventative maintenance shall be non-intrusive to the day-to-day operation of the train service and be capable of being pre-planned in advance of the work.

Corrective maintenance shall be available 24 hours per day, able to respond to all foreseeable circumstances**.**

The maintenance regime shall cover all parts and equipment of the system designed, installed and commissioned by the Contractor.

The Contractor shall take into account the requirements of the operations and maintenance when determining and proposing its maintenance regime.

VII. Scope and Hours of Coverage

The regime and structure of corrective maintenance shall be robust in design.

The Contractor shall provide full 24 hour On-Call coverage and shall be such that initial response and rectification of failure are in accordance with the following:

i. Assistance to first level and corrective maintenance within 30 minutes, upon request of first line maintainer.

ii. All elements of preventative maintenance shall be carried out and completed during non-traffic hours without interrupting train services.

VIII. Routine and Corrective Maintenance Procedures

Routine and corrective maintenance procedures shall be supplied for all equipment. The format shall be as follows:

i. Uniform format and layout irrespective of equipment supplier.

ii. Colour coding for each activity.

iii. Cross referenced to the Operation and Maintenance Manuals.

iv. Document control information.

IX. Maintenance Manuals

The Contractor particulars of operating parameters, tools for dismantling and testing, methods of assembly and disassembly, tolerances, repair techniques and all other information necessary to set up a repair and servicing programme as per satisfaction of Engineer.

The Contractor shall *prepare maintenance manual and* provide documentation for all hardware and software for computer systems and other associated electronic equipment to meet the following requirements.

Such documents shall include but not be limited to:

i. manufacturers' documentation supplied as standard with the equipment.

ii. hardware configuration with details of expansion capabilities and options.

iii. programme loading instructions, including runtime environment configuration.

iv. programme listing including comprehensive 'comment statements' in hard copy and soft format for source code, compilers and development tools necessary to modify and recompile software.

v. flow charts, data flow diagrams and state diagrams as appropriate.

vi. description of software modules including purpose, linkage with other modules, error routines and any special considerations.

vii. memory maps for both internal and peripheral memory showing description of all programmes, data files, overlay areas, memory available for expansion and the like;

viii. loading and operating instructions for diagnostic programmes and specifically developed debugging tools; and

ix. Programming manuals relevant to operating systems, languages, development tools, etc.

The manual shall also include inspection/overhaul procedure and periodicity of various inspection/overhaul schedules in detail including the tools, special tools/plants, and facilities required.

5.3 TRAINING:

During the contract period, the contractor shall provide training manuals, as well as onsite training and training courses to ensure that the Engineer and employer's staff associated with this project may acquire full knowledge and appreciation / understanding of all aspects of the design, day to day operation, breakdown and routine maintenance and fault diagnosis of the power supply, the surveillance and control equipment as well as the belonging hard- and software.

The contractor shall train the Engineer and Employer's personnel about all equipment in theoretical and practical way. Also, the maintenance staff shall be trained. The Engineer will nominate members of his staff, who are attending the training courses.

The contractor shall nominate qualified instructors. It shall be essential that prior approval of the Engineer is obtained for the instructor and the instructor's qualifications in each case.

The contractor shall provide all relevant and necessary facilities which are needed for complete and effective staff training (such as video, TV, slide- and film-projectors and others) and venue. The contractor shall provide all facilities including accommodation, transport and catering of all trainees. Within three months after the signing of the contract, the contractor shall submit a detailed syllabus for the training courses for approval by the Engineer.

5.3.1 General Requirements

The Contractor keeping the above aspect in view shall provide comprehensive training to the Engineer's staff in accordance with the requirements contained in this Particular specification and general specification. The training courses and/or sessions shall include system performance requirements and all major equipment and works designed, by the Contractor.

The specific objectives of each course, training facilities to be used, the qualification and experience of the training instructors and the assessment criteria shall be developed by the Contractor and submitted to the Engineer for review at least three months before any course is conducted.

The Contractor shall provide full-time on-Site management and co-ordination of the entire training programme to ensure the continuity of classes, and proper distribution of training materials, and be responsible for interfacing with the instructors.

The training courses shall be delivered to all relevant Engineer's staff, including instructors, operation and maintenance Engineering staff.

5.3.2 Mock-Up for Training

The Contractor shall install mock-up equipment for system and any such facility(s) considered necessary for the training of Engineer's staff in the training school.

The training mock-up shall include but not limited to the following: -

i. Clear Cut Section drawings / photographs of various power supply equipment's such as Circuit Breakers, HT/LT panel, Power supply arraignment, Current Transformers and Potential Transformers.

ii. Cut Section drawings / photographs of HT/LT cables.

iii. Cut Section drawings / photographs of Gas Insulated Switchgear and other types of panels.

iv. Clear photographs of transformers, their windings, bushings etc.

v. Samples of various item used in substations.

vi. Clear drawings and photographs of Control panel, protection schemes, earthing and complete power supply arrangement system.

The Contractor shall submit full details of the training span and other mock up equipment, photographs etc. including proposed training activities and objectives.

5.3.3 Training of Engineer's Training Instructors (ETI)

The objective of the training is to enable the Engineer's Training Instructors to be competent to deliver future training courses for other employees of the Engineer.

The Contractor shall provide training to the Engineer's Training Instructors on the various Systems. Aspects covered shall include, but not be limited to, the following:

i. Configuration of the entire System, including interface with the DHBVNL supply system at the feeding points;

ii. Feature and functional principles of the entire System;

iii. System design aspects including but not limited to design standards, design criteria and parameters, short-circuit and other calculations, insulation and protection co-ordination;

iv. Details of major equipment and material including but not limited to voltage and current transformers, Electrical fittings, assemblies and protection relays, and cables of different types and their joints used in the system;

v. System operation and maintenance management and procedures;

vi. Earthing arrangement, covering safety aspects of touch and step potential, safety to personnel, passengers and outsiders;

5.3.4 Operations Staff Training

The objective of the training is to enable the Engineer's operations staff to be familiar with the Systems, with focus on the operational aspects under normal and emergency conditions.

The training shall also enable the trainee to acquire full capability for identification, trouble shooting and rectification of faults in the specified duration. After classroom training which includes mock ups of equipment, the staff shall be trained in actual operation.

5.3.4.1 Maintenance Staff Training

The objective of the training is to enable the Engineer's maintenance staff and Engineering staff to be familiar with the Systems focus on the maintenance aspects of the System including but not limited to the following: -

i. Full understanding of all the equipment, sub-systems and system, their function, maintenance and overall requirements.
ii. Procedures to be followed for unscheduled maintenance and repair.
iii. Identification of failed components and sub-systems in electronic equipment by use of special test kit as necessary.
iv. Modification in the software to extend or modify the control, monitoring and protection functions.

5.3.4.2 Training Requirements

Man weeks of contractor's Training Instructors for training Engineer's maintenance personnel in India.

S. No	Training	Man-Weeks
1	HT/LT panels, Transformer, Circuit Breakers, DG set, Switchgear and cables	2
2	Other General services Equipment/Electrical wiring *biz MCCB, MCB, Fuses, Cable laying, conduiting, wiring, Busbars, UPS, Battery, Lighting, High Mast Lighting etc.*	2
3	Electrical safety & Earthing system	1

5.4 Defects Notification Period (DNP)

The Contractor shall be responsible for all the Defects and deficiencies, till the expiry of a **period of 01 (One) year**. The Contractor shall repair or rectify all Defects and deficiencies observed by the Authority Engineer during the Defects Notification Period within time period as may be determined by the Engineer in accordance with Good Industry Practice. *All materials required/ rectification during DNP shall be arranged by contractor. Contractor shall submit the list of DNP spares with types and quantity which contractor intends to hold during DNP, at least six months before start of DNP, to Engineer for review.*

5.4.1 Warranty Certificates from OEM:

i. All Original Warranty Certificates of OEMs of all Electrical system or equipment including contract spare, Commissioning spare, DNP spares and Special tools & Test and Measuring equipment shall be valid for three years or as specified in RDSO Specification of the equipment whichever is later and registered in the name of Engineer. These warranty certificates received from the OEMs should be passed on to Engineer before final Taking over.

ii. Validity of period of Warranty Certificates shall start from date of Commissioning.

iii. Original invoice shall also be submitted with the OEM warranty certificates in a booklet form before Commissioning.

iv. Warranty period and defect liability support shall start from the date of Commissioning.

5.5 Spare material

5.5.1 General

The Contractor shall supply spare parts, special tools and test equipment in accordance with the requirements and as decided by Engineer.

5.5.2 Contract Spares

The Contractor shall supply quantity of spare parts with minimum quantity as given below in Table. The price of below quantity of spare should be quoted in the item provided in Sub - Cost Center E2 –Inventory/spares items. The evaluation of the tender shall be done considering this price of spares. Upon approval of the Engineer the procurement of spares should be done by contractor.

Sr. No	Item	Unit	Quantity
1	Copper cable of all sizes	Meter	5% of the total cable laid subject to a minimum of 500 mtrs of each type.
2	All other Copper wires	Meter	5% of the total wire used / laid subject to a minimum of 100 meter of each type.
3	Maintenance free batteries	Nos.	10% of each type installed. Subject to minimum of one.
4	UPS	Nos	2 (20 kVA minimum)
5	Battery Charger	Nos	1 No

6	MCB, surge protection device, fuses & other switch gears of HT/LT panel	Nos	15% of each type installed. Subject to minimum of one.
7	All other interconnecting cables/ connectors not included above	Nos	10% of each type installed. Subject to minimum of 2 Nos
8	All type of LED fittings and other Electrical equipment	Nos	10% of each type installed. Subject to minimum of 10 Nos
9	*Straight through joint 11 kV*	*Nos*	*4*

Note: - Spare shall be procured only after the approval from the Engineer. The Items of spares given are indicative and final items shall be approved by the Engineer. The equipment/kits supplied should be as per latest specifications/models and should be compatible with the existing system being installed in this contract. Approval for the specifications should be taken from engineer before placement of the order.

5.5.3 Long Lead Times

The Contractor shall identify the lead times for all spare parts. Parts with long lead times shall be identified in the spares list.

5.5.4 Routine Change

In the event that any item of the supply requires to be routinely changed or calibrated regardless of whether it appears in the spares list or not, it shall be identified to the Engineer together with the routine change interval.

5.5.5 Shelf Life

In the event that any of the spares identified have a particular life or storage requirement, this shall be made known to the Engineer with the submission of the spares list, including the necessary action for disposal or storage.

5.5.6 Special Tools, Testing and Diagnostic Equipment and Measuring Instruments

The Contractor shall supply adequate quantity of special tools, testing and diagnostic equipment and measuring instruments in accordance in order to carry out all the functions necessary for operation and maintenance of the entire system and also considering the requirements as described in the Operation and Maintenance Manuals. The special tools, testing and diagnostic equipment and measuring instruments shall also include apart from the other necessary items.

The contractor should ensure that the special tools and test equipment provided are compatible with equipment supplied under this Contract. The details of item are as under:

Sr. No	***Item***	***Unit***	***Quantity***
1	*Cable fault locator*	*No*	*1*
2	*Digital Earth Tester*	*Nos*	*2*
3	*Earth Leakage detector 1000 Volt.*	*Nos*	*1*
4	*Digital Insulation Tester 2.5-5 kV*	*Nos*	*2*

5	*Digital Insulation Tester 0-1000V*	*Nos*	*2*
6	*Vernier Caliper*	*No*	*1*
7	*Aluminum Ladder (5 m)*	*Nos*	*2*
8	*Wire cutter 12"*	*Nos*	*6*
9	*Non-Metallic Hammer*	*Nos*	*2*
10	*Digital Multimeter*	*Nos*	*4*
11	*Electrical tool kit*	*Nos*	*4*
12	*Safety PPE (Jacket and Helmet)*	*Nos*	*10*
13	*Portable grinder electrically operated*	*Nos*	*2*
14	*D shackle set (1", ¾", 5/8' -one each)*	*set*	*5*
15	*Single sleeve pulley block (100 mm wheel dia & 15 mm groove)*	*set*	*5*

5.5.7 Coding and Tagging of Spare Parts and Special Tools and Test Equipment

i. All Spares/Spare Parts and Special Tools and Test Equipment to be delivered to the Engineer shall each carry a tag suitably marked, bar-coded (as directed by the Engineer) and numbered.

ii. The numbers on the tags shall correspond with those on the coding system developed by the Contractor for all Electrical components, parts and equipment.

XXXX

CHAPTER – 6 TECHNICAL SPECIFICATION

6.1 SUBSTATION (11/0.433) kV :-

Indicative conceptual layout plan of civil structure/building of Sub-stations attached in Section VII-8: Tender Drawings and Documents. The contractor has to construct Sub-Station building accordingly.

The electrical sub-station consists of following electrical equipment but not limit to:-

6.1.1 11 kV GIS HT Panel Board :-

This specification covers design, manufacture, assembly, testing before supply, inspection, packing and delivery of metal clad partitioned, SF6 gas insulated switchgear confirming to IEC-62271-200.The GIS (Gas Insulated Switchgear) type switchgears shall be complete with all the accessories and auxiliary equipment's required for their satisfactory operation such as switchboard panels for line bays, bus coupler/bus section bays etc. shall be fitted with vacuum circuit breakers, three position disconnect and earthing switches, voltage transformers, current transformers, metering instruments, protection relays, cable terminal ends/plugs for incoming & outgoing cable feeders etc.

6.1.1.1 OBJECTIVE & TOLERANCES:-

It is intended to have:

a. Enhanced safety, availability, maintainability and reliability
b. Maintenance free switchgear
c. Reduction in space requirement with low environmental footprint
d. Integrated remote control and monitoring-SCADA compatible.

Tolerances: -

Tolerances on all the dimensions shall be in accordance with provisions made in the relevant IS/IEC standards and in these specifications. otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

6.1.1.2 SERVICE CONDITIONS:

A. System particulars:

a) Nominal system voltage ... 11 kV
b) Corresponding highest system voltage ... 12 kV
c) Frequency ... 50 Hz ± 3%
d) Number of phases ... 3
e) Neutral earthing grounded ... Solidly
f) Short Current Rating ... 25 kA

B. Auxiliary supplies available through UPS are as follows

a) A. C. Supply ---- 433/240 volts with ± 10% variation
b) Frequency ---- 50 Hz with ± 3% variation

6.1.1.3 SWITCH GEAR PANEL: -

a) The Gas insulated Metal clad switchgear shall be complete with all the accessories for efficient and trouble-free operation. The equipment offered shall be safe, reliable, high availability, easily maintainable and compact to install. The workmanship shall be of high order. The circuit breaker, switches and protective device etc. shall be latest design so as to ensure rapid and efficient interruption of fault current low arc energy, small arching time and freedom from fire hazards.

b) The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification. Adequate safety margin with respect to thermal, mechanical, dielectric stress, dynamic short circuit fault and insulation coordination is to be maintained during design, selection of raw material, manufacturing process etc. so that the GIS provides long life with least maintenance. The complete switchgear shall be designed to manage the risks associated with it such that there shall not be any safety hazard to the employees in normal service and during inspection and maintenance.

c) The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.

d) The switchgear panel shall be fully arc proof, free standing, floor mounted, fully compartmentalized, metal enclosed construction complying requirements of IEC 62271- 200. Each circuit shall have a separate vertical panel with required compartments for circuit breaker, cable termination, main bus-bars, three-position switch and auxiliary control devices.

e) The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch (by human/animal) of any of its constituent live parts.

f) The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The Service Class Continuity of Switchgears shall be LSC-2 (as per IEC 62271-200), LSC 2B-PM (as per IEC 62271-200) will be preferable.

g) All louvers (if provided) shall have very fine brass or GI mesh screen. Tight fitting gourmet /gaskets are to be provided at all openings in relay compartment. Relays shall be fully flush mounted on the switchgear panels at a suitable height from operator point of view.

h) Switchgear shall have an Internal Arc Classification of IAC-A-FL / A-FLR 25 KA,1 sec. (as per EI guidelines) The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Gas Pressure relief device/Explosion Vent/Pressure relief duct shall be provided for each SF6 gas compartment, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of it's spreading to other compartments and panels. The pressure relief device/Explosion Vent/Pressure relief duct shall not however, reduce the degree of protection of panels under normal working conditions.

i) The switchgear shall be cooled by natural air flow.

j) Suitable interlock & Indications shall be provided to prevent opening of any HT compartment doors, in case the incoming HT supply is ON.

k) Suitable base frames made out of *stainless*-steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be

dispatched in advance so that they may be installed and levelled when the flooring is being done, welding of base frame to the insert plates shall be in Contractor' scope. The Contractor may offer panels with built in base frame ready for dispatch and suitable for installation on indoor cable trenches.

l) The switch board shall have the facility for extension on both sides. The facility of extension of additional breakers (to existing set up) for future expansion shall be provided.

m) The manufacturer shall give guarantee for maximum leakage rate of SF6 gas will be lower than 0.1 % per year, sealed FOR LIFE pressure system and guarantee no gas handling at a site during extension, removal and installation at site. In case of Gas leakage, the GIS should have the capability to withstand di-electric strength at 1bar pressure. Separate gas monitoring sensors should be available for all the gas filled chambers.

n) The minimum operating SF6 gas pressure shall be 1.2 bar. Alarm shall be generated if the SF6 gas pressure drops to 85% of the minimum operating pressure and if it further drops below 80% the Circuit breaker shall trip & go into lockout mode.

o) Thermostatically controlled space heater with common MCB shall be provided for various compartments.

p) The SF6 gas insulated metal enclosed switchgear shall be constructed from corrosion resistant stainless-steel sheet of min 2 mm thickness, filled with SF6 accommodating the primary switching devices (Bus bar, VCB and Three position disconnect or cum earthing switch) and all live parts. This panel complying ingress protection min IP 65.

q) The interconnection of individual panels shall not require any gas work neither for installation at site nor for extension of the panel board. It shall be possible to extend the panel board on either side.

r) All the mechanical parts shall be surface treated to prevent corrosion.

s) In case of non-gas enclosing parts of the offered panels are with painted design, the panels must be suitably treated, and powder coated with 60-70-micron thickness, to achieve indoor worthiness and corrosion protection and should pass salt spray test as per ISO 9227-2017.

t) It shall be with pressure relief device with controlled direction of flow of the hot gasses generated in rare event of internal arc. The panel board with minimum gas pressure shall withstand the rated highest system voltage. Temperature compensated gas density monitor shall be provided on the front side to monitor SF6 gas and for interlock purpose. The design of the panel should be such that no permanent or harmful distortion occurs either when being lifted by eyebolts or when moved into position by rollers.

u) Paint shade of Indoor Switchgear shall be 694 /RAL 7032 as per IS:5(Dove Grey).

v) SF6 gas pressure and density should maintained as per relevant IS and IEC, if gas pressure or density goes below specified limits, breaker should go in lockout mode.

6.1.1.4 TECHNICAL DATASHEET FOR 11KV GAS INSULATED SWITCHGEAR

Sl. No	Description	Technical Parameters
1	Switchboard	-
2	Manufacturer's Name	By Contractor
3	Type	------
4	Standards Followed	IS/ IEC 62271-100/200
5	Main Bus bar	
	a) Current Rating	800A
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
6	Earth Bus bar	
	a) Current Rating	25kA
	b) Material	CU
	c) Grade	Electrolytic Cu
	d) Whether Joints are Silver Plated	N.A
	e) Thickness of Coating	N.A
7	Continuous current Rating for Ambient Condition of site when installed in IP 65 Switch board	
	a) Main Bus bar at Ambient Specified	800A
	b) Tappings at Ambient Specified	800A
8	Temperature rise of Bus bars while	
	a) Carrying rated Current and Installed in IP65 enclosure at an Ambient Temp specified.	As per IS/IEC-62271
	b) Under Short Circuit Condition	N.A
9	Degree of Protection of Enclosure	SF6 gas chamber- Stainless Steel IP65 Drive-IP2X Low Voltage-IP3X
10	Minimum Clearance in Air	

Sl. No	Description	Technical Parameters
	a) Between Phases	Since all parts in SF6, clearance is not applicable.
	b) Between Phase to Earth	Since all parts in SF6, clearance is not applicable.
11	Clearance required at the Back & Front of Panel	AFL: 1700 mm @ front and minimum 1200mm from back (in case of AFLR)
12	Overall Dimension of the Switch Board (mm)	
	a) Length	In line with Switch Board Configuration
	b) Width	450m/ 600mm
	c) Depth	1400mm
	d) Height	2400/2800mm
12	a) Access Height (mm)	
	i) Maximum	1850 mm height of lock of LV box door (as per site feasibility)
	ii) Minimum	830 mm height of cable box handle
	b) Weight of Panel Board (kg)	
	i) Maximum:	By Contractor
	ii) Minimum:	By Contractor
13	Insulation Level including all the Components	
	a) Power frequency withstand Voltage for 1 min	28 kV
	b) 1.2/50 µ sec Impulse Withstand Level	75 kV
14	Circuit Breakers	
(i)	Manufacturer's Name	
(ii)	Type	
(iii)	Manufacturer's Type reference	
(iv)	Closing Mechanism	spring
(v)	Normal Current rating in Air & corresponding	800A
(vi)	Ambient Temperature	40°C
(vii)	Derating factor for Ambient condition at Site	N. A.
(viii)	Service Voltage & Frequency	11 kV, 50 Hz
(ix)	Maximum Voltage at which CB can Operate continuously	12 kV

Sl. No	Description	Technical Parameters
(x)	Rated Making Capacity	63kAp
(xi)	Rated Breaking Capacity	25kA
(xii)	a) Symmetrical	25kA
(xiii)	b) Asymmetrical	27kA
(xiv)	Short Circuit Withstand Capacity	
	a) 3 Sec	25kA
(xv)	Total Make time	Within 60ms
(xvi)	Total Break time	Within 60ms
(xvii)	No. of Breaks per pole	1 No.
(xviii)	Total Length of Break per pole	
(xix)	No. of Auxiliary Contacts (NO/NC) for Engineer use	8
(xx)	Type of Arc Control Device	Vacuum
(xxi)	Arc Duration time	
	a) 100 % Load Current	Within 10ms
	b) 10 % Load Current	Within 10ms
(xxii)	Spring Charging Motor	
	a) Type	Universal Motor
	b) Voltage	240 V AC
	c) Rating in kW	0.223
	d) Protection relay provided	Not Applicable
	e) Protective MCB s provided	Yes
(xxiii)	Power required for :	
	a) Closing	
	i) Momentary	250W
	b) Holding	N.A
	c) Tripping	250W
	d) Time taken for Charging Motor to Charge Spring completely	8 seconds
(xxiv)	Number of consecutive operation the breaker can withstand and the recommended interval between these operations:	O-0.3Sec-CO-3Min-CO
(xxv)	Number of short circuit current interruption after which the breaker requires attention & maintenance	by Contractor

Sl. No	Description	Technical Parameters
(xxvi)	Number of normal operations after which the breaker requires attention & Maintenance	10000
(xxvii)	Rated capacitor breaking current of breaker/ contactor of each rating	N.A.
(xxviii)	Confirm that trip and closing coils will be suitable for 110 V DC and the spring charging motor will be suitable for 240 V AC	Yes
(xix)	Maximum number of XLPE cables & sizes that can be terminated safely in the cable chamber without extension panel	
	a) Single core (Size & No. of Runs)	As Applicable
	b) Three core (Size & No. of Runs)	As Applicable
(xx)	Maximum no of cables that can be terminated in the cable extension box (Please state the dimensions of such cable extension Box)	N.A
(xxi)	Minimum available distance from the bottom of the panel to the terminals in cable box/chamber for terminating cables	500mm.
(xxii)	Weight of circuit breaker and truck	fixed mounted GIS
15	Instrument Transformers	
(i)	Makes	
	a) CTs	By Contractor
	b) PTs	By Contractor
(ii)	Standards followed	IS/IEC
(iii)	Confirm that CTs and PTs will be epoxy resin cast insulated	CT foil, VT metal-cast resin
(iv)	3 second short time current rating of CTs, kA.	25kA
(vi)	Dynamic current rating of CTs, kA :	63kAp
(vii)	Confirm that accuracy classes shall be as specified and ratios and capacities shall be as required	Yes/No
(viii)	Confirm that all protective, metering, control and annunciation devices, transducers as specified shall be provided	Yes/No
(ix)	Enclose technical particulars, data sheets, catalogues of all types of relays and other plant being offered by you	Yes/No
17	SF6 Gas Pressure	*1.2 bar*
18	Gas Leakage Rate	< 0,1% per year
19	Gas handling Requirement at Site	No Gas handling allowed at site

Sl. No	Description	Technical Parameters
20	Cable Terminations	
	Make	By Contractor
	Type	Inner cone / Outer Cone

6.1.1.5 Busbar and Insulators: -

a) 11KV bus bar can be housed in SF6 gas chamber. 11 kV bus bars shall be made ofelectrolytic copper and shall be rated for 800 Amps continuous current. Cross sectional area shall not be less than 500 sq.mm. and bus bar size calculation /supporting type test report shall be submitted for approval. Current density of copper shall not exceed more than 1.6Amps/sq. mm. Bus bar cross-section shall be uniform throughout the length of switchgear panel. The bus bar edges/ends shall be rounded off/chamfered so that there will not be any sharp edges/projections. Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators and should withstand electrical and mechanical stresses due to specified short circuit currents. (IS)

b) All piping for SF6 gas shall be made of copper & their fittings shall be made of nonmagnetic stainless steel.

c) Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. In case of organic insulator partial discharge shall be limited to 50 Pico coulomb at rated Voltage X 1.1/√3 as per IS 3156.

d) All busbars shall have suitable phase identification. Bus switching scheme shall be as per Engineer.

e) The temperature of the bus bars and all other equipment, when carrying the rated current continuously shall be limited 65deg C for tin plated joints and 75 deg C for silver plated joint above ambient temperature 40deg C as per the relevant Standards.

f) Clearances between phases and between phase and earth shall be as per OEM type tested design complying to relevant IEC standards.

6.1.1.6 Circuit Breaker: -

a) Vacuum circuit breaker shall be used for 11KV GIS (Gas Insulated Switchgear) 11 KV Vacuum circuit breaker shall comprise of three single pole interrupting units or 3-pole interrupting unit, operated through a common shaft by a sturdy operating mechanism. Circuit breaker shall be re-strike free, stored energy operated and trip free type. Motor wound closing spring charging shall be preferred. Anti-pumping features shall be provided for each breaker. An arrangement of two breakers in parallel to meet a specified current rating shall not be acceptable. (No parallel interrupter).

b) Circuit breaker shall be provided with two trip coils.

c) Suitable indicators shall be provided on the front of panel to indicate OPEN / CLOSED conditions of the circuit breaker, and CHARGED / DISCHARGED conditions of the closing spring, SF6 gas density monitor for all gas compartment.

d) The rated control supply voltage shall be as mentioned elsewhere under Technical parameters. The closing coil shall operate satisfactorily at all values of control supply voltage between 85-110% of the rated voltage. The trip coil shall operate satisfactorily under all operating conditions of the circuit breaker up to its rated short circuit breaking current at all values of control supply voltage between 70-110% of the rated voltage. The trip coil shall be so designed that it does not get energized when its healthiness is monitored by indicating lamps and trip coil supervision relay.

e) The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor, a continuous sequence of closing and opening operations (CO) shall be possible. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the supply voltage is anywhere between 85-110% of rated voltage. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 40 deg. C ambient air temperature. The motor shall be provided with overload protection.

f) Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.

g) For 11kv incomer: Tripping time: 60-70 ms (Including Relay Time) Closing Time < 80 ms.

h) For 11kv feeder: Tripping time:45-50 ms (Including Relay Time) Closing Time: 40-60 ms

i) Manual Spring Charging shall be provided. All the basic mechanical ON/OFF Circuit breaker, Disconnect or & earth switch operation, manual spring charge of Circuit Breaker must be possible without opening the door to ensure the operator safety.

j) Breaker operations (Mechanical Endurance) as per relevant IS/IEC Amended up to date. The circuit-breaker has to control at least 10,000 Make-Break cycles without maintenance. The mechanical life and operating cycles of the vacuum interrupter shall confirm relevant IS/IEC amended up to date.

k) Tripping coil, closing coil and motor mechanism shall be easily accessible for maintenance purpose.

l) The circuit breaker shall be provided with motor operated spring charged closing. Spring charging motor shall be suitable for 240V, 50 Hz, single phase AC. Suitable rating starter shall be provided for Motor protection.

m) Tripping of the circuit breakers shall be through "Shunt trip" coils rated for suitable auxiliary supply. It shall be possible to trip the breaker manually in case of necessity.

6.1.1.7 Disconnector and Earthing switch

a) Each Switchgear panel shall be provided with three (3) position disconnecting-cum earthing switch of required rating.

b) It shall be possible to control these switches from front of the panel & remotely from SCADA *from operation control centre (OCC).*

c) Necessary indication shall be provided on the front of the panel for Close/Open status of the three position switches.

d) The safe, positive and fool proof interlocks shall be provided for personnel safety and equipment safety.

e) Key interlocks shall be provided for local manual operations.

f) Mechanical interlocks shall be provided for following conditions Three position disconnector cum earth switch cannot be operated when circuit breaker is closed.

g) The operating handle /lever cannot be removed until the switching operation has been completed.

h) Earthing shall be additionally secured against" de-earthing" by providing a padlock.

i) The cable compartment cover can only be opened if the panel is earthed.

j) In addition to above, relevant all electrical interlocks shall also be provided.

k) Disconnecting switches shall be motor operated as SCADA is implemented. Isolators or isolators combined with earthing switches (3 position switches) shall be motor operated. In cases of emergency, manual operation must be possible.

l) The earthing position for all 3 phases must be visible via a mechanical position indicator (MIMIC) directly connected to the drive shaft on panel front Fascia. The mechanical operation of isolator / 3 position disconnects or should be with door close only to insure operator safety.

6.1.1.8 Control and Interlocks: -

a) The circuit breaker shall normally be controlled remotely from SCADA system (OCC) through closing and trip coils. However, it shall also be designed to control locally from Indoor Switchgear panel. Suitable mimic on Panel shall be provided.

b) Facilities shall be provided for mechanical tripping of the breaker in an emergency. Facility shall also be provided for manual charging of the stored energy mechanism for a complete duty cycle.

c) Necessary mechanical & Electrical interlocks shall be provided between CB, Isolator & Earth switches for safe operation.

d) Each CB, Isolator & earth switch shall have 8 NO + 8 NC Auxiliary spares of good quality (corrosion free and easy for making connection) for future use. It should be located at accessible position in panel.

e) All the binary inputs/outputs shall be wired to the terminals & kept ready for future SCADA connectivity.

6.1.1.9 Earthing and Earthing Devices

a) The grounding system for GIS shall be designed and provided as per IEEE-80-2000 and CIGRE- 44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.

b) The earth busbar made of electrolytic high-grade copper with cross sectional area of minimum 240 sq. mm shall be provided at the bottom in all the panels and interconnected with adjacent panels in the panel board through a connecting link to form a common earth busbar for the entire panel board ready to connect to the substation earthing grid. It shall be welded to the framework of each panel and each breaker earthing contact bar. The earth bus shall have sufficient cross section (minimum 240 sq. mm) to carry the momentary short-circuit and short time fault currents to earth without exceeding the allowable temperature rise.

c) Suitable arrangement shall be provided at each end of the earth bus for bolting to station earthing grid. All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.

d) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure frame work and the truck shall be maintained even after painting.

e) All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. Insulation color code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering shall not be acceptable. Looping of earth connections which would result in loss of earth connection to other devices, when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths of earth bus is acceptable.

f) PT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.

g) The panel shall have Voltage Presence Indicator (VPI) to warn the operator against earthing of live connections.

h) All hinged doors shall be earthed through flexible earthing braid.

Separate earthing for switchgear and Control & Relay panel shall be provided.

6.1.1.10 CURRENT TRANSFORMERS:

a) The C.Ts. being prone to failure due to various reasons, the quality and reliability of the CTs are of vital importance. C.T. shall be rated for 25 kA for 3 sec. short time current. Insulation used shall be of very high quality, details of which shall be furnished in the technical offer.

b) The instrument security factor for metering core shall be low enough but not greater than 5 at lower ratio. This shall be demonstrated on metering core in accordance with the procedure specified in relevant IS/IEC.

c) All current transformers for GIS shall be ring type (Tape wound / resin cast). Suitable insulated copper wire of electrolytic grade shall be used for CT secondary winding. Multi ratio in CT shall be achieved by reconnection of secondary winding tapping.

d) Secondary terminal studs shall be provided with at least three nuts, two plain and two spring washers for fixing leads. The stud, nut and washer shall be of brass, duly nickel plated. The minimum outside diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads. The space clearance between nuts on adjacent studs when fitted shall be at least 10 mm.

e) The CTs shall be resin/epoxy cast. Contact tips on primary terminals shall be silver plated. Correct polarity shall be invariably marked on each primary and secondary terminal.

6.1.1.11 POTENTIAL TRANSFORMER

a) Potential transformers shall be single phase units connected to the line side in the respective incomer. H.V side shall be connected in star formation and L.V. side in star/open delta formation.

b) PT may be provided in a separate compartment. The primary and secondary contacts (moving & fixed type) shall have firm grip while in service. Service position locking mechanism shall be provided and indicated by Contractor in relevant drawing. Rigidity of primary stud point with earth bus in service position shall be confirmed.

c) P.T. shall be epoxy/resign cast. Contact tips of primary/secondary contacts shall be silver plated. Correct polarity shall be distinctly marked on primary and secondary terminal.

d) Secondary terminal studs shall be provided with at least three nuts, two plain and two spring washers for fixing leads. The stud, nut and washer shall be of brass, duly nickel plated. The minimum outside diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads. The space clearance between nuts on adjacent studs when fitted shall be at least 10 mm.

e) Each secondary core will be protected by suitable MCB.

f) In case of 2 Power Transformers are in parallel, 2nd core of PTs shall be used for directional protection.

6.1.1.12 Low voltage Compartment (Instrument Chamber)

a. The panels shall be with low voltage compartment consisting of control switches, indication and metering instruments, protection relays and other secondary equipment's. The dynamic mimic shall be provided on the front fascia and not on the LV chamber.

b. The front side shall have Mimic as per single line diagram with control switches and mechanical and electrical 'Position indicators' circuit breakers, disconnectors and earth switch.

c. Control switches/Pushbuttons shall be provided adjacent to respective equipment position indicators in Mimic for ON-OFF operation of circuit breakers, disconnectors and earth switches.

d. The SCADA compatible Metering instrument shall be provided.

e. Live line Indicators: - Capacitive voltage indicators shall be provided on feeder side in incoming and outgoing feeders to indicate the voltage presence in each phase and to prevent the closing of earth switch in case the part is live. It shall have sufficient output contacts for substation Automation System and interlock purpose.

6.1.1.13 Numerical Protection Relays

Numerical relays shall be of modular type and have native IS/IEC 61850 (to latest version/amendment of the series of this standard) communication support for RTU/SCADA integration. Relay shall have graphical LCD dot matrix display with single line diagram mimic with control, indication, programmable function key and LED' relay shall have minimum protections as per SLD however any addition protection if required, is to be considered by the contractor or OEM (price to be included in the offer). Protection relay PCB hardware should be with conformal coating to protect the relay from hazardous environment.

Relay hardware, control cables and separate arc sensors shall be included. Any arc flash fault in the cable compartment is selectively cleared by the feeder protection relay.

NOTE: Erection, Testing & Commissioning of the GIS panel must be done through the OEM of GIS panel only & OEM will issue the certificate of successful commissioning of GIS panel in all respect.

6.1.1.14 11kV SWITCH BOARDS

The switchgear and busbar shall meet the "sealed pressure system" criterion in accordance with the IS/ IEC 62271. The manufacturer certificate shall confirm that maximum *gas* leakage rate is lower than 0.1 % / year. It shall provide full insulation, for switchgear insensitive to the environment (temporary flooding, high humidity, etc.), IP65 degrees of protection in accordance with recommendation IS/ IEC 60529.

a) The switchgear shall be maintenance-free and the switchboard shall be low-maintenance.

b) The switchboards drive suitable for IP protection.

c) The cable compartment shall integrate:

   i. Adjustable cable fixing devices

   ii. Earth connecting point

   iii. Metal partition between cable compartments and tank pressure relief area.

d) The cable compartment shall be arc resistant and suitable for the following cable connecting systems:

1. Partial insulated cable connectors

2. Fully screened cable connectors

3. Metal enclosed cable connectors according to DIN EN 50181, IS-10314, IS/IEC-62155 and IEC-60137 standards to latest versions.

The color shall be as per Engineer requirement / as approved for the enclosure and mimic panel. The switchgear and switchboards shall be designed so that the position of the different devices is visible to the operator on the front of the switchboard and operations are visible as well. In accordance with the standards in effect, the switchboards shall be designed to prevent access to all live parts during operation without the use of tools.

6.1.1.14.1 EARTHING OF METALLIC PARTS

There shall be continuity between the metallic parts of the switchboard and cables so that there is no electric field pattern in the surrounding air, thereby ensuring the safety of people. The substation frames shall be connected to the main earth busbar without dismantling any bus bars.

6.1.1.14.2 EARTHING OF THE MAIN CIRCUIT

The cables shall be earthed by an earthing switch with short-circuit making capacity, in compliance with IS/IEC 62271-102 standard. The earthing switch can only be operated when the switch is open. The earthing switch shall be fitted with its own operating mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action. Mechanical interlocking systems shall prevent access to the operating shaft to avoid all operator errors such as closing the earthing switch when the switch is closed.

6.1.1.14.3 FEEDER WITH SWITCH-DISCONNECTOR

They shall be maintenance-free. The position of the power contacts and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with IEC 62271-102 standard.

The switches shall be of the "increased operating frequency" in accordance with IEC 62271-102 standard. They shall have 3 positions, "open-disconnected", "closed" and "earthed", and will be constructed in such a way that interlocking prevents unauthorized operations. The switch disconnector and earthing switch shall be equipped with two separate operating entry points. Manual opening and closing will be driven by a fast-acting mechanism, independent of operator action. Each switch can be fitted with an electrical operating mechanism in a specially reserved location, by addition of a motorization unit and without de-energizing the switchboard. The switch and earthing switch operating mechanism shall have a mechanical endurance of at least 1000 operations, in line with IS/IEC 6227-102.

6.1.1.14.4 TRANSFORMER PROTECTION WITH VACUUM CIRCUIT BREAKER

The circuit breakers shall be of the maintenance-free, vacuum type. The position of the power and earthing contacts shall be clearly visible on the front of the switchboard. The position indicator shall provide positive contact indication in accordance with IS/IEC 62271-102 standards and prove reliability of indication in accordance with IS /IEC 62271-102 & 6.105 standard. An operating mechanism can be used to manually close the circuit breaker and charge the mechanism in a single movement. An independent mechanism shall be fitted for the 3-position earthing switch and disconnector and include a local system for manual tripping by an integrated push button. There will be no automatic reclosing. The circuit breaker shall

be associated with an integrated protection unit that will operate without any auxiliary power supply and shall include:

a) Three toroidal transformers incorporated in the transformer tee-off bushings,
b) An electronic relay (Self Powered),
c) A low energy release,
d) A system protection testing (with or without CB tripping)

6.1.1.14.5 MV METERING

MV Metering shall be carried out by a factory assembled type tested cubicle.

The metering cubicle shall withstand internal arc. Connection with adjacent cells will be direct through bus bar but MV cables shall be possible.

VT's and CT's to comply with type DIN 42600 standards, IS-2705, IS-16227 and the following configuration shall be available:

a) 2 VT's phase-phase,
b) 2 VT's phase-earth,
c) 3 VT's phase-earth
d) 2 or 3 CT's. (as per design)

6.1.1.14.6 Substation Buildings

Contractor Shall design and construct the substation buildings and shall be responsible for land preparation, Boundary wall, entrance gate, foundation, support anchor block, Baffle wall between transformers, door, windows including architecture, civil, structural, drainage, plumbing, conduiting, wiring, provision of lights, fans, Exhaust fan. All such parts accessories shall be deemed to be within the scope of specification weather specifically mentioned or not. The soil investigation for foundations for building work, foundation etc shall be undertaken and Engineer approval shall be taken. Electrical resistivity of soil for designing safe grounding system shall be done.

The Grade of concrete should be as per approved design and Minimum M-25 as per IS 456 for all civil construction of Substations. The cement plaster shall be 1:4 (cement: sand) and, *Brick class designation not less than 7.5 shall be used*. The earth compaction shall not be less than 95%. This site above to cleared of all existing encumbrances, levelled and compacted. The finished ground level o0f substation site shall be above the highest flood level HFL in the region. The finish ground level shall be at least 600 mm above the main rail /road level near to site.

The drainage of substation shall be provided as per best engineering practices to prevent surface flooding and cooling of water. suitable drainage system and earth recharge pit shall be made. All fencing items i.e., wire mesh, angles, flats etc shall be GI.

The ceiling height of the substation building shall be minimum 4.5 above floor level. The plinth of the substation building shall be 300 mm above the natural ground level of substation.
All windows of substation building shall be fitted with burglar bars firmly attached to the structure of building. The windows shall be appropriate section and shall be fitted with locks. The windows shall be provided with minimum 5mm thick toughened glass. Doors and shutters shall be sturdy and having corrosion proof material. Parapet wall shall be

provided on windows and doors to avoid of ingress of rain water. Toilet rooms and water supply arrangement shall be made in the substation building along with provision of submersible pump.

Substation building shall be provided necessary lighting and Fans. The battery room shall be provided with exhaust fan and acid resistant tile on the floor on the site wall upto height of 1.5 meter. The ceiling shall be painted with acid resistant paint. Substation building shall be properly earthed against any lightning.
Necessary trenches shall be made and these shall be covered with GI chequered sheets 8 mm thick.
The indicative layout of the substation along with area has been given in the Tender drawings. Contractor shall submit the final layout design for Engineer's approval after taking consideration the sizes of various equipment, other requirement mentioned in these specifications.

6.1.2 11 kV RING MAIN UNIT (RMU): -

RMU type, metal-enclosed indoor switchgears, shall be compact switchboard and comply to following requirements. The RMU shall be capable of being installed in either concrete indoor substations or in compact metal substations and kiosks with an IP67 rating.

6.1.2.1 FUNCTION REQUIREMENTS

The following functions shall be available:

a) Feeder with switch-disconnector
b) Transformer protection with vacuum circuit breaker

6.1.2.2 Enclosure:

The RMU enclosure shall be made up of CRCA of 3 mm thickness with appropriate rust prevention treatment suitable for humid and corrosive atmospheres / alternatively of stainless steel SS316L of at least 1.6 mm thickness. The rating of enclosure shall be suitable for operation on three phase, three wire, 11 KV, 50 cycles, A.C. System with short time current rating in the range of 20kA – 25 kA for 3 seconds with Panels. The enclosure shall provide full insulation, making the Switchgear insensitive to the environment like temporary flooding, high humidity etc. The active parts of the Switchgear shall be maintenance-free and the unit shall be minimum -maintenance. The Switchgear and Switchboards shall be designed such that the position of the different devices is visible to the operator on the front of the Switchboard and operations are visible. The RMU metal parts shall be made of high thickness high tensile steel grit/short blasted, thermally sprayed with Zinc alloy (not for galvanized steel), phosphate and subsequently painted with Polyurethane based powder paint, the overall (including outer and inner paint layer), the thickness of paint layer shall be not less than 150 microns.

6.1.2.3 Configuration requirements

Extensible range:
3 function unit: Switch-disconnector Load Break Switch (LBS)- Switch-disconnector (LBS)- Transformer protection with vacuum circuit breaker. The RMU shall meet the criteria for compact, metal-enclosed indoor switchgear in accordance with IS/ IEC 62271-200:
Switchgear classification: PM class
Loss of service continuity class: LSC2

It shall include, within the same metal enclosure, the number of MV functional units required for connection, power supply and protection of transformers.

6.1.2.4 RMU BUSHINGS AND CABLE TERMINATIONS Bushing

It is preferable to have all bushings accessible from the front of the RMU. Bushings along the sides or the rear of the RMU are not acceptable. For each cable compartment, the bushing shall be at the same height in order to facilitate a possible reversal of the cables
The bushing should be conveniently located for working with cables specified and allow for the termination of these cables:

a) 630 A M16 bolted connectors for switch-disconnectors and vacuum circuit breakers functions
b) 200 A plug-in connector for transformer protection feeder with fuse combination. The profiles of the cable connection bushings shall be in compliance with IEC-60137, IS- 10314, IS/IEC-62155 standards of latest versions. A cable clamp arrangement must be provided for all network cables terminated on the RMU.

6.1.2.5 PADLOCKING FACILITIES

Circuit breakers, fuse-switches combination, switches and earthing switches can be locked in the open or closed position by at least 1 padlock.

6.1.2.6 VOLTAGE INDICATORS AND PHASE COMPARATORS

Each function shall be equipped with a voltage indicator box on the front of the device to indicate presence of voltage in the cables. The capacitive dividers will supply low voltage power to the lamps. Three inlets can be used to check the synchronization of phases. This device shall be in compliance with IEC 62271-206, IEC 61243-5(to latest versions).

6.1.2.7 FAULT PASSAGE INDICATORS (FPI)

The FPI shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The FPI should be self-powered and should have internal lithium battery for external indication and setting of FPI in the absence of current. The FPIs shall include:
Fault detection - Phase to phase and Phase to earth faults.
One potential-free output contacts for hardwiring to RTUs. On this basis, the SCADA will be able to monitor phase / earth fault condition. Local fault indications – LED/ LCD display on FPI front panel along with LED indication on front panel of RMU enclosure.
The FPI should indicate load current on display to understand loading of RMU.
Multiple reset option –

a) End of time delay
b) Remote reset (Via potential free input contact of FPI)
c) Manual reset (Reset button on front panel of FPI)
d) Automatic reset on current restoration.

The characteristics of the FPIs shall include:

i. ▪ Phase fault thresholds configurable from at least 100 to 800 A
ii. ▪ Earth fault thresholds configurable from at least 20 to 200 A
iii. ▪ Multiple number of steps for adjusting phase and earth fault thresholds.
iv. ▪ Fault current duration range configurable.

RMU should have VCB, FRTU and FPI supplied and integrated by the same OEM to ensure seamless integration.

6.1.2.8 OPERATING LEVER

An anti-reflex mechanism on the operating lever shall prevent any attempts to reopen immediately after closing of the switch or earthing switch.
All manual operations will be carried out on the front of the switchboard.

6.1.2.9 FRONT PLATE

The front plate shall have suitable IP degree of protection. The front shall include a clear mimic diagram which indicates the different functions.
The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator. The lever operating direction shall be clearly indicated in the mimic diagram.
The manufacturer's plate shall include the switchboard's main electrical characteristics.

6.1.2.10 REMOTE CONTROL OF THE RMUs

A limited number of applications for remote operation of the RMU are required.
Remote operation of the RMUs line switches must be possible using motors fitted to the operating mechanism. It shall be possible to fit the motors either directly in manufacturing plant or on site when required. Installation on site shall be possible with the RMU fully energized and manufacturer should provide detailed instructions for installation to the control mechanism.

Auxiliary contacts for remote indication of switch status are also required. The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches. An auxiliary contact to prevent motorized operation of the mechanism while the operating handle is inserted into the operating point must also be provided. The device shall be fully designed for use in a hot, humid atmosphere and shall be low maintenance. All metallic parts shall have rust protection. Two lifting rings shall be installed on the top of the switchboards for handling.

6.1.2.11 TECHNICAL DATASHEET FOR RING MAIN UNIT (RMU)

Network	Three phases - Three wires
Rated Voltage	12 kV
Service Voltage	11 kV
System Frequency	50 Hz
Lightning Impulse withstand Voltage • Phase to phase, phase to earth • Across the isolating distance	 75kV 85 kV
Power Frequency withstand voltage	28 kV rms - 1 min

Rated Normal Current a) Line switch b) Transformer feeder c) Branch circuit breaker feeder	 630 A 630 A 630 A
Rated Short time current withstand (3 sec)	20 - 25 kA
Internal Arc IAC – AFL (SF6 tank and cable box)	20kA for 1sec
Rated Short circuit making capacity of line switches and earthing switches	62.5 kA peak at Rated Voltage
Number of operations at rated short circuit current online switches, earthing switches and CB	5 closing operations
Rated load interrupting current Line switch	 630 A rms
Rated cable charging interrupting current Line switch	 30 A
Number of mechanical operations a) Line switches and earthing switches b) Switch-fuse combination c) Circuit breaker	 1000 O/C 1000 O/C 2000 O/C
Number of electrical operations at full load breaking current	100 O/C
Number of operations at rated short circuit current on circuit breaker	Manufacturer's design

6.1.3 ACCESSORIES FOR 11 KV SYSTEM: -

6.1.3.1 DISTRIBUTED I/O

Distributed Input /Output (I/O) are required for using the advantages of a double-sided feeding at the 11
kV System. The distributed I/Os will be provided by the contractor of Electrical /SCADA. All data points of the 11 kV-System run to the distributed I/Os.

6.1.3.2 FIRE EXTINGUISHER

CO2 fire extinguishers shall be provided in substation, equipment room . This includes necessary fixing arrangement, accessories etc.

6.1.4 ACCESSORIES FOR EACH 11KV SUB –STATION: -

Each 11 kV sub- station shall be equipped with:

a) Single Line Diagram of 11 kV-System of tunnel with glass-covering
b) Sheet / Board including the instruction for first aid by electrical accidents
c) - Sheet / Board including the instructions for fire-fighting measures in electrical plants
d) Prescription of operation of High Voltage Systems
e) Suspension Device for accessories
f) Warning Sign "Attention High Voltage"
g) Voltage Detector
h) Earthing Accessories and other safety equipment as per standard.

6.1.5 OPERATION MODES: -

All switching equipment, which shall be equipped with a remote control switch, shall need a changeover switch. Therewith a switching between local- or remote-control is possible.

6.1.5.1 LOCAL CONTROL:

If the changeover switch is positioned at "local control", all up streamed switching equipment has to switch off the remote controlling. The whole switchgear interlocking shall also work at local control.

6.1.5.2 REMOTE CONTROL:

At this position of the changeover switch the user shall be able to choose between different switch possibilities out of a predefined matrix. Generally, it shall be possible to decide which of the two feedings shall be switched. A remote controlling of the high voltage power supply shall only be possible, if:

a) No changeover switch is positioned at local control
b) No earthing switch is switched
c) No fault is stored.

6.1.6 APFC PANEL WITH ALL ACCESSORIES: -

SITC of APFC Panel of 250 kVAR heavy duty capacitor bank with MCCB as incomer or as per site requirement. Automatic Power Factor Correction (APFC) panel shall be totally enclosed, metal clad, sheet steel fabricated, fixed feeder type, dust and vermin-proof, free standing, floor mounting type. The enclosure shall be pre-treated as per 11 tanks process and finished with powder coating of shade RAL 7032. The panel shall be built to ensure:

a) Proper thermal design, by providing louvers and fans in appropriate location,
b) Accurate selection of switchgear, capacitors-reactors and others in the panel.
c) Safety during operation, inspection and maintenance.

6.1.6.1 Minimum features required are: -

i. Advanced microcontroller based APFC relay
ii. Four quadrant sensing
iii. Reliable switching sequence
iv. Hunt free operation
v. Reliability in operation
vi. Program based rotation of duty cycle pre set
vii. Programming ensures stability
viii. Faster response time

ix. Accurate compensation
x. Contactor duty cycle optimization in case of equal step sizes
xi. Various system parameter display
xii. Fully automatic / manual setup and operation
xiii. Minimal joining in all the connections to ensure better reliability and lower losses.
xiv. Use of special connecting cables suitable for high temperature withstands.
xv. Flush mounted meter to indicate line voltage and current.

6.1.6.2 PROTECTION:

The following protection schemes must be provided for APFC panels:

a) Over voltage: The APFC equipment must be switched off in the event of over voltage with suitable over voltage relay.
b) Under voltage: This condition is not harmful. But protection must be provided to protect system from under voltage.
c) Over Current: All the switchgears are selected on a higher maximum current carrying capacity. Hence, suitable over current relays with alarm can be used for over current protection.
d) Short circuit protection: At the incomer level short circuit protection shall be provided by devices such as MCCB, ACB. At the step protection level, MCCB/ MCB shall be used Thermal Overload: The APFC controller must be tripped in cases where internal ambient temperature exceeds the limits. Reactors are also provided with thermal switches, to trip in the case of temperature increase.
e) Earthing: Two earthing points shall be provided in the APFC panel for connection with the earth bus. This will ensure the overall safety of operating personnel and equipment protection in case of earth faults.
f) Earth Leakage Relay: It must be connected at power incoming side of the panel. Earth leakage relay must be provided to safeguard the operator by tripping the incomer.
g) Timers: Capacitors require a minimum discharge time of approximately 60 seconds after they are switched off before they can be switched on again. This shall be set in the APFC controller. Capacitors must be provided with discharge resistors.
h) Over Temperature trip mechanism: Temperatures sensors (two thermostats) to be connected for operation of the fans/ industrial air conditioners above 35°C and to disconnect main incomer of APFC if the temperature exceeds 55°C inside the panel.

6.1.7 11/0.433 KV TRANSFORMERS: -

The transformers shall be installed in such away, that no vibrations will be transmitted to the building / construction. The connecting of the 11 kV-cables at the transformers only shall occur with right-angle connectors. Those right-angle connectors shall be calculated into the price of the 11 kV-cable.

6.1.7.1 DRY TYPE 11 / 0.433 KV TRANSFORMER (2000 kVA for Portal sub-station)

Dry transformers shall be built with an air-natural – air-natural cooling (ANAN).
The 11/0.433 kV transformers shall be copper wounded equipped with off-load tap changer on primary side, with positions at +5 %, +2.5 %, ± 0 %, -2.5 % and -5 %. Generally, the tap changers shall operate under OFF-circuit conditions (through the cover) and shall be able to be fixed in any position by an adjusting screw. Winding terminations shall be realized as strip or foil windings. Additional to the turn insulation, the windings shall be embedded with a mixture of epoxy resin.

The mixture of epoxy resin shall be *non-inflammable* and self-extinguishing. Transformers shall be at least fire class F1 according to BS EN IEC 60076-11:2018, IS-11171.The neutral point (on the low-voltage side) shall be designed in a total insulated form, like the phase conductor. The iron core shall be designed with step-lap joints. The yoke shall be mounted with yoke chipboards. The use of bolts is not allowed. The yoke-chipboards of both sides of the yoke shall be linked with pull rods. On the stiffening frame near the ground a base shall be provided for the approach of winches and lifting jacks. Also, eyebolts with a diameter of at least 60 mm shall be provided on the top. The transformer shall be equipped with massive plain wheels, rotatable for lengthwise and crosswise driving. The ground clearance shall be at least 50 mm. The core assembly of Dry type transformers enclosure shall be electrically connected to the transformer tank for effective core earthing. Also copper flexible for earth continuity purpose shall connect different parts of transformers.

6.1.7.2 PROTECTION AND MONITORING EQUIPMENT

For the windings, a temperature monitoring by using separated PTC thermistor detectors for warnings and alarms shall be provided.

6.1.7.3 TECHNICAL DATASHEET FOR DRY TYPE 2000 kVA (11/0.433 KV) TRANSFORMER

Rated power:	2000 kVA
Voltage (primary side):	11 kV
Voltage (secondary side):	0.433 kV
Nominal frequency:	50 Hz
Thermic power loss:	5.5 kW (max.)
No Load Loss	1.3 kW (max)
Cooling:	ANAN
Tapping range:	+ 5%, +2.5 %, ± 0 %, -2.5 %, -5 %
Impedance voltage:	5 %
Vector Group:	Dyn 11
Primary connection:	Totally insulated plug-in connector

Secondary connection:	Connection safe insulating cover to touch with connecting lug.

Note: - The contractor shall ensure that equipment provided in sub-stations should be compatible to SCADA, so that they can be operated remotely *from OCC*.

6.2 11kV HT/LT COPPER CABLE: -

6.2.1 TECHNICAL SPECIFICARTION (HT CABLE): -

Three core 11 kV grade, heavy duty power cable with stranded compacted circular copper conductor with non-metallic semi-conducting screening, shielded with extruded semi-conducting compound, cross linked polyethylene insulated, shielded with extruded semi-conducting compound and copper tape, shielded cores laid up with fillers, Galvanized steel wire/strips Armoured and FRLS-ZH cable .

6.2.2 STANDARD: -

The 11 kV cables shall, in general, meet the requirements of the latest edition of the IS 7098 (Part-2) 1985. The cables and components in general shall meet the requirement Standards with latest amendments or equivalent International Standards.

IS:7098 (Part-2) (R2016) 2011:	Specification for cross linked polyethylene insulated PVC sheathed cables
IS:8130 (R2015) 2013:	Specifications for conductors for insulated Electric cables
IS:3975 (R2004) 1999:	Specification for mild steel wires, strips and tapes for armouring of cables
IS:10810 (Part 1 to 55) (R2016)1984:	Speciation for test on cables
IS:5831 (R2016) 1984:	Specification for PVC insulation and sheath of electric cables
IS:10418 (R2016) 1982	Specifications for drums of electric cables
IS:10462 (Part-1) (R2016) 1983:	Fictitious calculations method for determination of dimensions of protective covering of cables
IEC:60754-1 / IEC:60754-2 2011	Determination of the amount of Halogen acid Gas, Determination of degree of acidity of gases
IEC:60332 / IEC:60331 2004	Flammability test for electric cables
BS 7835 2007	Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV having low emission of smoke and corrosive gases when affected by fire.

6.2.3 TECHNICAL DATASHEET - FOR HT CABLE

S.NO.	PARTICULARS	3Cx120	3Cx95	3Cx50
1	Make	as per list of approved makes		
2	Voltage Grade in kV (System highest voltage)	6/10(12) or as per Standard	6/10 (12)	6/10 (12)
3	Type	XLPE Cable		
4	Reference Standards	IEC 60502-2, IEC 60228: 2004, BS 7655, IS 5831, IEC 60332,		
5	Conductor			
(i)	Material as per IEC 60228	Annealed Plain Copper		
(ii)	Nominal Cross Section Area (sq.mm)	120	95	50
(iii)	Class of Conductor	Class-2		
(iv)	Shape of Conductor	Stranded Compacted Circular		
(v)	Min. no. of strands	As per IEC 60228		
(vi)	Max. DC conductor resistance 20 °C (Ohm/Km)	As per IEC 60228		
(vii)	AC resistance at 90 °C (Ohm/Km)	As per IEC 60228		
6	Insulation			
(i)	Material as per 60502-2	XLPE	XLPE	XLPE
(ii)	Nominal thickness of insulation(mm)	3.4	3.4	3.4
7	Insulation Screening			
(i)	Material	Extruded Semiconducting compound (bonded type) followed by a layer of copper tape		
(ii)	Min. thickness of extruded layer (mm)	0.3	0.3	0 .
(iii)	Approx. thickness of copper tape	0.035	0.035	0.035
(iv)	Layer over laid-up	2 layers of Glass Mica Tape applied over conductor		
8	Core Identification	By colored strip Red, Yellow and Blue		
9	Laying Up	Cores laid up suitably		
10	Inner Sheath			
(i)	Material as per IEC 60502 - 2	Extruded LSZH Compound Type ST-8		
(ii)	Min. Thickness (mm)	As per IEC 60502-2		
11	Armouring			
(i)	Material	Single layer of galvanized steel round wire		
(ii)	Nominal Dia of armour wire (mm)	As per IEC 60502		
12	Outer Sheath			
(i)	Material as per IEC 60502 - 2	LSZH Compound Type ST-8		
(ii)	Min. Thickness (mm)	As per IEC 60502-2		
(iii)	Sheath Color	Black		
(iv)	Approx overall dia of Cable (mm)	As per IEC 60502-2		
13	Marking on cable	Make, Electric cable, Voltage Grade, Size of Cable, ---- meter, NR logo		

6.2.4 TECHNICAL SPECIFICATION (LT CABLE): -

S.NO.	PARTICULARS	4Cx300	4Cx185	4Cx120	4Cx95	4Cx70	4Cx35	4Cx25	4Cx16	4Cx10	4Cx6	4Cx4	3Cx4	3Cx2.5	3Cx1.5
1	Make	As per list of approved makes													
2	Voltage Grade (kV)	1.1													
3	Type	Fire Survival Cable													
4	Reference Standards	BS 7846, IS 8130, BS 7655, IS 5831, IEC 60332													
5	Conductor														
(i)	Material	Annealed Plain Copper Conductor as per IS 8130													
(ii)	Nominal Cross Section Area (sq.mm)	300	185	120	95	70	35	25	16	10	6	4	4	2.5	1.5
(iii)	Class of Conductor	Class-2													
(iv)	Shape of Conductor	Stranded sector shaped							Stranded compacted circular		Stranded circular				
(v)	2 layers of Glass Mica Tape applied over conductor	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(vi)	Min. no. of strands	As per IS 8130													
(vii)	Max. DC conductor resistance 20 °C (Ohm/Km)	As per IS 8130													
(viii)	AC resistance at 90 °C (Ohm/Km)	As per IS 8130													
6	Insulation														
(i)	Material	XLPE													
(ii)	Nominal thickness of insulation(mm)	1.8	1.5	1.2	1.1	1.1	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.6
7	Core Identification	Red, Yellow, Blue and Black											Red, Yellow and Blue		

8	Laying Up	Cores laid up suitably by Plain Glass Fibre tape

S.NO.	PARTICULARS	4Cx300	4Cx185	4Cx120	4Cx95	4Cx70	4Cx35	4Cx25	4Cx16	4Cx10	4Cx6	4Cx4	3Cx4	3Cx2.5	3Cx1.5
9	Inner Sheath														
(i)	Material as per BS 7846 : 2000	Extruded LSZH compound													
(ii)	Min. Thickness (mm)	as per BS 7846 : 2000													
10	Armouring														
(i)	Material as per BS 7846 : 2000	Single Layer of Galvanized steel Round Wire													
(ii)	Nominal Dia of armour wire (mm)	as per BS 7846 : 2000													
11	Outer Sheath														
(i)	Material as per BS 7655	LSZH Compound Type LTS-1													
(ii)	Min. Thickness (mm)	as per BS 7655													
(iii)	Sheath Color	Black													
(iv)	Approx overall dia of Cable (mm)	By Contractor													
12	Marking on cable	Make, Electric cable, Voltage Grade, Size of Cable, meter, NR logo													

6.2.5 CONTROL CABLES

The control & instrumentation cables shall be multicore, colour coded, annealed stranded high conductivity copper, single conductor, insulated with PVC insulation, PVC sheathed, conforming to IS 1554 (Part I & II) / IS 7098 Part 1, relevant IEC. The outer sheath is of specially formulated PVC compound which will give the following properties: -

Oxygen - Index Min. 29,
Smoke density - Min. 40% light transmittance,
Acid gas - Max. 20% by weight,
Flame propagation - Shall meet IEC 60332-1, IEEE 383.
Cables for use in the tunnel shall be low-smoke, non-halogenated type and FRLS type.

6.2.6 MODBUS CABLE

Communications cable suitable for Modbus RS-485 providing a master / slave communication between intelligent automation devices, controllers and FLTA wireless interfaces.

6.2.6.1 These shall have following minimum features:

a) Outer sheath Low smoke halogen Free
b) Insulation material polypropylene
c) 22 (7) multi‐paired AWG Tinned copper conductor
d) Individual Aluminium foil screen 100% coverage
e) Individual tape polyester each pair Overall tape polyester
f) Cores twisted into pairs, pairs laid up
g) Polyethylene insulation
h) Drain wire 24 (7) AWG Tinned copper conductor
i) Working voltage 300 V
j) Velocity of propagation 66%
k) Temperature range ‐20 deg C to +80 Deg C Nominal conductor resistance < 53 Ohm per kilometre
l) Insulation resistance > 200 M Ohm.M
m) Characteristic Impedance 50 Ohms
n) Capacitance Core to Core 98 pF/m
o) Capacitance core to screen 180 Pf/m
p) Nominal velocity of propagation 66%

6.2.6.2 Relevant standards to be complied:

a) Low smoke generation: EN 61034‐2
b) Halogen Gas Emission: EN 60754‐1&2
c) Flame retardant: EN 60332‐1‐2
d) RoHS2 compliant: Yes
e) CE complaint: LVD(2014/35/EU), CPR (305/2011)
f) CPR classification: ECA (EN50575: 2014+A1 :2016)

DATASHEET FOR MULTICORE CABLES

S.NO.	PARTICULARS	19Cx1.5	12Cx1.5	7Cx1.5	2Cx1.5
1	Make	as per approved makes			
2	Voltage Grade (kV)	1.1			
3	Type	Fire Survival Cable			
4	Reference Standards	BS 7846, IS 8130, IS 10462, BS 7655, IEC 60331, IEC 60332, BS 6387, BS EN 61034, IEC-60754			
5	Conductor				
(i)	Material	Stranded Annealed Tinned Copper Conductor as per IS 8130			
(ii)	Nominal Cross Section Area (sq.mm)	1.5	1.5	1.5	1.5
(iii)	Class of Conductor	Class-2			
(iv)	Shape of Conductor	Stranded circular			
(v)	2 layers of Glass Mica Tape applied over conductor	Yes	Yes	Yes	Yes
(vi)	Min. no. of strands	As per IS 8130			
(vii)	Max. DC conductor resistance 20 °C (Ohm/Km)	As per IS 8130			
(viii)	AC resistance at 90 °C (Ohm/Km)	As per IS 8130			
6	Insulation				

S.NO.	PARTICULARS	19Cx1.5	12Cx1.5	7Cx1.5	2Cx1.5
(i)	Material	XLPE			
(ii)	Nominal thickness of insulation(mm)	0.6	0.6	0.6	0.6
7	Core Identification	For 2 cores: Red & Black, For 3 cores: Red, Yellow, Blue. For 7 cores & above: White color cores with number printing on cores.			
8	Screening/ Shielding	The laid up Cores shall be screened with Aluminium Mylar/ Polyster tape (min. thickness 0.028 mm) with 100% coverage & min. 20% overlap. ATC Drain Wire of 0.5 Sq.mm (7/0.3 mm), shall be provided under Al- Mylar tape in continuous touch with Aluminium side of the tape.			
9	Inner Sheath				
(i)	Material as per BS 7846 : 2000	Extruded LSZH compound			
(ii)	Min. Thickness (mm)	as per BS 7846 : 2000			
10	Armouring				
(i)	Material as per BS 7846 : 2000	Single Layer of Galvanized steel Round Wire			
(ii)	Nominal Dia of armour wire (mm)	as per BS 7846 : 2000			
11	Outer Sheath				
(i)	Material as per BS 7655	LSZH Compound Type LTS-1			
(ii)	Min. Thickness (mm)	as per BS 7655			

6.2.7 CABLE CONDUITS

Cable conduits shall consist of stainless steel, material no. 1.4401 and shall be free of halogen. They shall be laid in accordance with the relevant standards. Those cables which run from the cable pit outlets along the tunnel wall to the safety equipment will run in conduits (control and power cabling).
These conduits shall be fixed with help of brackets and C-section rails on the wall. The material of these brackets, section rails and their fasting bolts shall be made of stainless steel, material no. 1.4401.

6.2.8 INSTALLATION *OF CABLES* ON WALL /INSIDE THE CONDUITS AS PER SITE REQUIREMENT

3 nos. 3 core, 11 KV copper cables shall be laid all along the route forming two 3 phase circuits and one cable as standby. Each circuit is capable to carry full design load of the tunnels as per load summary sheet.

11 KV cables in the tunnel are proposed to be laid on the wall / tray/inside the conduit as there is a space constraint in cable trench as per requirements for respective tunnels.

The 11 kV cable laying configuration on the wall / inside the conduit of the tunnel & and actual fixing arrangement (with cover) will applicable to suit site condition as per recommendations and approved by the Engineer.

6.2.9 CABLE JOINTS & TERMINATIONS

All joints and terminations shall be of the heat-shrink type, manufactured and tested to meet the requirements of IS-13573-2/3, IEC-60502-2/4 & IEEE48 standards to latest versions. Material used for construction of a joint/termination shall perfectly match with the di-electric, chemical and physical characteristics of the associated cable. The material and design concepts shall incorporate a high degree of operating compatibility between the cable end joints. The Straight through joint kit or termination kit shall be complete with all accessories, jointing material, insulating stress control and sealing material, lugs, nuts, bolts etc. as well as an instruction booklet explaining the method of using the kit. In case of heat shrinkable type kit, the joint shall include a heat shrinkable dual wall tubing which shall be insulating from inside and semi conductive from outside. Detailed sectional views of the assemblies shall be submitted along with the offer.

The cable termination kit shall be suitable for terminating the cable on indoor or outdoor installation as per requirement. The type of cable will be armoured XLPE insulated H.T/L.T. Cable. The straight through joints should be absolutely impervious to the entry of water. The manufacturer shall use the proven technologies and design to ensure a construction which will prevent entry of water or any other liquid inside the straight through joint and cable

6.2.9.1 Heat Shrinkable Straight Through Joints for MV Cables

The heat shrinkable straight through joints shall have following function abilities:

a) For encapsulation, environmental sealing set of heat shrink outer insulating tubes with hot melt adhesive coating is required to be provided.
b) To reduce stress over conductor, heat shrinkable stress control tube to be provided. The stress control tube has to be in electrical contact with the outer insulation screen of the cable. Impedance of the tube shall be constant up to an operating temperature and shall be within the range 1x108 ohm-cm to 8x108 ohm-cm and with Relative permittivity shall be minimum 15. Voids filling and stress relief over crimped connector and cut point of the insulation screen to be provided with void filling and moisture sealing high permittivity yellow mastic and lubricant.
c) For joining of main conductor cores suitable size of ferrules/mechanical connectors with range taking feature should be provided. The cross-sectional area (CSA) of the ferrule/mechanical connector shall not be less than CSA of the conductor of the cable.
d) Earth Continuity between armour to be provided by tinned copper braid of adequate cross section. This is required for proper earthing of the joint. Also, to support armour wire supporting is to be provided. The material of support ring to be steel (G.I.) for 3 core Cable
e) For cleaning of cores, removing burrs on ferrules & rough insulation sufficient quantity of cleaning solvent & aluminium oxide cloth is required to be provided.

6.2.9.2 Heat Shrinkable Termination for MV Cables

a) The cable termination (Indoor & Outdoor) shall be of Class-I type which consist of following points:
   i. Stress control layer
   ii. Resistance against UV light environmental protection
   iii. Moisture seal-for environmental sealing against ingress of moisture & aggressive gases.
b) To protect the cable breakout mono-plast tape is required to be applied.
c) For proper sealing of Lugs at end of the termination suitable size & length of Heat Shrinkable tube is to be provided.
d) Suitable size of heat stress control tubes is to be provided to reduce stress at cut back of scree. Void filling yellow mastic is to be provided at semi-conducting screen. Heat shrinkable anti tracking tubes are to be provided to cover bare XLPE insulation and to provide UV resistance & environmental sealing.
e) For cleaning of cores, removing burrs on ferrules & rough insulation, sufficient quantity of cleaning solvent & aluminium oxide cloth is required to be provided. Adhesive tapes to be provided in sufficient length for marking on cables.

6.2.10 The Scope of this work also includes: -

a) Supply, Laying, testing & commissioning of PE DWC/HDPE pipe 160/75 mm type 750N pipes as per RDSO Spec. No. RDSP/SPN/204/2011 with latest amendment & as per IS 16205 Part-24 for cables including along with all accessories like bends, couplers, etc. as required.

b) Excavation and refill of 0.50 mtr. Width, 1.20 mtr. Deep trench and Hard trench in all kinds of soil/ Hard surface for laying of HDPE/DWC pipe for underground cable crossing. Contractor will clear all metallic part & stones etc. after cable/pipe laying contractor will clear all site, refilling by available soil and ramming the same to make good in same level and same quality.

6.3 EMERGENCY POWER SUPPLY ARRANGEMENT (DG SETS of 900/910 kVA Capacity)

One no of 11 KV DG set shall be installed in each substation. DG sets must be automatically start direct coupled engine- alternator assembly mounted on rigid fabricated steel base frame with resilient anti-vibration mountings complete with but not limited to engine, alternator, exhaust piping (as per CPCB norms) with silencer to provide at least 25 dBA insertion loss, electric starting equipment including batteries and battery chargers, acoustic enclosure, auxiliary system, AVR, AMF panel with protection and metering equipment, etc. connected to the 11 KV panel through cables.

a) The DG sets shall be kept outside the tunnel at portals substations to prevent unsafe conditions inside the tunnels due to fuel handling and exhaust fumes. The DG set terminal voltage has been chosen as 11 KV since the system bus at portal substation is at 11 KV.

b) Diesel engine shall be turbo-charged, multi-cylinder, electronic fuel injection cold starting with speed variation within 2% for load between 10% and 100%, with positively pressurized lubricating oil with engine driven lube oil pump, low lube oil pressure sensors and potential free contacts for conveying the signal to SCADA system, sensor and alarm for high jacket- cooling water temperature with suitable potential free contacts for conveying the signal to SCADA system, speed control mechanism with automatic fuel oil supply cut-off system for stopping the engine. Also, the engine shall be adequately protected against operating under overload conditions either by fixed overload limit stop on the fuel pump rack control rod or an alternate reliable mechanism to prevent the DG set being subject to a load exceeding the site rating plus 10% complete with potential free contacts for conveying the signal to the SCADA system.

c) The DG set shall be silent type in each substation in the covered but naturally ventilated area with adequate exhaust piping planning (as per latest CPCB norms) and comply generally to IS:13364-Part 2:1992(R2018).

d) The 11 KV DG set shall be complete with cooling system, fuel system, lubricating system, air intake system, exhaust system as per latest CPCB norms, governing and speed control system, standby system, engine protection safety system with microprocessor based power control command generator set monitoring, metering, protection and control system to meet demands of engine driven generator sets.

e) The alternator shall be brushless, rotating field design alternator voltage 11 kV, power factor 0.8, with voltage regulation ± 0.5% for all loads between no load to full load conditions of insulation with sound proof enclosure, weather proof enclosure Prime Power Rating (PRP) conforming to ISO 8528 part - I as per environment noise level norms 75 Db (decibels) as at one meter.

f) The alternator shall be self-excited, self-regulator, self-ventilated in brushless design processed with suitable AVR and shall conform to BS:269, BS:5000, IS/IEC 60034-1 2004 and shall give rated output at NTP conditions.

g) One number free standing 990 liters Day Fuel tank shall be provided with each DG set fabricated from GI /stainless steel sheet with inlet, outlet connections, air vent tap, drain plug and level indicator (gauge) GI/copper/stainless steel. fuel piping from tank to engine

with valves, unions, reducers, flexible hose connection and floor mounting pedestals, twin fuel filters and fuel injectors. The location of the tank shall depend on standard manufactures design.

h) Foundation should be designed considering safe bearing capacity of soil. Anti-Vibration Mountings (AVMs) should be provided to reduce vibration transmission to the surrounding structure.

i) Deleted.

j) Deleted

6.3.1 TECHNICAL DATASHEET FOR 910 KVA DG SET

GENERATOR SET SPECIFICATION	
Duty	Prime
Power Rating kVA	900/910 KVA
No. of Phases	3
Output Voltage and Frequency (kV and Hz)	11 kV, 50 Hz
Power Factor	0.8 (lagging)
Current (A)	48
RPM	1500
ENGINE SPECIFICATION	
Make	As per approved make
Model	as applicable / EQU approved
Certified Power (hp)	1069
Required Power for Rated kVA (hp)	1069
Cooling	Liquid cooled (Distilled Water +DCA2)
Aspiration	Turbocharged After-cooled
No. of cylinders	12, Vee arrangement
Bore (mm) x Stroke (mm)	159 x 159
Compression ratio	16.7:1
Displacement (litre)	38
Fuel	High Speed Diesel
Fuel consumption @75% load with radiator and fan* (litre/hr)	151.22

Fuel consumption @100% load with radiator and fan* (litre/hr)	192.55
Performance class of generator set	ISO 8528-5 G2
Starting system	suitable DC battery supply
Lube oil sump capacity, High-Low level (litre)	140 - 114
Total lubrication system capacity (litre)	155
Lube oil consumption @ full load** (litre/hr)	0.28

6.3.2 TECHNICAL DATASHEET FOR ACOUSTIC ENCLOSURE FOR DIESEL GENERATORS

1	DG Set Capacities	900/910 KVA
2	Structure	MS Press bend 2 mm
3	Panels	Steel Fabricated double wall insulated panel
	Thickness of panels	100 mm thick
	Outer Sheet	2 mm thick CRCA sheet steel
	Inner Sheet	1.25 mm thick CRCA perforated sheet steel
	Frame & Strainer	2 mm thick CRCA sheet steel
4	Insulation	Mineral Wool as per IS 8183 – 1993
	Thickness	100 mm thick (50 mm x 2 slabs)
	Density	64 Kg / m3
	Anti-Droning	HDPE sheet
	Thickness	6 mm thick
5	Air Circulation System	Axial flow fans of suitable capacity required for DG set offered
6	Finishing	Powder coating of color shade approved by consultant/ owner
7	Noise level	75 DBA at a distance of 1 meter
8	Location	Outdoor
Painting of Exhaust Piping		High Temperature aluminium paint shall be used (600- 700 deg C) for painting of uncladed exhaust pipe and top of the chimney
Base Frame for canopy		Powder coated as per approved color.

6.3.3 AUTO MAINS FAILURE (AMF) PANEL/ AUTO SYNCHRONIZING PANEL: -

The AMF panel shall be capable of starting DG set automatically in the event of unhealthy conditions of main power supply including power (MAINS) failure, single phasing or voltage going below 85% of bus bar of main panel and shall switch over essential load from main power supply to DG set. The DG set will start automatically within 10 seconds of main supply failure. The synchronising logic shall be achieved through MICRO PROCESSOR based circuitry to monitor engine control, with an online MIMIC giving status. The generator set shall be capable of starting and taking up the load with-in-time stipulated in data sheet. The DG set will have protection / annunciation system conforming to latest standards like BS/ IEC or IS with soft control and torch resets shall be designed comprising complete protection/ annunciation requirement (overload, high temperature, alarms, earth fault, low battery voltage, fault indication alarm, fuel low level, metering indication etc.) The DG sets AMF panel shall be provided with interface for remote monitoring by SCADA *(from OCC*). The sequence of operation of synchronization of DG sets and Utility power, and NGR panels' operation with Transformers and DG sets neutral are as per standard.

6.3.4 TECHNICAL DATASHEET FOR NGR & NIS PANEL WITH VACCUM CONTACTOR

NEUTRAL GROUNDING RESISTOR PANEL		
1.0	SYSTEM DESIGN DATA	
1.1	Design Ambient	50˚C
1.2	Reference Standards	IEEE-C57.32:2015
1.3	Rated Voltage	11 kV
1.4	Location of NGR	Outside
1.5	Resistance per resistor element	As per requirement
1.6	Material for resistor element	
i)	For high value of current	AISI-304, ASTM-A240
ii)	For low value of current	AISI-406
1.7	No. of parallel path	Two
1.8	Max. allowable temperature rise (over ambient) of resistor element	300˚C - 350˚C
2.0	ENCLOSURE	
2.1	Material and thickness	Sheet steel of 2.0 mm
2.2	Degree protection (as per IS2147 of /IEC-60529)	
i)	Enclosure	IP-55 with canopy
ii)	Terminal Box	IP-55
3.0	SUPPORT INSULATORS	
3.1	Material	Porcelain
3.2	*Rated Voltage for 11 kV NGR*	*12 kV*
3.3	*One-minute voltage*	*power frequency*
3.4	*Creep-age Distance*	*25 mm / kV*
4.0	*PAINT / FINISH*	
4.1	*Paint*	*Powder Coated or epoxy painted as per specification. Synthetic enamel shade 632 as per IS-5*

5.0	MOUNTING STRUCTURE	
5.1	Material	Hot dip galvanized standard steel section
5.2	Thickness / deposit of galvanization	75 Microns / 610 g/m2
6.0	TERMINAL CONNECTION	
6.1	Type	Bushing
6.2	Material	Porcelain
6.3	Rated Voltage	11 kV
6.4	One minute power frequency dry withstand voltage	75kVp/28kV r.m.s.
6.5	Creepage Distance	25 mm / kV
6.6	Connection neutral between NGR & Transformer	Tinned Copper Flat

Neutral Grounding Register (NGR) and Neutral Isolating Switch (NIS) Panel shall be provided with each DG set. The NIS cubical houses the isolating switch (Manual as well as motorised) and CTs as per design. Contractor shall submit the complete design for Engineer's review.

6.3.5 AUTOMATION SYSTEM

The EPC contractor shall ensure that following operations of DG will be controlled and monitored through SCADA.

a) Stop/Manual/Auto switch along with potential free contacts for monitoring the manual operation status (wherever applicable), to be provided for that equipment whose start/stop is controlled by SCADA Automation System.

b) Potential frees 'NO' contacts for monitoring 'RUN' status of equipment wherever required.

c) The installation of current transformer & transducer along with wiring between current transformer & transducer up to the terminal block shall be provided by the Contractor. All transducers shall be supplied by SCADA contractor in future.

d) Provide all necessary relays, contactors, current & potential transformers required by SCADA system. CT's for SCADA system shall be of 15 VA rating and of metering class. Also, adequate space in the panels shall be provided for mounting of electrical transducers as required.

e) The low voltage SCADA cables shall be brought up to AMF panels by SCADA contractor and all terminations into AMF panels shall be made by Generating set contractor after satisfying himself of the wiring system. It is to be clearly understood that the final responsibility for the sufficiency, adequacy and conformity to the contract requirements, lies solely with the Generator Contractor. The following (but not limited to) shall be monitored through SCADA *from OCC:*

i. Radiator temperature at each generating set.
ii. Start / Stop each Transfer pumps.
iii. Status monitoring for oil transfer pumps
iv. Duplicate monitoring of each indication as given in annunciation window of AMF panel

v. Battery voltage status.
vi. Voltage, current, power factor, frequency and power consumption monitoring at each generating set.

Auto / Manual / Stop changeover switch shall be provided by the contractor for each mechanical equipment related to generating sets with potential free contacts. For the temperature monitoring, all nipple / sockets in the pipe shall also be in scope of contractor.

6.4 TUNNEL LIGHTING: -

6.4.1 GENERAL

This covers the complete Tunnel Lighting System for the tunnel, consisting of tunnel lighting and emergency lighting including control, all required equipment, materials, and accessories. The detail drawing of **power supply arrangement** (Indicative) is attached in section VII-II: Tender Drawings and Documents.

This includes SITC of following Panel/ DB's: -

a) Lighting SDB (Day time lighting) Threshold-1 and Threshold-2 1100x200x1200 mm, IP 54 stainless steel (AISI 316)
b) Lighting DB with 1 no. incomer (63A, FP, MCCB) from Main LT Panel, Copper Bus bar (433V, TPN, 63A) and 10 nos. outgoing feeders (6-16A, FP, MCB) including 2 nos., 3nos. or 4nos. spare feeders, IP54 stainless steel. (AISI 316)

c) Lighting DB with 1 no. incomer (63A, FP, MCCB) from Main LT Panel, Copper Bus bar (433V, TPN, 63A) and 14 nos. outgoing feeders (6-16A, FP, MCB) including 2 nos. spare feeders, IP54 stainless steel (AISI 316)

d) Lighting DB with 1 no. incomer (63A, FP, MCCB) from Main LT Panel, Copper Bus bar (433V, TPN, 63A) and 18 nos. outgoing feeders (6-16A, FP, MCB) including 2 nos. spare feeders, IP54 stainless steel. (AISI 316)

e) Lighting SDB, 700x200x1200 mm, IP 54 stainless steel (AISI 316)

f) Main UPS Panel with 1 no. incomer (80A, TPN, MCCB) from UPS, Copper Busbar (433V, TPN, 80A) and 6 nos. outgoing feeders 16A - 63A, TP MCB) including 2 nos. spare feeders, IP 55 stainless steel (AISI 316)

g) UPS SDB, 700x300x1200 mm, 12 Outgoing panel, IP 54 stainless steel (AISI 316)

h) Main UPS Panel with 1 no. incomer (160A, TPN, MCCB) from UPS, Copper Busbar (433V, TPN, 160A) and 18 nos. outgoing feeders 16A - 63A, TP, MCB) including 4 nos. spare feeders, IP 55 stainless steel (AISI 316)

i) UPS Lighting DB with 1 no. incomer (63A, FP, MCCB) from Main LT Panel, Copper Bus bar (433V, TPN, 63A) and 6 nos. outgoing feeders (6-16A, FP, MCB) including 2 nos. spare feeders, IP54 stainless steel (AISI 316)

j) Maintenance SDB with 1 no. incomer (32A, FP, MCCB) from Maintenance power socket DB, Copper Busbar (433V, FP, 50A) and 6 nos. (16A, DP, MCB) outgoing feeders including spare feeders, IP 54 stainless steel (AISI 316).

k) Maintenance DB with 1 no. incomer (63A, FP, MCCB) from Main LT Panel, Copper Busbar (433V, TPN, 63A) and 4 nos. outgoing feeders (32A, FP, MCB) including 1 no. spare feeders, IP 54 stainless steel (AISI 316)

6.4.2 VALUES AND DEFINITIONS

Regular lighting inside the tunnel for service, maintenance works and for rescue reasons shall be provided. The lighting system consists of LED lamps. The lighting is partitioned in individual sections. Each section contains normal supply and UPS power supply. All normal and UPS supplied sections shall be connected.

6.4.2.1 Level-1, Round the Clock / emergency illumination (10 lux minimum or as per latest guideline issued by RDSO/Railway Board)

20 watt LED luminaries shall be fixed at every 24 meters (or as per lux level calculation to maintain minimum lux level inside the tunnel) distance on each of the side walls of the tunnel at a height of 2.5 meter from the walkway level. These luminaries are connected with UPS power supply. After every two normally power supplied luminaire (maintenance), there is a UPS supplied luminaire. As per NFPA-130, these luminaries shall give minimum illumination of 10 lux (or as per latest guideline issued by RDSO/Railway Board) throughout the tunnel round the clock.

6.4.2.2 Level-2, Reading and Maintenance illumination (27 lux minimum or as per latest guideline issued by RDSO/Railway Board)

2 nos. 20 watt LED luminaries shall be fixed at equal distance of 8 meters between two round the clock luminaries on each of the side walls of the tunnel at a height of 2.5 meter from the walkway level. Normally these luminaries shall be off and shall be switched on only when maintenance and inspection work is carried out. These luminaries will be on separate circuit, supplied by normal power supply. These luminaries along with round the clock luminaries shall give a minimum of 27 lux illumination.

6.4.3 Day / Night Time Lighting

The day time lighting has been designed in two zones (Threshold zone: 1 & Threshold zone: 2) at lux level of 350 lux Avg. and 180 lux Avg. respectively for both entrance and exit portal of each tunnel. Day and night time luminaries are connected through two different circuits. The Night time luminaries at spacing of 24 meter (10 lux) are connected through UPS circuit which will remain on round the clock while Day time luminaries are controlled through photometer sensor / timer. These photo sensors sense the outdoor lighting intensity and weather conditions for switching ON / OFF/ control of luminaries through SCADA system.

6.4.4 Day time Lighting Design

A. Tunnel Portal Entrance

i. Threshold Zone 1 (TH 1): Zone Length – 100 Meters, Lux Level – 350 lux Avg. *(from 0-100 m at the entrance)*

ii. Threshold Zone 2 (TH 2): Zone Length – 100 Meters, Lux Level – 180 lux Avg. *(from 100-200 m at the entrance)*

B. Tunnel Portal Exit

i. Threshold Zone 1 (TH 1): Zone Length – 100 Meters, Lux Level – 180 lux Avg. *(from 200-100 m from the exit*)

ii. Threshold Zone 2 (TH 2): Zone Length – 100 Meters, Lux Level – 350 lux Avg. *(from 100-0 m at the exit*).

6.4.5 Emergency Tunnel Lighting

The emergency lighting allows illumination while the main power supply has broken down. Therefore, each third lamp of the Tunnel Lighting System shall be supplied from UPS power which is also known as round the clock lighting. Emergency lighting allows safe walking on the walkway path throughout the tunnel in case of evacuation. During abnormal conditions (e.g. fire alarm) the lights must remain switched ON.

6.4.6 Main Tunnel Cross Passages / Adits Lighting/pathway Lighting

Detailed specifications of luminaries shall be as per Northern Railways (NR) CEE Spec No: CEE/NR/121-Elect/PS/2019(REV-04) Dated-04.11.2019 or latest for LED light specification
The cross passages/ Main tunnel/pathway luminaries shall fulfil following conditions:
Degree of protection: IP 66 (as in the main tunnel tube) – IP 66
Impact Resistance: IK 10
Protection class: II
Luminaire: 1 X 20 watt LED
Installation of Luminaries: T
he LED Luminaires in the cross passages shall be fixed below the cable trays. A distance of 8 m spacing on the both sides of the wall.
The lighting in the Accesses will be switched ON, if:

i. A fire is detected, automatically
ii. The doors of the air locks will be opened, automatically
iii. By the tunnel operator, manually
iv. By the tunnel's maintenance personal, manually with switch on-site.

6.4.7 LIGHTING CONTROL

Tunnel lighting shall be controlled from the control units in SCADA control room of substation at Sonepat end. The tunnel lighting system shall be compatible to SCADA in future. Additionally, it shall be controlled by switches at the substation E&M niches as applicable.

6.4.8 POWER SUPPLIES – SPECIFICATIONS

OPERATIONAL INFORMATION
Supply voltage - 240 V a.c.
Supply frequency - 50 Hz
Output - SCADA
Maximum output current - 235mA per Line
Ambient temperature - 0-50˚ C
Relative humidity - 0-90% non- condensing

Mounting - Surface

TESTS: The LED, LED driver and luminaries shall be tested with the applicable IS/IEC reference
standards.

6.4.9 TECHNICAL SPECIFICATIONS - GENERAL 433 / 240 V – 50 Hz POWER SUPPLY

The general power supply of the 433 / 240 Volt-level to the different equipment occurs from the main power supply from substation to the Electrical Niches as applicable and then further to the ultimate equipments.

In the tunnel the distribution of the energy occurs from the both substation to electrical Niches and then further to the ultimate equipments. All power and control units shall be installed into distribution panels, all different voltages (e.g. Main power, UPS power, safety extra-low voltages, different control units and so on) shall be placed in separated or comprehensive different distribution panels. Grounding and protection cables shall be coloured yellow-green as per standards compliance. The inlet of the cables into the distribution panel generally shall be made from bottom with a degree of protection of IP 54 in Electrical Niches and Service Buildings / control room. The Niches also shall have cable inlets on top. This is necessary to lay the cables from the Niche to the cable tray along the tunnel wall. Switches, push buttons, pilot lamps and measuring instruments shall be installed into the distribution panels' front doors. All electrical equipment, inside a distribution panels / boards shall be labelled. Also, the distribution panels themselves shall be labelled with a combination of letters and numbers, which shall be engraved into an aluminium-plate. Equipment inside the tunnel, measuring instruments, etc. shall be labelled with stainless steel-boards. Each distribution panel shall be provided with a pocket for the drawings, this pocket shall be fixed on the inside of the distribution panel's door (fixed with screws or rivets, the use of glue is not allowed). All distribution panels shall be grounded. Distribution panels shall have lightning arrestors/ surge protection device to protect all facilities from voltages higher than 433 V. All distribution panels, situated in the main tunnel, as well as in the cross passage shall be equipped with anti-condensation heating. Circuit breakers and fuses shall be discriminating to each other facilities (discriminating ratio) in direction of the power / current flow. The contractor is obligated to offer a system which shall be installed without any structural alteration.

6.4.10 Central Connection Element:

All control and data cables shall be connected with the central connection element, this shall be a distribution panels equipped with terminals for jumpering the cables and relay units for order multiplexing. All data shall be available at the central connection element, this element shall be at the central data exchange location of the tunnel site (substation / control room) and the SCADA system shall be connected to this.

6.4.11 MAIN LT PANEL & DISTRIBUTION PANELS

All wiring and cabling inside the panels shall be laid in GI-ducts. All metal parts which are not under voltage shall be GI/stainless steel. All incoming and outgoing cables with a cross section equal to or less than 25 mm² shall be based on terminal boards and shall have strain relief devices. For cable centres at distribution panels with degree of protection of IP54 cable glands shall be used.

All cables with larger cross sections shall be directly connected to the particular electrical equipment inside the distribution panels. If the cross section of the cables is although too high for connecting with the electrical equipment, nevertheless terminals for reducing the cross section shall be used. Terminal strips shall be provided with a numbering-system. The strips shall be labelled. All incoming and outgoing cables also shall be labelled (number of cables, starting position and destination).

The internal wiring, cabling and bus bars in the panels and small accessories to follow the function and regulations, like coverings, top-hat rails, C-profiles, GI/stainless-ducts, screwed conduit entries, etc. shall be calculated in the position of the distribution panels. Light-current parts installed in panels shall be suitable for a mounting on top-hat rails or Profiles and respectively in 50 mm racks / as applicable.

Each distributor which will carry electrical equipment, which is provided for mounting at 50 mm frames, shall have 50 mm swing frames or 50 mm fixed frames / as applicable. The height of those frames depend on the height of electrical equipment which shall be installed on it, and the height of distributor. Depending on the thermos technical requirement, the distribution panels shall be equipped with ventilation openings with grids. The degree of protection shall be observed for standards compliance.

The contractor shall provide enough mounting rails for all devices and equipment which shall be installed inside the distribution panels. All equipment shall be accessible.
For cable entries at distribution panels with a degree of protection of IP 54 cable glands shall be used. The Electrical Panels shall be a minimum of Form 4b Type 5 separation in accordance with BS EN 61439-2/IEC 61439-2 for Main LT Panel and Form 3b separation as per IEC 60439 for Distribution panels.

Each distribution panels shall be equipped with 1 lock (incl. key). The lock shall be fixed at 3-points at each door of distribution panels (on the top, on the bottom and in the middle of the doors). The 3 fixed points shall be connected with one rod/ latest version as applicable for distribution panels of reputed manufactures of approved make. The maximum height of panel shall be 2400 mm. with maximum height of operating handle be 1800 mm. from bottom. The termination height shall be 300 mm (minimum).

6.4.12 JUNCTION BOX:

Cable junction boxes shall be used for normal and emergency equipment's (lighting, power, control circuit) conforming to IP66 with intrinsic fire resistance & insulation integrity (E90) complete with cable glands suitable for the connected cable.

Application area

- Day time lighting, night-time lighting, accentuating light, inside main tunnel.
- cross passage lighting inside the tunnel.
- Functional integrity E90 junction boxes for fire alarm system.
- Emergency communication or telecom box inside the tunnel.
- Functional integrity E90 junction boxes for operating the emergency exhaust and smoke extractor.

For Lighting, the junction box is required for reducing the cable's cross section, if they are higher than 4 sqmm, and for dividing the main supplier cable into the individual single feeders for the lamps. They shall be made for through-wiring in a 3-phase system with maximum wiring diameter of 4mm2, feeder cable to luminaries is a single feeder cable 3x2.5 sqmm. The lighting cables shall be FRLS with min. functional integrity E30.the junction box shall also be with E90 resistance integrity. The junction boxes shall be equipped with compressed synthetic cable glands suitable for the connected cables.

6.4.12.1 JUNCTION BOX SPECIFICATION FOR EMERGENCY EQUIPMENT'S

The junction boxes (JB) shall be made of sheet steel material with IK 10 impact resistance having no toxic or corrosive resistance. The junction box shall comply and test certificates for intrinsic fire resistance accordance with DIN 4102 part 12 together with function retaining cables. The junction box shall comply to IEC 60670-22 for requirement, as per connecting boxes & enclosures. The JB shall be complete with screw anchors for external wall fixing and connecting terminals made of high grade ceramic and resistant to high temperature. The sheet steel junction box shall be power coated & suitable earthed.

Supply of **IP 66** cable boxes for emergency equipment (lighting, power and control circuits). The junction's boxes shall be made of Sheet **Steel Powder Coated material** and shall be Orange in colour **RAL 2003** having no toxic or corrosive emissions. The junction box shall comply and shall be tested for **intrinsic fire resistance accordance DIN 4102 part 12 (German standard)** together with function-retaining cables of 1.5 sq. mm to 16 sq. mm as specified. The junction box shall comply to **IEC 60670-22** for particular requirements for connecting boxes and enclosures. **The insulation integrity E90 of the boxes shall be BS EN 50200**. The junction boxes shall have included screw anchors for external wall fixing and connecting terminals shall be made of high grade ceramic and shall be resistant to high temperatures E90 and cable entries shall be with metric system.

The terminals will be 5 pole and shall be suitable for 1.5 sq. mm upto 16 sq. mm cable sizes, multi-level knockouts shall be provided for cable glands in different sizes. The material of construction used shall be free of halogen and junction box shall be insulated and shock-proof. In case of sheet steel, power coated, the box shall be suitably earthed. The junction boxes shall be used only with type tested cables for the functional integrity class E90 (Tested with cables of approved make). The entire solution shall be tested in accordance with DIN

4102 part 12 for functional integrity and EN50200 for insulation integrity and the vendor shall submit the test report/certificate for the product from Exova laboratories or equivalent institute for fire safety.

6.4.12.1.1 TECHNICAL DATA SHEET FOR EMERGENCY JUNCTION BOXES

Materials	Sheet Steel
Degree of Protection	IP66
Degree of protection against mechanical load	IK 10
Fire Protection in the event of internal faults	Minimum requirements: -Intrinsic Fire resistance accordance with DIN 4102 part 12 together with function retaining cables. - 650°C for boxes & cable glands - 860°C for conducting components
Burning behavior	- Junction Box shall comply to IEC 60670-22 - Insulation integrity E90 of the boxes shall be BS EN 50200 - Intrinsic fire resistance / fire rated & insulation integrity (E90)
Toxic behavior	Halogen free, Silicon free, conform to RoHS directive 2002/95/EC

Chemical resistant	Acid, Lye, Petrol, Mineral Oil & partially resistant from Benzene
Rated Insulated Voltage	AC/DC 690V
Connecting Terminals	High grade ceramic resistant to high temperatures
Terminals	5 pole
Cable entries	Shall have option for cable plate
Protection Class	Class II, totally insulated
Type test certificate	Comply to IEC 60670-22 as per connecting boxes & enclosures
Mounting Type	Wall / floor mounting.

6.4.12.2 JUNCTION BOX SPECIFICATION FOR NORMAL EQUIPMENT :-

The Junction Box shall be insulated and made out of Polycarbonate with glass fibre reinforced. The Polycarbonate Junction Box shall be environment friendly, recyclable, UV resistant, halogen & silicon free, anti-acid & anti corrosive. The Junction Box shall be rated for Degree of Ingress Protection IP66 in accordance with IEC 60529. The gasket material shall be Polyurethane, and the gasket shall be internally embedded. The JBs shall be complying the standards IEC 60670 – 1, IEC 60670 – 22 & IS-13252. The manufacturer of Junction Box / Enclosure shall submit a copy of IEC Certificate.

For better safety the Polycarbonate encl. shall be fire retardant & self-extinguishing in accordance with IEC 60 695-2-1, DIN VDE 0304 Part 3. It should be tested at Glow Wire test for 960 deg. Cent. The impact strength of polycarbonate enclosures / boards i.e. the Degree of Protection against Mechanical load shall be in accordance with EN 62208: 2012 for IK 09. **Cable junction boxes with intrinsic fire resistance / fire rated & insulation integrity (E90).**

6.4.12.2.1 TECHNICAL DATASHEET FOR NORMAL JUNCTION BOXES

Materials	Thermoplastic Polycarbonate (PC-GFS)
Gasket	Internally embedded made of Polyurethane
Degree of Protection	IP66
Fire Protection in the event of internal faults	Minimum requirements: - Glow wire test in accordance with IEC 60 695- 2-11- UL Subject 94, IS-11000 - 650°C for boxes & cable glands - 860°C for conducting components
Burning behaviour	- Glow wire test in accordance with IEC 60 695- 2-UL Subject 94 at 960°C, flame retardant &self-extinguishing.
Degree of protection against mechanical load	IK 09 (10 Joule)
Toxic behaviour	Halogen free, Silicon free, conform to RoHS directive 2002/95/EC
Temperature resistant	-40°C to +120°C
Chemical resistant	Acid, Lye, Petrol, Mineral Oil & partially resistant from Benzene
Rated Insulated Voltage	AC/DC 690V
Cable entries	Shall have option for cable plate
Protection Class	Class II, totally insulated
Type test certificate	Should hold type test certificate with switchgear assemblies (TTA), according to IEC 60 439-1 (IS 8623)

Mounting Type	Wall / floor mounting.

6.4.13 ELECTRICAL NETWORK PANELS

These Panels carry the components for network. The Network panels, installed inside the tunnel, are made of stainless steel of 316L grade. The dimensions of Network panels are as per standard or as per site conditions requirement for those situated in the Control Centre. The Network Panels will have a single door, to have only front accessibility for the Network equipment's installed. The Network Panels also have front panels made of glass, to see the electrical equipment inside. These will comply to IS standards.

6.4.13.1 **CIRCUIT BREAKER:** Circuit breakers shall have a rated breaking capacity of at least 36 kA / 50 kA at 433 VAC and a current limiting class 3. Some shall be executed inclusive switched neutral conductor (+N).

Residual-Current-Operated Circuit-Breaker: They shall be alternating current sensitive;
surge-proved up to 36kA / 50 Ka.
Residual-Current-Operated Circuit-Breaker with Integral Overcurrent Protection: They shall be alternating current sensitive; surge-proved up to 36kA/ 50kA; 2 or 4-pole switched and at least 1 or 3-pole protected (2 pole or 4 pole).

6.4.13.2 AIR CIRCUIT BREAKER

a. ACB should be mechanically robust of compact moulded case design, air break horizontal and withdrawable type, conforming to IS / IEC / BS EN 60947-2. 24-240 V A.C shunt-trip coil shall be operable, within operational voltage range of 70% to 110% of rated voltage as per Clause 7.2.1.3 of IEC 60947-1.

b) Maximum number of circuit breaker auxiliary switches, spare auxiliary switches to be equally divided between normally open and normally closed. Additionally, 4 spare pairs of N.O. and N.C. volt free contacts shall be provided.

c) Indicating lamps for on, off, ready to close, tripped on fault with all necessary push buttons, panel wiring, bus wiring, terminals, fuses, etc.

d) Power and control cable terminals with undrilled gland plates for outgoing power cables and multi-core cables.

e) An interlock to prevent withdrawal when the breaker is closed.

f) The automatic control shall be defeated when the selector switch is put at local or OFF position as per requirement.

g) Remote indication and alarm facilities shall be provided for Circuit-breaker open, Circuit-breaker closed, Circuit Breaker is ready to close (UV release energized, Shunt release de-energized, spring charged, Breaker is not "ON", Breaker is not mechanically interlocked with other breaker and ACB is not racked in completely in service position) and Circuit-breaker tripped on fault.

h) Automatic changeover and interlocking with the help of an external controller.
i) Operation of emergency push button.

6.4.13.3 MOULDED CASE CIRCUIT BREAKERS (MCCB)

Moulded case circuit breakers shall be in accordance with IS: 2516 (Pt-I&II)/1977, IEC 60947, IEC 60664, IEC 61557-12 with degree of protection IP 20 and shall be of microprocessor based release having a quick break, quick make trips free mechanism and according to the relevant standards, which were mentioned herein. The electronic trip shall be adjustable.

The operating switch dolly shall provide a clear indication of "ON", "OFF" and "TRIPPED" positions and shall have provision for locking in the "OFF" position. They shall be equipped with time delay tripping on low overloads and high speed tripping on short circuits. Contacts shall be tipped and shall have a quick break and quick make wiping action. The case shall be moulded in non-hygroscopic material of arc resisting characteristics and shall incorporated- ionising type arc chutes.

MCCBs shall comprise a device, designed to trip the circuit-breaker in the event of high value short-circuit currents. This device shall be independent of the thermal-magnetic or electronic trip unit. The breaking will be carried out in less than 10ms for short-circuit currents above 25 In. MCCBs with ratings up to 250 A shall be equipped with fully interchangeable trip units in order to ensure the protection against overcharge and short-circuit. The trip units shall be either of:

a. thermal-magnetic
b. electronic

MCCBs with ratings over 250 A shall be equipped with electronic trip units. Electronic and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorised access to the settings

Thermo-magnetic trip units shall offer:

a. Adjustable Thermal protection from 0.7 to 1.0 times the current rating.
b. Fixed Magnetic protection for current ratings up to 200A.
c. Adjustable (from 5 to10 times the current rating) for current ratings greater than 200A.
d. Adjustable (from 9 (or less) to 14 times) the current rating for magnetic only motor protection.

Electronic trip units shall offer:

a. Electronic trip units shall be fitted with thermal memory
b. It shall be possible to adjust basic protections with a knob without any power supply or when the main is off.
c. It shall consist 2 LED for load indication, one lighted above 90% of Ir, and one lighted above 105% of Ir.
d. A test connector shall be installed for checks on electronic and tripping mechanism operation using an external device.
e. MCCBs shall be equipped with a self-test of the connection between the electronic trip unit, the current transformers and the actuator. The self-test will be of positive logic and visible through the flashing of a green LED in case the self-test occurred correctly and the extinction of the LED in case the self-test failed.

Each moulded case circuit breaker shall be equipped with auxiliary contacts to monitor its control state. An accumulated fault alarm (one per system, e.g. lighting, ventilation, etc.) shall be handed over to the SCADA system via local distributed unit and further to the PLC.

6.4.13.4 MINIATURE CIRCUIT BREAKERS (MCB)

Miniature circuit breakers shall be in accordance with a degree of protection IP 20 and shall be of magnetic and thermal trip type and according to the relevant standards of IEC 60898, IEC 60947, which were mentioned herein. For arc quenching, the breakers shall be equipped with magnetic blow out contacts.

Each miniature circuit breaker shall be equipped with an auxiliary contact to monitor its control state. An accumulated fault alarm (one per system, for example lighting, ventilation, etc.) shall be handed over to the SCADA system via local distributed unit and further to the PLC.

6.4.14 COMMUNICATION WITH CONTROL CENTRE

Following signals and control states shall be transmitted to the Control Centre by use of the Tele control system (SCADA). Therefore, all these signals and control states shall be based in / at the central connection element. Signals and control states to be transmitted are:

a. Tripping of any isolating circuit breaker, moulded circuit breaker or miniature automatic circuit breaker, combined to one signal per network for niches substation / E & M Niches / E & M NICHEs (one signal for each distribution point and one for each network) for following but not limited to:
b. Breakdown of the main power supply
c. Power supply from the UPS
d. Failure of the UPS
e. Actual active power (kW) at the niche's substation / E & M Niches/ control room
f. Transformers secondary voltage
g. Cumulative fuse tripping
h. as per data points (I / O points approved by Engineer).

Note: -The tunnel is situated in an area highly endangered by lightning and unstable power supply is expected. Therefore, all the electrical equipment installed shall have Over voltage protection, Under Voltage Protection and surge voltage protection as per standard and requirement.

6.5 PLUG SOCKETS & MAINTENANCE SOCKETS CABINET

The cabin of the plug sockets its size shall be about 200 x 178 mm (width x height) or as per drawing. The depth is about 150 mm or as per standard. The used material shall be stainless steel, material no. 1.4401, high-quality stainless-steel equivalent to SS-316L, degree of protection min IP 65. The Power Socket shall be made of High-quality Thermoplastic Polycarbonate (rust free, shock proof, corrosion free, fire retardant) with IP-67 protection, contact terminals made of high-quality copper alloy (brass) & all steel components (screws, springs, etc.) shall be zinc plated or nickel plated. The socket outlets shall be compatible to the rescue and maintenance equipment. Power sockets also shall be provided for emergency

and maintenance. These plug sockets shall consist of power sockets and standard electrical sockets. The power socket shall be supplied by standard power**.** In the Access-Tunnel, the plug socket and maintenance cabinets are different to those cabinets in the main tunnel tube. The ones in the Accesses shall not be equipped with plug sockets. These cabinets only shall provide space for spare / reserve. These plug sockets shall be provided every 50 meter on one side of tunnel wall having 3-Phase supply.

6.5.1 CABIN FOR PLUG SOCKETS, MOUNTED ON TUNNEL WALL

Housing: 260 mm x 210 mm x 168 mm (w x h x d) (max)

Material: Polycarbonate / Stainless steel Protection Class: min IP 65

The Maintenance Power Sockets should hold type test certificates as per IEC 60309, EN60529, DIN 4102-12. The Socket assembly should consist of proper Insulation bolt, Stainless steel screws / bolts and fasteners, MCB, Hinged Flap (optional), along with wiring accessories, Earth strips, Sleeves, etc. of standard specifications.

Single Phase Maintenance power socket should consist of 16 A DP 10 kA MCB with allowable cable sizing of 3Cx4 Sq.mm cable. Three Phase Maintenance Power Socket should consist of 16A FP 10 kA MCB with allowable cable sizing of 4Cx4 Sq.mm cable.

Allowable number of single phase sockets shall be 4 nos. and three phase sockets shall be 2 nos. per circuit or as per standard.

6.6 UNINTERRUPTIBLE POWER SUPPLY SYSTEM (EMERGENCY POWER SUPPLY SYSTEM): -

This covers the emergency power supply of all required equipment, materials, accessories, and all labour for the complete emergency power installation. All data required by the Control Centre shall be based at the central connection element. Contractor shall access the entire load for UPS and submit the same for Engineer's approval. If UPS of capacity more than 20 kVA is required than same shall be provided by the contractor and 20 kVA id the minimum capacity of UPS.

6.6.1 UNINTERRUPTIBLE POWER SUPPLY

The UPS units (Uninterruptible power supply) will be installed with two hours (120 minutes) autonomy period as required to guarantee that following plants/ equipments can be supplied power in case of main power failure:

a. Tunnel emergency lighting
b. Emergency call system
c. Signs, escape route lighting and orientation signage, other sign guidance
d. Public address & sound system (if Available)
e. Integrated tunnel control system (SCADA)
f. Other emergency requirement
g. Fire detection and fire alarm system

The UPS system will be complete with inverter battery bank, rectifier charging unit, inverter units, protective devices, filter circuits, system static transfer switches/bypass switches, auxiliary equipments etc. All the characteristics of UPS (like THD, overload, etc.) shall be as per IEC/EN 62040.

The UPS has to be fed from the main power supply (433 V, 50 Hz) and shall supply the connected equipment via rectifier, battery and inverter.

In the event of a main power supply failure the equipment has to be fed from the battery and inverter system without any interruption.

The UPS shall be equipped inclusive bypass switch and an interface for Tele control System/ SCADA.

6.6.2 TECHNICAL SPECIFICATION (UPS COMPONENTS) BATTERY BANK

6.6.2.1 BATTERIES:

Sealed Maintenance-free (SMF) Lead-Acid Power Battery Voltage as required by the UPS-system. The battery capacity at all locations shall ensure supplying the full load for at least 120 minutes with elevated temperatures up to 40 Deg C. Batteries shall be of rugged design in order to provide a heavy-duty operation of at least 5 years with low internal resistance and minimal maintenance with minimal ventilation. Operational temperature range: + -5° to + 40° C with humidity up to 95% non-condensing

6.6.2.2 INTERCONNECTION BUS BARS:

The bus bars shall be made of copper according to the relevant standards, which were mentioned herein. Suitable size to provide a minimum voltage drop PVC clad to provide protection against accidental contact.

6.6.2.3 BATTERY STANDS / RACKS:

The batteries at the substation & control room shall be mounted on GI/stainless steel racks to provide a compact arrangement, with easy installation and access for servicing.
The racks shall be made of steel with electro statically deposited powder coating.
The coating shall be resistant against acid, saline and highly resistant against scratching and / or impact. All other required materials shall be highly resistant against environmental conditions as experienced in battery rooms .an electric ventilation and climate shall ventilate the battery room in niches substation/ control room as applicable. The complete air shall be changed a minimum of six times per hour. The acid proof tiles shall be provided on the floor and on all the walls upto height of 1.5 meter.

The ventilation has to be realized with all required facilities like ducts, louvers, installation of the fan with a switch beside the door. All wall ducts shall be closed and covered after the

ventilation is installed. The ventilation to comply with international / IS standards as per site requirements.

6.6.2.4 RECTIFIER / CHARGER UNIT

This unit has to be equipped with output current limiting, whereby the maximum output current shall be limited to 125 % of the nominal output current rating. The UPS unit shall have ammeter and voltmeters to indicate both charging and mains current / voltage and amps meter to indicate rate of charge and discharge of batteries. This current limit shall be adjustable from 100 % up to 125 %.

The output filter shall minimize the ripple of the current in the batteries. Under normal conditions the ripple of the current in the battery shall comply to 3 % RMS.

The filter shall be adequate to ensure that the DC output of each rectifier / charger shall meet the input requirements of the inverter.

The UPS shall have the capability of operating the inverter directly from the rectifier with the batteries being disconnected.

Quick charging equipment shall be capable of charging fully discharged batteries within six hours.

Input: 0.433 VAC, 3-phase, 4 wire, 50 Hz

INVERTER UNIT

Input: Output from the rectifier / charger unit (batteries).

Output: 433/ 240 V sinusoidal AC.

Maximum of total harmonic distortion: +/- 1 % at power factor 1 from No-load operation to full load. 50 Hz +/- 1 % at power factor 1 from no-load to full load.

Maximum dynamic Voltage deviation: +/- 5 % during power failure and +/- 10 % during major load change Recovery to a maximum deviation of +/- 3 % within 50 ms and to+/- 1 % within 100 ms.

Total harmonic Distortion: 2.5 % maximum

The rectifier shall be able to operate 10 minutes at 125 % overload at unity power factor after the working temperature has been stabilized at the nominal workload. Under normal conditions, the surrounding temperature will not exceed + 25 °C. A self-protecting current limiting circuit shall limit the inverter output to 125 % of the rated load or respectively in case of a short circuit. UPS system should consist of integrated Surge protection circuit.

Constant synchronisation of the oscillator shall define the converter frequency and its stability during stand-alone operation. During normal operation, the inverter shall be synchronised by

the main supply. In case of mains failure or frequency-deviation larger than +2 % / -1 %, the inverter shall automatically switch-over to its interior oscillator.

Upon return of main supply, resynchronisation shall be started automatically. Resynchronisation at full load and / or full voltage shall be achieved within 30 seconds.

The deviation from 50 Hz shall never exceed +/- 1 Hz. The power semiconductors of the inverter shall be fused with fast blowing fuses to prevent cascading failures.

Each fuse shall be controlled by fuse monitoring circuit leading to an indicator light on the UPS's control panel as well as to a common fault indication.

6.6.2.5 PROTECTIVE DEVICES AND FILTER CIRCUITS

A DC (direct current) smoothing equipment shall enable the system to achieve a total harmonic distortion, which isn't larger than 2.5 % RMS of the output. Protective devices shall avoid any damage or failure on the UPS caused by excessive overload, short circuits, surges, high voltages caused by lightning activity and/or other conditions.

6.6.2.6 DC CIRCUIT BREAKER

The UPS shall contain a DC circuit breaker. If open, the battery shall be completely disconnected from the rectifier / charger and the inverter.

6.6.2.7 SYSTEM BYPASS SWITCH

The UPS system shall be by-passed automatically in case of overload.
The static switch detection and transfer time shall not exceed 5 ms.

6.6.2.8 STATIC TRANSFER SWITCH

The static transfer switch shall be equipped with a manual selector switch to allow manually controlled switching between the UPS and the bypass source for maintenance and service purposes. The static transfer switch shall be rated higher (power, respectively current) than the inverter current limiting rate and shall have a short circuit current and time rating equivalent to the fault level of the bypass source at the static transfer switch. Control interlocks shall be provided in order to prevent the inverter from being manually switched back to the essential bus (main power) without synchronisation.

6.6.2.9 ISOLATING TRANSFORMER

In-built Isolation transformers should be provided for galvanic isolation and are used to protect against electric shock, to suppress electrical noise in sensitive devices, or to transfer power between two circuits which must not be connected.

6.6.2.10AUXILIARY EQUIPMENT

a. Emergency flash light with battery charger installed in the battery room.
b. All facilities required for handling of acids and gasses.

c. Warning notices concerning the handling of the whole UPS system in English and Hindi language.
d. Working instructions for UPS Warning notices and working instructions shall be in two separate and properly indicated pockets on the inside of the UPS switchboard as well inside the battery room. Cable dimensioning shall be in accordance to the relevant standards and shall have a diameter that the voltage drop is not more than 4 % to the nominal voltage from the transformer to the furthest supplied electrical facility. Also, the cables shall have such a diameter that, if there is a short circuit at the furthest point to the circuit breaker, the circuit breaker cuts off without the cable exceeding its rated temperature.

6.6.2.11 MAINTENANCE

The emergency power supply shall be designed for continuous reliable operation such that the "Mean-Time-Between-Failures" (MTBF) for individual modules of the UPS through the rectifier / charger unit, inverter unit and static switch etc., shall be more than 80 000 hours. To ensure a minimum down-time, the "Mean-Time-To-Repair "(MTTR) of the emergency power supply shall not exceed 24 hours for the UPS.
The MTTR shall be the time, excluding travel time, required to diagnose the fault and restore the emergency power supply to normal working condition by means of modular replacement at the tunnel site. The travel time must not exceed 12 hours to keep down time to bare minimum.

6.6.2.12 TECHNICAL DATASHEET FOR UPS (20 kVA)

	SPECIFICATIONS	REQUIREMENT
1	**TECHNOLOGY & CAPABILITY**	
	UPS should have its own DSP controller and contains a full rated rectifier, full rated inverter and battery charging circuit	
	UPS should be with inbuilt Isolators for Input, Output, static & maintenance bypass.	
	There should be isolating transformer at UPS output.	
	Integrated Surge Arrestor must be included in UPS system.	
2	**INPUT**	
	Input facility -Phases / Wires	3-Phase / 4-Wire & Ground (R, Y, B -Phases & Neutral + Ground)
	Input Voltage	433 V AC
	Nominal Input Frequency	50 Hz
	Input Frequency	50 Hz ±3%
	Input Power Factor	0.9 on rated load
	Generator Compatibility	Compatibility to genset supply required
3	**OUTPUT**	
	Nominal Output Voltage	380 / 400 / 433V AC (Selectable)

	Output Voltage Regulation	+/- 1%
	Nominal Output Frequency	50 Hz
	Output Frequency Regulation	+/- 0.05 Hz (Free Running / Self Clocked Mode) + / - 5 % (Synchronized to Mains Mode, Selectable)
	Output Frequency Slew Rate	1 Hz / s
	Output Wave Form	Pure sine wave
	Output Voltage Distortion	<=2.5% (For 100% Linear) <= 5 % (For 100% Non-Linear)
	Crest Factor	3: 1 On Full Load
	Unbalanced load on phases	100% unbalanced load should be allowed
	Voltage symmetry with 100% Unbalanced Load	+/- 2 %
	Displacement angle for 100% balanced Load	120 deg +/- 2 deg
	Transient Response / Recovery	
	Dynamic Regulation for 0% to 90% step load	+/- 5 %
4	EFFICIENCY (at nominal voltage & Resistive load upto KW rating of UPS	
	Overall Efficiency (AC to AC) – Online	>85 % @ 100 % load
5	Alarms	
	Audible Alarms	Mains Failure / Battery Low Alarm / UPS Overload / Fault / Shutdown / Charger Fails Alarm / Battery High / Battery Temperature Cut off Alarm
6	Battery Backup / Battery Bank & Charger	
	Backup Required	2 hours (120 minutes)
	Battery Bank V Ah (Vendor to include battery sizing calculations with tender)	
	Batteries Type	Inbuilt Sealed Maintenance Free (SMF) Lead-Acid batteries- 12V Cells
	Minimum Charger Rating (Including internal / external)	10% of Battery Ah rating offered

hanger type / Charging Method & Charging Voltages	Constant Voltage Constant Current Solid state SMPS charger designed for at least 10% of Battery Ah offered Float Voltage: 2.25 VPC Boost Voltage: 2.32 VPC
Battery recharge time (After complete discharge) to 90% capacity	8 to 10 hours to 90% capacity
Quick Charge System	6 Hours after complete discharge of system (optional)
Battery Housing (Vendor to provide the GA drawings of the offered Battery open Rack)	
Battery End Cell Voltage	1.7 V / Cell
Interfaces	
Serial Communication Port	RS232: Should be provided as standard
REPO (Remote Emergency Power Off)	Provided in-built in the UPS
Interface to SCADA System	Modbus Card for connecting to UPS to SCADA through RS485 & monitoring thru SCADA
Restart / Testing Capability	
Automatic Restart	UPS should start up automatically on mains resumption after battery low shutdown
Battery Self-Test	Manual / Scheduled battery test to ensure healthiness of batteries. However, in event of weak batteries, test should be aborted and fault reported to the user thru replace battery warning
Physical	
Operating Temperature	0 to 40 deg C
Storage Temperature	-25 to 55 deg C
Operating Humidity	0 to 95% RH (Non-condensing)
Ambient Relative Humidity	20% to 80%
Operating Altitude	< 1000 m above sea level
Protection Class	IP – 20

Type of Cooling	Forced Air
Noise Level	< 65 dbA at I meter distance
Form Factor	Free Standing Floor Mounted UPS
Dimension (w x d x h) in mm	To be furnished by the vendor
Weight - in kg	To be furnished by the vendor
Packaging Material	Recyclable (No CFC)
Connections - Rectifier Input / Output / Bypass Input / Battery	Hardwired
Conformity and Standards	
General and safety requirements for UPS used in operator access areas	EN50091-1-1/IEC62040-1-1/AS 62040-1- 1/IS-16242 (Part-1):2014
Electromagnetic compatibility (EMC) requirements for UPS	EN50091-2/IEC62040-2/AS 62040-2 (C3) /IS-16242 (Part-1):2014
Method of specifying the performance and test requirements of UPS	EN50091-3/IEC62040-3/AS 62040-3 (VFI SS 111) /IS-16242 (Part-1):2014

6.6.2.13 Deleted

6.7 Escape Route Orientation sign and Fire Extinguisher glow signage

These signs indicate the escapees the direction of escape route into the cross passage or out of the tunnel. Those signs shall be mounted at both sides of the main tunnel. The signs shall fulfil following conditions: -
Degree of protection: min. IP 65
Protection class: II
Static symbol: LED≥ 200 cd/m2
Dynamic symbol: LED with minimum 5 arrows for each direction

The escape route indication is giving escape route orientation with signs which are installed throughout the entire tunnel and shall increase the level of visibility of the escape route during fire.

Therefore, the escape route orientation signs shall be mounted in a distance of 50 meters or as per standard on both tunnel walls (next to the railway track and walkway path) throughout the tunnel at a height (lower edge) of 1 m above the path respectively the rail track.

The escape route indication shall consist of two parts; the upper part is a static sign which is illuminated by LED-lamps and shows an escaping person. The lower part of the sign shows flashing LED-arrows which shall display the direction (north or south) of the escape route by flashing.

Dimensions of the static symbol (h x w), approx.: 400 x 400 x 80 mm (h x w x d)
Dimensions of the LED symbol (h x w), approx.: 150 x 400 x 80 mm (h x w x d)
The dimensions are approx. values only; they can vary depending on the manufacturer.
The luminance of the static part of the symbol shall be ≥ 200cd/m2.

The controlling of the escape route orientation signs shall be realized by a main control unit. This control unit shall be placed in the control room.

In emergency case the distributed I/O Unit in the control Room shall transmit the data to the Escape Route Orientation Sign Control Unit (EROSCU), which shall switch on the signs with the correct direction. Every escape route orientation sign shall be adjusted separately with determined patterns. For example, when the pattern "one" will be activated, all signs will be switched on and the LED symbols shall display the direction "right". The pattern "two" indicates the direction "left". The escape route orientation signs also shall have the function of indicating both directions simultaneous. The contractor shall design the program of the sign in accordance with Engineer. (when/ which directions are shown).
The data connection from the EROSCU to the signs shall be realized by OFC (optical fibre cabling).

6.7.1 ESCAPE ROUTE SIGNS

The illuminated signs (escape route orientation-, emergency- and escape route sign) shall be illuminated with LEDs.

a) Degree of protection: IP 65
b) Luminance: ≥200 cd/m2
c) Housing material: Stainless steel (material No. 1.4401 = "AISI 316"), thickness 2 mm, with powder coating. The swing-out bezel shall be fixed with hinges made of stainless steel
d) Support: Stainless steel (material No. 1.4401)

6.7.2 EMERGENCY SIGN

This sign indicates the people the situation of an emergency telephone. Those signs shall be mounted above all panels.
The signs shall fulfil following conditions:

a) Degree of protection: min. IP65
b) Protection class: II
c) Static symbol: LED ≥ 200 cd/m2
d) Dimensions: approx. 470 mm x 470 mm
e) Front sheeting: on both side(s) 3 mm Acryl glass with emergency telephone
f) Symbol, dimensions and colours according to Indian standards.

6.7.3 Visibility Sensors

Visibility is monitored in Infrared units with necessary reflector which monitor the density of smoke between the IRU and the reflector. It indicates the % level/status of visibility to present values on SCADA station. Alarm will sound in the control room along with indication when visibility falls below the present prescribed limit.

6.7.3.1 Technical Data of Visibility Sensors

a) Features Parameters

i. Measuring units' ppm for CO & NO, m-1 or m for visibility
ii. Path Length - 3m (6m folded beam)
iii. Calibration - Automatic zero calibration - manual span check by check cell
iv. Measurement - Visibility (Opacity)
v. Measurement Technique – Optical Transmissivity
vi. Measurement range - 0.015 m-1
vii. Accuracy - ± 0.0002 m-1
viii. Resolution -- ± 0.0001 m-1
ix. Response Time - 10 sec to 2 min.
x. Analogue outputs - 3 x 4-20mA current outputs as standard, isolated, 500Ω maximum load.
xi. Relay Outputs - 3 x volt-free SPCO contacts, 50V/1A maximum load, configurable as alarm contacts
xii. Communications Port - RS485 interface
xiii. Power supply - to be derived from available UPS supply
xiv. Construction - Corrosion resistant epoxy coated aluminium housing sealed to IP65

b) Calibration Accessories:

Flow Through Check Cell - CO/NO span check using bottled audit gases
Check Cell - Visibility span check optical cell

c) **Temperature Sensors:** -Tunnel temperature monitoring equipment are used for monitoring the tunnel ambient temperature with sensors placed at suitable locations inside the tunnel. When the tunnel ambient temperature rises beyond a pre-set limit (>40ºC), an audio-visual alarm shall be activated in the control room as per site requirement.

6.8 SITC OF STAINLESS STEEL CABLE TRAY (LADDER AND PERFORATED TYPE) : -

The cable tray in the tunnels will mainly be used to carry the power cabling of the tunnel's safety equipment. If necessary, also the control cabling of safety equipment shall be laid in the cable tray. Following size of cable tray will be in the scope of work but not limited to: -

6.8.1 SITC of Stainless Steel Cable Tray for HT and LT cables, Ladder type of size 150 x 50 x 2 mm thick, wall mounted on suitable supporting arrangement, throughout the tunnel and both side of wall tunnel made of material no. 1.4404, continuously connected including reducers, tees, coupling plate and nut bolts, washers, etc. made of stainless steel material no. 1.4401 conforming to specifications complete as per requirement.

6.8.2 SITC of Stainless Steel Cable Tray for Lighting cables, Perforated type of size 150 x 50 x 2 mm thick, wall mounted on both sides on suitable supporting arrangement, throughout the tunnel, made of material no. 1.4404, continuously connected including reducers, tees, coupling plate and nut bolts, washers, etc. made of stainless steel material no. 1.4401 conforming to specifications complete as required, as per the specification.

The cable tray shall be mounted on the tunnel wall, next to the walkway path side. In front of the EM-Niches, the cable tray shall be mounted on the ceiling (height of down-hanging between 150-200 mm). The height of lower edge shall be as per standard. For fixing the cable tray on the tunnel wall, substructures shall be needed. The substructure shall have a L-profile and shall be made of one piece.

The cable trays shall consist of U-section sheets made of stainless steel, material no. 1.4401, with a width as per Engineer approval. The fixing arrangement (including support arm/ angle) shall be "hot dip galvanized heavy duty steel".

Note: -

1. **The Contractor should refer cable tray size for reference only. Detailed size and fixing arrangement shall be furnished by EPC contractor after award of work for approval by Engineer.**
2. **The contractor will have to ensure that the HT and LT cable is placed on separate trays.**

Depending on the used cable tray, expansion joints shall be required. These expansions joints shall be included in the price of cable tray. The fastening bolts for mounting the substructure on the tunnel wall also shall be made of stainless steel, material no. 1.4401.

Each Cable tray section should be properly connected to the adjacent trays to maintain the earth continuity of the cable tray. The cable tray's substructure normally shall be mounted in a span of about 1.0 m / as per drawing. Due to the fact that in the areas of Electrical Niches and of the Access-Tunnel, the cross section of tunnel is different to the other sections, so there the cable tray cannot be mounted in a height of 3.5 m lower edge. The cables shall be laid along the tunnel wall up to upper edges of Electrical- Niches. For leading the cables along the tunnel wall there, cable ladders shall be used.

The substructures of the cable trays above the Electrical-Niches and cross passage have to be different to the remaining tunnel. That means, the substructures shall not be mounted at the tunnel walls, but hanging down from ceiling, above the walkway path side.

The material also shall be stainless steel. The length of the suspension is determined as per standard.

The EPC contractor has to guarantee, that the cable tray shall be laid in one level.

6.9 ELECTRIFICATION OF SUB-STATION AND OTHER SERVICE BUILDING/ROOMS WITH ALLIED FACILITIES

a) Wiring for light/ceiling fan/exhaust fan/call bell etc. points including circuit wiring, sub-main wiring with Fire Retardant (FR), XLPE insulated, multistranded, copper conductor (3x1.5sqmm,3x2.5sqmm,3x4sqmm and 3x6 sqmm single core cable) on surface/in recessed PVC conduits, distribution boards, sub distribution boards, earthing and suitable number of modular switch & socket and single phase/ Three phase DB complete in all respect as per requirement specification and standard Railway practices. Cables/Wiring shall be laid down in metallic/rigid fir resistant PVC conduits. PVC conduits shall be used in concealed wiring only.

b) SITC of LED tube light fittings, LED flood light fittings, ceiling fan, Exhaust fan with lower shutter and other Electrical equipment as per requirement and standard Railway practices.

c) SITC of 150 Ltrs water cooler – 01 Nos and 1.5 Ton heavy duty, 5-star inverter type split air conditioner with required suitable size nuts, bolts, fasteners, cu pipe & petty hard ware in all respect. Top up the required refrigerant & maintain the pressure (If required) as per company recommendation or latest Eco-friendly refrigerant for Control room or any other service building as per decision of Engineer.

6.10 NEW CONNECTION OF ELECTRIC POWER SUPPLY (3 PHASE, 11 KV) FOR BOTH SUBSTATIONS OF HORC TUNNEL AND ALL ASSOCIATED WORKS:

Reliable Electrical Power Supply (3 phase, 11 kV) for both sub-stations (Separate feeder circuit for each substation) of tunnel and associated works including all liaison work from State DISCOM. The Contractor shall assess the load requirement and connected load of each substation after load calculation for each tunnel and obtain approval of the Engineer for getting new connection.

The cost Include (for each substation) copper cable laying/Overhead Line with H-pole from DISCOM substation to HRIDC HT panel, Metering arrangement, protection,

earthing connection of DISCOM end and connection at HRIDC substation including payment for application fees, charges etc. for 2000 kVA load for each substation. Necessary clearance from statutory authorities.

6.11 DESIGN, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING OF EARTHING SYSTEM BY USING OF: -

a) The earthing shall be done with 3 meters long 50 mm dia. 'B' class G.I. Pipe earth electrode with l2 mm dia. holes around the pipe at distance of 30 cm, downside tapered. Earth electrode to be put vertically 3-meter-deep with alternate layer of salt & charcoal approx. 50 kg charcoal and l0 kg salt. 8 SWG hot dip G.I. or 7/4 mm dia. galvanized steel stranded earth wire shall be connected from earth electrode top with l2 mm dia. G.l. nut bolt to main board / equipment with masonry / RCC earth enclosure of size 300x300x300 mm (ln side to inside) with I25 mm wall thickness & suitable size MS/RCC pull out cover. The G.l. wire shall run in l2 mm 'B'class G. I. Pipe along with wall / pole up to height of 1.5 meter. The depth of 8 SWG hot dip G. I. or 7/4 mm dia galvanized steel stranded earth wire including connections from earth pipe to main board / equipment /H pole etc in ground shall be 30 cms.

b) Supply, Erection and commissioning of maintenance free earthing (chemical to enhance earth bonding improving compound) using 80 mm Dia. Copper earth electrode of tube/ rod of 3 Mtr. Length including inspection chamber, CI funnel with 20 gauge G.I wire mesh, RCC chamber 300X300 mm with concrete base, Cast Iron / heavy plate manhole cover with frame.

c) Supply, Installation, testing & Commissioning of Copper Bonded Steel Earth Rod of 3-meter length, 17.2 mm dia with Exothermically welded busbar along with 50 kg Earth Enhancement Compound in each pit. With pit covers made up of Poly plastic with SITC of 10 mm Copper Clad Steel Round Conductor laid at 600mm below the ground, as per specification and code of practice.

d) SITC of Earthing Grid of 11/0.433kV portal substation: -

An earthing grid with a combination of 17.2mm dia. horizontal copper bonded steel earth conductor and 17.2 mm dia. 3 meter length vertical copper bonded steel rod conductors along with 50 kg Earth Enhancement Compound and exothermic welding joints shall be laid in a grid foundation layout of 15x6 meter at a depth of 0.5 meter below the ground for 25kA of fault current at each substation. Both substation of 11/0.433kV shall be interconnected with each other using 150 sq. mm Copper Clad Steel Stranded Conductor. This conductor shall be laid throughout the tunnel. The calculations shall be done as per IEEE 80:2013. The earth resistance for the portal/external **station grid shall be less than 1 ohm**. The interconnection of 11/0.433 kV grid shall be done using 150 sq. mm copper bonded steel conductor along with ISG.

Note: - Earth resistance value of each type of earth should be with in limit and as per standard issued by RDSO/Railway Board.

6.11.1 EARTHING DESIGN FOR ELECTRICAL SUBSTATION AT CENTER OF TUNNEL

Two isolated maintenance free earth pits with 17.2mm dia, copper bonded steel rod of 3-meter length along with 50 kg Earth Enhancement Compound shall be installed for Transformer Neutral in order to avoid floating Neutral. For Transformer Body two separate earthing pits shall be installed with same specification and both these pits shall be interconnected with the main earthing conductor (150 sq.mm) coming from the portal stations.

For PLC Panels, an Isolation Spark Gap shall be connected before connecting it through the main earthing busbar.

6.12 SUPPLY & INSTALLATION OF EARTHING AND POTENTIAL EQUALIZATION SYSTEM FOR INSIDE TUNNEL WITH CROSSINGS

6.12.1 Earthing Design for Main Conductor and Equipment Installed In The Tunnel: -

A stainless steel conductor main potential equaliser of 150 sq. mm shall be laid through the overall length of the tunnel on both the sides. At every crossing, the conductor on the opposite sides shall be interconnected with each other for equi-potential bonding. Also, an equi-potential bus-bar shall be installed at every crossing, which will again connect through these conductors. All the electrical equipment shall be connected to these bus-bars for the earthing and equipotential bonding.

For the tunnel body earth, the EPC contractor needs to leave a point at every crossing for connecting the reinforcement of the tunnel with the earthing conductor for proper equipotential bonding and for cathodic protection. The tunnel body reinforcement earthing shall be provided at every 200 m at both the tunnels. Contractor shall ensure from calculation that the reinforcement earthing at every 200 m is safe and if spacing of less than 200 m is required than less spacing shall be provided.

All equipment, which is placed outside of the tunnel also shall be included to the potential equalization.

All metal constructions, although they are not current-carrying, for example cable trays, E & M niches, distributors, doors and others shall be included to the potential equalization.

The fire main also shall be connected with the earthing system at every 100 m or as per standard. The insulation of these potential equalization connections in the tunnels in the niches shall be free of halogen or as per design requirement. The connections of earthing and bonding shall be stud- or clamp-type. These requirements shall apply irrespective of the operating voltage and purpose of the equipment. All necessary suppression chokes /

filters shall be included and shall be capable of withstanding fault conditions. All cable shields shall be bonded together and connected to the ground rod. Particular attention shall be paid on the correct bonding and grounding of single core cable shields.
The design of the system shall include protection against lightning, all effects of stray current and else due to faults in adjacent circuits, which may cause damage or incorrect performance of the equipment.

6.12.2 Potential Equalization Bus Bar/ Main Earthing Terminal (MET):

In Niches potential equalization bus bars shall be erected. The materials of the bus bars are:
Main Tunnel Tube (E & M NICHE, etc.): Tinned Copper
Cross passages: Tinned Copper
Buildings (Control Centre): Tinned Copper
The bus bars shall be insulated (this shall be calculated into the price of the PE bus bars).

6.12.3 Electrochemical Reaction:

A connection of two different metals, affects by electrolytes (e.g. tunnel wash water), causes a chemical reaction. To avoid these reactions, precautions have to take place. If required, the connections to the potential equalization bus bars shall be made with a two-metal conductor, for avoiding electrochemical reaction. Before the contractor connects the potential equalization to the earthing, he shall measure the resistance of the earthing. Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.

6.12.4 Tinned Copper MET:

Copper earth terminal 500mm long and 50mm wide and 6mm thickness with 8 no. of factory drilled holes mounted inside the enclosure boxes, for terminating incoming / outgoing earth conductors mounted with nylon insulated supports with brass threaded inserts, entire assembly supported on galvanized steel channel suitable for mounting on tunnel wall / Electrical niche wall. Suitable disconnecting link(s) shall be provided to facilitate earthing measurement. A transparent enclosure shall be given for more protection.

6.12.5 LIGHTNING PROTECTION SYSTEM

SCOPE:

The scope of work under this section covers the Engineering / Design, supply, installation, connection, testing and commissioning of lightning protection system. The lightning protection system shall be designed and installed as per IS / IEC 62305 and additional requirements (if any) of this specification. General arrangement of the protection system shall be as indicated in the drawings and consisting of the

following:

- Air termination network.
- Down conductors.
- Joint and Bonds.
- Conductor Holders
- Expansion Piece
- Testing Links.
- Earth termination network.

CODES AND STANDARDS:

The Component and accessories covered by this specification shall be designed, manufactured and tested in compliance with the latest relevant standards published by the Indian Standards institution wherever available in order that specific aspects under Indian conditions are taken care of.

The Component and accessories for which Indian Standards are not available shall be designed, manufactured and tested in accordance with the latest and relevant IEC.

The component and installation shall also conform to the latest Indian Electricity Rules and requirement of Indian Electricity Act. Nothing in this specification shall be constructed to relieve the Contractor of his responsibilities.

Generally, the Lightning protection system shall conform to IS/IEC: 62305 unless otherwise stated. Following standards shall also be applicable: -

- IS/IEC 62305-1 : Protection against lightning – General Principles.
- IS/IEC 62305-2 : Protection against lightning – Risk Management.
- IS/IEC 62305-3 : Protection against lightning – Physical Damage to the structure and life hazard
- IS/IEC 62305-4 : Protection against lightning– Electrical and system within structure
- IEC: 62561-1 – Lightning Protection components Requirements for connection components.
- IEC: 62561-2 – Requirementsfor Lightning Protection components conductors and earth electrodes.
- IEC: 62561-3 – Requirementsfor Lightning Protection components isolating spark-gaps.
- IEC: 62561-4 – Requirementsfor Lightning Protection components conductor fasteners.
- IEC: 62561-5 Lightning Protection components

– Requirementsfor and earth electrode	Earth electrode inspection housing seals.
• IEC: 62561-6 – Requirementsfor	Lightning Protection components Lightning strike counters.
• IEC: 62561-7 – Requirementsfor	Lightning Protection components Earth enhancement compounds.
• NBC – 2016	National Building Code 2016

EXTERNAL LIGHTNING PROTECTION SYSTEM:

i. As air terminals shall be installed on the highest roof of the building, the air terminals shall be joined to horizontal roof conductor by means of proper clamps & connectors.
ii. Roof conductor shall be laid horizontally on the roof.
iii. Down conductor shall be installed on the vertical surface of the building. The down conductor shall be joined with roof conductors in the method as prescribed by the code.
iv. The down conductor shall be joined with earth termination network or to the earthing station as indicated on the drawing.
v. At every 1 mtr, the roof conductor holder for mesh and wall conductor holder for down conductor should be used.
vi. At every 20 mtr, an expansion piece should be connected in order to avoid unnecessary contraction and expansion of conductor due to change in weather conditions.
vii. At the connection of the earth-termination, a test joint should be fitted on each down conductor.
viii. A test joint shall be provided in the down conductor 1000 mm above the ground level at a place which is easily accessible for testing.

COMPONENT / PARTS:

Vertical Air Terminal at Portal Stations

The probability of structure penetration by a lightning current is considerably decreased bythe presence of a properly designed air-termination system as per IS/IEC 62305 and NBC 2016.

Air termination systems can be composed of any combination of the following elements-

a) Rods (including free-standing masts)
b) Catenary Wires
c) Meshed Conductors

The individual air-terminations rods should be connected together at roof level to ensure current division.

Vertical air terminals shall be provided for the Air Termination network, at the highest points, corners, and edges and at connection to down conductor, as per approved drawing. The Contractor shall co-ordinate the installation detail to allow for bonding of the network with the external façade elements, to comply with the requirement of IEC 62305-

3. All fixing accessories, installation materials etc. as required, shall be included

in the Contract. Roof mounted electrical/electronic equipment (for example, chillers, antennas, cameras etc.) need vertical air-termination to avoid direct flashover.

All metallic projections, ducts, vent pipe, railings, gutters etc., on or above the main surface of the roof of the structure shall be bonded to and form part of the air termination network.

The air terminal of 15 mm dia., 1 meter length made up of copper bonded steel material shall be installed at every corner of the building.

Horizontal Conductor/ Mesh Conductor

Copper bonded steel conductor of 8mm (min.) dia. can be used. The conductor shall be made of high tensile low carbon steel, molecularly bonded with copper on outer surface to comply the requirements of IS/IEC 62305. The minimum thickness of copper bonding shall be 250 microns.

The conductors shall be installed at locations in compliance with the code requirement and as per approved Drawings. The conductor and Air terminals shall be securely fixed in place with suitable clamps and hardware, to the building structure. The clamps / hardware used for jointing Air terminal to the roof conductor and for fixing of roof conductor to the metallic / Masonry / glass surface of facade, shall be according to the relevant part of IS/IEC 62305.

Wherever possible, the horizontal conductors shall be of continuous lengths. Where saddled to masonry the fixing screws shall be set in expansion type plugs contained in properly formed holes. All roof conductors are to be secured by roof conductor holders at intervals of 1000mm.

Drawings showing the various roof levels of the building indicating the general arrangement and layout of the air termination system. The Contractor shall ensure that air termination system, installed over its total route of the roof shall maintain absolute electrical continuity. Provision shall be made with suitable fittings to allow for expansion and contraction of the horizontal conductors at every 20 meter.

Down Conductor:

The Down Conductors shall be in compliance with the IEC 62561-2. Copper bonded steel rods of 8mm (min.) dia. can be used. The rod/ conductor shall be made of high tensile low carbon steel, molecularly bonded with copper on outer surface to comply the requirements of IEC 62561. The minimum thickness of copper bonding shall be 250 microns.

The down conductor shall be distributed around the outside wall / façade of the structure. Minimum Spacing between the down-conductors shall be as per designed level of protection and as per IS/IEC 62305-3. Down-Conductors are to be secured at intervals of 1000mm.

Any external metal running vertically through the structure shall be bonded to the down conductors. A down conductor shall follow the most direct path possible between the air terminals and the earth termination. Separation distance needs to be calculated and maintained from live parts/services while routing the down-conductors.

At the structures, which cannot be punctured for holding the down-conductors, like tin roofs, glass façade etc., the down-conductors should be supported with adhesive type clamps tested for weather durability, wind speed and for withstanding lightning currents asper designed Lightning Protection Level.

Joints and Bonds/ Connectors

a) The lightning protection system shall have minimum joints as possible. Joints and bonds shall be mechanically and electrically effective. Joints exposed to the atmosphere/open air can be clamped, screwed, bolted, riveted or exothermically welded joints. Joints and bonds made below earth and in concrete shall be through exothermic welding only.

b) With overlapping joint, the length of overlapping shall not be less than 25mm for all types of conductor. Contact surfaces shall be first cleaned, and then inhibited from oxidation with a suitable non-corrosive compound. Joints of dissimilar metals shall be protected from moisture by an inert, tenacious material.

Fixing Accessories/Conductor Holders

Suitable fixing accessories to be considered to support Roof conductor as well as down conductor at every 1 meter as per IS/IEC 62305-3. The fixing accessories and the conductor holders shall be complying IEC 62561.

Lightning Strike Counter

The Lightning systems shall be installed complete with the lightning strike recorder. The lightning strike recorder shall contain a mechanical 6-digit display which will register all lightning discharges. The lightning strike recorder shall be housed in an IP 67 rated enclosure and operate without reliance on batteries or on any other external power source.

Test Clamp

Each down conductor shall be provided with a testing joint in such a position that, it is convenient for testing (about 1000 mm above Ground level). It shall be made of copper and shall be connected at every down conductor for connection and disconnection purpose.

Earth termination Network

The resistance from any part of the lightning protection system to earth shall not exceed 10 Ohm before any bonding has been affected to metal in or on a structure or to services below ground. If the value obtained exceeds the specified 10 Ohm it shall be reduced by adding to the number of earth electrode.

An earth termination network shall consist of vertical and horizontal conductor comprising of ring earthing at a min. distance of 3.0 meter from the structure.

6.12.6 Isolation Spark Gap (ISG):

An isolation spark gap shall be used with every transformer neutral at substations and with every PLC & SCADA Connection when connecting them with a common Earthing Grid. Also, when interconnecting 11/0.433kV station, an ISG shall be installed. Inside

the tunnel also, at every crossing the ISG shall be considered with PLC panels, Transformer Neutrals and with other sensitive equipment.

Note: -

a) All materials used in the work shall be procured from RDSO approved sources or ISI marked only and of the best quality and of the class suited for the purpose specified.
b) Design codal life of all type of material/equipment should be as per RDSO codal life standard.
c) The contractor shall be solely responsible for the correctness of the position, levels and dimensions of the works according to approved drawings, notwithstanding that he may have been assisted by the Engineer or his men in setting out the same.
d) Notwithstanding anything given anywhere else all work execution shall be as per latest design and drawing of RDSO and latest guideline issue by Railway Board.
e) The contractor should follow all the clearances as per latest CEA regulation.
f) Meet the all protective provisions relating to electrical safety.

XXXXX

Section VII-8: Tender Drawings and Documents

A- Tender Drawings
B- Tender Documents

Section VII-8
A: Tender Drawings

List of Drawings

-Black colour shows Tender drawings which have not been revised

-Blue colour shows Tender drawings which have been revised

-Red colour shows New additional Tender drawings

Note:

1. Tenderer shall download Tender drawings from HRIDC website. Tender Drawings are available for downloading on HRIDC website under Active Tender Section (https://hridc.co.in/active-tender.php). Tender drawings uploaded on HRIDC website for Package 4 shall be deemed to form part of final Tender Documents. List of Tender Drawings are enclosed hereunder.

S. No	TITLE	DRAWING NO.
1	**ALIGNMENT PLAN AND L-SECTION:**	
1.	Conceptual plan and longitudinal section from chainage 10.0KM to chainage 15.185KM (tunnel)	GC-HRIDC-ALL-DRW-ALN-P&P-10-15KM_A1
2.	Conceptual plan and longitudinal section from chainage 15.185KM to chainage 20.0KM	GC-HRIDC-ALL-DRW-ALN-P&P-15-20KM_A1
3.	Conceptual plan and longitudinal section from chainage 24.0KM to chainage 30.0KM (tunnel)	GC-HRIDC-ALL-DRW-ALN-P&P-24-30KM_A2
2	**TUNNEL**	
1.	Conceptual drawing for Single track tunnel cross section (Rock)	GC-HRIDC-C4-DRW-TTL-CLT-01001_A1
2.	Conceptual drawing for Single track tunnel cross section (Soil)	GC-HRIDC-C4-DRW-TTL-CLT-01002_A1
3.	Conceptual drawing for Support class III from CH: 24940 to CH: 26000	GC-HRIDC-C4-DRW-TTL-CLT-01003_A0
4.	Conceptual drawing for Support class IV from CH: 24880 to CH: 24940	GC-HRIDC-C4-DRW-TTL-CLT-01004_A0
5.	Conceptual drawing for Support class VI (i) from CH: 26000 to CH: 28420	GC-HRIDC-C4-DRW-TTL-CLT-01005_A0
6.	Conceptual drawing for Support class VI(ii) from CH: 28420 to CH: 28480	GC-HRIDC-C4-DRW-TTL-CLT-01006_A0
7.	Conceptual drawing for Tunnel typical detail of lattice girder	GC-HRIDC-C4-DRW-TTL-CLT-01007_A0
8.	Conceptual drawing for Cut & cover section of tunnel	GC-HRIDC-C4-DRW-TTL-CLT-01008_A1

S. No	TITLE	DRAWING NO.
9.	Conceptual drawing for Cross passage junction with main tunnel	GC-HRIDC-C4-DRW-TTL-CLT-01009_A1
10.	Conceptual drawing for Permanent Ventilation shaft junction with main tunnel	GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 (Sheet 1 of 3)
		GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 (Sheet 2 of 3)
		GC-HRIDC-C4-DRW-TTL-CLT-01010_A2 (Sheet 3 of 3)
11.	Conceptual drawing for Construction cum utility shaft	GC-HRIDC-C4-DRW-TTL-CLT-01011_A2
12.	Conceptual drawing for Portal-1 & Abutment A2 of proposed HORC viaduct	GC-HRIDC-C4-DRW-TTL-CLT-01012_A1
13.	Conceptual drawing for Portal-2 & open cutting area with 100m ballastless track	GC-HRIDC-C4-DRW-TTL-CLT-01013_A1
3 BRIDGES		
3.1 MINOR BRIDGES		
1.	Conceptual general arrangement drawing for Balancing culvert Bridge no. 047 Span 1.0x2.0x2.0 RCC box at Ch: 12208.018	GC-HRIDC-C4-DRW-BRD-GAD-01047_A1
2.	Conceptual general arrangement drawing for Drain + Road Bridge no. 048 span 1x4.0×5.0+1x5×5 RCC box at Ch: 12298.962	GC-HRIDC-C4-DRW-BRD-GAD-01048_A1
3.	Conceptual general arrangement drawing for pipe culvert Bridge no. 049 span 1.0x1.80ø Pipe culvert at Ch: 12341.836	GC-HRIDC-C4-DRW-BRD-GAD-01049_A1
4.	Conceptual general arrangement drawing for Balancing culvert Bridge no. 050 Span 1.0x2.0x2.0 RCC box at Ch: 12645.715	GC-HRIDC-C4-DRW-BRD-GAD-01050_A1
5.	Conceptual general arrangement drawing canal Bridge no. 051 span 1.0x3.0x3.0 RCC box at Ch: 13114.998	GC-HRIDC-C4-DRW-BRD-GAD-01051_A1
6.	Conceptual general arrangement drawing for Balancing culvert Bridge no. 052 Span 1.0x3.0x3.0 RCC box at Ch: 13903.112	GC-HRIDC-C4-DRW-BRD-GAD-01052_A1

S. No	TITLE	DRAWING NO.
7.	Conceptual general arrangement drawing for canal Bridge no. 054 1.0x3.0x3.0 RCC box at Ch: 14601.627	GC-HRIDC-C4-DRW-BRD-GAD-01054_A1
8.	Conceptual general arrangement drawing for Road under bridge, Bridge no. 055 Span 1×5.0×5.0 RCC box at Ch: 14756.727	GC-HRIDC-C4-DRW-BRD-GAD-01055_A1
9.	Conceptual general arrangement drawing for Balancing culvert Bridge no. 056 Span 1.0x2.0x2.0 RCC box at Ch: 15100.163	GC-HRIDC-C4-DRW-BRD-GAD-01056_A1
10.	Conceptual general arrangement drawing for Road under bridge, Bridge no. 057 Span 1×5.0×5.0 RCC box at Ch: 15944	GC-HRIDC-C4-DRW-BRD-GAD-01057_A1
11.	Conceptual general arrangement drawing proposed RUB no. 060 Span 2×7.0×5.6 RCC box at Ch: 16827	GC-HRIDC-C4-DRW-BRD-GAD-01060_A2
3.2 MAJOR BRIDGES		
1.	Conceptual general arrangement drawing for stream bridge no.53 2x24.4 CG at Ch: 14472.112m	GC-HRIDC-C4-DRW-BRD-GAD-01053_A2
2.	Conceptual general arrangement drawing for Canal Br.no. 058 1 x 5 x 5.4m + 1 x 12.2m + 1 x 5 x 5.4m PSC U slab Ch: 16127	GC-HRIDC-C4-DRW-BRD-GAD-01058_A2
3.	Conceptual general arrangement drawing proposed RUB no. 059 2 x 12.2m PSC U slab Ch: 16727	GC-HRIDC-C4-DRW-BRD-GAD-01059_A2
4.	Conceptual general arrangement drawing proposed Canal Br. No. 061 1x5x5.4+1x12.2+1x5x5.4m PSC U slab Ch: 16917	GC-HRIDC-C4-DRW-BRD-GAD-01061_A2
5.	Conceptual general arrangement drawing proposed RUB no. 062 1 x 12.2m PSC U slab Ch: 17500	GC-HRIDC-C4-DRW-BRD-GAD-01062_A2

S. No	TITLE	DRAWING NO.
4	**MISCELLANEOUS DRAWINGS (CONCEPTUAL PLANS)**	
1.	Jurisdictional sketch of C-4 package	GC-HRIDC-C4-SK-CIVIL-001_A1
2.	Schematic diagram of HORC tunnel	GC-HRIDC-C4-SK-TUNNEL-001_A1
3.	Conceptual Plan Typical embankment/cutting profile	GC-HRIDC-SK-GEN-001_A2
4.	Conceptual Plan Drains for Embankment	GC-HRIDC-SK-GEN-008_A2
5.	Conceptual Plan Steel barricade	GC-HRIDC-SK-GEN-009
6.	Conceptual Plan Interfacing location bank benching	GC-HRIDC-C4-SK-012_A2
7.	Conceptual Plan CC Toe wall	GC-HRIDC-SK-GEN-014_A2
8.	Conceptual Plan Typical details of protection work	GC-HRIDC-SK-GEN-015_A1
9.	Conceptual Plan Barbed wire fencing	GC-HRIDC-SK-GEN-016_A1
10.	Conceptual Plan for Transition system of bridge approaches	GC-HRIDC-SK-GEN-019_A1
11.	Conceptual plan for Trolley Refuge in embankment	GC-HRIDC-SK-GEN-022
12.	Conceptual plan for Trolley Refuge in cutting	GC-HRIDC-SK-GEN-023
13.	Conceptual sketch for NP4 pipe of 450mm Dia	GC-HRIDC-SK-GEN-028_A1
14.	Conceptual sketch for box culvert 500 x 500 mm size	GC-HRIDC-SK-GEN-029_A1
15.	Conceptual general arrangement drawing crossing of HORC rail line below Vadodara expressway	GC-HRIDC-SK-GEN-030
16.	Conceptual sketch for road within PROWs in RUBs.	GC-HRIDC-SK-GEN-031
17.	Conceptual sketch for details of inspection steps from cutting in formation to ground	GC-HRIDC-C4-SK-TUNNEL-002_A0
5	**GENERAL ELECTRICAL SERVICES DRAWINGS**	
1.	Indicative layout plan of Sub-station 11/0.433KV near utility shaft	GC-HRIDC-C4-DRW-TTL-ELE-001_A2
2.	Indicative layout plan of Sub-station 11/0.433KV	GC-HRIDC-C4-DRW-TTL-ELE-002_A2
3.	Power supply for lighting arrangement (Indicative)	GC-HRIDC-C4-DRW-TTL-ELE-003_A2
4.	Power supply arrangement for emergency and maintenance power socket diagram (Indicative)	GC-HRIDC-C4-DRW-TTL-ELE-004_A2
5.	Single line diagram of HT system in tunnel (Indicative)	GC-HRIDC-C4-DRW-TTL-ELE-005_A1

S. No	TITLE	DRAWING NO.
6	**LAND AREA FOR TUNNEL**	
1.	Land area near Portal-1	HRIDC-C4-SK-LANDPLAN-001_A1
2.	Land area near permanent Ventilation shaft 1 & 2	HRIDC-C4-SK-LANDPLAN-002_A1
3.	Land area near Construction cum utility shaft	HRIDC-C4-SK-LANDPLAN-003_A1
4.	Land area near permanent Ventilation shaft 3 & 4	HRIDC-C4-SK-LANDPLAN-004_A1
5.	Land details from Ch: 28341m to 29680m	HRIDC-C4-SK-LANDPLAN-005_A1

Section VII-8
B. Tender Documents
List of Documents

-Black Colour shows Tender documents which have not been revised

-Blue Colour shows Tender documents which have been revised

-Red Colour shows New Additional Tender documents

List of Documents		
S.NO.	Existing Documents Title	Revised/New Documents Title
1.	Design Basis Report	Design Basis Report
2.	List of Curve and Gradients	List of Curve and Gradients
3.	List of Control Points	List of Control Points
4.	List of Charted Utilities	List of Charted Utilities
5.	Geotechnical Investigation Reports for Tunnel	Geotechnical Investigation Reports for Tunnel
	i. Geotechnical Investigation Report	i. Geotechnical Investigation Report No. SMC/2050.
	ii. Geological Interpretive Report	ii. Geological Interpretive Report No. SMC/2050
	iii. Geotechnical Investigation Report Old Ch. 27+620 to Old Ch. 28+900 km	iii. Geotechnical Investigation Report No. SR NO.: 544_21-22 Old Ch. 27+620 to Old Ch. 28+900 km
6.	Geotechnical Investigation Report for Bridge Old Ch. 11+523 to Old Ch. 16+815 (New CH: 12+208 to 17+500)	Geotechnical Investigation Report No. SR NO.: 544_21-22 for Bridge Old Ch. 11+523 to Old Ch. 16+815 (New CH: 12+208 to 17+500)
7.	Approved Manufactures/Suppliers List	Approved Manufactures/Suppliers List
8.	-	KMZ File of Package C-4 Alignment

1. DESIGN BASIS REPORT

DESIGN BASIS REPORT

(FINAL)

EXPLORING ALTERNATE ALIGNMENTS, FINAL LOCATION SURVEY, GEOLOGICAL MAPPING, GEO-TECHNICAL INVESTIGATION, DETAIL DESIGN OF TUNNEL & ITS APPROACHES INCLUDING VIADUCT IF ANY AND OTHER ANCILLARY WORK IN SOHNA-MANESAR SECTION OF HRDC PROJECT.

Client:

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

Prepared By:

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010, ODISHA

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Prepared & Submitted By		
M/s. S. M. Consultants		
Prepared By	Tunnel Designer	(Shivendra Kumar)
Approved By	Sr. Tunnel Consultant	(B. R. Sharma)

Client:

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

Prepared By:

S.M. CONSULTANTS, S.M.TOWER, PLOT NO.-130, MANCHESWAR INDUSTRIAL ESTATE, RASULGARH, BHUBANESWAR-751010, ODISHA

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LIST OF TABLE

1. Introduction

Haryana Rail Infrastructure Development Corporation Ltd. (HRIDC) has been incorporated under the provision of Companies Act on 22.08.2017 with equity contribution of 51% from Govt. of Haryana and 49% from Ministry of Railways with an objective to develop, finance and implement viable railway projects (by itself or through a subsidiary SPV) including projects which require viability gap funding (VGF). Presently, HRIDC is implementing various Railway infrastructure development projects in Haryana with necessary cooperation from Indian Railways. As a sequel to its project development in Haryana state, HRIDC has planned for design and construction of New Board Gauge Double Railway line from Palwal to Sonipat via Sohna, Manesar and Kharkhouda for passenger and freight traffic. It will provide seamless connectivity to Dedicated Freight Corridors (DFC) at Prithala station and to Indian Railways at Palwal, Patli, Sultanpur, Asaudha and Harsana Kalan stations. The projected route named as Haryana orbital rail corridor, which is 140 km rail link project to provide alternative route to Goods traffic presently moving in a circuitous and congested path via Delhi and consuming more time. Once this line is constructed movement by rail only instead of road due to curb pollution menace. This project will be beneficial to the industrial Hubs of Kharkhouda, Manesar and Sohna and will help in development, traffic can run faster and attract new traffic because of opening of rail transport. In future, environmental issues will come up in a big way favoring long distance traffic of this region of Haryana. This project has a tunnel for crossing Aravali Range near Sohna.

2. Salient Features of Tunnel Portion

FEATURES		
SL.NO,	***DESCRIPTION***	***DETAILS***
1	PROJECT SECTION	IMT SOHANA-DULAWAHT SECTION
2	NO OF TUNNEL	2 Nos Tunnel (UP Main/DN Main)
3	TUNNEL	Single Tube single track
4	STANDARD OF LOADING	32.5T Axel Load
5	TOTAL LENGTH OF TUNNEL	4700 M (EACH LINE)
6	LENGTH OF NATM TUNNEL IN ROCK	1120 M (24880-26000)
7	LENGTH OF NATM TUNNEL IN SOIL	2480 M (26000-28480)
8	LENGTH OF CUT &COVER TUNNEL IN SOIL	1100M (28480-29580)
9	PORTAL 1 IN ROCK	CH:24880 M
10	PORTAL 2 IN SOIL (Cut& Cover)	CH:29580 M
11	NO. OF SHAFT	5Nos (4 Permanent Ventilation Shafts & 1 Construction cum utility Shaft)
12	LOCATION OF SHAFTS	Permanent Ventilation Shaft Ch:26080
		Construction cum utility shaft Ch:26950
		Permanent Ventilation Shaft Ch:27680
13	MAX. DEGREE OF CURVATURE IN TUNNEL	1-degree RHS
		0.5-degree LHS
14	LENGTH OF STRAIGHT TRACK IN TUNNEL	1660.32 M
15	LENGTH OF CURVATURE TRACK IN TUNNEL	3039.68 m
16	TYPE OF TRACK	Ballast Less track
17	TRACTION	Electrified with high rise OHE (rocs)
18	CROSS PASSAGE	At 350.0 m interval.
17	MAX.ROCK/SOIL PILLAR THICKNESS BETWEEN TWO TUNNEL	2D

3. Scope of DBR

This DBR deals with preparation of methodology and baseline of support system design for portals (P1 & P2), cut and cover, tunnel excavation and primary lining design of the proposed alignment of tunnel between chainage 24+880 to Ch 29+580, total length of4700m long tunnel (1120m tunnel in Phyllite Rock, 2480m in Soil& 1100m in Cut &Cover).

4. References

The following references are used in the context of the analysis and design of slope:

i. Finite Element Analysis code for Excavations and Slopes.
ii. Redate Manual
iii. IS: 456: 2000–Plain and Reinforced Concrete Code of Practice
iv. RDSO Design and Construction Guidelines of Tunnels – G17
v. IS:13365 (Part-2)-1992: Quantitative Classification Systems of Rock Mass- Guidelines - Rock Mass Quality for Prediction of Support Pressure in Underground Openings, Bureau on Indian Standards, New Delhi.
vi. IS:15026-2002: Tunneling methods in rock masses – Guidelines, Bureau on Indian Standards, New Delhi.
vii. Indian Railway Standard Code of Practice for Plain, Reinforced and Pre-Stressed Concrete Bridge [IRS-CBC]
viii. IS 1893(Part-1): 2002 Criteria for earthquake resistant design of structures
ix. Seismic design and analysis of underground structures" by YMA Hashish, JJ Hook, Birger Schmidt and John I-Chiang Yao.
x. Lowson, A.R., and Z.T. Bieniawski. 2013. Critical Assessment of RMR based Tunnel Design Practices: a Practical Engineer's Approach. Rapid Excavation &Tunneling Conference. Washington DC.16 pp
xi. ITA guidelines for Tunnel ventilations and Fire Safety.
xii. Other relevant IS Codes and IRS Code.
xiii. U.S. Army Corps of Engineers Manual EM1110-2-2901 - Engineering and Design Tunnel and Shafts in Rock

5. Geological/Geotechnical Conditions of Project Area

Tunnel proposed lies in Delhi Ridge, Delhi ridge constitutes northernmost extension of the Aravalli range in the form of two ridges, i.e. Sohna ridge in Haryana, nearly 45 km from Delhi, and west of it is Harachandpur ridge also known as Delhi ridge, which has become famous for its environmental importance to this region. Physio-graphically the north-western part of the India covers deserts of the Rajasthan and Haryana, Aravalli ranges and Indo-Gangetic alluvium. The Aravalli Mountains constitute remnant monuments of Precambrian times, whereas Thar desert and alluvium are Quaternary features formed by

Aeolian and alluvial processes. In Haryana and Delhi region quartzites are exposed as NE-SW trending ridges amidst the alluvial and aeolian cover. Sohna-Ferozpur Jhiraka ridge runs from Nowganawa in Rajasthan to Bhundsi a place about 45 km south of Delhi. Northeast of the Sohna is a broad Harachandpur ridge, which extends up to Delhi, where it is known as famous Delhi ridge. These two ridges consist of thickly bedded quartzites with minor schist. The quartzites are reported to exhibit sedimentary structures like ripple marks, current bedding, mud cracks, flute cast and certain depositional features. Volcanic fragments and bands within the Alwar quartzites in and around Sohna and stratified tuffbeds in Badkhal-Surajkund area have also been reported, indicating pen contemporaneous volcanic activity in the area. The region around the site consists of metamorphosed arenaceous rocks of the Alwar group. The Lithology is dominated by Quartzite's with some intercalations of phyllites near the southern portal. The Quartzite's are met sedimentary rocks that comprise greater than 80% quartz along with feldspar and mica minerals, the mineral grains show an equigranularity interlocking texture.

The phyllites are low-grade metamorphic rocks, they have a marked fissility (a tendency to split into sheets or slabs) due to the parallel alignment of platy minerals; they have a sheen on their surfaces due to tiny plates of micas.

The quartzite's near to surface showed high weathering and were highly friable and non-cohesive while as we move deeper (> 15 m) the quartzite becomes more resistive and less weathered. Quartz is a tectosilicate mineral that ranks 7 on the Mohr hardness scale, since it crystallizes later according to the Bowen reaction series it is also resistive to weathering. Feldspar on the other hand ranks 6 on the Mohr hardness scale and crystallizes earlier thus is prone to weathering. in the southern part intercalation of phyllites/schist along with quartzite are observed.

The total tunnel length is 4.7 km, out of which 1.1 km of tunnel will be within the quartzite rock mass of Delhi Supergroup and 2.9 km will run through soil and remaining 0.7Km will be Cut Cover type structure. Based on the available surface information from the geological field investigation and close observation of the drilled cores from the litho-logs, it has been observed that after crossing the soil

the tunnel will enter into a folded rock mass where the axis of the tunnel will be perpendicular to the fold axis, thus favorably oriented with respect to the folded bedding planes. However, the folded rock layer has suffered extreme level of later brittle fracturing, which has been testified by the presence of 6 sets of joints of different orientation and a few late brittle discrete shear zones (which is certainly not active in nature). These joints and the fractures have significantly reduced the strength of the otherwise sufficiently cohesive metamorphic rock mass. Presence of the intersecting closely spaced joint sets make the tunnel part within the rock body highly susceptible to wedge failure.

Figure 1: Google Map of proposed Tunnel

6. Determination of Cross Section of Tunnel

Following factors shall be taken into account while deciding the cross section of tunnel,

1. Fixed Structure Gauge for tunnel of HORC
2. Horizontal & Vertical clearance on curves as per IRSOD
3. Footpath Size

4. Drain Size
5. Type of OHE.
6. Provision for Space for Ventilation Fan
7. Geological Features

Maximum fixed structure gauge provided by RDSO for the HORC tunnel is shown in Annexure-1. Based on the above parameters tentative cross section of tunnel for rock and soil has been shown in **Annexure-*1.***

7. Design Basis Report for Portal Slope Stability Analysis

7.1. Geology of Portal Area

For the proposed tunnel, Portal-1 is placed in moderately strong phyllite which is suitable for portal location whereas Portal-2 is placed in soil whose stability shall be ensured by suitable protection measures. The Proposed portals of tunnel are namely Portal P1 and Portal P2 at chainage 24+880 m and 29+580 m of the project area. At portal P1 there is an overburden of Rock of around 25m while at portal P2 there is an overburden of soil of less than around 1m. During the excavation and portal formation adequate slope shall be provided so that failure of any overburden material (rock/soil) shall be avoided.

Major discontinuity sets mapped in and around the portals area are presented below which is taken from **GIR Table No-3.2.**

Joint Set	Average Strike	Average True Dip amount	Average True Dip direction
J1	035	80	SE
J2	035	20	NW
J3	000	84	E
J4	000	40	W
J5	300	55	NE
J6	300	80	NE

*Table 1: Discontinuity Sets for Portal-*P1

Test on joint infill material have not been carried out by the Employer. The contractor shall get infill material tested for shear strength parameters. The above proposed joint set and shear parameter which shall be obtained by the Contractor, shall be considered for kinematic analysis of rock slope at portal P1. Tunnel portal P2 falls in soil. So kinematic analysis of the same is not required. Its slope protection measures shall be designed for global failure using suitable protection measures such as SDA, shotcrete with wire mesh.

7.2. Design Data for Portal Slopes

7.2.1. Factor of Safety for portal

Local stability for portal P1 and global stability of cut slope of Portals P1 & P2 shall be checked. Minimum factors of safety for different failure load cases are tabulated in Table 2. These are based on FHWA (Federal Highway of America) guidelines

Load Case	Description	Minimum FOS Required
Dead Load + Water	Normal condition	1.5
Dead Load + Water + Seismic	Extreme Condition	1.1

Table 2: FOS for various Loading Conditions

7.2.2. Self-Weight of Rock Mass:

As per GIR Para 4.5.1.2-self-weight of rock mass (saturated unit weight) may be taken as 26.72 kN/m^3 for rock while for soil it may be taken as 19kN/m3 as per GIR Para 5.4.2.

7.2.3. Earthquake Loads:

This Project area falls under seismic zone IV of Indian Seismic Zoning Map, where maximum seismic zone coefficient (Z) is0.24, so Horizontal seismic coefficient Ah = Z/2 *Sa/g *I/R here Sa/g =2.5, I =importance Factor = 1.5, R=

Response Reduction Factor =2.5 so Ah = 0.24/2*2.5*1.5/2.5 =0.18 and Vertical Seismic Coefficient equal to 2/3rd of horizontal Coefficient will be 0.12.

7.2.4. *Geotechnical Parameters for Portal P1:*

Intact rock properties are based on bore holeBH-13. Rock mass properties have been determined based on laboratory test results of intact rock using Mohr Columb fit parameters using Roc Data software. For deriving rock mass property for FEM analysis of cut slope, shear strength parameters are required which have been derived using Roc lab software in which input parameters are UCS, GSI and mi.

Description		**Unit**	**Rock Mass Portal (P1) From Bore Hole BH-13**
Intact Rock Properties	UCS(Table 6.1 of GIR)	MPa	60
	RMR (Table 6.1 of GIR)		20-40
	$GSI=RMR_{av}-5$		25
	mi (Roc Lab Software)		20(For quartzite)
	D-disturbance factor		0.2
	ν		0.3
Rock Mass Parameters	c (peak)	MPa	0.395
	Φ (peak)	deg	49.38
	c (residual)	MPa	0.354
	Φ (residual)	deg	46.93
	Tensile Strength	MPa	0.008
	Deformation Modulus	MPa	1836
Disturbed 2m thick Rock Mass D=0.7(Will be modelled in Phase2 to consider effect of blasting during excavation.)	c	MPa	0.233
	Φ	deg	37.06
	Tensile Strength	MPa	0.004
	Deformation Modulus	MPa	1193

Table 3: Rock Mass Parameters for Portal Slopes.

The above tabulated parameter of rock mass may be used for Global slope stability analysis of Portal Cut Slopes (Portal P1). The Mohr Coulomb fit parameter for rock mass has been attached as ***Annexure-2.***

Value of K (In -situ stress ratio) for slope stability analysis for the Portal P1 and P2shall be taken as 0.5.

7.2.5. Geotechnical Parameters for Portal P2:

As per geological section Portal P2 falls in soil .and bore hole data obtained from **BH-32 &33 has been considered to derive geotechnical parameter** for global stability of slope. Following geotechnical parameters may be taken for global stability analysis of slope. Refer **Table 3.3 of GIR.**

Soil Properties for Portal	E Value	MPa	31
	C Cohesion	KPa	8
	Φ	Degree	26
	Saturated Density	kN/m3	22

Table 4: Soil Properties for Portal

7.2.6. Support/Reinforcement Properties for Portals:

Support in the form of systematic rock bolt/self-drilling anchor SDA and shotcrete with wire mesh shall be used for portals. The following support properties will be considered for the shotcrete and soil nails.

7.2.7. Shotcrete with wire mesh:

The 28 days strength of shotcrete shall be minimum 25 N/mm2. The early strength will be estimated using young shotcrete strength development curve as per class J2 of Austrian guidelines (Fig 2). At portals shotcrete with wire mesh (100mmx100mm x5 mm) will be used.

Grade of mix	Unit	Reference Code	M25
Characteristic Compressive	MPa	IS 456:2000	25

strength(fck)			
Allowable Compressive Strength	MPa	IS 456:2000	6.0
Tensile strength=	MPa	IS 456:2000, B2.1.1	3.2
Allowable Shear Strength	MPa	*IS15026:2002*	5.5
Young's Modulus	MPa	IS 456:2000	25000

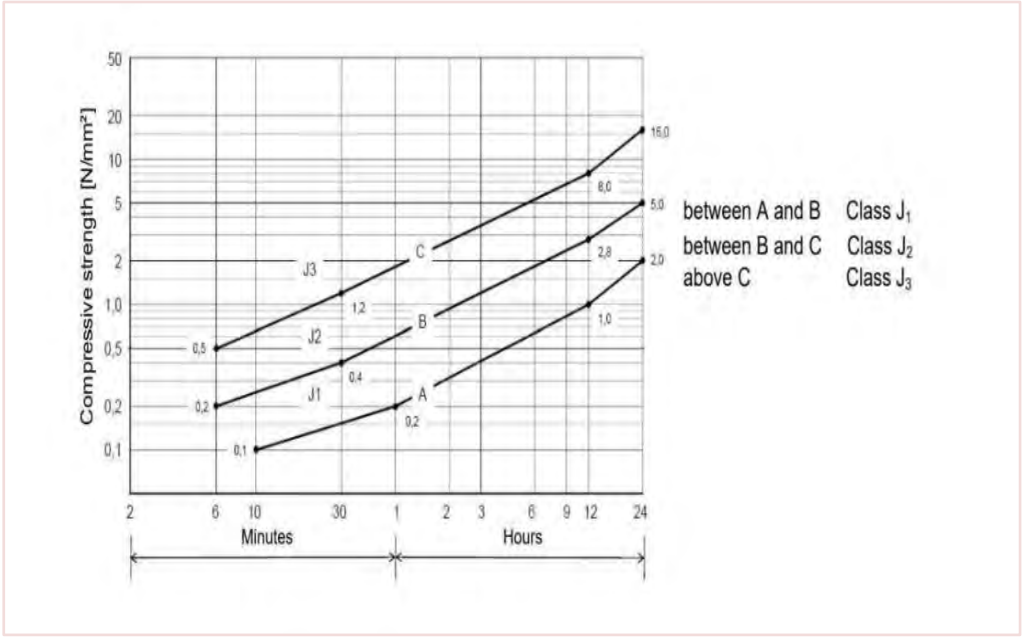


*Figure 2:*Early strength development of young shotcrete

7.2.8. *Anchor Plate*

For rock bolt anchor plate of Mild steel Fe 500 of size 150 mm x150 mm x 8 mm shall be used, which is adequate for 25 mm diameter rock bolts but its adequacy will be verified at site during pull out test of rock bolts.

7.2.9. *Fully Grouted rock bolt*

Rock bolt of Portals will be deformed bar of Grade Fe500D, whose characteristic curve with reference to IS 456:2000 is attached as figure 3.

Diameter of Rock Bolt	mm	25
Minimum Dia of Hole	mm	38/45*
Steel Grade (Yield Strength)	MPa	Fe 500 (500)

Cross-sectional Area	mm^2	491
Yield Capacity	kN	245.43
Elastic Capacity (0.80x yield)	kN	196
Design Capacity Considered (Approx.)	kN	190
Length of Rock Bolt	m	4/6/8
Factor of Safety		1.25

*Diameter of hole of rock bolt may vary from 38 mm to 45 mm. Final decision of its diameter will be taken after pull out test carried out on rock bolt at site. Pull out test shall be carried out for its full design capacity of 190 kN.

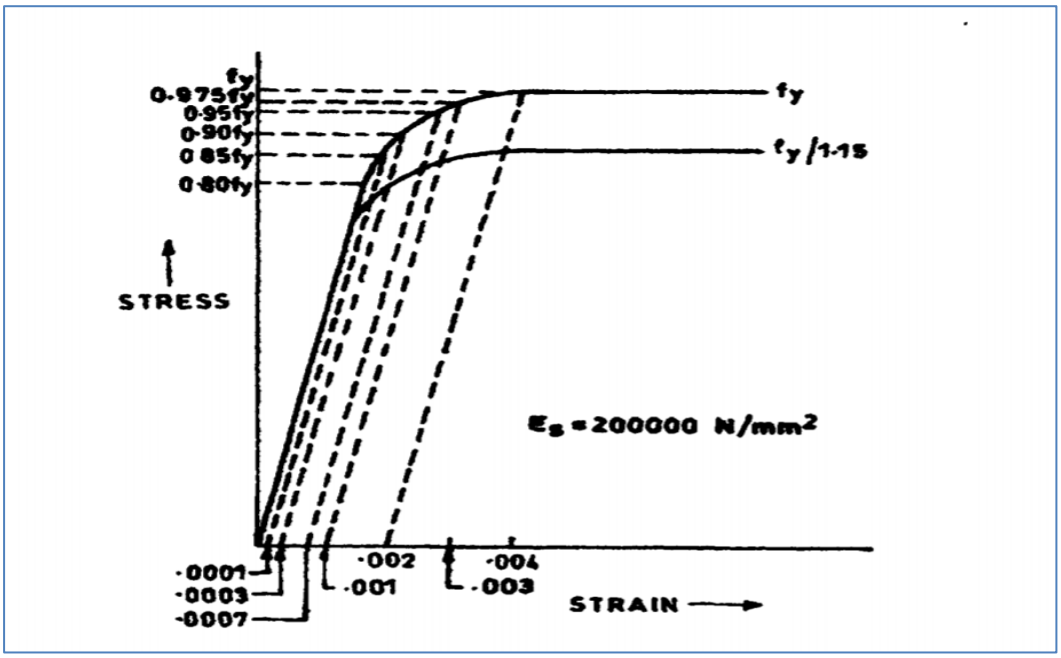


Figure 3: Characteristic Curve of Fe500D

7.2.10. Self-Drilling Anchor

For Portal P2 which falls in soil self-drilling anchor of suitable length shall be used along with shotcrete and wire mesh.

Specification of Self Drilling Anchor	**SDRA 38/19**
Outside Diameter (mm)	38
Internal Diameter (mm)	19

Cross Sectional Area (mm^2)	700
Ultimate Load (kN)	500
Yield Load (kN)	400
Weight (kg/m)	5.5
Length of Self Drilling Anchor	6m/8m/10m
Factor of Safety	1.25
Design Capacity (KN)	300kN (Approx.)

7.2.11. Steel Rib

Steel Ribs shall be used in portal region (around 15 m from start) where chance of rock mass movement due to planar slide and creep is more. Size of steel ribs can be optimized as per design. Steel ribs used will be of Grade Fe250. Characteristic curve of mild steel with reference to IS456:200 is attached as figure -4.

Support type	Steel rib			
Grade of Steel	Fe 250			
Description of section as per IS 808		ISMB 150 @15 kg/m	ISMB200@	ISMB 250 @ 37.3 kg/m
Depth of section	mm	150	200	250
Cross-sectional Area	mm^2	1910	30800	4750
Moment of Inertia	m^4	$7.18x10^{-6}$	2.12×10^{-5}	5.13×10^{-5}
Modulus of Elasticity	MPa	200000	200000	200000
Yeild Strength of Steel Rib	MPa	250	250	250

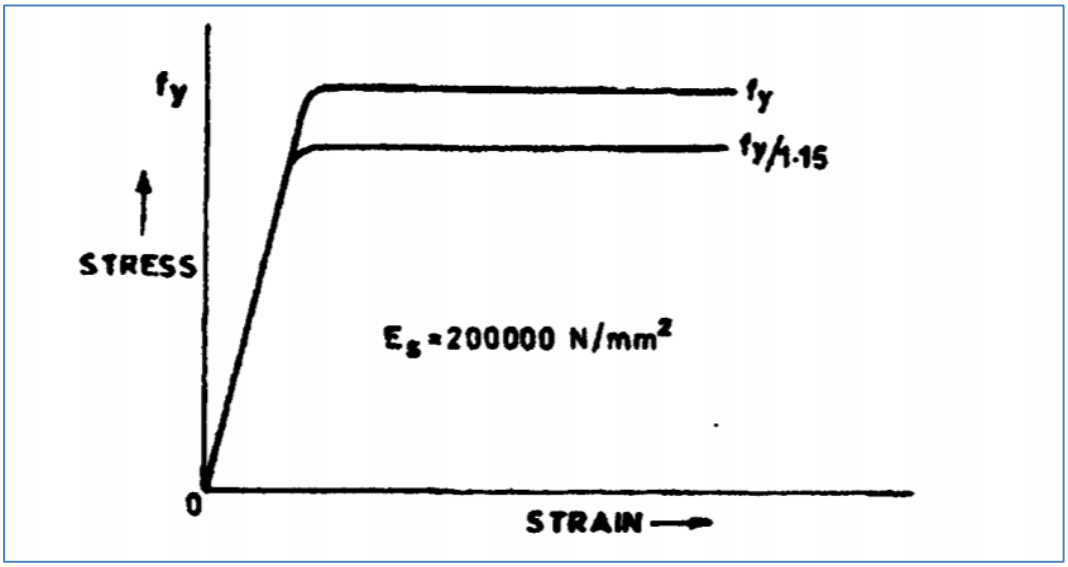


Figure 4:Characteristic Curve of Fe250

7.3. Methodology for Portals Slope Design

Tunnel Portal P1 is located in quartzite's and quartzitewith thin- inter bedded layer schist type rock. The rock mass available around the portal P1 is slightly weathered rock. Excavation of Portal shall be planned so as to minimize excavation and cut height. Portal P2 falls in soil. So kinematic analysis is omitted but global stability check shall be carried out as described below.

1. First Kinematic analysis shall be carried out to check toppling, planar and wedge failure.
2. Planar and wedge failure shall be checked with and without support system, if wedges are not stable (FOS is less than desirable) wedge shall be analyzed with support system and its adequacy against desired FOS shall be checked.
3. An excavated slope will be checked against global failure using strength reduction method with help of RS^2. Excavated slope shall be analyzed stage wise- first up to heading excavation level and then upto final excavation level. If excavated slope is unstable (factor of safety is less than desired), it shall be reanalyzed with suitable slope protection measures to achieve desired factor of safety.

7.3.1. Design of Portal Slope for various failure mode.

Portal slope shall be analyzed for various failure modes to check stability of slope. Following sections describe the methodology for slope stability of portal for different failure modes.

7.3.2. Types of Failure

Various types of failure of portal cut slope have been given below, for which adequacy of support system shall be checked.

7.3.3. Planar Failure for Portal Slope

For this type of failure to occur, the following geometrical conditions must be satisfied:

a) The plane on which sliding occurs must strike parallel or nearly parallel (within approximately ± 20°) to the slope face.

b) The sliding plane must "daylight" in the slope face, which means that the dip of the plane must be less than the dip of the slope face, that is, $\psi_p < \psi_f$.

c) The dip of the sliding plane must be greater than the angle of friction of this plane, i.e. $\psi_p > \varphi$.

d) The upper end of the sliding surface either intersects the upper slope, or terminates in a tension crack.

e) Release surfaces that provide negligible resistance to sliding must be present in the rock mass to define the lateral boundaries of the slide. Alternatively, failure can occur on a sliding plane passing through the convex "nose" of a slope.

The typical plane sliding mechanism is shown in Figure 7.

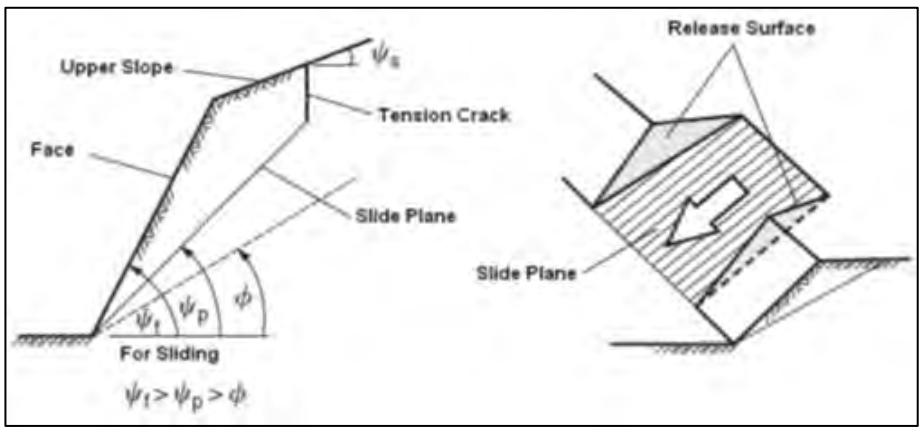


Figure 5: Geometric Conditions for Planar Failure

7.3.4. *Wedge Failure for Portal Slope*

This failure occurs when slopes containing discontinuities striking obliquely to the slope face and sliding of a wedge of rock takes place along the line of intersection of two such planes. The geometry of the wedge for analyzing the basic mechanics of sliding is defined in Figure 8. Based on this geometry, the general conditions for wedge failure are as follows:

a) Two planes will always intersect in a line. On the stereo net, the line of intersection is represented by the point where the two great circles of the planes intersect, and the orientation of the line is defined by its trend (α_i) and its plunge (ψ_i).

b) The plunge of the lb line of intersection must be flatter than the dip of the face, and steeper than the average friction angle of the two slide planes, that is $\psi_{fi} > \psi_i > \varphi$. The inclination of the slope face ψfi is measured in the view at right angles to the line of intersection. (**Note:** ψ_{fi} would only be the same as ψ_f, the true dip of the slope face, if the dip direction of the line of intersection were the same as the dip direction of the slope face).

The line of intersection must dip in a direction out of the face for sliding to be feasible; the possible range in the trend of the line of intersection is between α_i and $\alpha_{i'}$.

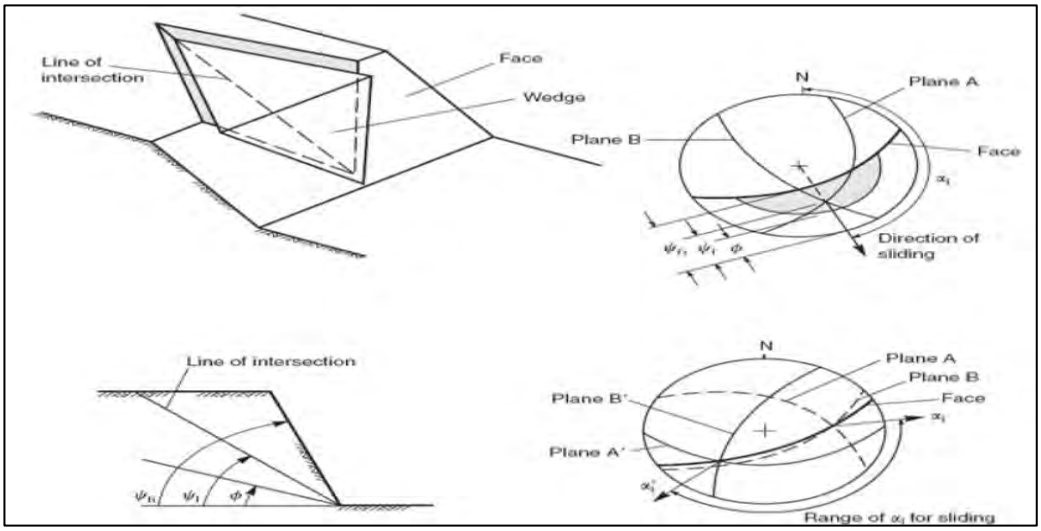


Figure 6: Geometric Conditions for Wedge Failure

7.3.5. Global Stability Check for Portal Slopes

The stage wise global stability analysis for portal slopes shall be carried out for critical section using RS^2 software. First The critical section will be analyzed without any support system. The results of the analysis will be expressed as a factor of safety which is defined as the ratio of available shear strength to the shear stresses developed on the sliding plane. If FOS of unsupported slope is less than desired, suitable support system shall be used, and it will be reanalyzed to achieve desired FOS. In global stability analysis of portal slope stage wise analysis first up to tunnel heading excavation level shall be carried out.After that analysis for final excavation up to invert level will be carried out.Although support requirement for analysis of final stage is likely to govern but stage analysis shall be included in design report pertaining to portal cut slopes.

7.3.6. Global Stability Check with Tunnel opening

After excavation and support of portal slope tunnel will be excavated stage wise up to heading level and then up to invert level. So stability of rock mass after tunnel opening shall be checked for various conditions and requirement of steel ribs, concrete lining and fore poling will be assessed. The analysis of portal slope with tunnel opening will be covered in report pertaining to design of underground support system.

At site at many places big size boulders are available which can cause problem during portal excavations. So it will be advisable to use rock fall barrier at different locations specially at portal locations.

7.3.7. Rock Fall Barrier

At portal-1 rock fall barrier at different locations shall be installed based on the size of the boulder and its kinetic energy to protect both portal and DFCC track.

8 Design Basis Report for Tunnel Underground Excavation

8.1. Geology of Tunnel

Proposed HORC tunnel for NATM is around3600 m long out of which 1120m is inside the rock while remaining 2480 m falls in soil as indicated in geological section. For 1120m long Tunnel sub surface exploration has been carried out with total 6 Nos of bore hole namely BH-13, BH-14, BH-15, BH-15A, BH-16& BH-17. It is anticipated that rock mass encountered inside the tunnel will be mainly strong phyllite with more than six joints.

For assessing the material properties for tunneling in soil 16 Nos of bore holes have been carried out which are namely BH-17 to BH-33.

Laboratory test conducted for rock	1. Unconfined Compressive Strength, 2. Point Load Index Test 3. Tensile Strength 4. Specific Gravity 5. Modulus of elasticity 6. Water absorption 7. Poisons' ratio 8. Triaxial Test 9. Hardness test 10. Abrasive test

Table 5: Laboratory Test carried out in rock

Sl. No.	Laboratory tests	IS Codes
1	Preparation of soil sample	IS: 2720(part-1)-1983 (Reaffirmed 2015)
2	Moisture Content	IS: 2720(part-2)-1973 (Reaffirmed 2015)
3	Specific Gravity	IS: 2720(part-3)(sec-1)-1980 (Reaffirmed 2016)
4	Grain Size Analysis	IS: 2720(part-4)-1985 (Reaffirmed 2015)
5	Atterberg's Limits	IS: 2720(part-5)-1985 (Reaffirmed 2015)
6	Bulk Density	----
7	Triaxial Shear Strength	IS: 2720(part-11)-1993 (Reaffirmed 2016)
8	Direct Shear Strength	IS: 2720(part-13)-1986 (Reaffirmed 2016)
9	Consolidation Test	IS: 2720(part-15)-1986 (Reaffirmed 2016)

Table 6: Laboratory Test carried out in Soil

8.2. Geotechnical Design Parameters for Tunnel

The geotechnical design parameters for the analysis shall be derived from bore holes information of tunnel (Laboratory test data & GIR). Major Discontinuities based on geological report of tunnels for kinematic analysis have been tabulated in **Table-7**.

Tunnels	Bore Hole	Unconfined Compressive Strength (MPa)	Modulus of Elasticity (GPa)	Point Load Index Range (MPa)
Tunnel (1100 m long) in Quartzite Rock	BH-13	63	53-31	2.18
	BH-14	56	53-33	2.99
	BH-15	67	52-41	3.37
	BH-15A	65	50-42	3.14
	BH-16	64	55-39	3.07

Table 7: Summary of Intact Rock Mass properties

Joint Set	Average Strike	Average True Dip amount	Average True Dip direction
J1	035	80	SE
J2	035	20	NW
J3	000	84	E
J4	000	40	W
J5	300	55	NE
J6	300	80	NE

Table 8: Discontinuity Sets along Tunnels (As per GIR Table No 3.2)

8.3. Material Strength Criterion

For the numerical analysis of underground excavations, selection of the material model is a critical issue in terms of the rock mass behavior. Most widely accepted material models that phase^2 supports are,

- Mohr-Coulomb (for Tunnel in Soil)

- Hoek-Brown (For tunnel in rock)

The first material model Mohr-Coulomb is best suited to model the behaviour of soils, especially shear strength characteristics of soils. In case of rock, where shear modulus is high, it is recommended to use the Hoek-Brown material model. Hoek-Brown criterion is extensively used in analysis of underground excavations in rock and is based upon an assessment of the interlocking of rock blocks and the condition of the surface between these blocks. The generalized Hoek-Brown criterion is expressed by the equation

$\sigma 1' = \sigma_{3'} + \sigma_{ci} ((m_b \times \sigma_{3'}/ \sigma_{ci}) + s)^{a}$

$m_b = m_i \exp ((GSI - 100)/(28-14D))$

$s = \exp ((GSI-100)/ (9-3D))$

$a = ½ + 1/6 \times (e^{-GSI/15} - e^{-20/3})$

$Em = Ei (0.02 + ((1-D/2)/ (1+e ((60+15D-GSI)/11))))$

$\sigma_3$and σ_1' are the minor and major effective principal stresses at failure.

σ_{ci} is the uniaxial compressive strength of the intact rock material.

m_i , s and a are material constants.

m_b is a reduced value of the material constant mi.

GSI = Geological Strength Index.

D = Factor depends on degree of disturbance to which the rock mass has been subjected by blast damage and stress relaxation.

Ei = Intact Rock modulus.

Erm = Rock mass deformation modulus.

8.4. Strength Properties of Material for Tunnel

A summary of the material strength parameters for Hoek-Brown criterion adopted in the analysis is presented in Table 9 below.

Rock mass Designation	**Class IV (Poor Rock)**
RMR Range (GIR Table 6.1)	20< RMR≤40
RMR_{av}	30
GSI= RMR-5	25
UCS (MPa) (GIR Table 6.1)	60
m_i(Rock Lab for Quartzite Rock)	20
D=Disturbance Factor	0
m_b	1.373
s	0.0002
a	0.531
E_d (MPa)	1836
Residual Property has been calculated by taking D=0.2	
m_b	1.516
s	0.0004
a	0.516
Poisson's ratio	0.20

Table-9: Material Strength Parameters for Hoek-Brown Criterion-Rock

Above parameter shall be used as rock mass parameter for support design using FEM software RS^2 ($Phase^2$) software. It is anticipated as per Geological Exploration that all condition of rock mass of whole stretch of tunnel in rock will be covered in Class IV category. Derived rock mass parameter from Roclab software is appended as ***Annexture-3***.

Parameter	*Type of Soil*	
Φ for cohesive soil (from Laboratory Test)	CL	19°
Φ for non-cohesive soil (from corrected N Value)	ML ML-CL SM	32°
Cohesion (C) (from Laboratory Test)	CL	25 KPa
Cohesion (C) (from Laboratory Test)	ML ML-CL SM	3 KPa
Modulus of Elasticity (E)	Cohesive (CL)	28 MPa
	Non-Cohesive (ML, SM, ML-CL)	30 MPa
Density	Cohesive (CL)	1852 kg/m^3
	Non-Cohesive (ML, SM, ML-CL)	1765 kg/m^3

Table-10: Recommended material Properties for tunneling in Soil

Note: Above mentioned property of soil has been taken from Table 6.2 of GIR.

8.5. In-Situ Stress for Tunnel

In tectonically active areas, tectonic stresses affect the stress regime possibly leading to development of locked-in stresses within rock mass Also, overlying rock mass strata gives rise to stresses due to its weight which plays important role in local stress field. Due to excavation, redistribution of stresses will take place creating new stress field around the opening. Thus, the magnitude and orientation of virgin stress field plays an important role in deciding the stability of an opening. As tunnelling projects always have limited information on in-situ stress testing, it is proposed to undertake a sensitivity analysis and adopt such stress values which may lead to the development of the critical stress field. Calculations, in the general case where field test data is absent, will be

based on Sheory simplified equation to estimate the horizontal to vertical stress ratio k. This equation is **k = 0.25+7Eh(0.001+1/z**), where z (m) is the depth below surface and Eh (GPa) is the average deformation modulus of the upper part of the earth's crust measured in a horizontal direction. For different classes of rock horizontal stress coefficient by Sheory's formula has also been calculated. This tunnel is shallow tunnel (where cover is less than 3 times the diameter of tunnel) and no Techtronic stress is anticipated. So, taking K value as more than 1 is not advisable. So, considering fair rock k value of 1 may be considered. While k Value for soil has been adopted as per Jacky's formula

K by Sheory's Formula		K	0.73
K Value to be considered for Rock		K	**1.0**
K value considered for soil		K	0.5
In-Situ Stress	Vertical Stress (σ_3)	MPa	It will be applied according to Natural Surface of above tunnel surface by in-built command of RS^2 (Phase^2 software)
	In Plane Horizontal Stress (σ_1)	MPa	
	Out of Plane Horizontal Stress (σ_z)	MPa	

Table 11: In-Situ Stress Parameters for Tunnels

8.6. Support Properties for Tunnel

8.6.1. Shotcrete Properties

The shotcrete is modeled as plastic standard beam element, so that the excess forces are transferred to the adjacent rock mass and support element, if the shotcrete yield at any point. Shotcrete with Steel Fiber or Polymer Fiber will be used for Tunnel. Addition of fiber in shotcrete will increase its flexural and shear strength, which will be validated by laboratory test. Compressive Strength, Cracking Strength and Elastic Modulus variation with addition to fiber has been attached in ***Annexure-3***. For improving

strength of shotcrete either steel fiber or synthetic polymer fiber shall be used.

8.6.2. Steel fibers:

Steel fibres shall comply with the requirements given in ASTM A 820 or similar national regulations. Following will be specification of steel fibre used for SFRS.

- Average Tensile strength of fibre shall not be less than 345 MPa.
- The tensile strength of any one of the ten specimens shall not be less than 310 MPa).
- Fibers shall withstand being bent around 3.2-mm diameter pin to an angle of 90° at temperatures not less than 16°C without breaking.
- Type I:Straight/Deformed cold-drawn wire shall be used for fibers.
- Aspect ratio (l/d) shall be 40 to 60.
- The length of the steel fibers shall not exceed 0.7 of the internal diameters of the pipes or hoses used unless a test has proven that longer fibers can be sprayed without blockage.
- *During design of secondary lining fiber content per kg/m^3 of shotcrete shall be derived.*

8.6.3. Synthetic fibers:

Synthetic fibres shall be in accordance with ASTM C1116 or regulations valid in the place of use of the sprayed concrete. Product description of synthetic fibre reinforcement is given below

Name: Structural Synthetic Fibres

Product Description: Macro Structural Synthetic Polypropylene Fibre. Minimum tensile strength 550 MPa. These fibers show very defined ductile behavior characteristics. Performance levels are excellent in shotcrete. Width = 1.6825 Thickness = 0.4822 Length = 65mm Generates

a very high energy absorption rate when used in the concrete mix for shotcreting, enabling the matrix to provide greater flexural toughness.

Since tunnel will be lined with SFRS and its durability is very important for 120 years of life so we proposed higher grade shotcrete. During design of secondary lining synthetic fiber content per kg/m³ of Shotcrete shall be derived.

Grade of mix	FRS	Reference Code	M35
Modelled in Phase² as			*Elasto-Plastic element*
Characteristic Compressive strength(fck) Cube	MPa	IS456:2000	35
Mean Tensile Strength of SFRS	MPa	IS 456:2000	3.5
Allowable Shear strength	MPa	IS15026	5.5
Young's Modulus	MPa	IS 456:2000	29580

Table 12: Shotcrete Properties (SFRS)

8.6.4. Fully Grouted Rock Bolt

Rock Bolt used for tunnel shall be deformed bar type of Fe500D Grade whose characteristic curve is attached ***Annexure-3.*** Grout hole may vary from 38 mm to 45 mm, which will be verified by pull out test up to design load at site.

Modelled in Phase2 as		**Elastic -Element**
Diameter of rock bolts	mm	25
Dia of Grout Hole	mm	38/45*
Steel Grade (Yield Strength)	MPa	500
Cross-sectional Area	mm²	491

Modelled in Phase2 as		Elastic -Element
Yield Capacity	kN	245
Elastic Capacity (0.80x yield)	kN	203.2
Design Capacity Considered (approx)	kN	190

Table 13: Rock Bolt Properties

Specification of Self Drilling Anchor	SDRA 38/19
Outside Diameter (mm)	38
Internal Diameter (mm)	19
Cross Sectional Area (mm^2)	700
Ultimate Load (kN)	500
Yield Load (kN)	400
Weight (kg/m)	5.5
Length of Self Drilling Anchor	4m/6m
Factor of Safety	1.25
Design Capacity (KN)	300KN (Approx.)

Table 14: Self Drilling Anchor Properties

8.6.5. Lattice Girder

Steel of Fe500D grade will be used for lattice girder formation which will be used for poor and very poor rock condition. Adequacy of lattice girder such as size and spacing will be validated by empirical and FEM design.

Support type	Lattice Girder	
Modelled in Phase2 as	Elastic Element	
Description of section	Lattice Girder (25-25-32)	
Depth of section	mm	187
Cross-sectional Area	mm^2	1784
Moment of Inertia	m^4	1.16×10^{-5}
Modulus of Elasticity	MPa	200000
Yield Strength of Steel	MPa	500

Table 15: Lattice Girder Properties

8.7. NATM Tunnelling – Concept

The tunnel construction is proposed to be carried out in accordance with the principles of the New Austrian Tunnelling Method (NATM). The method is based on the concept of a cyclic sequence of excavation with subsequent installation of a primary support (outer lining) followed by the delayed installation of a secondary lining (inner or final lining).

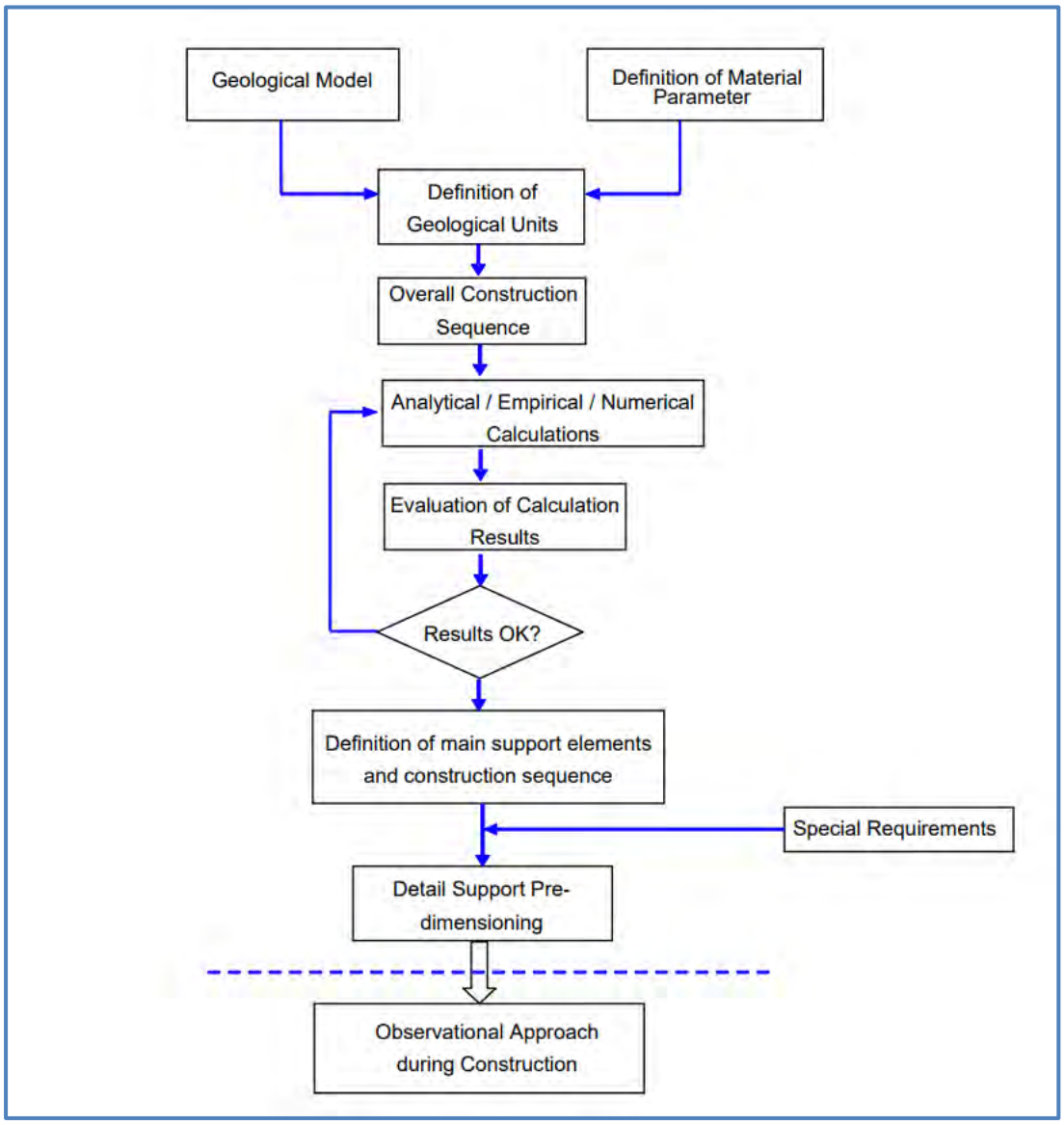
The primary support, which consists of shotcrete, generally reinforced by wire mesh, lattice girders (where required) and rock bolts, will provide the immediate support and stability of the excavation. The secondary lining will provide the long-term support and durability of the tunnel.

Tunnel excavation will generally be carried out by means of drilling & blasting with drilling jumbos in rock or by tunnel excavator in soil. The ground support system will vary from place to place along the tunnel length, depending on ground properties.

8.8. Design Approach

NATM tunnel design shall be based on well accepted empirical, analytical methods and finite element numerical modeling. Empirical method shall be used for preliminary design of support system as per IS:13365 using RMR. Analytical method shall be used as the second method for design calculations for the support system and deflection. After assessing support requirement with empirical and analytical method, numerical method shall be used to check adequacy of support system, deflection and other parameters for tunnel.

The following flowchart shows the general design approach for the primary (outer) lining of NATM tunneling sections.



The design methodology shall cover design phases (preliminary design & definitive design) prior to construction. The design will be adjusted (if required) during construction in an "observational approach".

8.9. Design Methodology for Tunnel Support Design

The support system shall be designed by considering rock mass type, rock mass quality and in-situ stress conditions expected to be encountered along the tunnel alignment as determined by review and assessment of available geotechnical data.

The preliminary support assessment will be carried out using rock mass classification by IS RMR system (Bieniwaski2013). For the analysis, various

parameters like rock strength, joint characteristics, ground water and orientation of discontinuities will be taken into consideration. Support recommendations will be made, based on stress-deformation analysis using RS^2 FEM software. The possibility of any wedge formation and tunnel stability will be also checked with UNWEDGE software (kinematic analysis will be carried out strictly for tunnel which falls in jointed rock mass).

During construction process, the support assessment shall be continuously reviewed to account for the actual geological conditions including joints, bedding, faults and fractures, infill material, surface roughness, water bearing properties and stress state and required changes in designed support shall be made accordingly.

Following steps will be followed to design rock support system of tunnel:

Step 1 : Assess rock type and find rock mass property such as RMR (Rock Mass Rating), GSI (Geological Strength Index), MR_{value}, M_i and UCS (Unconfined Compressive Strength)

Step 2 : From assessed rock mass categorize different class of rock mass using software Roc Data.

Step 3 : Assess major discontinuities available along tunnel alignment and shear strength parameter of joint infill material.

Step 4 : Find unstable wedges formed for defined tunnel section using Unwedge software, if factor of safety is greater than desired ok, otherwise re –analyse with support system as shotcrete and rock bolt at suitable spacing so that factor of safety of unstable wedges become greater than desired.

Step 5: Design preliminary support system by empirical method (IS Code method) using RMR.

Step 6: After design of support system by empirical method use analytical method as a second method to verify the support system.

Step 7: Finally, verify support system by numerical method in following steps.

Step 7A : Model different class of rock/Soil with different rock/soil parameters obtained from Roc Data and also incorporate different stages of excavation.

Step 7B : Simulate and analyse each class of rock/soil without support systems and observe deformation, strength factor and yielded zone.

Step 7C : Simulate and analyse each class of rock/soil with suitable support systems and observe deformation, yielded zone, and strength factor and check suitability of support system provided with capacity plots.

8.10. Wedge Analysis-Kinematic Analysis

Geo-mechanical wedge analysis shall also be carried out for rock portion. Analysis shall be carried out taking into account available joint data as main input and based upon the assumption that the wedges defined by three intersecting discontinuities are subjected to gravitational loading only.

The steps which are taken to support the structural instability caused due to discontinuities shall be as follows-

- Determination of average dip and dip direction of significant discontinuity sets.
- Identification of potential wedges which can slide or fall from the roof or walls.
- Calculation of the factor of safety of these wedges, depending upon the mode of failure.
- Calculation of the amount of reinforcement required to bring the factor of safety of individual wedges up to an acceptable level (FOS 1.5).
- Calculation of the amount of reinforcement required to bring the factor of safety of individual wedges up to an acceptable level (FOS 1.1) with seismic loading.

In this analysis, wedges that will be formed on excavation boundary will be evaluated providing detailed information for each wedge as listed below:

- Weight of the wedge

- Apex height
- Safety factor without support
- Required support pressure
- Bolt type (diameter & design tensile capacity)
- Length
- Pattern spacing (in plane, and out of plane)
- Safety factor with support

8.11. IS Code Method-Tunnel in Rock

IS code 13365 (Part-1) gives guidelines to use support pressure in terms of RMR as load on opening of tunnel which needs to be balanced by support system. In the present case the height of overburden above the crown of tunnel is moderate (varies from 20 m to 40m), hence the ground has been considered as non-squeezing for the design of rock support of tunnel. For non-squeezing ground IS: 13365 (part 1) has recommended following empirical equations for calculating Roof and wall support pressure. For deriving design parameter/roof pressure latest Lawson -Beniawiski RMR method shall be used (10).

The permanent roof support pressure Proof (kN/m^2) can be estimated using the following empirical relationship between the joint number RMR, Density of rock and Span of Tunnel.

$$P_r = \frac{100 - RMR}{100}.10m.\left(\frac{Span}{10m}\right)^{\frac{1}{2}}.\rho_r.\gamma_r$$

By Lawson and Bieniawiski (10)

Where γ_r is partial safety factor and ρ_r density of rock , $\gamma_r = 1$ shall be adopted.

$\mathbf{P_v}$ rock load intensity in kN/m^2

8.12. Ultimate wall support pressure

In view of the more favorable position of walls as compared to roofs, the following formula shall be applied for calculating P_{wall}:

$P_{wall} = K_h x P_v$

Where $K_h = 1-Sin\varphi$

where φ is friction angle

Horizontal Stress Coefficient which shall be taken as 0.5, considering a conservative value of 30 degree.

8.13. Bolt Spacing

Bolt spacing is taken as a function of RMR only. Spacing has to reflect fracture frequency and the need for shotcrete to provide adequate support between the bolts at the better rock end of the scale where the shotcrete cannot realistically be considered as working on its own as an arch. Spot bolting only is assumed to be needed above RMR = 85.

Rock bolt spacing

a) if 20<RMR<=85

$$S_b = 0.5m + 2.5m.\frac{RMR-20}{65}$$

b) if 10 < RMR<= 20

$$S_b = 0.25m + \frac{(RMR-10)^{1.5}}{140}.m$$

c) RMR <=10

$$S_b = 0.25m$$

8.14. Bolt Length

Bolt length must vary with span and RMR. Based on empirical guidelines used in mining and the results of numerical modeling studies, the following relationship was obtained:

$$Span = \frac{(L_b + 2.5)^{\frac{RMR+25}{52}}}{3.6}$$

where Span is width of excavation in meters and L_b is embedded bolt length in meters.

8.15. Rock bolt capacity

Bolt capacity

$$F_{bd} = \frac{F_b}{\gamma_b} \cdot \left(\frac{RMR}{85}\right)^{\frac{40}{RMR}}$$

8.16. Shotcrete capacity

The design capacity of shotcrete support is based on the concept of the shotcrete acting simply as an arch in compression. The basic formula for this type of support is:

Support Pressure = Thickness x design strength / Radius

Design capacity

$$f_{cd} = \frac{f_{ck}}{\gamma_s} \cdot \left[0.2 + 0.8 \cdot \left(\frac{RMR}{100}\right)^{\frac{3}{2}}\right]$$

Wheref_{ck} is shotcrete cylinder strength and γ_s is a partial factor. Ys may be taken as = 1

8.17. : Analytical Method According to Prof. Feder and Erdmann/Duddeck

The detailed geotechnical and structural design of the primary support shall be carried out using the closed-form solutions according to Prof. Feder (Mining University of Leoben, Austria) and the analytical approach according to H. Duddeck / J. Erdmann. The main variables considered in the analyses shall be tunnel overburden, excavation cross-section, ground types and its properties and in-situ stress condition.

The analytical calculation approach after Prof. Feder is based on the closed – form solution for a circular opening in an elastoplastic medium with a primary stress field of K_0 = 1.0. This closed form solution has been extended by Prof. Feder to allow for primary stress fields different from K_0 = 1. Different rock strength parameters in the elastic and the plastic (fractured) zone around the tunnel and volume increase of the rock mass material in the fractured zone due to crack development is considered. The method allows for easy and fast parameter studies regarding the determination of the stress and displacement field around a tunnel. The bending moments are derived by assuming an eccentricity of the normal forces by 1/30 of the sprayed concrete shell thickness or 20mm whichever is higher (according to EN 1992-1-1: 2004).

This analytical calculation approach uses elastic, uniform soil/rock conditions and full shear bond between the elastic lining and the subsoil. Further circular shaped full-face excavation is assumed. As result of the Erdmann / Duddeck calculation normal forces N, bending moments M and shear forces V in the shotcrete shell at the crown, bench and invert – sections are obtained. The analysis according to Erdmann/Duddeck is generally used for shallow tunnels with a low stress-level.

9 Numerical Analysis for Tunnel

9.1 Loads

Following loads shall be considered for design of support system of tunnel excavation. Numerical analysis shall be carried out using FEM program RS^2.

9.2 Dead Load

Dead Load of support element (liner, rib etc.) shall be simulated in FEM program RS^2 by using inbuilt command.

9.3 Rock Load:

In-Situ Stress corresponding maximum vertical cover above the tunnel shall be considered with given horizontal stress coefficient in Table 7.

9.4 Seismic Load

In the underground tunnel, seismic loading is not generally considered, unless any poor ground condition (i.e., fault) is passing through the tunnel.

9.5 External Water Pressure

The water table is below the grade level for most of the reach of tunnel. Hence, no permanent water table anticipated above the tunnel. However, to account for saturation due to rains/monsoons, saturated unit weight is considered in the analysis. Therefore, there is no need to consider the effect of external water pressure on tunnel support system design.

9.6 Future Road Traffic Load

A load of 20 kN/m^2 shall be considered over top of the tunnel for future road traffic.

9.7 Properties of Proposed support system

Properties for support system for tunnel excavation such liner and rock bolts shall be adopted as per working stress method.

9.8 Material Factor of Safety

For rock bolt, lattice girder and steel rib material factor of safety of 1.25 will be taken, while shotcrete will be allowed to yield and its full strength can be used for design of support system.

10 Stages of Analysis in Numerical Method of Design:

The stability analysis of the Tunnel shall be carried out using Finite Element Program RS^2, as a continuum model using Hoek and Brown criteria and stresses and deformations around the tunnel shall be estimated to check the stability of the tunnel. The numerical model of excavated cavity has been conceived as plain strain model with external boundaries as natural surface around tunnel. Six node triangular finite elements with fine meshing shall be used close to the excavation boundaries of the tunnel, so that the variations in the stress field could be captured with higher precision. Size of the elements shall be gradually increased toward the external boundaries to reduce the number of elements and calculation time. External boundaries shall be taken as fixed and in-situ stresses are applied as per the loading corresponding to cover and horizontal stress coefficient obtained for tunnel.

Excavation sequence of the tunnel shall be simulated in the model using the stage construction approach. For all class of rock mass, heading and benching excavation will be simulated. Stage-1 is generation of model and initialization of in-situ stress. stage-2 is material softening of heading portion. stage-3 is heading excavation and support, stage-4 is material softening of benching-1 portion and stage-5 is benching-1 excavation and installation of rock support. stage-6 is material softening of benching-2 portion and stage-7 is benching-2 excavation and installation of rock support.

10.1 Sensitivity Analysis:

While doing Analysis and design of tunnel support system specifically in soil where parameters are very sensitive and has serious impact on requirement of tunnel support system, deflection and method of excavation.

Following parameters are sensitive.

1. Overburden depth in soil (H)
2. Cohesion Value of Soil C
3. Friction Angle value of Soil φ
4. Deformation Modulus of Soil E

As per GIR and Longitudinal profile specifically in soil overburden depth varies between 8m to 40m while other parameters are varying too, which has been taken from Table 5-7 of GIR as follow.

SOIL			
Properties	**Values**		
	Silty Sand(SM)	**Inorganic Silt (ML)**	**Clay (CL)**
Modulus of Elasticity (E)	28-30 MPa	10-40 MPa (increasing with depth)	10-28 MPa (increasing with depth)
cohesion (kgf/cm^2)	0.04-0.08	0.11 – 0.14	0.25 – 0.35
friction angle (Deg.)	26-27	23 – 28	10 – 16
unit weight (γ) (gm/cc)	1.90-1.91	1.7-1.8	1.8-2.0

For sensitivity analysis of support system above mentioned 4 Parameters shall be varied and its adequacy shall be checked.

10.2 Interpretation of Results

The analysis results shall be used to investigate the influence of geometry and in-situ stress variability on stress changes. The induced stresses in the plane of the analysis can be viewed by means of stress contour patterns in the region surrounding the excavations. As a tool for interpreting the amount of deviatory overstress (principal stress difference) around openings, strength factor contours give a quantitative measure of "(strength) / (induced stress)" according to failure criterion for the rock mass. Adequacy of rock support system as estimated by rock classification approach will thus be verified. Analysis results will provide the following information.

- Deformation of tunnel calculated by FEM analysis shall be permitted up to 1% of the excavated size of the opening. If deformation is more than 1%, these cases shall be treated separately.
- Depth of Plastic Zone: It will be used to check the adequacy of bolt length.
- Utilization of Rock Bolts and Liners: Utilization of rock bolt shall be assessed by its axial force, while utilization of steel liners will be assessed through capacity plot with significant factor of safety to cater uncertainty of geological parameters.
- Shotcrete will be modeled as elasto-plastic element and its yielding will be allowed below springing line as this will not depict complete failure of shotcrete.

10.3 Instrumentation and Support Performance

In NATM, the primary purpose of geotechnical and structural instrumentation is to monitor the performance of the underground construction process in order to avoid or mitigate problems. Instrumentation and monitoring scheme for NATM tunnel shall be submitted by contractor to Engineer for approval.

List of Instrumentation to be provided in NATM tunnel is given below in table 16.

S. No	Instrumentation Details	Locations of Instrumentation to be provided in tunnel
1	3 Point MPBX	3 Nos of 3 Point MPBX at every 50 m.
2	Optical 3-D Deformation Monitoring	7 Point Optical Convergence Array (with accuracy of 1 mm) at every 25 m.
3	Roof settlement Point	1-Point roof settlement at every 25m.
4	Load Cells	five center hole load cells (with accuracy 0.5%) of250 kN capacity at identified locations as approved by the Engineer.
5	Pressure Cells	7 Nos of Pressure cells of 100 bars (accuracy 0.25%) at each section at every 100 m.
6	Switch Box	2 Nos of Switch Box at every 50 m
7	Strain Gauge	7 Nos of Strain Gauge per section @ every 100 m.

Table-16: Instrumentation Proposed for Tunnel Excavation

11 *Design of RCC Portal*

RCC portal with adequate thickness shall be designed at both end of NATM Tunnel for a length of 10m. Final thickness of portal members and size shall be decided as per structural design of portal.

11.1. Material Properties

- **Concrete**
  - Grade of Concrete: M35
  - Young's Modulus of Concrete (E) :29580MPa (as per IS 456:2000)
- **Reinforcement steel**

The steel for structural reinforcement shall correspond to Fe 500D according to IS 1786-2008:

Young's modulus : E=200 GPa

Yield strength : f_y=500 MPa

11.2. Methodology for Design of RCC Portals

The structural analysis of portal frame shall be carried out using 2D model. The model shall be analyzed for various load combinations using STAAD Pro software. The resulting moments and forces shall be used to verify the ultimate limit state of collapse. The beam and columns of portal shall be designed for Limit state of collapse. The area of the footings shall be fixed on the basis of the allowable bearing pressure and the applied loads and moments under service load conditions.

11.3. Design Assumptions

(a) Unit Weights:

Following unit weights for different materials shall be considered for the design:

Material	**Unit weight (kN/m^3)**
Reinforced Concrete	25
Rock	27
Soil-rock debris	22

(b) Site Specific Peak ground acceleration for DBE shall be 0.24 g.

Portal frame structure shall be considered as primary structure with importance factor 1.5 and IS456:2000 shall be adopted for design and detailing.

(c) Response reduction factor shall be taken as 3.

(d) Allowable Bearing Capacity:

The allowable bearing capacity of rock mass shall be calculated as per IS:12070 – 1987. Allowable Bearing capacity of soil shall be calculated from the shear strength parameters of the soil as per GIR .

11.4. Boundary Conditions

The model of portal frame shall be fixed at foundation level.

11.5. Design Loads

The following loads shall be applied to the frame model:

(a) Dead load [G1]

(i) The dead load shall include self-weight of structural concrete. The self-weight of structural concrete is calculated internally by STAAD Pro software.

(ii) Rock Load: Distribution of rock loading on the portal beam along its length shall be assumed as triangular with 45° dispersion at the ends.

(b) Live Load [G2]

Live load to be applied on the beam element of portal frame shall be as follows:

Accidental Load: Uniformly distributed load corresponding to 2.0 m height of soil-rock debris over portal beam shall be considered to account for additional load in the event of slide of rock mass.

(c) Earthquake Load (EQ):

Lateral loads on joints at the beam level shall be applied on the structure.

Wind load and temperature load shall not be considered for the design.

11.6. Load Combinations

Following load combinations shall be considered as applicable loading conditions for the structure:

11.6.1. Ultimate Limit State (ULS)

I $=1.25\times G_1$
II $=1.25\times G_1+1.70\times G_2$
III $=1.25\times G_1+1.70\times G_2+1.6\times EQ$

11.6.2. Serviceability Limit State (SLS)

I $=1.0\times G_1$
II $=1.0\times G_1+1.0\times G_2$
III $=1.0\times G_1+1.0\times G_2+1xEQ$

11.6.3. Concrete Cover

Nominal cover to the reinforcement shall be provided considering mild exposure condition of weather and 1.5 hours of fire resistance. The nominal cover to the reinforcement (including links) shall not be less than dia of bar or 20 mm (for mild exposure). The nominal concrete covers adopted for the different members are as below:

Beam	35 mm
Columns	50 mm

11.6.4. Reinforcement

All members shall be designed based on IS 456: 2000. The reinforcements are designed to resist factored flexural moments, shear forces and axial forces for the most critical combination of loads. Shear reinforcement is designed as per the provisions stipulated in IS 456:2000

11.6.5. Crack width

A maximum crack width of 0.25 mm (moderate durability exposure) is proposed. The crack width will be calculated in accordance with IS 456-2000 or RCC shall be designed such that tensile stress in lining is within cracking strength.

11.6.6. Deflection:

The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, roofs and all other horizontal members, should not normally exceed Span/250.

12 Secondary Lining Design

Secondary lining shall be provided in complete length of NATM tunnel. RCC lining shall be provided in soil portion tunnel and initial 20 m reach of Portal P1 of rock. The minimum grade of concrete shall be M35. Minimum thickness of secondary lining shall be 300mm.

12.1 Method of Analysis

A two-dimensional Plane Frame Analyses shall be performed using the computer program STAAD Pro. V8i SS5. A near realistic 2Dmodel using beams bedded by radial and tangential springs shall be considered. Analysis and design shall be carried out as per CBC.

12.2 Calculation of Spring Constants

The lining shall be modeled as a beam bedded by springs. Multiple beam elements shall be created along centroidal axis of lining subtending angle of 5^0 to 10^0 representing linear 2D structure.

Beam model spring constants shall be derived from following formula:

$$C_r = K_S \times A$$

$$K_S = \frac{E}{(1+\nu)\times R}$$, **From EM 1110-2-2901**

where:

Cr = Radial Spring Constant of soil/rock

A= Tributary area of beam element

Ks = Modulus of Sub grade reaction

E… Young's Modulus of soil/rock (As per GIR)

v Poisson's Ratio of rock mass (As per GIR)

R…. Radius of Tunnel (with R ≤ 7 m)

The tangential spring constants are set as 1% of normal (radial) spring constants:

Kt = 0.01× Ks

12.3 Load Cases

12.3.1 Self-Weight [G1]

The volume used for calculation of self-weight of structures is based on the nominal dimensions of the structure. Self-weight of the reinforced concrete lining will be calculated with unit weight of concrete of y_{con}=25kN/m^3.

Self-Weight will be considered as dead load with partial load safety factor of 1.25 as per IRS – CBC 1997.

12.3.2 Invert Fill [G1]

As the invert fill is acting favorable on the tunnel invert, this load is not considered in the analysis.

12.3.3 Exhaust Fan & Overhead System [G1]

An overhead system for exhaust fan load is considered to be acting on inner lining of the tunnel. These systems are directly fixed by anchors. A suitable load on 7.2kN acting apart 1m shall be applied to inner lining.

An overhead system is considered as a single vertical concentrated load with a value of *3.0* kN placed 1m horizontal from the centerline of the tunnel on the left side of the arch.

A load factor of 1.25 is considered as per as per IRS – CBC 1997.

12.3.4 Earth Pressure [G2]-Rock

With regard to vertical rock pressure (vertical load of overburden to the lining),) following loads are considered to be l to be applied on lining:

Earth Pressure shall be calculated based on RMR value of different class of rock.

$$P_r = \frac{100 - RMR}{100}.10m.\left(\frac{Span}{10m}\right)^{\frac{1}{2}}.\rho_r.\gamma_r$$

By Lawson and Bieniawiski

Where γ_r is partial safety factor for lining design this will be equal to unity and ρ_r density of rock.

P_v rock load intensity in kN/m^2

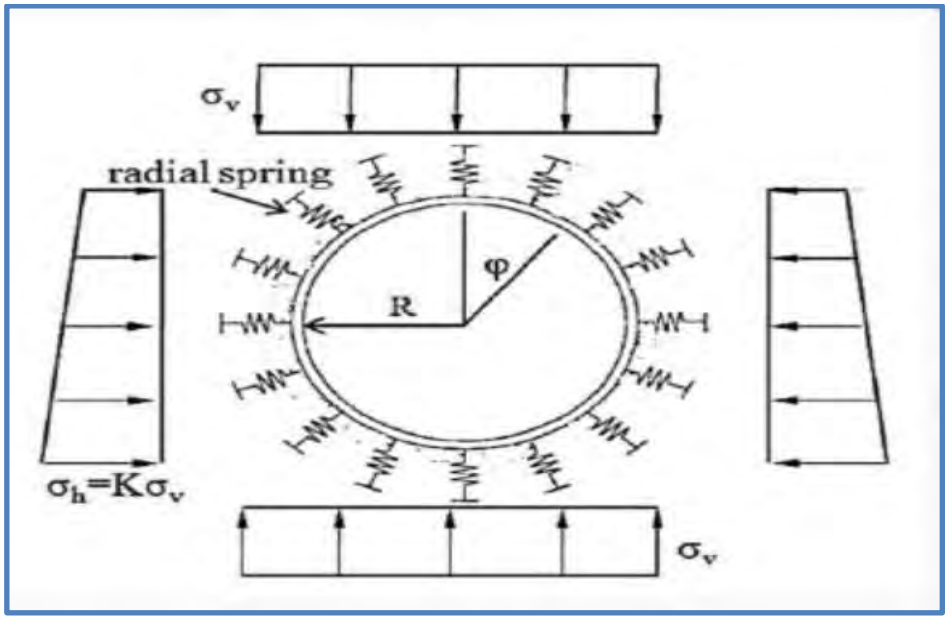
The effective lateral earth pressure is equal to the product of load due to weight of overburden and coefficient of lateral earth pressure K_0. The assumed Earth Pressure Coefficient $K_0 = 0.5$

Earth pressure is considered with partial load safety factor of 1.70 as per IRS – CBC 1997.

12.3.5 Earth Pressure [G2]-for Soil:

With regard to vertical earth pressure (vertical load of overburden to the lining) the same shall be applied as follows:

For soil, earth pressure σ_v shall be given by equation $\sigma_v = H^*\gamma_s$ subject to a maximum of $D^*\gamma_s$ where H is height of overburden. For secondary lining design earth pressure shall be applied as indicated in sketch below.



12.3.6 Lateral Load for Rock and soft ground:

The effective lateral earth pressure is equal to the product of load due to weight of overburden and coefficient of lateral earth pressure K0. The invert loading shall be applied up to springing line as per given vertical load distribution. For lining design both for rock and soil K value shall be considered as 0.5.

12.3.7 Shrinkage [G3]

The self-tension of the tunnel bearing elements due to concrete shrinkage is simulated as uniform cooling of the lining. The amount of lining deformation is calculated according to IS 456 -2000 and converted into uniform cooling temperature difference of -15°C.

Since the internal forces due to shrinkage results from constraint deformation the partial load factor shall be set equal to 1.25 as per IRS – CBC 1997.

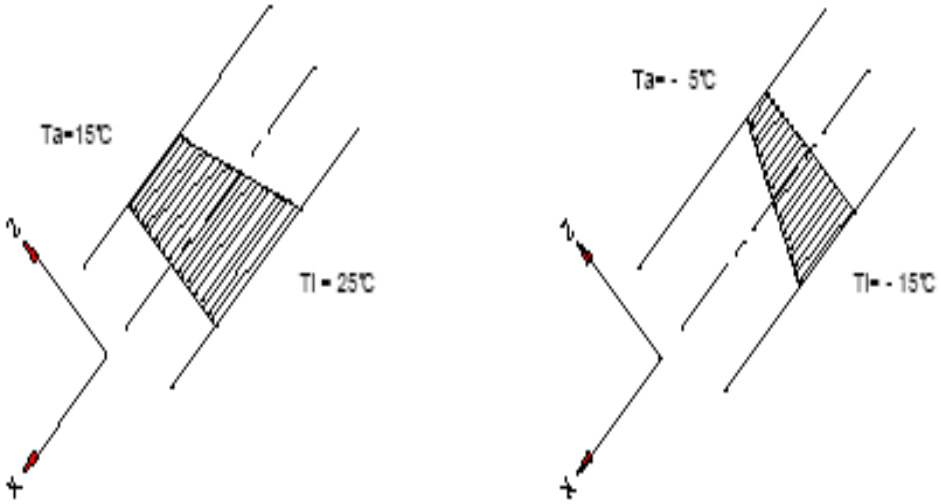
12.3.8 Water Pressure [G4]

Water pressure on permanent lining shall be considered as per "design water table" along tunnel.

12.4 Live Loads [Q]

12.4.1 Temperature Load [Q1]

The temperature loads are applied only onto the tunnel arch above the construction joint. An average temperature during construction equal to t_m=+10° is assumed and active temperature differences acting on the tunnel lining are taken as follows:



b) Since the internal forces due to temperature differences result from constraint deformation the partial load safety factor according is adopted equal to 1.15 for ULS and 0.80 for SLS as per IRS – CBC 1997.

12.4.2 Earthquake

In general, subsurface structures are subjected to much less stress in earthquake than buildings/structures above ground. These stresses reduce with increase in depth. So, it can be assumed that earthquake induced stress in tunnel are much lower due to earthquakes. As a rule, tunnels are not designed for earthquake forces. (PI refer "Guide 853.9120 to 853.2001 DB directive", concerning paragraph 16).

Hence, the effect of earthquake force is not considered for structural design of tunnel inner lining.

Further, to verify this assumption, effect of seismic on tunnel evaluated as described in literature "***Seismic design and analysis of underground structures***" by YMA Hashish, JJ Hook, Birger Schmidt and John I-Chiang Yao (ref Tunneling and Underground Space Technology 16 (2001) 247-293) shall be considered and manually seismic forces induced shall be considered.

But at initial 20m reach of the portal tunnel lining shall be designed for earthquake forces due to inclined cutting /movement of overburden of portal slope.

12.4.3 Applied load cases

The applied load cases will be following:

- G_1 Self weight (Includes Fan & Overhead System Weight)
- G_2 Earth pressure
- G_3 Shrinkage
- Q_1 Temperature loads (winter and summer)
- E Earthquake loads

The general formats for combinations of actions for the ultimate and serviceability limit states as given in Indian Railway Standard- Concrete Bridge Code 1997 (IRS-CBC), Table-12

The partial factors for actions and combination of actions are taken from IRS Concrete Bridge Code 1997.

The load combinations used for the calculation are listed in the following tables.

12.4.4 Ultimate Limit State (ULS)

Calculations of ultimate limit state consider the following load combinations: Ordinary load combinations:

I $=1.25\times G_1$
II $=1.25\times G_1+1.70\times G_2$
III $=1.25G_1+1.70\times G_2+1.25\times G_3$
IV $=1.25\times G_1+1.70\times G_2+1.25\times G_3+1.15\times Q_{1,summer}$
V $=1.25\times G_1+1.70\times G_2+1.25\times G_3+1.15\times Q_{1,winter}$

12.4.5 Serviceability Limit State (SLS)

Calculations of serviceability limit state consider the following load combinations:

I $=1.0\times G_1$
II $=1.0\times G_1+1.0\times G_2$
III $=1.0\times G_1+1.0\times G_2+1.0\times G_3$
IV $=1.0\times G_1+1.0\times G_2+1.0\times G_3+0.80\times Q_{1,summer}$
V $=1.0\times G_1+1.0\times G_2+1.0\times G_3+0.80\times Q_{1,winter}$

12.4.6 Structural design method

The structural design is carried out in accordance with EN 1992 as Indian codes does not provide any guidelines for design of plain cement concrete

Load combinations for the Ultimate Limit States (ULS) and the Serviceability Limit States (SLS) are considered for the reinforcement design as described in section above.

Partial safety factors for materials for ultimate limit states are adopted according to Indian codes IS456- 2000

Load Combination	*Concrete*	*Reinforcement Steel*
Ordinary Load Combination	**1.5**	**1.15**

Table-17: Partial factors for materials for ULS

12.4.7 Concrete cover

The minimum concrete covers to all reinforcement (main and distribution reinforcing bars) considering the exposure conditions are adopted as follows:

- Concrete exposed to earth (external face) 50 mm
- Concrete not exposed to earth (internal face) 40 mm

12.4.8 Crack width

A maximum crack width of 0.2 mm (moderate durability exposure) is proposed. The crack width shall be calculated in accordance with IS 456-2000 or RCC shall be designed such that tensile stress in lining is within cracking strength.

13 Design Basis for Cut and Cover Tunnel

The following Cross Section of Cut & Cover Structures shall be used as described in Figure7. As per proposed alignment where soil cover is less than 10m, twin rectangular Cut and Cover tunnel is proposed.

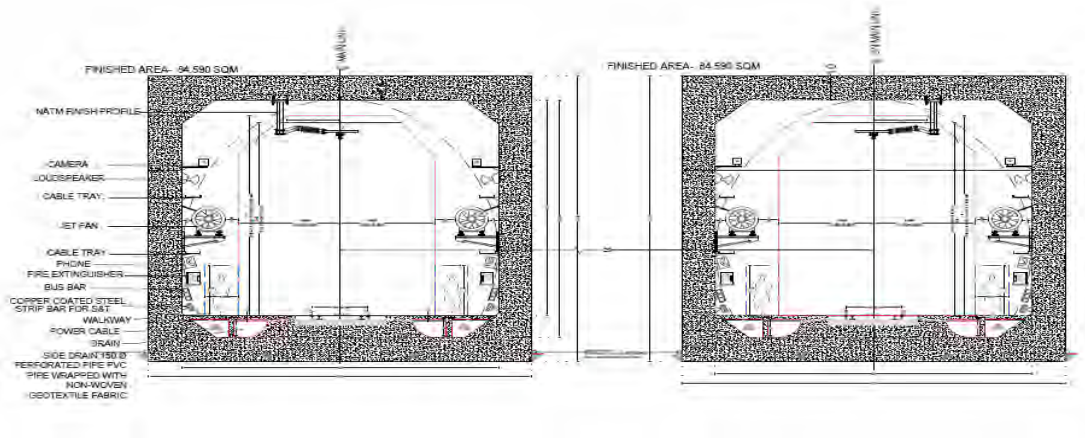


*Figure 7:*Twin Rectangular Shape Cut and Cover for Two Single track

The proposed cross section is preferred over a circular crown section due to anticipated difficulties by the construction agency.

13.1 Soil parameters

The following geotechnical parameters have been considered for the analysis and design of Cut & Cover structures.

Below Mentioned soil parameter for Cut and Cover has been taken from Table 3.3 of GIR.

Location	Depth from N.G.L in m.	Group of sample	Cohesion (C) in KPa	Angle of internal friction (Φ)	E (in MPa)	Safe Bearing Pressure for 25 mm settlement in T/m²	Recommended SBC in T/m²
BH-32	21.0	ML	4	26	31	39.0	35
	24.0					35.0	35
BH-33	20.0	ML-CL	8	26	27.6	27	27

Table-18: Soil parameter for Cut& cover Box

13.2 Cast in place concrete

- Specified characteristic compressive Cylinder strength f_{ck} = 35 N/mm^2 (Concrete Grade M35 according to IS 456:2000)
- Young's modulus: E = 29580 MPa
- Poisson's ratio: v = 0.2
- Unit weight: Y = 25 kN/m^3
- The steel for structural reinforcement shall correspond to Fe 500 according to IS 1786-2008:
- Young's modulus E=200 Gpa
- Yield strength f_{yk}=500 MPa

13.3 Concrete cover

For Underground structural elements in contact with non- aggressive soil

Sl. No.	Structural Components	Nominal Cover(mm)
1.	Inner slabs, walls	50
2.	Outer slabs	70
3.	Walls outer	70

13.4 Crack Width

All structural concrete elements shall be designed to prevent excessive cracking due to flexure. The maximum crack widths shall be as specified below.

A. Permissible crack width

Flexural crack width for different structural components is to be checked for all the load combinations at service stage except for instantaneous loading like seismic, winds.

1. For Members in Contact with Soil: -
   - 0.2mm for soil face
   - 0.3mm for inner face

13.5 Calculation of Spring Constants

The cut and cover box are modelled as a beam bedded by springs.

Beam model spring constants are derived from modulus of sub grade reaction Ks, which is calculated from: Ks= E / [1+ν) **From EM 1110-2-2901**

where: E… Young's Modulus of soil/rock mass

ν …Poisson's Ratio of soil/rock mass = 0.2

The spring constant of a bedding spring representing a certain area A of sub grade is derived as: (Ks x A) per meter.

For a typical E value of 30 MPa, Ks=25 MPa/m i.e. 25000 kN/m^2 /m

13.6 Primary Load case for Cut and Cover

13.6.1 G1 -Self-Weight:

The structural thickness/sizes of various elements are described in STAAD input and self-weight of all these members are calculated by STAAD itself by specifying the density of material used.

Density of reinforced concrete is considered as 25 KN/m3.

13.6.2 G2-Lateral Earth Pressure on Wall

The walls of the cut and cover tunnel will have compacted granular backfill and for that the soil properties proposed for design are as follows:

E = 15000 KN/m^2

Angle of Friction (Ø) = 30 degrees

Unit Weight (γ) = 20 KN/m^3

K_o the initial geological earth pressure at rest coefficient is used in the ground/structure interaction analysis with design earth pressure at rest (K_o = 0.5)

LEP at top of Roof slab (K_oγH)

13.6.3 G3- Weight of Fill

This load corresponds to dead weight of soil above roof of box. It is height of fill above top slab multiplied by density of soil.

13.6.4 E1 -Earthquake/Seismic Load

Following the seismic mapping as per Indian Seismic Zoning Map IS 1893 and 1984, the project site is situated in seismic zone *IV*. Seismic coefficient has been calculated as per IS 1893-1:2002,

As per IS 1893:2002, the design horizontal seismic coefficient (Ah) for a structure shall be determined by the following expression:

$$Ah = (ZISa) / (2Rg)$$

The description and values of above variables as per viii are provided below:

Z: Zone Factor = 0.24 (for Seismic Zone IV)

I: Importance factor = 1.5

Sa/g:Average response acceleration factor = 2.5

R Response reduction factor = 3.0 (OMRF)

Hence, the design horizontal seismic coefficient (Ah), using above values has been calculated as,

$$Ah = 0.15$$

Seismic load due to earth pressure from soil has been calculated in accordance with IS 1893-2002, wherein Dynamic earth pressure (full value) is considered up to a depth of $0.5H_T$ (where H_T = Depth to bottom of Tunnel box) and reduces linearly from this value to half of this value at the base of the structure.

Dynamic lateral soil pressure increments at top of box = $A_h \times \gamma \times H_T$

Dynamic lateral soil pressure increments at Bottom of box = $0.5*A_h \times \gamma \times H_T$

13.6.5 Future Road Traffic Load [G2]

A load of 20 kN/m^2 shall be considered over top of the tunnel for future road traffic.

13.6.6 Exhaust Fan & Overhead System [G1]

An overhead system for exhaust fan load is considered to be acting on inner lining of the tunnel. These systems are directly fixed by anchors. A suitable load on 7.2kN acting apart 1m shall be applied to inner lining.

An overhead system is considered as a single vertical concentrated load with a value of 3.0 kN placed 1m horizontal from the centerline of the tunnel on the left side of the arch.

A load factor of 1.25 is considered as per as per IRS – CBC 1997.

13.7 Applied load cases

The applied load cases will be following:

G1 Self weight (Includes Fan & Overhead System Weight)

G2 Earth pressure & Future Road Traffic Load

G3 Weight of Fill

Q1 Temperature Loads (Winter and Summer)

E1 Earthquake loads

The general formats for combinations of actions for the ultimate and serviceability limit states as given in Indian Railway Standard- Concrete Bridge Code 1997 (IRS-CBC), Table-12

The partial factors for actions and combination of actions are taken from IRS Concrete Bridge Code 1997.

13.8 A layer of PCC of grade M20 150 mm thick shall be provided below bottom slab of the Cut and Cover tunnel.

13.9 Analysis Method of Cut and Cover

A two-dimensional Plane Frame Analyses are performed using the computer program from STAAD Pro. V8i SS5. A near realistic 2Dmodel using beams bedded by springs has been created and loads have been applied using STAAD command Springs have been generated by using Staad command and reference can be made to STAAD manual for further details.

The bedding is modeled in such a way that the parts of the cross-sections where inward deformation occurs, i.e. where the springs would be subject to tensions, are neglected. The material behavior of ground and lining is generally assumed as being elastic.

After applying all the forces on the model in STAAD Pro .The loads are combined as per the prescribed and the Members are checked for the load combiation for Ultimate Limit State (ULS) and Serviceability Limit State (SLS).

ULS Load Combinations

I $=1.25\times G_1$

II $=1.25\times G_1+1.70\times G_2$

III $=1.25\times G_1+1.70\times G_2+1.25\times G_3$

IV $=1.25\times G_1+1.70\times G_2+1.25\times G_3+1.15\times Q_{1,summer}$

V $=1.25\times G_1+1.70\times G_2+1.25\times G_3+1.15\times Q_{1,winter}$

SLS Load Combinations

I $=1.0\times G_1$

II $=1.0\times G_1+1.0\times G_2$

III $=1.0\times G_1+1.0\times G_2+1.0\times G_3$

IV $=1.0\times G_1+1.0\times G_2+1.0\times G_3+0.80\times Q_{1,summer}$

V $=1.0\times G_1+1.0\times G_2+1.0\times G_3+0.80\times Q_{1,winter}$

Seismic Load Combinations

Min V/ Max H == $1.0 \times G_1 + 1.0 \times E_1$

Max V/Max H = $= 1.0 \times G_1 + 1.0 \times G_2 + 1.0 \times G_3 + 1.0 \times E_1$

Where G1, G2 , G3, E1 and Q1 is explained in Para 8.1.2.4

The Normal force, Bending moment and shear force for all members are taken from the Staad Pro and designed as per ,''*IS 456:2000 Plain and Reinforced Concrete (Fourth Revision)* .

Deflection:

As per clause No-23.2 of IS456:2000 Deflection of Top slab and Wall shall be restricted to Span/250 and H/250 respectively.

14 Cross Passages

Cross passages shall be provided at maximum distance of 350m c/c. The main purpose of cross passage is to connect the running twin tunnels for the purpose of emergency egress. The cross passages shall be constructed by NATM method and temporary support using rock bolt, shotcrete linings and lattice girders. The design of the temporary support will encompass issues such as:

- Temporary face stability and support;
- The need for ground treatment and/or pre-support measures;
- Control of groundwater; and
- Excavation and support sequencing to limit ground movement.

For cross passage Concrete lining of minimum thickness 250mm shall be used.

Primary support and secondary lining Design shall be carried similar to main tunnel.

15 Permanent Ventilation Shafts

15.1 To minimize ventilation requirement four rectangular permanent ventilation shafts at Chainage Km 26+080 and Chainage Km 27+680 have been provided. Size of rectangular ventilation shaft shall be 25m x 12m (clear opening). At the locations of permanent ventilation shafts it is mandatory to provide connecting cross passage with clear opening as shown in Tender drawings. All the permanent ventilation shafts shall be of RCC and shall be designed for all the loadings during construction and design life.

15.2 Permanent ventilation shafts shall be designed for all load cases and combination as mentioned in *Clause 13 of this DBR. Inspection arrangements of permanent ventilation shafts during service life shall also be designed by the Contractor.*

15.3 *Precast /Cast in Situ PSC/RCC roofing system over the shafts with proper ventilation arrangement shall be designed by the Contractor as per relevant IS Codes/NBC. Each shaft shall be provided with steel access door at natural ground level having sturdy locking arrangement with anti-theft features.*

16 Construction cum Utility Shaft

16.1 *A construction cum utility shaft shall be provided at Chainage Km 26+950. The main purpose of construction shaft is to provide multiple faces to expedite the tunnel excavation and to provide access for utilities to the tunnel. At the location of construction cum utility shaft cross passage shall be provided having the same cross-sectional area as the main tunnel.*

16.2 *Construction cum utility shaft shall be designed for all load cases and combination as mentioned in Clause 13 of this DBR. Inspection arrangements of construction cum utility shaft during service life shall also be designed by the Contractor.*

16.3 *Precast /Cast in Situ PSC/RCC roofing system over the shaft with proper ventilation arrangement shall be designed by the Contractor as per relevant IS Codes/NBC. Shaft shall be provided with steel access door at natural ground level having sturdy locking arrangement with anti-theft features.*

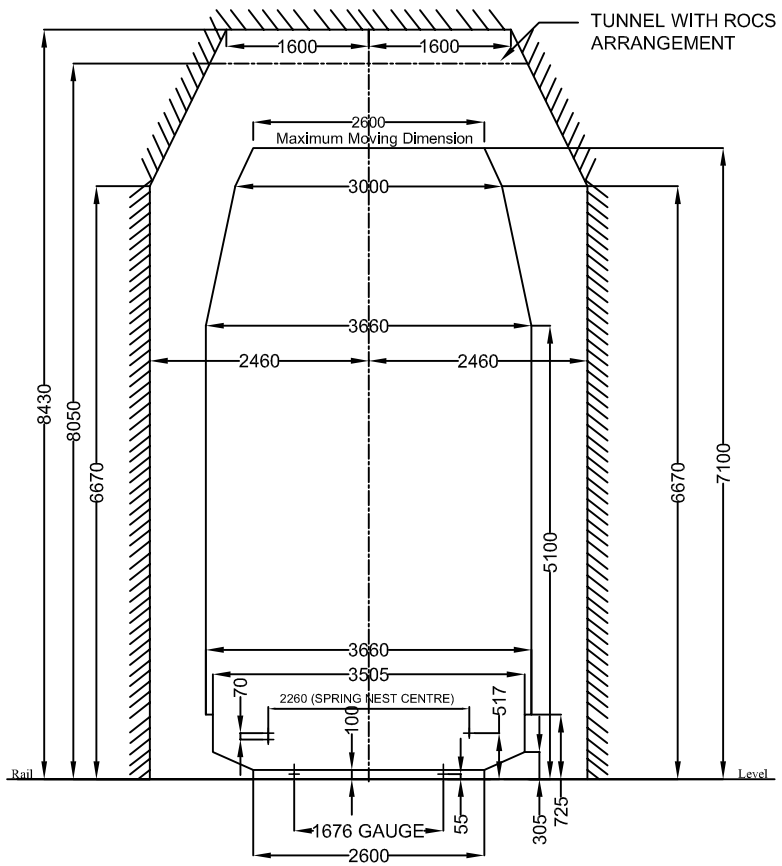
Annexures

ANNEXURE – 1

MMD AND FIXED STRUCTURE GAUGE FOR TUNNEL AND THROUGH GIRDER BRIDGES FOR HORC PROJECT OF HRIDC

(Applicable at location of connectivity at Palwal, Patli, Sultanpur, Asaudha and Harsana Kalan (Single Line)

Fixed Structure Gauge



NOTE :-

(i) ALL DIMENSIONS ARE IN MILIMETRES EXCEPT WHERE OTHERWISE SHOWN.

(ii) THE TRACK SHALL BE BALLASTLESS.

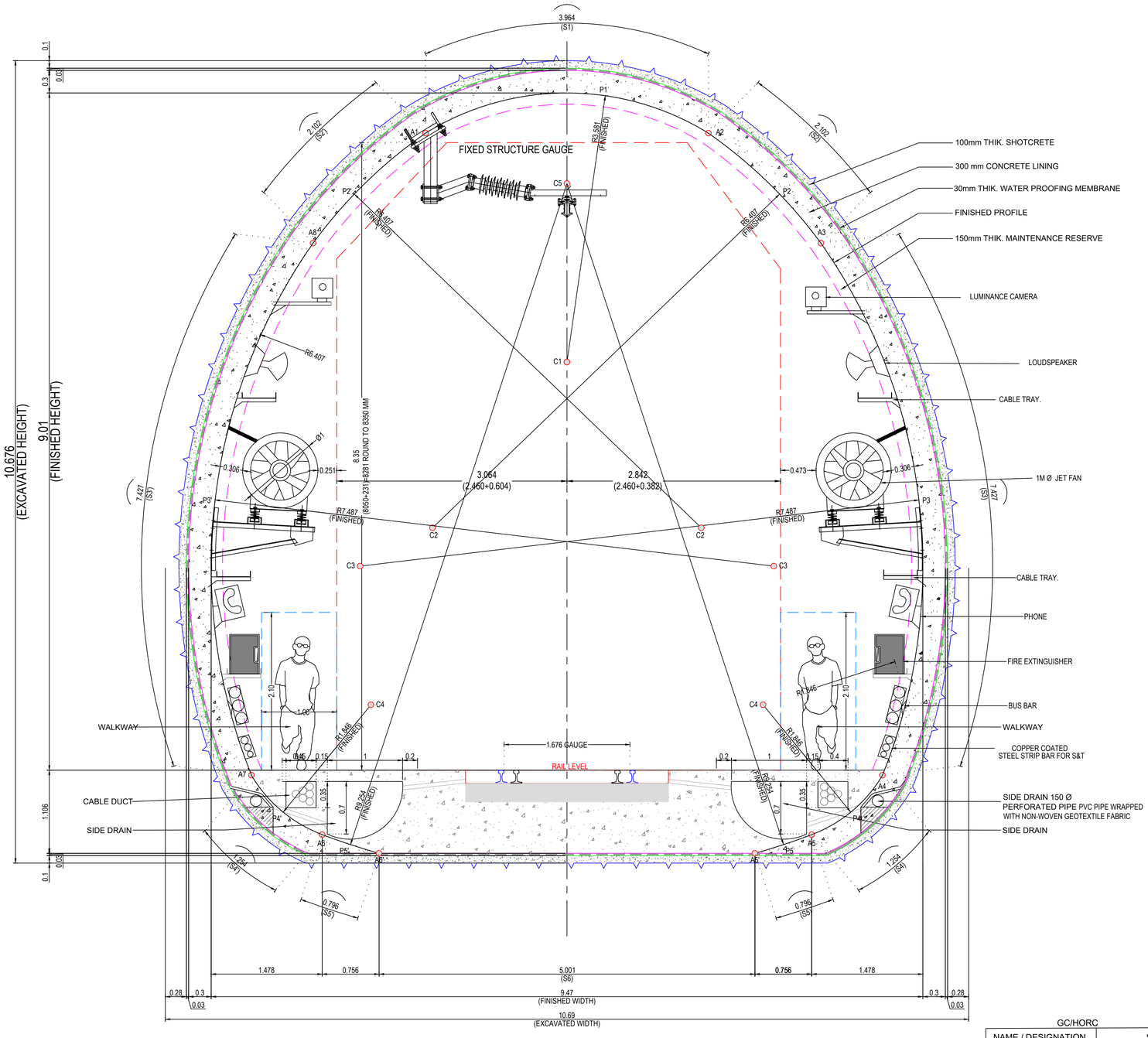
(iii) EXTRA HORIZONTAL CLEARANCES REQUIRED ON CURVES SHALL BE AS PER APPENDIX OF IRSOD (BG), REVISED - 2022.

(iv) EXTRA VERTICAL CLEARANCE SHALL BE PROVIDED ON CURVES AS UNDER:

$$\text{EXTRA VERTICAL CLEARANCE (MM)} = \frac{\text{WIDTH OF MMD(MM) X SUPERELEVATION (MM)}}{\text{DYNAMIC GAUGE (MM)}}$$

(v) HEIGHT OF FIXED STRUCTURE GAUGE WITH ROCS ARRANGEMENT WOULD BE 8050MM.

(vi) IN CASE OF BALLASTED TRACK, NECESSARY PROVISION SHOULD BE MADE IN OVERHEAD STRUCTURES AND OVERHEAD EQUIPMENT TO PERMIT POSSIBLE RAISING OF TRACK BY 275mm IN FUTURE TO CATER TO INCREASED HEIGHT OF TRACK STRUCTURE AND OTHER UNFORESEEN FACTORS SUCH AS RE-GRADING etc.



NOTES:-

1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METER, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
3. TUNNEL EXCAVATED BY HEADING AND BENCHING METHOD (NATM).
4. THE GRADE OF SHOTCRETE WITH SFRS AS PER DETAIL DESIGN.
5. NEAR PORTAL PULL LENGTH SHOULD BE LIMITED TO 500 MM, ONLY AFTER SUPPORTING EXCAVATED STRETCH (500 MM) ,THEN NEXT CYCLE OF EXCAVATION SHALL BE CARRIED OUT .
6. IT IS PROPOSED TO PROVIDE 50 MM THICK SFRS IMMEDIATELY AFTER EXCAVATION OF FACE .
7. IT IS PROPOSED TO PROVIDE 100 MM THICK SFRS ON SLOPE PROTECTION. ALTERNATIVELY, PLAIN SHOTCRETE WITH WIREMESH 150x150x5mm MAY ALSO BE USED.
8. PROPOSED ROCK BOLT SHALL BE WITH FOLLOWING SPECIFICATION CONFORMING TO IS 1786 ,DIAMETER OF ROCK BOLT =25 MM , GRADE OF ROCK BOLT Fe415 FULLY GROUTED ,SIZE OF ANCHOR PLATE =150X150X8MM
9. PROPOSED SUPPORT SYSTEM IS BASED ON GIR PROVIDED BY GEOLOGIST. ACTUAL SUPPORT SYSTEM MAY BE REVISED BASED ON ACTUAL RESPONSE OF STRATA DURING EXCAVATION.
10. THE NUT OF THE GROUTED ROCK BOLT SHALL BE TIGHTENED 12 HOURS AFTER INSTALLATION TO ACHIEVE A FORCE AT THE ANCHOR PLATE OF APPROX. 20KN. THIS FORCE SHALL BE APPLIED BY CALIBRATED TORQUE WRENCH.
11. THE LENGTH AND THE DIRECTION OF ROCK BOLTS MAY BE ALTERED IN CONSULTATION WITH SITE GEOLOGIST AND ENGINEER-IN-CHARGE. WHEREVER REQUIRED, ADDITIONAL SPOT BOLTING SHALL BE DONE IN LOCALIZED AREA OF POTENTIAL INSTABILITY OR WEAKNESS AS DETERMINED DURING EXCAVATION.
12. SLOPE SUPPORT SHALL BE INSTALLED AS EXCAVATION PROGRESSES SUCH THAT NOT MORE THAN 2.0m VERTICAL HEIGHT OF SLOPE IS LEFT UNSUPPORTED AT ANY TIME.
13. PULLOUT TEST SHALL BE CARRIED OUT ON ROCK BOLTS FOR 190KN. .
14. DRAINAGE PIPE SHALL BE 150mmØ, PERFORATED PVC PIPE WRAPPED WITH NON-WOVEN GEOTEXTILE FABRIC AS PER IS-4984.
15. EXCAVATION SEQUENCE WILL BE PROVIDED BASED ON GFC.
16. EXCAVATION AT EAST PORTAL LOCATION SHALL BE MATCHED WITH DEEP CUT EXCAVATION.
17. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK.
18. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING.
19. DIMENSIONS OF PRIMARY SUPPORT & CONCRETE ARE TENTATIVE.
20. 230V SOCKET AT 200M INTERVAL FOR S&T SYSTEM SHALL BE PROVIDED.
21. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
22. ANCHOR BOLT FOR ROCS SHALL BE INSTALLED DURING TUNNEL LINING.
23. CABLE CROSSING SHALL BE PROVIDED AT EVERY CROSS PASSAGE.
24. LUMINANCE CAMERA, LOUDSPEAKER, JET FAN, PHONE, BUS BAR, COPPER COATED STEEL STRIP BAR FOR S&T AND ROCS WORK (EXCLUDING ANCHOR BOLTS) IS NOT IN THE SCOPE OF WORK OF C-4.

S.N.	CURVE NAME	RADIUS (m.)	START	END	ARCH. LENGTH (m.)
1	S1	R3.581	A1	A2	3.964
2	S2	R6.407	A2	A3	2.102
3	S3	R7.487	A3	A4	7.427
4	S4	R1.846	A4	A5	1.254
5	S5	R9.254	A5	A5'	0.796
6	S6	R0	A5'	A6'	5.001
7	S5'	R9.254	A6'	A6	0.796
8	S4'	R1.846	A6	A7	1.254
9	S3'	R7.487	A7	A8	7.427
10	S2'	R6.407	A8	A1	2.102

EXCAVATED AREA	= 91.704 Sqm.
FINISHED AREA	= 71.063 Sqm.
EXCAVATED WIDTH	= 10.690m
EXCAVATED HEIGHT	= 10.676m
FINISHED WIDTH	= 9.470m
FINISHED HEIGHT	= 9.010m

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*		SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*			
AMARNATH SINGH *CRE/S&T*		*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*		*JGM/L&U*	

PROJECT:-

HARYANA ORBITAL RAIL CORRIDOR

CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:-

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT:

GENERAL CONSULTANT FOR HARYANA ORBITAL RAIL CORRIDOR

RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE | SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01001_A1

DRAWING NAME: CONCEPTUAL DRAWING FOR SINGLE TRACK TUNNEL CROSS SECTION (ROCK)

ISSUE DATE: 07.11.2022 | REVISED DATE: 03.01.2023

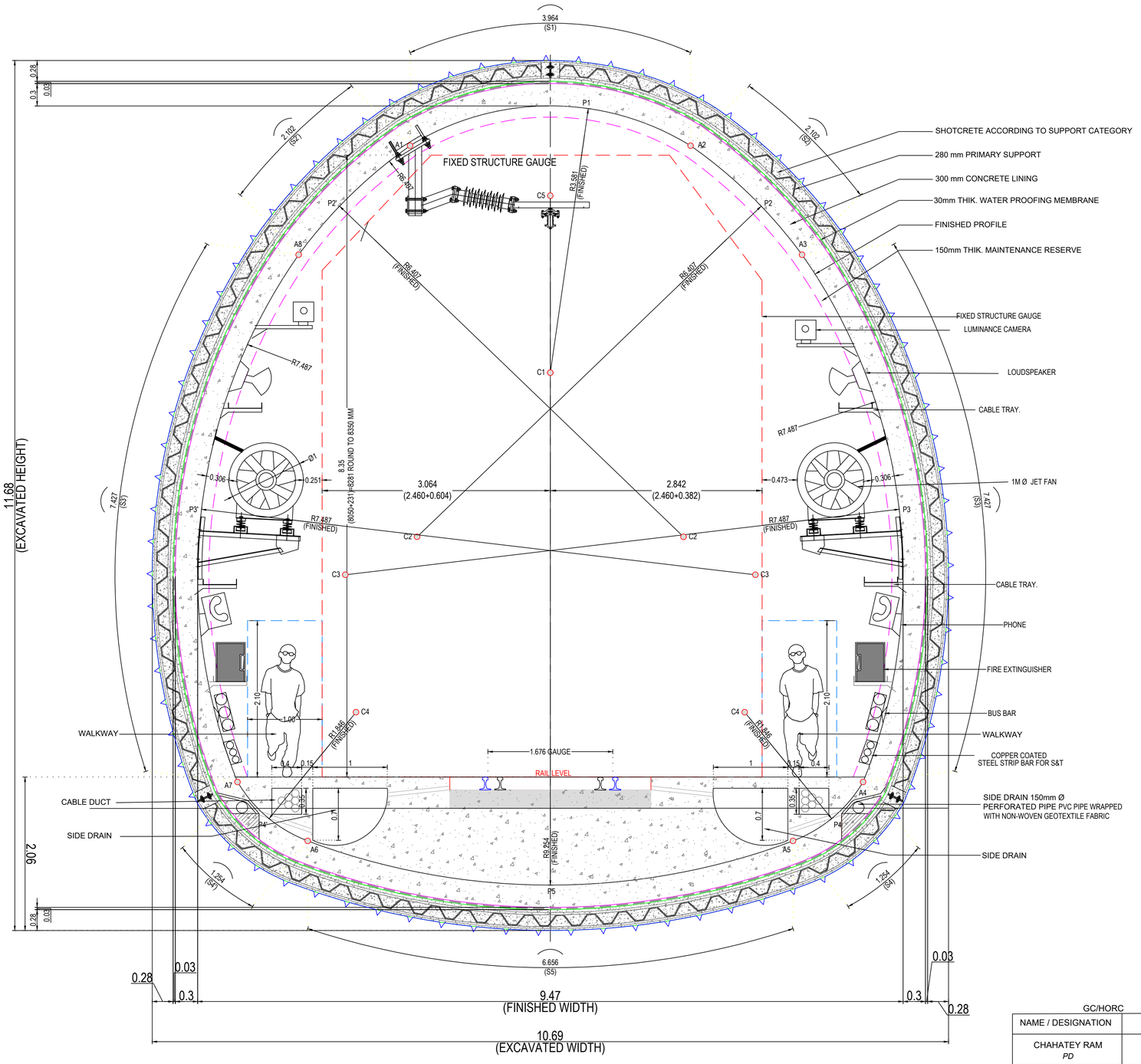
SCALE:- AS SHOWN.

SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

CONSULTANT: S.M. CONSULTANTS An ISO 9001 Company Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi Web : www.smcindia.com E-Mail : support@smcindia.com

SIVENDRA KUMAR *TUNNEL DESIGNER* | B.R.SHARMA *Sr.CONSULTANT / TUNNEL* | A. A. SAMANT *PROJECT INCHARGE*

RELEASED FOR: ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



1. ALL DIMENSIONS, NORTHING & EASTING AND LEVELS ARE IN METER, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSIONS SHALL BE MEASURED FROM DRAWING.
3. TUNNEL EXCAVATED BY HEADING, BENCHING / MULTI DRIFT METHOD (NATM).
4. THE GRADE OF SHOTCRETE WITH SFRS AS PER DETAIL DESIGN.
5. PROPOSED SUPPORT SYSTEM IS BASED ON GIR PROVIDED BY GEOLOGIST. ACTUAL SUPPORT SYSTEM MAY BE REVISED BASED ON ACTUAL RESPONSE OF STRATA DURING EXCAVATION.
6. DRAINAGE PIPE SHALL BE 150mmØ, PERFORATED PVC PIPE WRAPPED WITH NON-WOVEN GEOTEXTILE FABRIC AS PER IS-4989
7. EXCAVATION SEQUENCE WILL BE PROVIDED BASED ON GFC.
8. PIPE ROOFING/FOREPULING OF 114 MM DIA SHALL BE PROVIDED WHERE EVER IT IS REQUIRED.
9. SELF DRILLING ANCHOR OF CAPACITY 190 KN SHALL BE PROVIDED FOR PRIMARY SUPPORT DURING EXCAVATION.
10. LATTICE GIRDER 25-25-32 OF DEPTH 187 MM/ ISMB 200 MM SHALL BE INCASED IN SFRS OF MINIMUM THICKNESS 250 MM.
11. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK.
12. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING.
13. DIMENSION OF PRIMARY SUPPORT & CONCRETE ARE TENTATIVE.
14. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
15. ANCHOR BOLT FOR ROCS SHALL BE INSTALLED DURING TUNNEL LINING.
16. CABLE CROSSING SHALL BE PROVIDED AT EVERY CROSS PASSAGE.
17. LUMINANCE CAMERA, LOUDSPEAKER, JET FAN, PHONE, BUS BAR, COPPER COATED STEEL STRIP BAR FOR S&T AND ROCS WORK (EXCLUDING ANCHOR BOLTS) IS NOT IN THE SCOPE OF WORK OF C-4.

S.N.	CURVE NAME	RADIUS (m.)	START	END	ARCH. LENGTH (m.)
1	S1	R3.581	A1	A2	3.964
2	S2	R6.407	A2	A3	2.102
3	S3	R7.487	A3	A4	7.427
4	S4	R1.846	A4	A5	1.254
5	S5	R9.254	A5	A6	6.656
6	S4	R1.846	A6	A7	1.254
7	S3	R7.487	A7	A8	7.427
8	S2	R6.407	A8	A1	2.102

EXCAVATED AREA	= 101.090 Sqm.
FINISHED AREA	= 71.063 Sqm.
EXCAVATED WIDTH	= 10.690m
EXCAVATED HEIGHT	= 11.680m
FINISHED WIDTH	= 9.470m
FINISHED HEIGHT	= 9.010m

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
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SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*			
AMARNATH SINGH *CRE/S&T*		*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*		*JGM/L&U*	

PROJECT:- HARYANA ORBITAL RAIL CORRIDOR

CONNECTING PALWAL TO SONIPAT BYPASSING DELHI AREA BY LINKING ASAOTI-PATLI-SULTANPUR-ASAUDAH BY NEW ELECTRIFIED BG DOUBLE LINE

CLIENT:- HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT: GENERAL CONSULTANT FOR HARYANA ORBITAL RAIL CORRIDOR

RITES Limited in consortium with SMEC International Pty. Ltd.

RITES THE INFRASTRUCTURE PEOPLE | SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01002_A1

DRAWING NAME: CONCEPTUAL DRAWING FOR SINGLE TRACK TUNNEL CROSS SECTION (SOIL)

ISSUE DATE: 07.11.2022 REVISED DATE: 03.01.2023

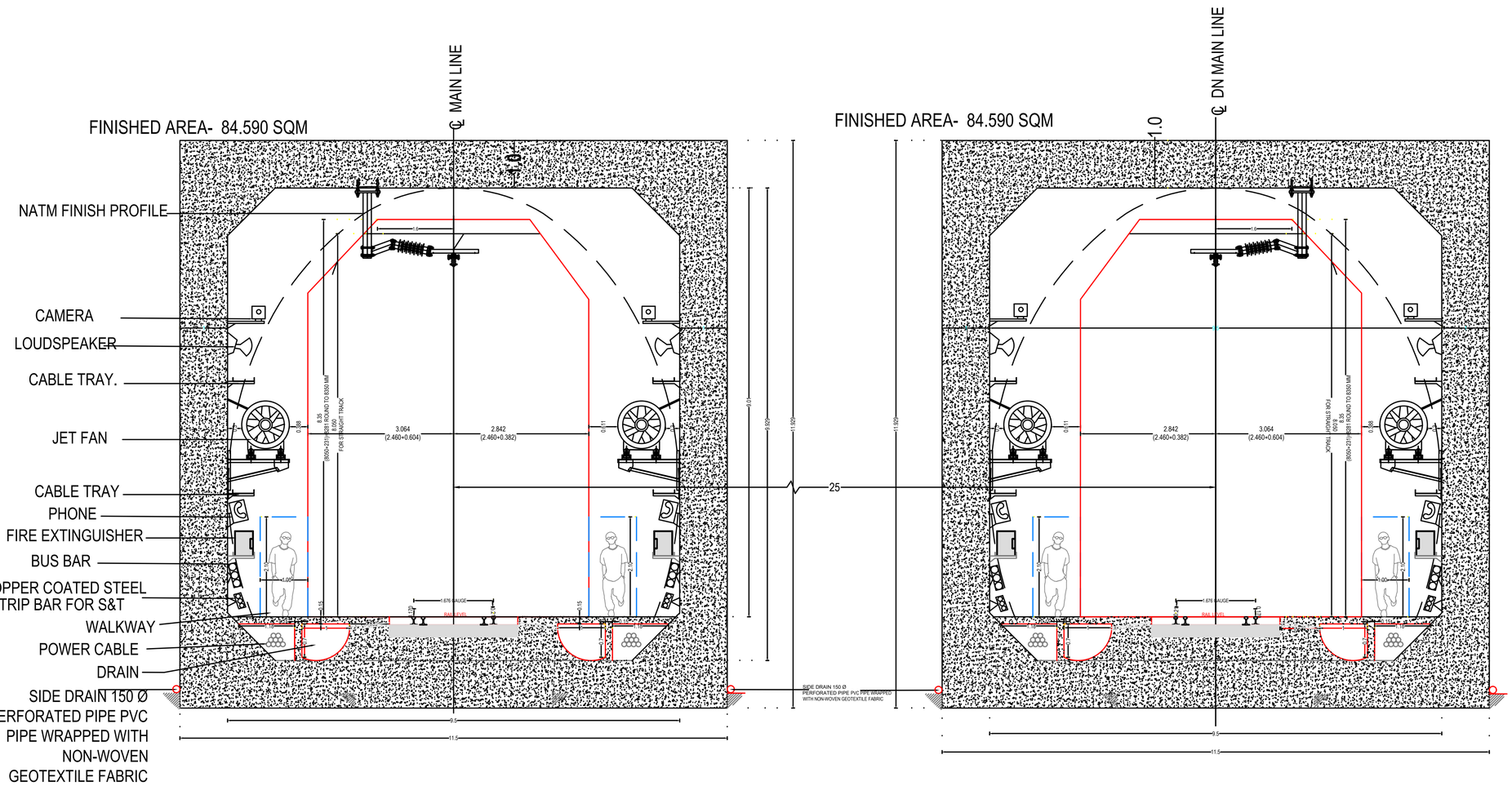
SCALE- AS SHOWN

SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

CONSULTANT: S.M.C. S.M. CONSULTANTS An ISO 9001 Company. Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi. Web : www.smcindia.com, E-Mail : support@smcindia.com

SIVENDRA KUMAR *TUNNEL DESIGNER* | B.R.SHARMA *Sr.CONSULTANT / TUNNEL* | A. A. SAMANT *PROJECT INCHARGE*

RELEASED FOR: ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



NOTES:~

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
2. NO DIMENSION SHALL BE MEASURED FROM THE DRAWING.
3. MINIMUM EXCAVATION LINE SHALL INCLUDE CONSTRUCTION & DEFORMATION TOLERANCE.
4. GUARD RAIL SHALL BE PROVIDED THROUGHOUT THE LENGTH OF BALLASTLESS TRACK
5. BALLASTLESS TRACK TO BE DESIGN FOR 32.5 T AXLE LOADING
6. DIMENSIONS OF SLAB THICKNESS ARE TENTATIVE.
7. SEPARATE EARTHING MET CONNECTION FOR S&T SYSTEM SHALL BE PROVIDED.
8. ANCHOR BOLT FOR ROCS SHALL BE INSTALLED DURING TUNNEL LINING.
9. CABLE CROSSING SHALL BE PROVIDED AT EVERY CROSS PASSAGE.
10. LUMINANCE CAMERA, LOUDSPEAKER, JET FAN, PHONE, BUS BAR, COPPER COATED STEEL STRIP BAR FOR S&T AND ROCS WORK (EXCLUDING ANCHOR BOLTS) IS NOT IN THE SCOPE OF WORK OF C-4.

GC/HORC		HRIDC	
NAME / DESIGNATION	SIGN	NAME / DESIGNATION	SIGN
CHAHATEY RAM *PD*		SHIV OM DWIVEDI *CPM/HRIDC*	
SUDHIR AGRAWAL *DPD/CIVIL*		RAJU SOLANKI *DGM/CIVIL/S*	
		AM/S&T	
REETU PATIAL *CDE /CIVIL*			
AMARNATH SINGH *CRE/S&T*		*AM/Civil/Plg.*	
STIPHEN SAHOO *SRE/Elect.*		*JGM/L&U*	

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CLIENT:- HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

GENERAL CONSULTANT: GENERAL CONSULTANT FOR HARYANA ORBITAL RAIL CORRIDOR
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RITES THE INFRASTRUCTURE PEOPLE | SMEC Member of the Surbana Jurong Group

GC/HORC DRG. NO:- GC-HRIDC-C4-DRW-TTL-CLT-01008_A1

DRAWING NAME: CONCEPTUAL DRAWING FOR CUT & COVER SECTION OF TUNNEL

ISSUE DATE: 07.11.2022 | REVISED DATE: 03.01.2023

SCALE:- AS SHOWN

SMC DRG. NO:- SMC/HRIDC/TUN/CS- 7

CONSULTANT: S.M. CONSULTANTS An ISO 9001 Company
Bhubaneswar / Balasore / Berhampur / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

S.KUMAR — SIVENDRA KUMAR, TUNNEL DESIGNER
B.R.SHARMA — Sr.CONSULTANT / TUNNEL
A. A. SAMANT — PROJECT INCHARGE

RELEASED FOR: ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION

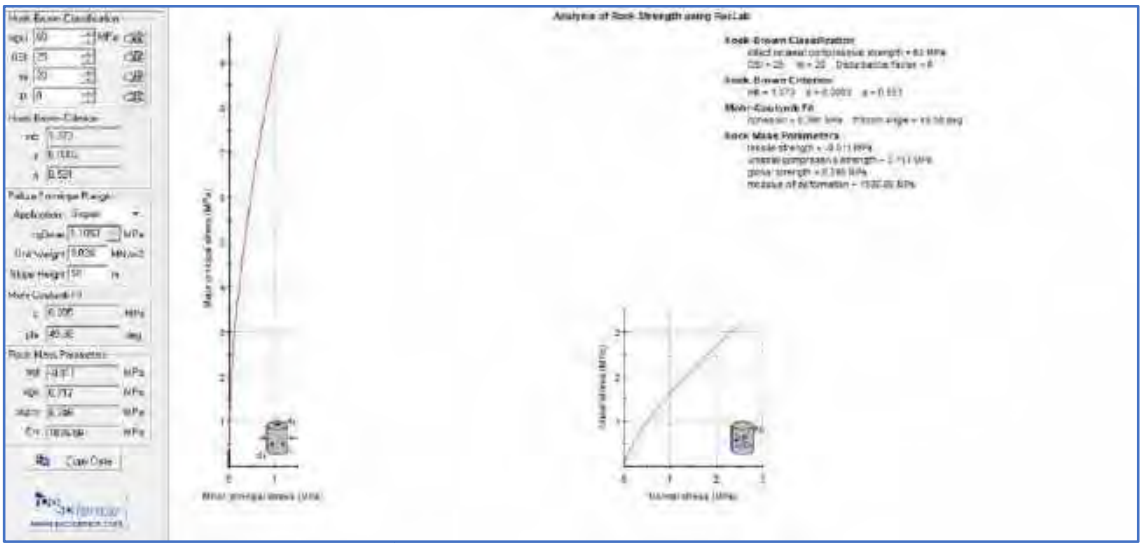

Figure 1: Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.

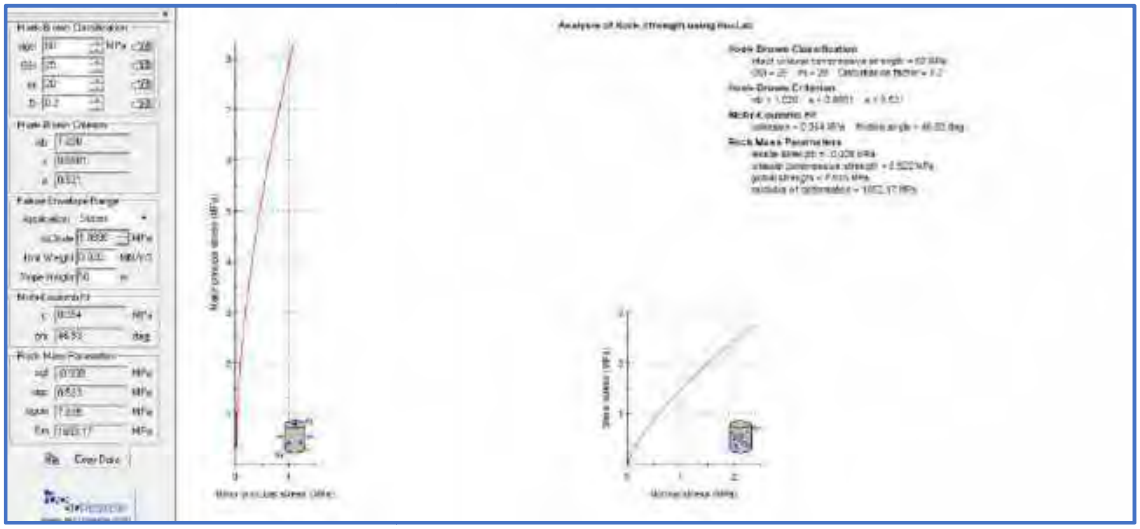

Figure 2: Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.2.

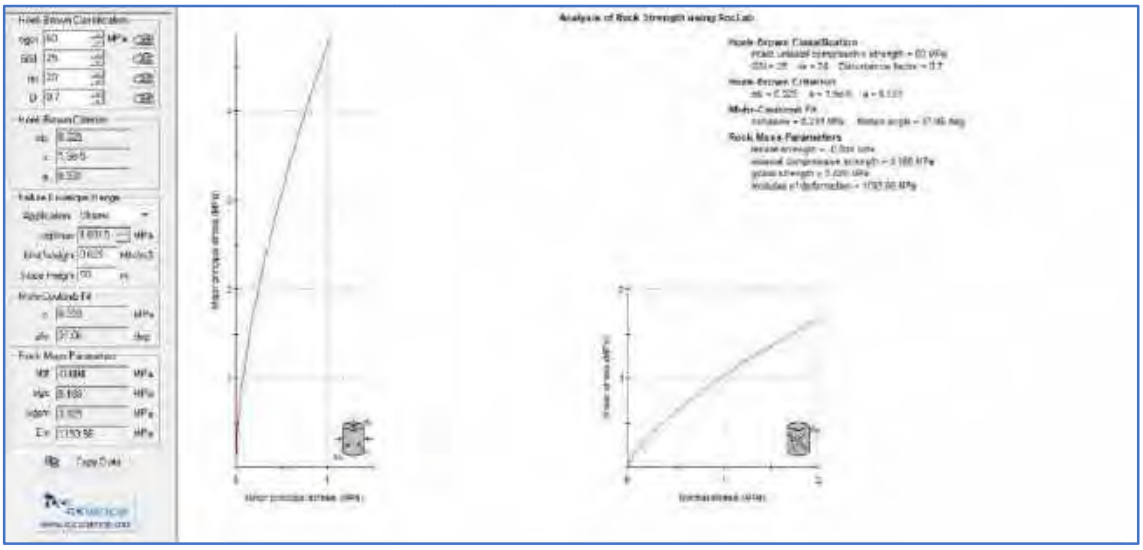

Figure 3 :Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.7

ANNEXURE-3

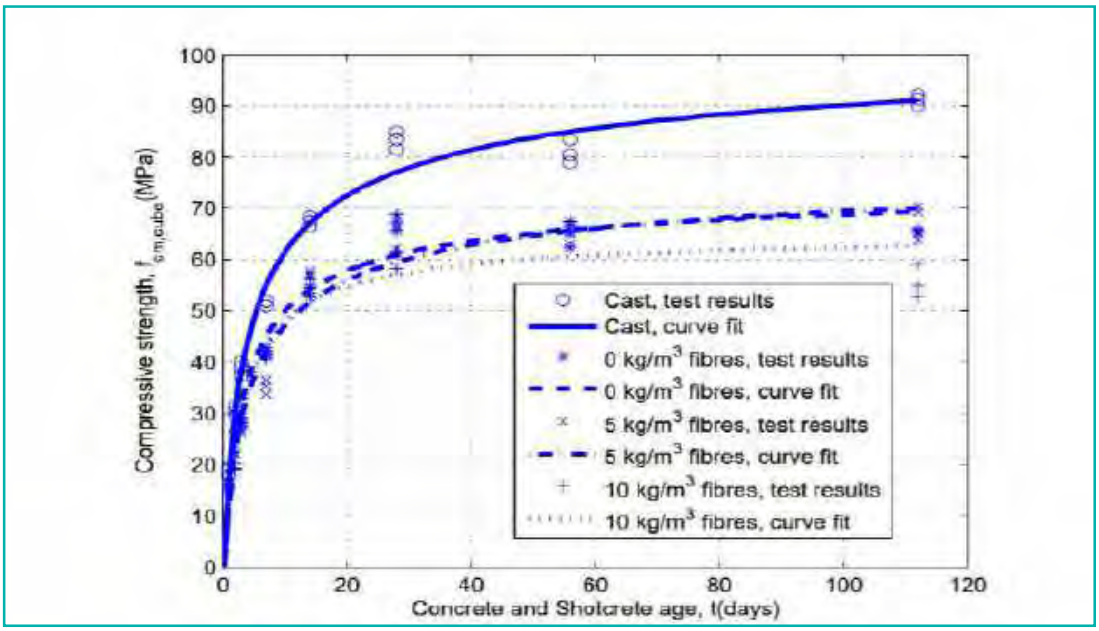

Figure 1: *Shotcrete Compressive Strength*

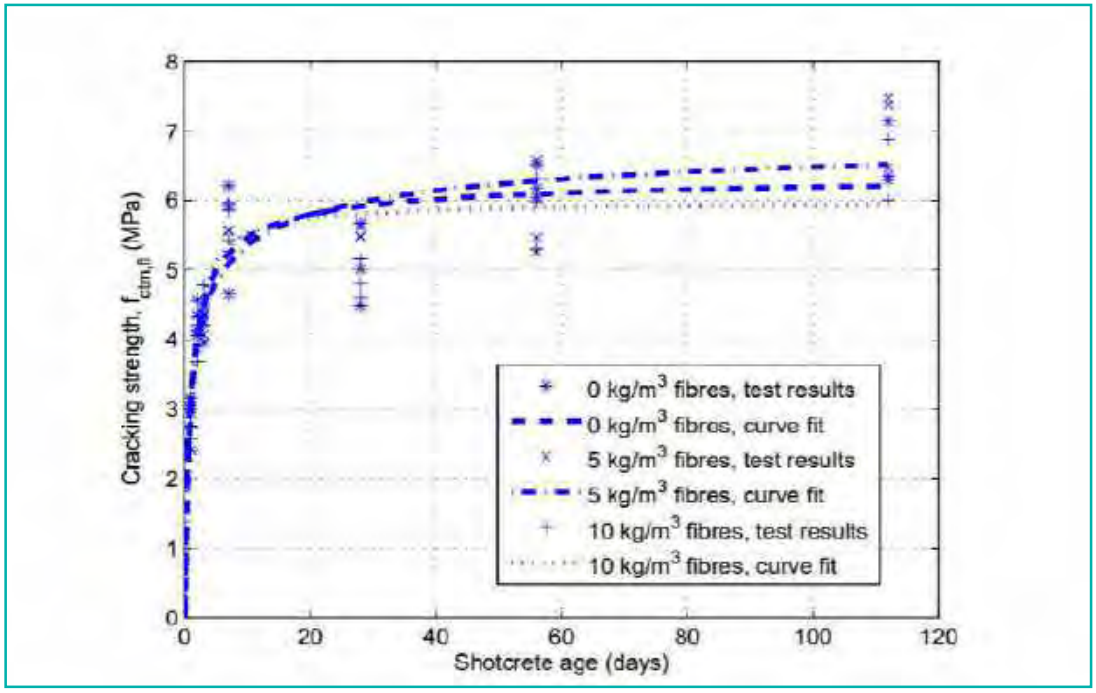

*Figure 2:*Shotcrete Cracking Strength

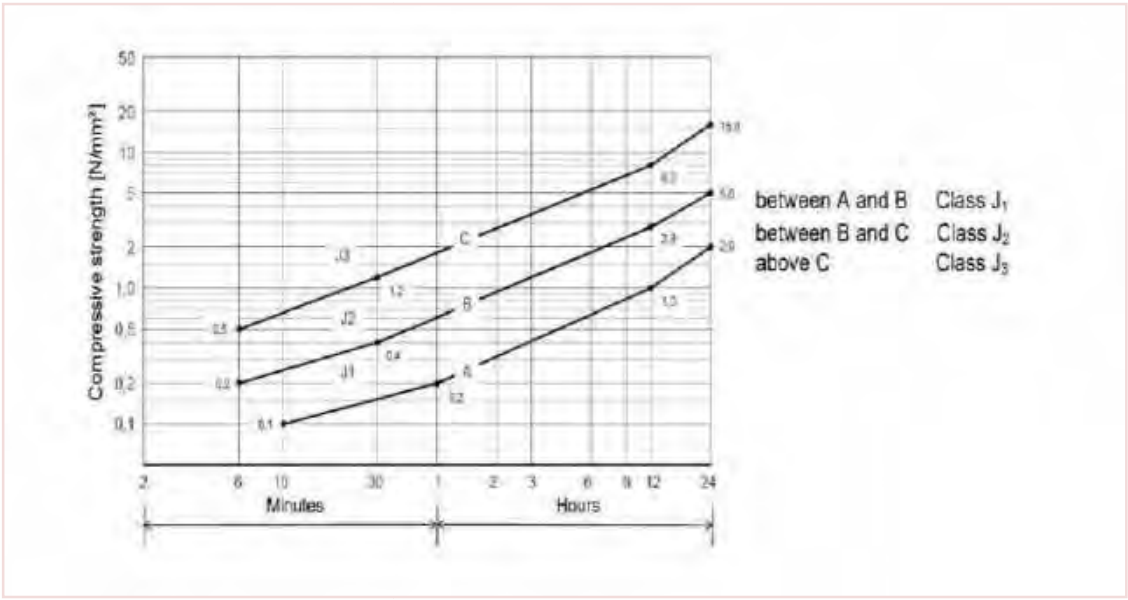

Figure 3: Early strength development of young shotcrete

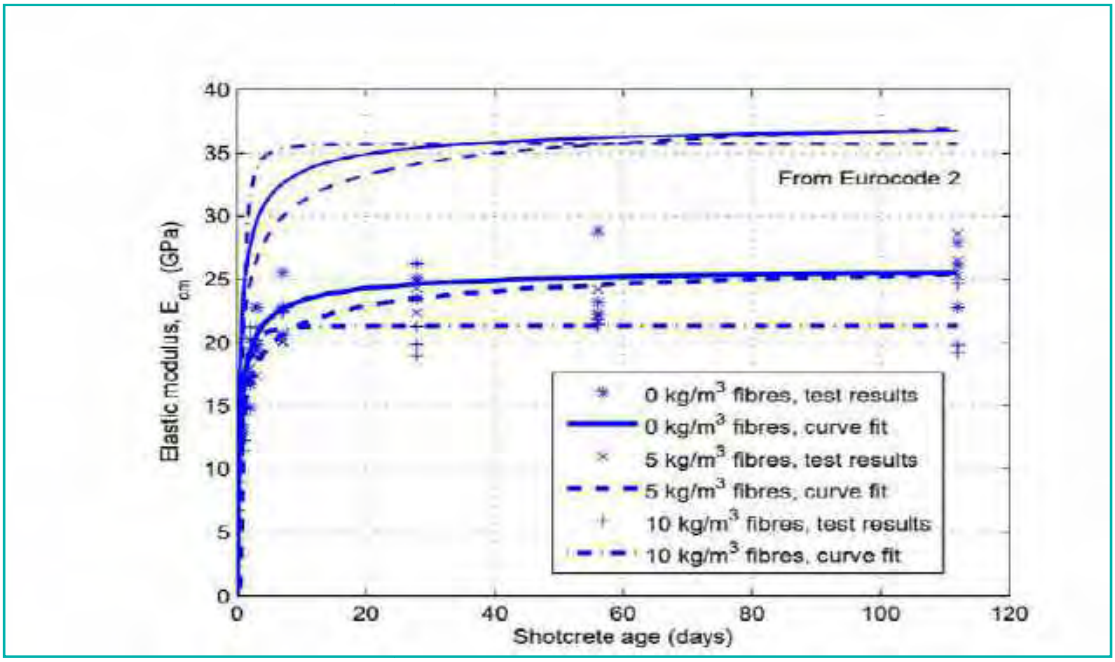

Figure 4:Shotcrete Elastic Modulus

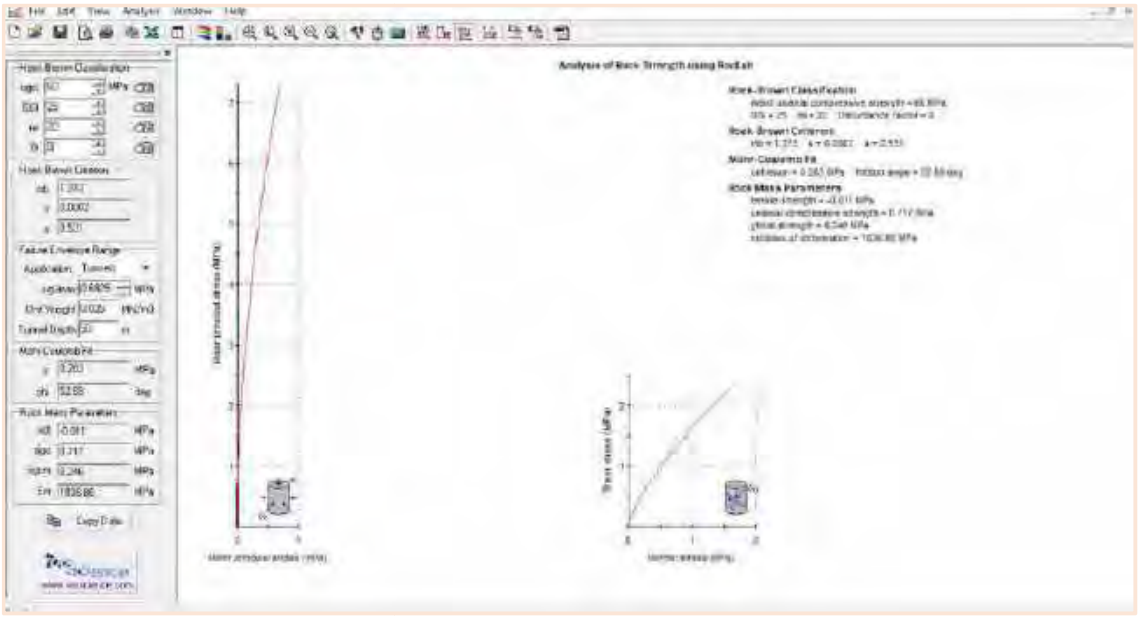

Figure 5 :For tunnel Above mentioned chart is Mohr Coulomb fit output from Roclab of rock mass derived from intact rock property of lab with disturbance factor D=0.

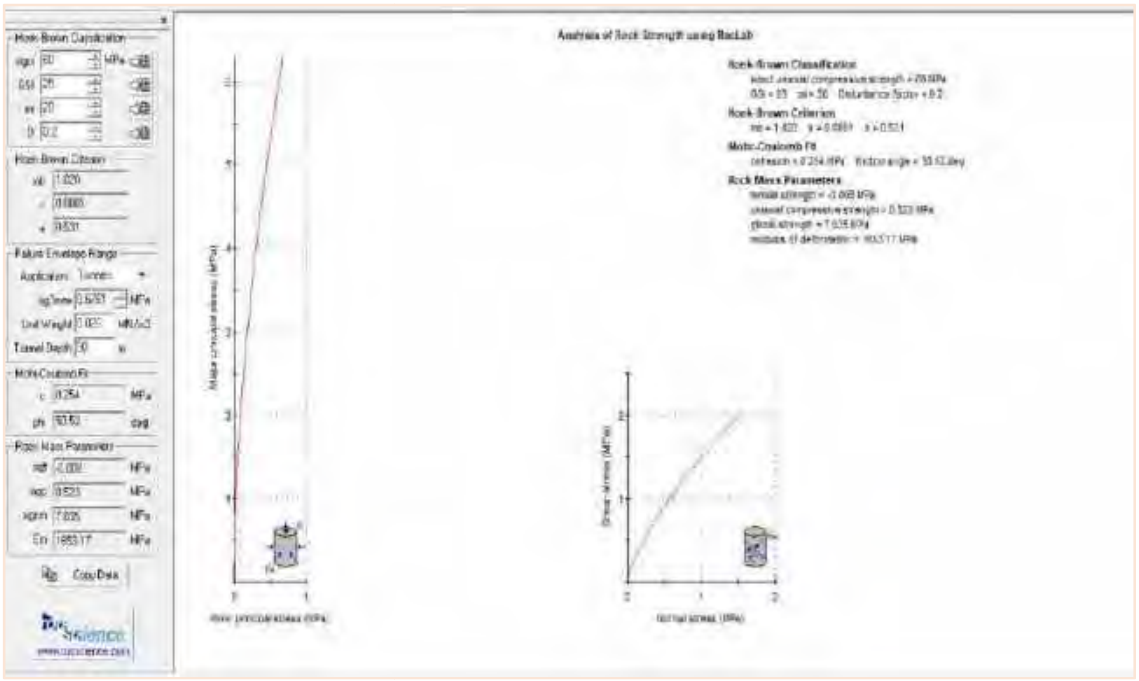

Figure 6 Above mentioned chart is Mohr Coulomb fit output from Roclab of rock mass derived from intact rock property of lab with disturbance factor D=0.2

2. LIST OF CURVE AND GRADIENT

Gradient Details PKG-C4 with Tunnel Portion

S.No.	Chainage KM		Length	Gradient	RISE/FALL	PFL		Remarks
	From	upto	metre	1 in		From	To	
1	11748	12208	460	170	F	203.018	200.312	Main Line
2	12208	12374	166	LEVEL		200.312	200.312	
3	12374	12859	485	200	F	200.312	197.945	
4	12859	13198	339	1200	R	197.945	198.158	
5	13198	13539	341	1201	F	198.158	196.136	
6	13539	14373	834	170	R	196.136	200.878	
7	14373	14573	200	LEVEL		200.878	200.947	
8	14573	14743	170	530	R	200.947	201.248	
9	14743	15000	257	157	F	201.248	199.749	
10	15185	15520	335	259	R	198.571	199.864	
11	15520	16200	680	LEVEL		199.864	199.864	
12	16200	16660	460	550	R	199.864	200.701	
13	16660	17000	340	LEVEL		200.701	200.701	
14	17000	17520	520	580	F	200.701	199.804	
15	17520	18020	500	175	F	199.804	196.947	
16	18020	18500	480	LEVEL		196.947	196.947	
17	18500	19840	1340	1200	R	196.947	198.064	
18	19840	20000	160	165	R	198.064	199.033	
19	**23740**	**25960**	2220	165	R	219.142	232.596	TUNNEL
20	**25960**	**26300**	340	152	R	232.596	234.833	
21	**26300**	**28230**	1930	165	R	234.833	246.53	
22	**28230**	**28420**	190	152	R	246.53	247.78	
23	**28420**	**29800**	1380	160	R	247.78	256.405	

Horizontal Curve Details PKG-C4 with Tunnel Portion

S.No.	Curve No.	SIDE	DEGREE	RADIUS	DEF.ANGLE (Delta)	CANT {SE) (mm)	TANGENT LENGTH	Circular Curve Length(CCL)	TRANSITION LENGTH In M	CH. TPTC-1	CH. TPTC-2	TOTAL LENGTH	
1	18	RHS	0.269	6500.000	0°51'14"	20.000	70.900	51.900	45.000	11879.919	12021.792	141.873	**Main Line UP line**
2	19	LHS	0.831	2105.300	26°30'21"	70.000	560.900	843.800	130.000	12070.033	13173.840	1103.807	
3	20	LHS	0.583	3000.000	33°19'13"	35.000	952.800	1634.600	110.000	15569.577	17424.179	1854.602	
4	24	LHS	0.884	1980.000	58°13'28"	80.000	1167.700	1881.900	130.000	23782.660	25924.604	2141.944	
5	**25**	LHS	1.000	1750.000	32°00'26"	105.000	571.900	834.400	140.000	26335.033	27452.394	1117.361	
6	**26**	RHS	0.500	3500.000	19°57'37"	30.000	665.900	1119.300	100.000	28468.702	29787.983	1319.281	
1	7	RHS	0.837	2092.000	26°30'21"	70.000	557.700	837.700	130.000	12073.179	13170.832	1097.653	**Main Line DN line**
2	8	RHS	0.585	2990.000	33°19'13"	35.000	949.800	1628.800	110.000	15575.528	17424.314	1848.786	
3	12	RHS	0.911	1920.000	58°13'24"	85.000	1134.300	1820.900	130.000	23834.934	25915.857	2080.923	
5	**13**	RHS	0.983	1780.000	32°00'30"	100.000	575.600	864.200	130.000	26352.336	27476.540	1124.204	
6	**14**	LHS	0.438	4000.000	19°57'37"	30.000	743.900	1313.500	80.000	28486.954	29960.434	1473.480	

3. LIST OF CONTROL POINTS

List of Control Points

GCP's DATA OF CH: -12KM TO 18 KM					
Name	**WGS84 Latitude**	**WGS84 Longitude**	**Grid Northing (m)**	**Grid Easting (m)**	**Elevation**
SCP'S					
SCP-009	28°12'25.3731"N	77°09'09.6978"E	3122015.079	711280.047	194.380
SCP-010	28°14'42.9312"N	77°08'00.6765"E	3126216.341	709323.220	199.402
SCP-011	28°11'39.2352"N	77°07'12.9607"E	3120538.658	708121.475	193.529
SCP-012	28°14'07.9269"N	77°06'12.5381"E	3125087.181	706394.085	199.346
SCP-013	28°10'47.0640"N	77°05'43.5348"E	3118890.253	705710.322	193.408
SCP-014	28°13'39.4318"N	77°03'49.0236"E	3124142.674	702496.512	206.820
TCP'S					
TCP-031	28°13'32.7210"N	77°08'15.0757"E	3124061.929	709753.912	196.424
TCP-032	28°13'34.4235"N	77°08'10.2582"E	3124112.021	709621.637	196.726
TCP-033	28°13'24.1071"N	77°07'33.5187"E	3123776.815	708625.507	195.883
TCP-034	28°13'26.0676"N	77°07'28.5870"E	3123834.806	708489.981	195.888
TCP-035	28°13'06.1224"N	77°07'04.0268"E	3123209.091	707831.072	196.092
TCP-036	28°13'08.4893"N	77°07'01.1748"E	3123280.594	707752.032	196.182
TCP-037	28°12'46.0137"N	77°06'30.9154"E	3122574.323	706939.003	196.105
TCP-038	28°12'48.2184"N	77°06'28.5920"E	3122641.090	706874.466	195.849
TCP-039	28°12'26.9901"N	77°06'02.1892"E	3121975.106	706165.842	195.179
TCP-040	28°12'28.5366"N	77°06'00.3063"E	3122021.822	706113.673	195.220
TCP-041	28°12'02.1341"N	77°05'38.0417"E	3121198.560	705520.574	194.986
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TCP-043	28°11'41.1865"N	77°05'25.8750"E	3120547.998	705199.897	196.170
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TCP-045	28°11'09.1126"N	77°05'11.8430"E	3119554.071	704834.200	192.723
TCP-046	28°11'10.7340"N	77°05'08.4153"E	3119602.374	704739.851	192.474
GCP's DATA OF CH: -29.200 KM TO 49.700KM					
SCP'S					
SCP-016	28°14'24.9297"N	77°00'38.4942"E	3125455.819	697278.697	293.012
SCP-017	28°12'09.7271"N	76°59'49.0726"E	3121271.671	696000.073	285.465
SCP-018	28°15'19.2876"N	76°59'11.9851"E	3127090.138	694892.969	273.709
SCP-019	28°12'36.4995"N	76°58'28.9449"E	3122059.974	693801.589	267.623
SCP-020	28°16'14.8549"N	76°57'40.0201"E	3128759.717	692358.624	265.112
SCP-021	28°13'47.9549"N	76°57'05.9422"E	3124222.828	691502.865	255.562
SCP-022	28°16'55.1346"N	76°56'08.4654"E	3129959.400	689843.726	263.025
SCP-023	28°15'13.5971"N	76°54'58.7895"E	3126803.659	687994.658	251.916
SCP-024	28°18'24.4724"N	76°55'12.5797"E	3132685.086	688277.200	269.222
SCP-025	28°17'16.6389"N	76°52'57.2887"E	3130539.057	684624.084	247.585
SCP-026	28°19'55.3848"N	76°54'39.3566"E	3135469.180	687327.824	274.734
SCP-027	28°18'49.3740"N	76°52'18.0110"E	3133376.943	683509.660	248.185
SCP-028	28°21'34.0782"N	76°54'03.4730"E	3138491.703	686302.627	280.255
SCP-029	28°20'24.3860"N	76°51'42.8468"E	3136286.731	682506.665	247.017
SCP-030	28°23'07.8703"N	76°53'32.8386"E	3141365.673	685423.154	233.634
SCP-031	28°22'08.1544"N	76°51'03.7859"E	3139464.494	681393.875	237.072

TCP'S					
TCP-067	28°13'06.4061"N	77°00'21.6871"E	3123031.074	696860.575	271.034
TCP-068	28°13'10.1973"N	77°00'24.0409"E	3123148.838	696922.820	267.933
TCP-069	28°13'18.2988"N	76°59'48.3517"E	3123382.138	695945.625	266.631
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TCP-074	28°13'56.2575"N	76°58'46.5997"E	3124522.949	694242.866	265.104
TCP-075	28°14'13.3161"N	76°58'21.1823"E	3125036.739	693541.378	264.634
TCP-076	28°14'16.1903"N	76°58'23.6378"E	3125126.302	693606.877	263.697
TCP-077	28°14'37.2068"N	76°57'55.7443"E	3125760.863	692835.976	265.078
TCP-078	28°14'39.8343"N	76°57'57.5805"E	3125842.554	692884.717	261.528
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TCP-089	28°16'33.0663"N	76°54'57.7123"E	3129249.383	687926.545	256.936
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TCP-091	28°16'58.1919"N	76°54'38.4368"E	3130014.477	687389.057	256.735
TCP-092	28°16'59.1606"N	76°54'42.0278"E	3130045.843	687486.435	254.180
TCP-093	28°17'27.8720"N	76°54'20.4598"E	3130920.345	686884.805	255.939
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TCP-095	28°17'57.4427"N	76°54'00.7114"E	3131822.106	686332.417	263.020
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TCP-097	28°18'28.6195"N	76°53'47.4042"E	3132776.079	685954.805	253.132
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TCP-099	28°19'00.8854"N	76°53'42.2393"E	3133767.067	685798.517	267.264
TCP-100	28°19'01.2164"N	76°53'44.2060"E	3133778.095	685851.931	264.187
TCP-101	28°19'36.3274"N	76°53'25.5125"E	3134850.886	685325.802	258.351
TCP-102	28°19'39.8222"N	76°53'26.5136"E	3134958.888	685351.382	258.279
TCP-103	28°20'00.9454"N	76°53'07.5761"E	3135601.025	684825.425	255.750
TCP-104	28°20'01.9312"N	76°53'09.9570"E	3135632.384	684889.796	256.456
TCP-105	28°20'26.6062"N	76°52'58.9299"E	3136387.228	684577.617	254.448
TCP-106	28°20'26.6381"N	76°53'00.7694"E	3136388.992	684627.698	254.540
TCP-107	28°21'02.7798"N	76°52'53.2526"E	3137498.297	684405.637	259.513
TCP-108	28°21'05.0330"N	76°52'55.7444"E	3137568.714	684472.409	260.368
TCP-109	28°21'33.4984"N	76°52'42.2721"E	3138439.205	684091.900	250.940
TCP-110	28°21'33.7066"N	76°52'45.7096"E	3138447.074	684185.399	251.315

4. LIST OF CHARTED UTILITIES

Nil

5. GEOTECHNICAL INVESTIGATION REPORTS FOR TUNNEL

Contents

i. Geotechnical Investigation Report No. SMC/2050.

GEOTECHNICAL INVESTIGATION REPORT
FOR
TUNNEL

EXPLORING ALTERNATE ALIGNMENTS, FINAL LOCATION SURVEY, GEOLOGICAL MAPPING, GEO-TECHNICAL INVESTIGATION, DETAIL DESIGN OF TUNNEL & ITS APPROACHES INCLUDING VIADUCT IF ANY AND OTHER ANCILLARY WORK IN SOHNA-MANESAR SECTION OF HORC PROJECT.

Client:

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

Prepared By:

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010, ODISHA

GEOTECHNICAL INVESTIGATION REPORT FOR TUNNEL

Prepared & Submitted By	
M/s. S. M. Consultants	
GEOTECHNICAL ENGINEER	Shreesty
GEOLOGIST	Dr Dipanjan Bhattacharjee Assistant Professor Department of Geology Indira Gandhi National Tribal University (A central university established by an act of Parliament) Amarkantak, Madhya Pradesh-484887
SENIOR CONSULTANT	Senior Consultant Virender Sharma

For S.M. Consultants

General Consultant	
PD/GC	
DPD/GC/CIVIL	

Client		
CPM/HRIDCL		
DGM/CIVIL/S/ HRIDCL		
EXE/CIVIL/ HRIDCL		

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Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

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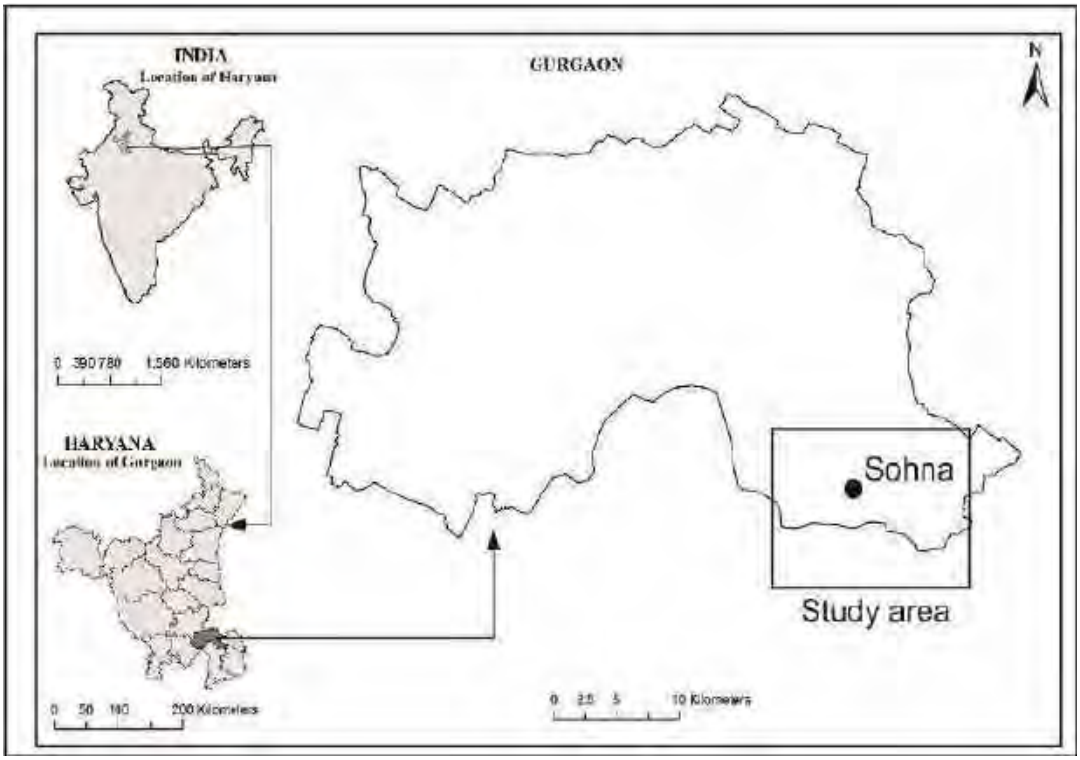
1 CHAPTER: INTRODUCTION

This report presents results of sub-soil Exploration work for **"Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"**. This work was performed by **M/s. S. M. Consultants, Bhubaneswar** which was assigned by **Haryana Rail Infrastructure Development Corporation Ltd.** At the proposed site twenty-two numbers of bore holes were drilled to explore the sub-strata. The findings of work presented in this report are based on the subsurface conditions encountered at exploration site and results of laboratory testing of soil and rock samples. The properties of sub-strata should not be extrapolated to other areas without our prior review.

2 CHAPTER: LOCATION MAP AND TOPOGRAPHY



2.1 Locality:

Figure 1 Geographical location of study area

The area in the report lies within the district of Gurgaon of Haryana. The concerned region is a part of survey of India toposheet No. 53H/04 and spanned between longitude 77°58′36″& 77°06′00″and latitude 28°14′0″ & 28°10′30″.

2.2 Accessibility:

The area is 20km away from Gurgaon. The important towns in the area are Sohna, Gurgaon, Palwal. These towns are connected with important cities of the state and Delhi by

metaled roads. Delhi Bombay National Highway (NH-6) passes through Gurgaon State Highway No 43 passes through Sohna. Gurgaon is a railway station on Delhi Rewari section of the meter gauge line of the Northern Railway whereas Faridabad and Palwal are on Delhi Bombay broad gauge line. Most of the villages in the area are connected by all-weather metaled roads

2.3 Flora and Fauna:

The vegetation is sparse in the area mainly composed of bushes and shrubs, palm trees can be seen at places where nalas emerge from hills. Among the common fauna found in the area are Nilgai (Becephalus tragecamelus), Hare (Lepus sp). Common bird species in the area include sparrow (Passer Domestica) Pigeon (Colomba Livia) spotted dove (Straptopelia Chinensism), House crow (Corvus splenders), Indian Parrot (Psittacula eupatria), Mynah (Acidotheras), Vultures, Owls etc. Migratory water birds are also found in the area.

2.4 Climate:

The area has semi-arid type of climate. Summer are extremely hot with the temperature shooting up to 47°C. The winters are quite cold. The minimum temperature recorded in Gurgaon during 1968-70 was 2.0°C. The related humidity is maximum in August (above 80%) and minimum in June (above 35%). In the month of November, the wind velocity in the morning remains about 2.5km whereas in June it is generally 8 km Per hour. The general wind direction is westerly. Summer monsoon starts by the end of June or early July and lasts up to September. Rainfall is generally

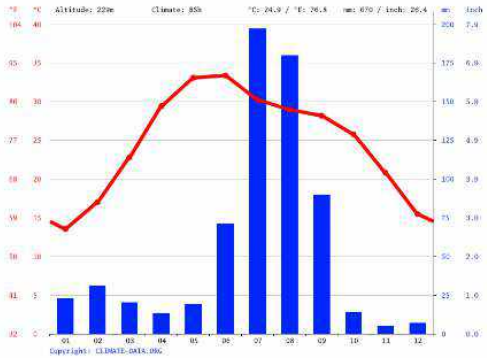


Figure 2: Graph showing month wise rainy days for Gurgaon district. (Climate-data.org)

restricted to this monsoon, though winter months also get some scanty rains Average annual rainfallis about 600 mm.

Climatic condition of the area is much varied characterized by hot and moist sub-humid climate. It has mainly 4 seasons. The summer season is from March to Mid-June, the period from Mid-June to September is the Rainy season, October and November constitute the post monsoon season and winter is from December to February. The best time to visit this district is during winter.

Ministry of housing and urban affair, Government of India has done vulnerability mapping for Haryana state which includes multiple hazard zonation maps. The results are given below:

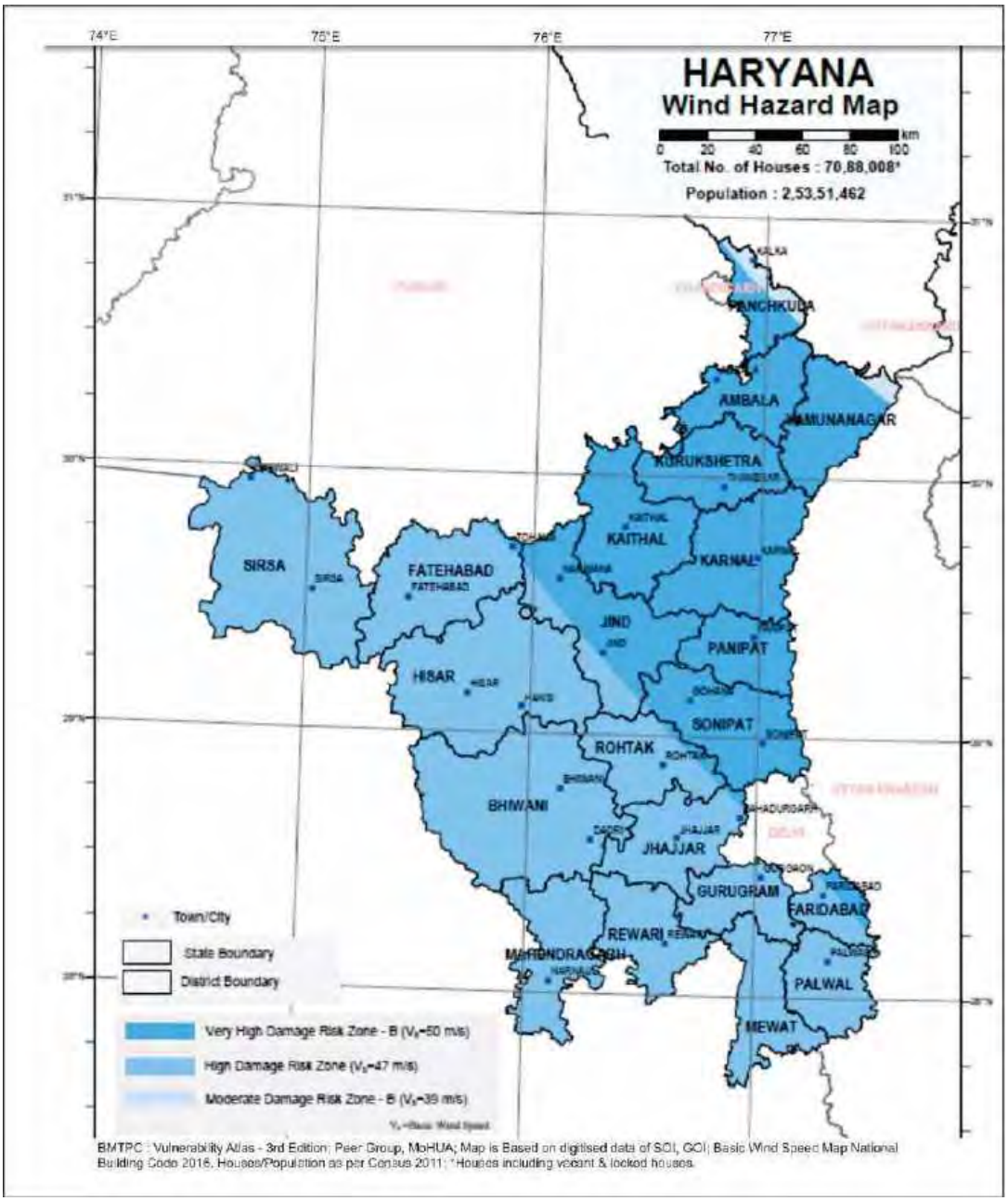


Figure 3: Wind Hazard map of Haryana (adopted from BMTPC)

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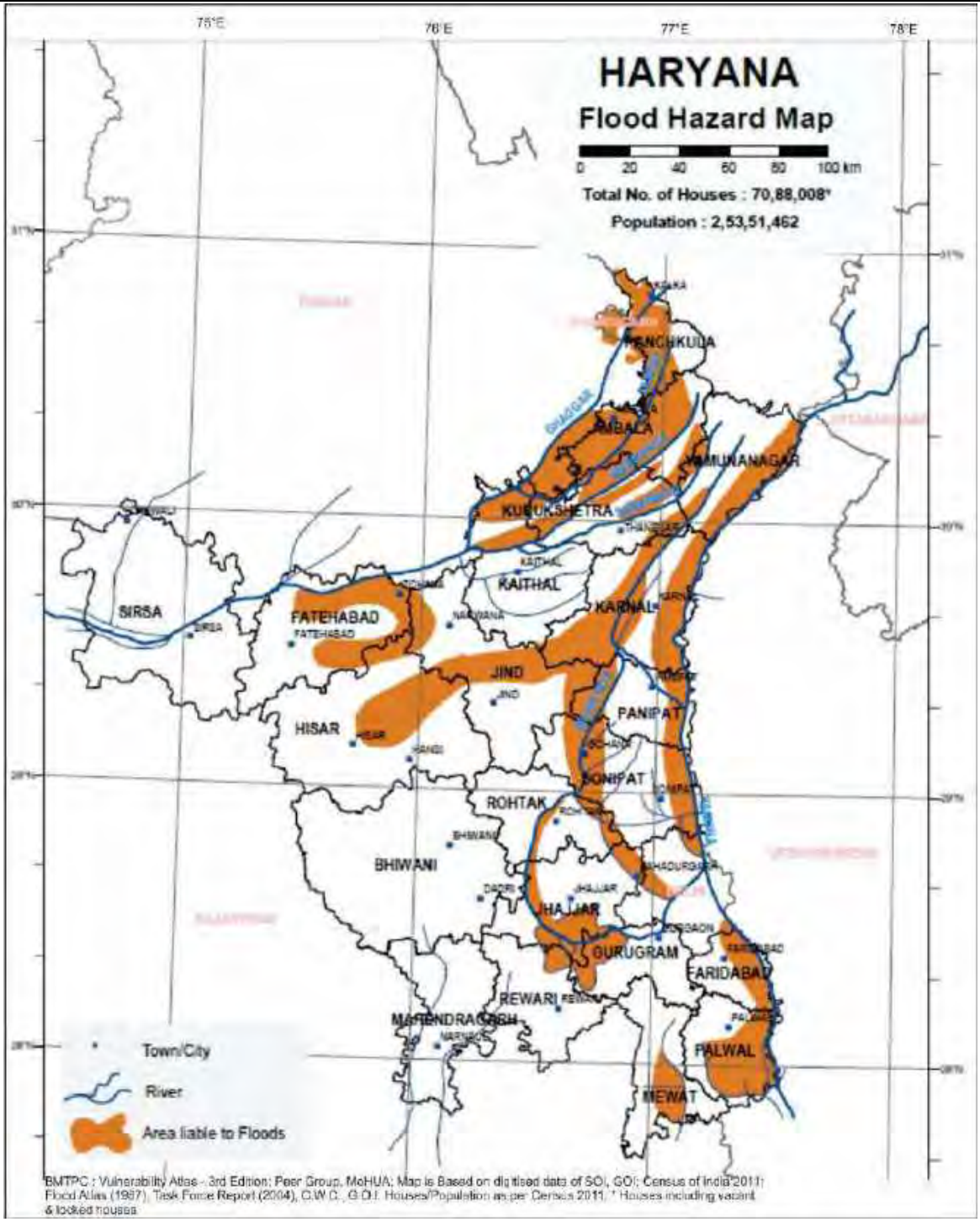

Figure 4: Flood zonation map of Haryana (adopted from BMTPC)

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2.5 Seismicity:

According to National Center for Seismology the state of Haryana comprises three earthquake zone. The western part comes under zone II, the central part zone III and the eastern- south-eastern part in zone IV. The region around the site of construction comes under the zone IV of earthquake. Being within the earthquake zone IV the area of interest is at high risk with reference to the seismic activity. This region is liable to MSK VIII on Medvedev–Sponheuer–Karnik Scale, a macro seismic intensity scale or lower and is classified as the High Damage Risk Zone.

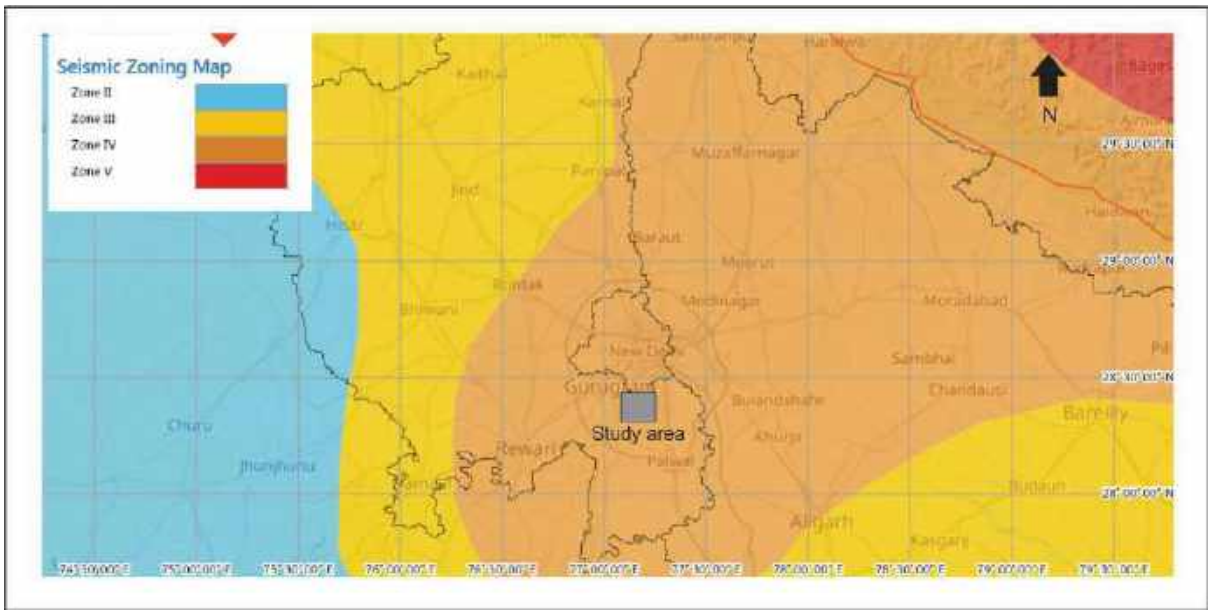

Figure 5: Seismic map of state Haryana (adopted from National Centre for seismology)

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3 CHAPTER: SITE GEOLOGY: Geological Investigation of Rock and Soil

3.1 Regional Geology:

The rocks exposed in the area consist of Mesoproterozoic rocks of the North Delhi Fold belt which occur as long, linear, discontinuous chain of hills. The overall Delhi fold belt shows a NE-SW trend and extends from Gujrat (Deri- Ambaji) in the south to Delhi in the north. In the north and south the belt is overlain by Indo-Gangatic alluvium with sparse outcrop jutting out from the plain. Towards west it shows an unconformable contact with Marwar craton along a Phulad lineament and in the east the belt shows a faulted contact with Banded Gneissic Complex of pre-Delhi origin along Kaliguman lineament. The North Delhi Fold Belt has been divided into two groups by Heron (1935): the lower arenaceous Alwar Group and the upper argellaceous Ajabgarh Group. The Alwar Group comprises arkosic schists, phyllites, quartzites and meta- conglomerates whereas, the Ajabgarh Group comprises calc-schists, biotite schists, calc-silicates and marbles.

The regional structure of Delhi fold belt is considered as a broad synclinorium having N to NNE trend (Heron 1953) with core occupied by Delhi group, within the broad synclinorium four generations of deformation (D1 – D4) (Fig. 6) are seen in Delhi fold belt (Naha and Mohanty 1988). D1 and D2 are ubiquitous in all scales while D3 and D4 are seen only in some sectors. D1 folds are tight to isoclinal with a pervasive axial planar cleavage (S1). There are multiple occurrences of boudinage in D1 fold, which are parallel to axial planer cleavage (Naha et al.,1984). D2 folds ranges from open to isoclinal with vertical axial plane striking NNE -SSW to NE-SW. A crenulation cleavage (S2) is developed parallel to axial planes of the fold. D2 fold is coaxial with DF1 fold. Due to D2 various superposed folds have been developed in DFB, most common is Ramsay Type III fold (non-planar cylindrical) (Roy and Das 1985). DF3 folds are kink folds with sub horizontal axial planes. It has affected S1 and S2 cleavages and axial surfaces of DF1 and DF2 folds. At some places DF3 has conjugate axial plane striking NE-SW and SE-NW. It is formed by vertical compression

(Naha and Mohanty 1988). Due to interference from D3 fold there is development of Ramsay Type II fold (non-planer non-cylindrical fold) in the DF1 and Ramsay Type I fold (planer non-cylindrical fold) in DF2 (Roy and Das 1985).

DF4 fold are upright chevron fold, having NW-SE striking axial plane. They are formed by horizontal compression in an NE-SW direction (Naha and Mohanty 1988).

The different phase of deformation has led to metamorphism raging from greenschist to amphibolite facies.

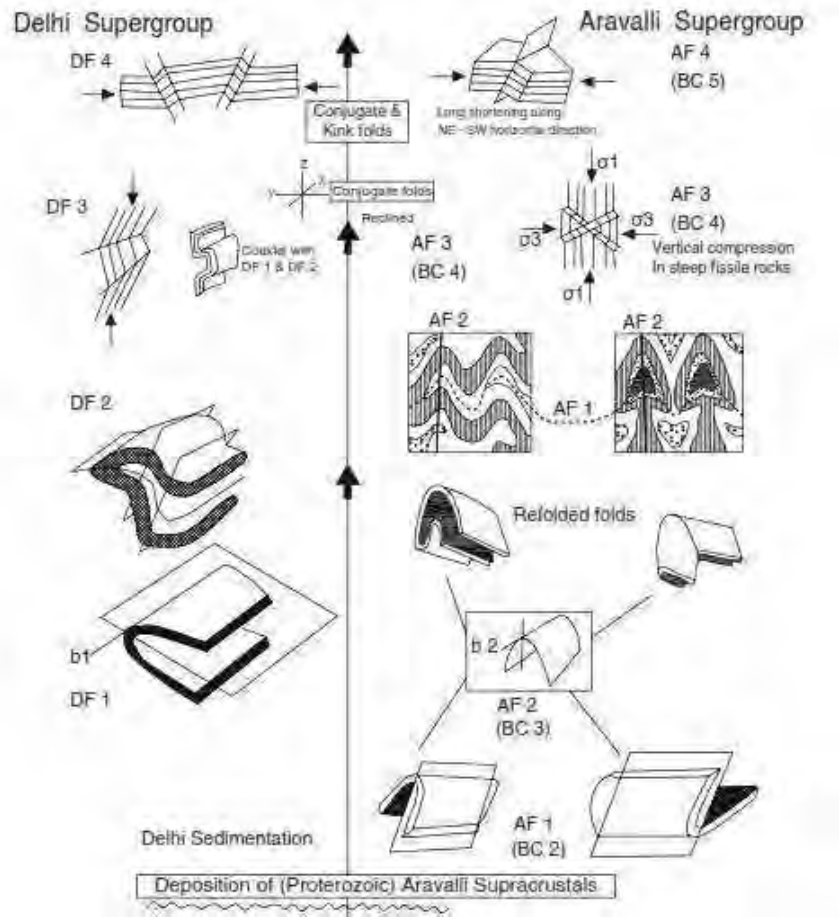

Figure 6: Regional structure of Delhi fold belt (Naha and Mohanty 1988).

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Recent		Alluvium and blown sand with thin Kankar bands at places
Post Delhi)		Quartz veins, pegmatites & Basalt. Intrusives)
	(Ajabgarh Formation	White, dull white to light brown, quartzite white gritty argillaceous intercalations and siltstone.
Delhi Group	(Alwar formation	Light to dark grey massive quartzite white gritty quartzite with subordinate amount of schist and phyllite

3.2 Stratigraphy of the Area:

Table 1 : Stratigraphy of North Delhi fold belt (after Roy 1988).

3.3 Local Geology:

The region around the site consists metamorphosed arenaceous rocks of Alwar group. The Lithology is dominated by Quartzites with some intercalations of phyllites near the southern portal.

The Quartzites are metasedimentary rocks comprises greater than 80% quartz along with feldspar and mica minerals, the mineral grains show an equigranular interlocking texture.

The phyllites are low grade metamorphic rocks, they have a marked fissility (a tendency to split into sheets or slabs) due to the parallel alignment of platy minerals; they have a sheen on its surfaces due to tiny plates of micas.

The quartzites near to surface showed high weathering and were highly friable and non-cohesive while as we move deeper (> 15 m) the quartzite becomes more resistive and less weathered. Quartz is a tectosilicate mineral which ranks 7 on Mohr hardness scale, since it crystallizes later according to Bowen reaction series it is also resistive to weathering. Feldspar on the other hand ranks 6 on Mohr hardness scale and crystallizes earlier thus is prone to weathering.

In the southern part intercalation of phyllites/schist along with quartzite are observed.

3.3.1 Structural study of hard rock

The compositional change in quartzite beds defines the bedding in the area and the regional trend of bedding plane is NE-SW with a steep dip towards SE.

A superposed fold was observed at 28°12′33.57″, 77°02′57.08″. DF2 and DF3 deformation phases of Delhi group was observed in the area. DF1 is the prominent fold pattern which was super posed with DF2 folding phase. Signatures of later brittle shearing, possibly related to DF4 phase, was also observed near the proposed portal face. The fold showed Ramsay's Type III folding pattern i.e., non-planar cylindrical (Fig. 7), the fold hinge showed a plunge of 20° towards 220. The Type III fold pattern in rest of the Delhi system of rocks are result of superposition of DF2 over DF3 deformation. The portal face lies perpendicular to the axial plane of the fold. The earlier generation of fold is isoclinal in nature where both the limbs dip towards south.

Near the fold area some quartz tension gashes were observed. Gash veins open up when rock gets stretched due to shearing and the tension fractures forms oblique to the shear zone which is later filled with mineral precipitate. In the present area the gash veins indicate a dextral shearing (Fig. 8)

At location 28° 12' 20.93'', 77° 02' 40.50'' another evidence of brittle-ductile shear zone was observed within the quartzite outcrop (Fig. 9). Prominent en-echelon fractures were observed within the outcrop which were rotated to form a sigmoidal structure, the fractures were not filled with mineral precipitate. The shear plane was dipping towards NE with a normal slip where the eastern block was showing a downthrown movement and the western block an upthrown movement. The last phase of deformation DF4 has led to the formation of brittle shearing.

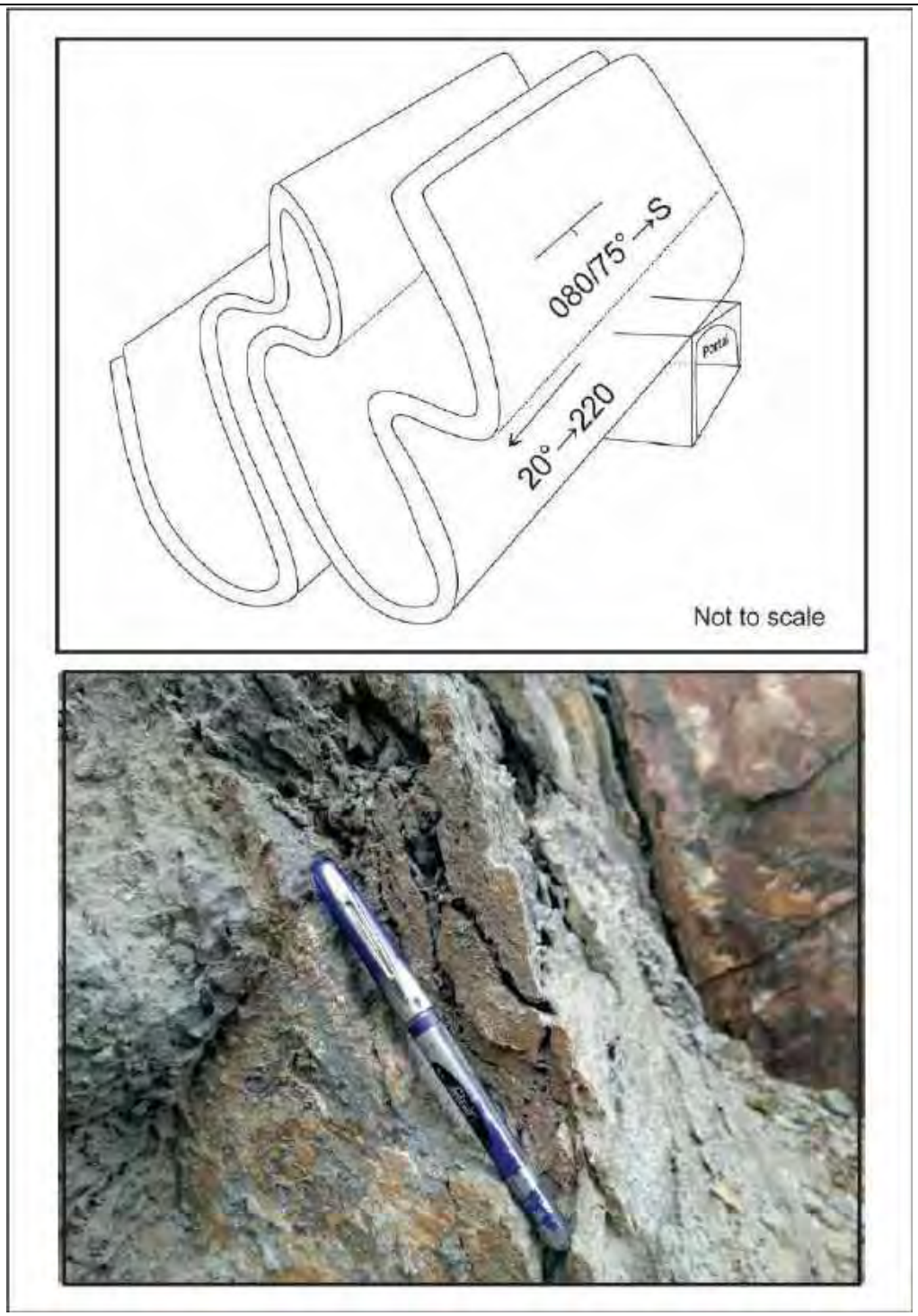

Figure 7: Superposed fold observed at 28 12' 33.57'', 77 02'57.08''

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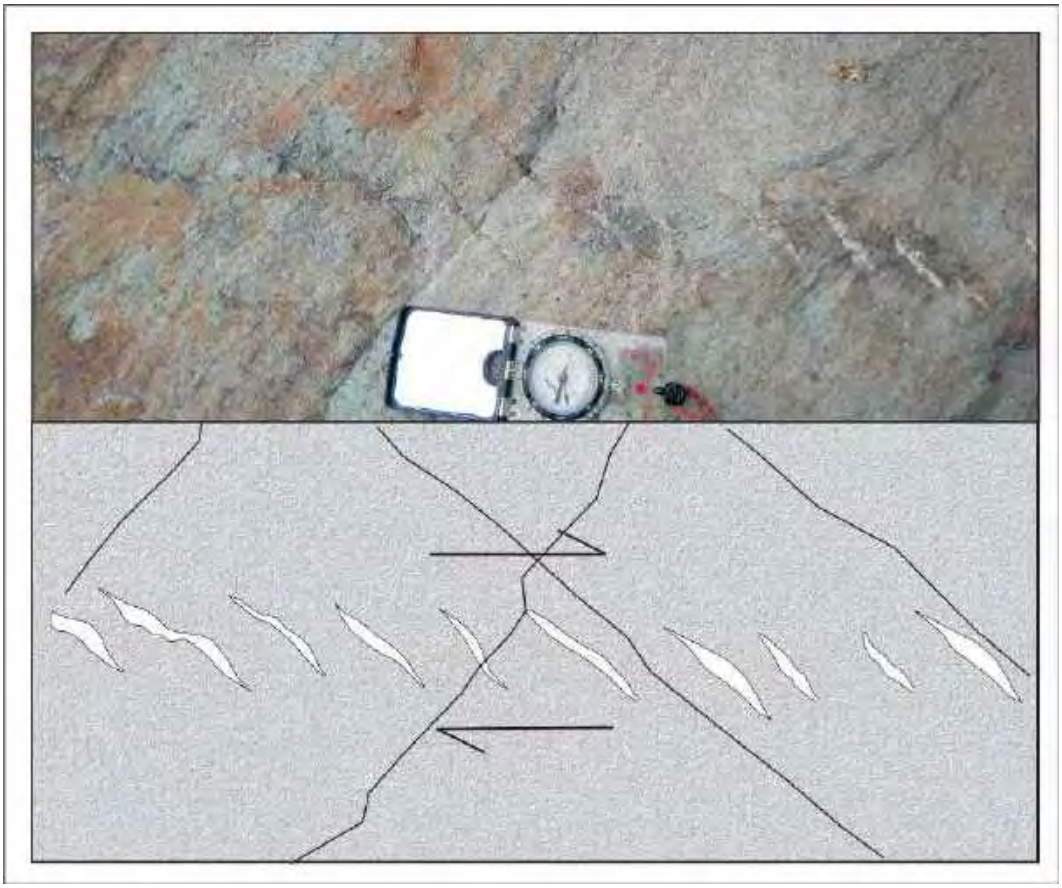

Figure 8 : Gash veins showing a dextral slip.

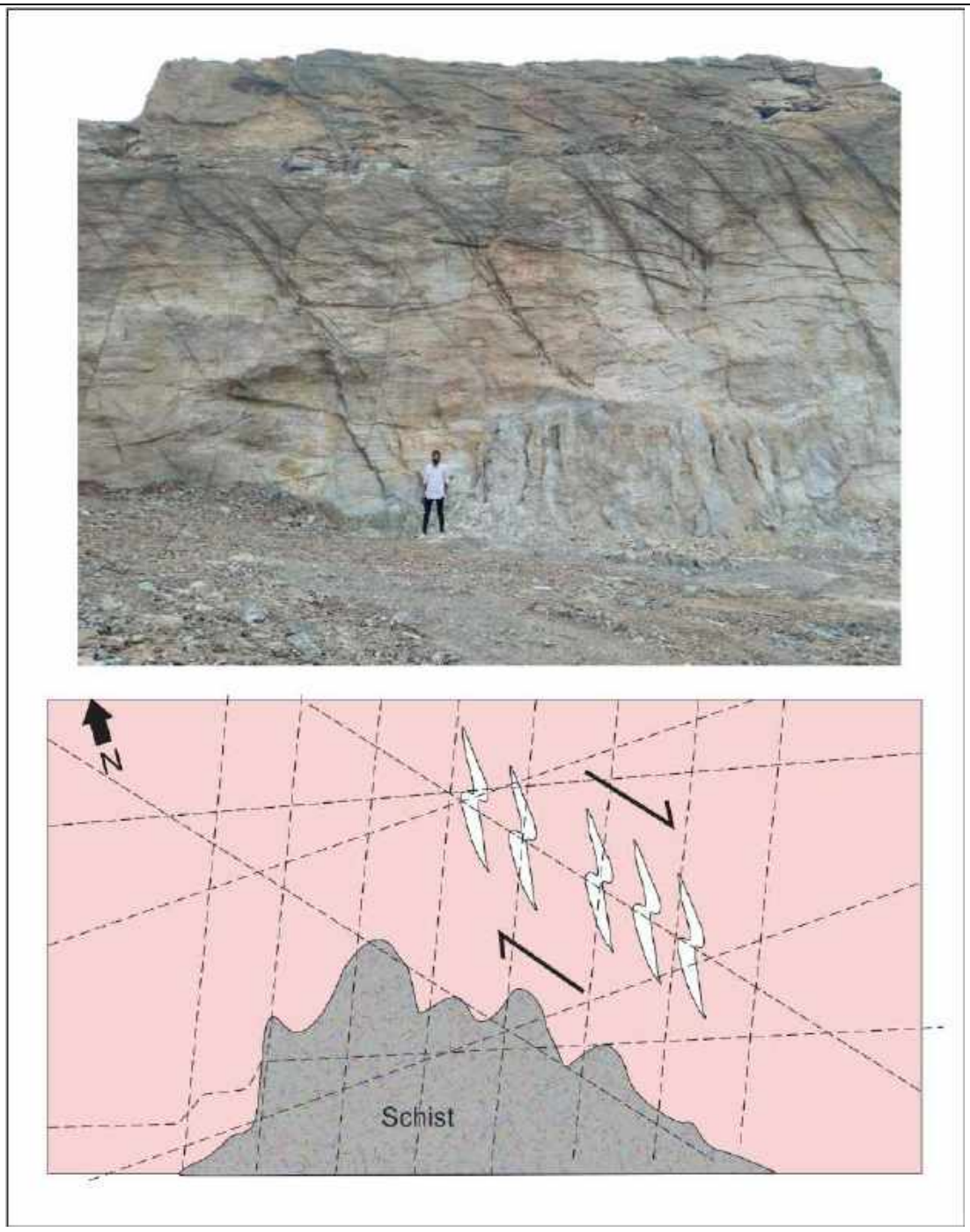

Figure 9: Shear zone observed at location 28 12' 20.93'', 77 02' 40.

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Figure 10: Multiple joint sets were observed throughout the area.

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Orientation of the joints measured in field (Table 2) has been plotted on stereo net and contouring was done following Schimidt's 1% area rule (Figure 11).The diagram shows 6 distinct cluster of the poles to the joint planes, hence we designate the sets as J1, J2, J3, J4, J5, and J6 (Table 3).

Table 2: Orientation of the joints at places around the site.

S. NO	Strike	Dip	Dip Direction
1.	034	11	NW
2.	028	13	NW
3.	029	13	NW
4.	027	15	NW
5.	027	15	NW
6.	026	16	NW
7.	029	18	NW
8.	033	18	NW
9.	028	19	NW
10.	032	19	NW
11.	042	21	NW
12.	040	22	NW
13.	036	23	NW
14.	041	24	NW
15.	037	25	NW
16.	036	26	NW
17.	043	27	NW
18.	040	28	NW
19.	037	30	NW
20.	038	30	NW
21.	178	31	W
22.	172	32	W
23.	175	32	W
24.	170	34	W
25.	174	34	W
26.	172	36	W
27.	178	37	W
28.	172	38	W
29.	178	38	W
30.	178	39	W
31.	003	40	W

S. NO	Strike	Dip	Dip Direction
32.	006	40	W
33.	004	41	W
34.	005	43	W
35.	008	43	W
36.	119	45	NE
37.	008	46	W
38.	009	46	W
39.	119	46	NE
40.	008	47	W
41.	002	49	W
42.	116	49	NE
43.	007	50	W
44.	110	50	NE
45.	110	51	NE
46.	111	51	NE
47.	114	51	NE
48.	117	51	NE
49.	115	52	NE
50.	119	52	NE
51.	122	57	NE
52.	126	59	NE
53.	127	60	NE
54.	130	60	NE
55.	121	62	NE
56.	129	62	NE
57.	122	63	NE
58.	128	63	NE
59.	124	64	NE
60.	126	65	NE
61.	117	70	NE
62.	117	70	NE
63.	029	71	SE
64.	032	71	SE
65.	026	72	SE
66.	111	72	NE
67.	028	73	SE
68.	030	73	SE
69.	035	73	SE
70.	116	73	NE

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S. NO	Strike	Dip	Dip Direction
71.	119	74	NE
72.	117	75	NE
73.	178	76	E
74.	030	76	SE
75.	170	77	E
76.	174	77	E
77.	030	77	SE
78.	110	77	NE
79.	113	77	NE
80.	171	79	E
81.	178	79	E
82.	179	79	E
83.	027	79	SE
84.	032	79	SE
85.	174	80	E
86.	176	80	E
87.	114	80	NE
88.	116	80	NE
89.	040	81	SE
90.	042	81	SE
91.	122	81	NE
92.	171	82	E
93.	175	82	E
94.	045	82	SE
95.	126	82	NE
96.	039	83	SE
97.	122	83	NE
98.	125	83	NE
99.	125	83	NE
100.	005	84	E
101.	038	84	SE
102.	001	85	E
103.	008	85	E
104.	129	85	NE
105.	124	86	NE
106.	127	86	NE
107.	002	87	E
108.	006	87	E
109.	037	87	SE

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S. NO	Strike	Dip	Dip Direction
110.	042	87	SE
111.	127	87	NE
112.	009	88	E
113.	002	89	E
114.	043	89	SE
115.	130	89	NE
116.	001	90	E
117.	036	90	SE
118.	040	90	SE
119.	006	91	E
120.	007	93	E
121.	045	82	SE
122.	126	82	NE
123.	039	83	SE
124.	122	83	NE
125.	130	89	NW

Table 3 : Average orientation of Joint sets

Joint Set	Average Strike	Average True Dip amount	Average True Dip direction
J1	035	80	SE
J2	035	20	NW
J3	000	84	E
J4	000	40	W
J5	300	55	NE
J6	300	80	NE

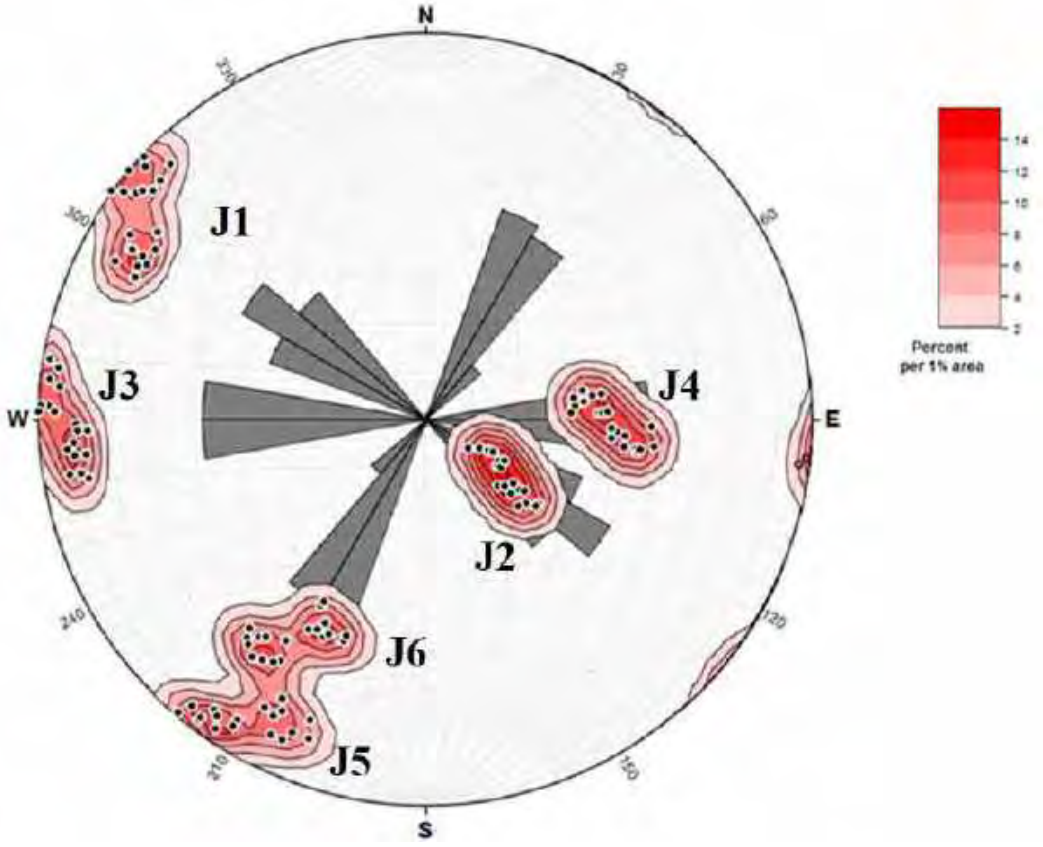

Figure 11: Rose and contour diagram of the orientation of the joint set.

3.3.2 Geological study of unconsolidated material and soil:

There are 4 types of soil were encountered along the tunnel alignment i.e., CL, ML, SM, ML-CL. From CH25800, the rock soil contact point in L-Section (Figure 19), upto CH26700 area were covered with ML type of soil. A very long patch of CL soil, from the boundary of ML at CH26700 up to CH28880, was present. A few small patches of ML and ML-CL soil were appeared within the large patch of CL. Two patches of ML soil, near CH27200 (around BH24) and near CH28560 (around BH29), and a patch of SM soil near CH 28500were found. Again, a portion of ML soil from CH2880 to CH29420 were found and rest of soil along the alignment were categorised into ML-CL type of soil.

Presence of any hot spring, artesian well/ free flowing well was not found and further, no active fault was detected in soil region along the proposed tunnel alignment.

A detailed geological map in a scale 1:25000 (Figure 12) and in 1:2000 scale showing all structural elements which includes faults, thrusts, shear zones, folds, joints, lithological boundaries along with finalised tunnel alignment(Figure 13), L-Section (Figure 19) along the hilly terrain (1:25000 H and 1:2500 V) and detailed cross sections (Figure 20,Figure 21,Figure 22) of the portal face on the mountain front and in the soil are given below;

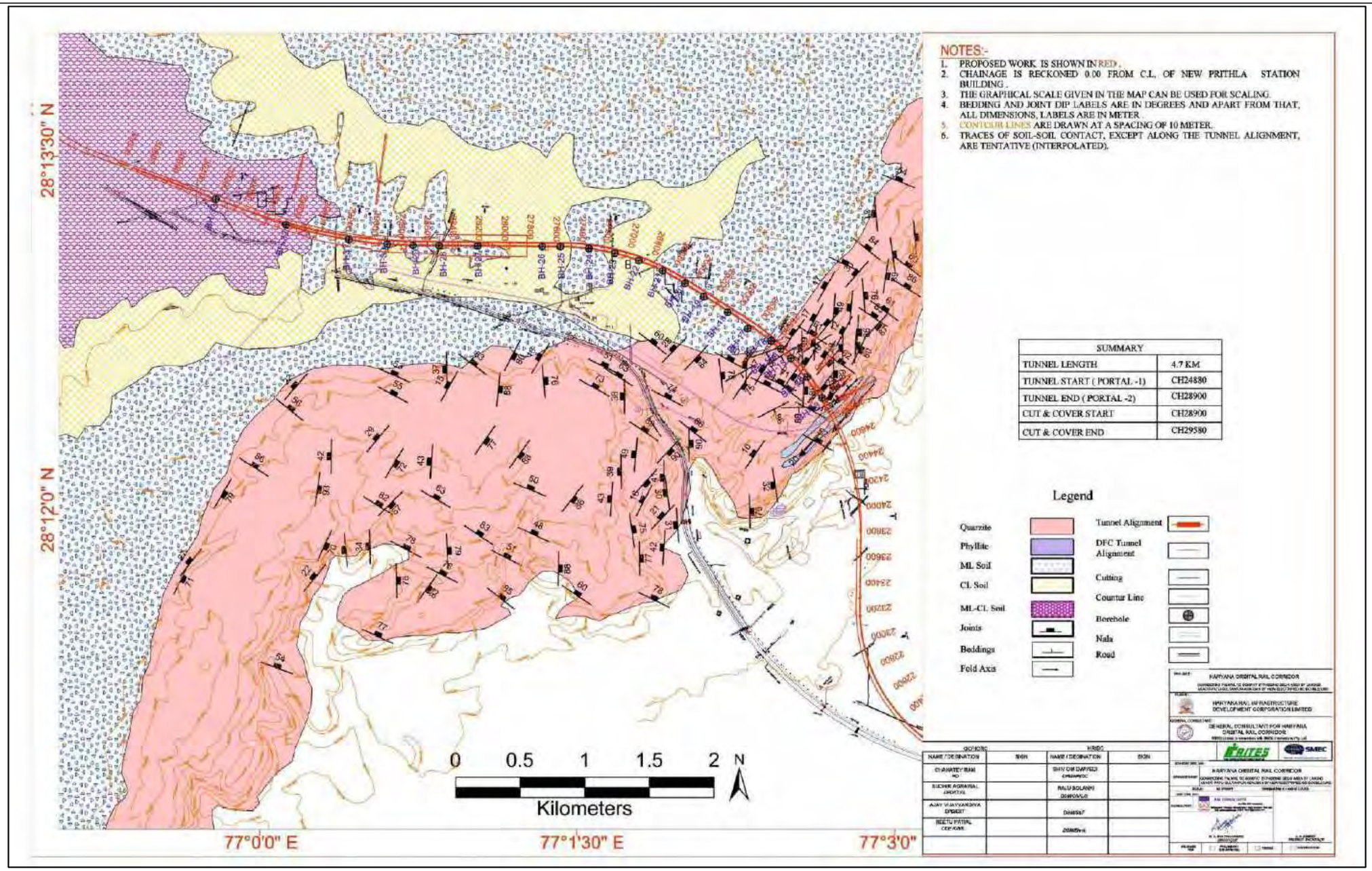

Figure 12: Geological map of the area at 1:25000 scale.

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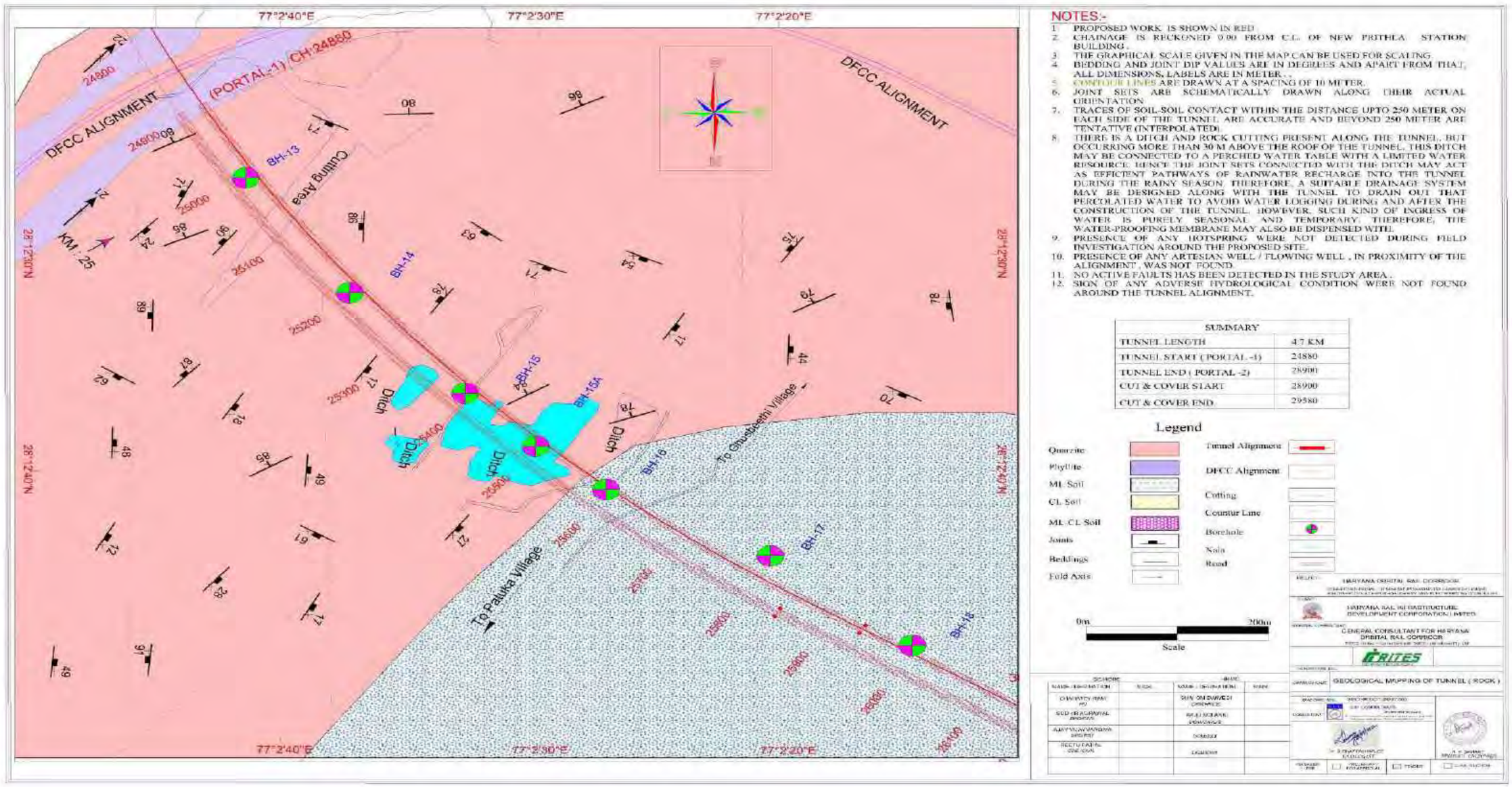

Figure 13: Detailed structural map of the major rocky area at 1:2000 scale. Joint sets are schematically drawn with their actual orientation. Average spacing between the joints are as follows J1: 300 cm, J2:252.78cm, J3:160cm, J4:80cm, J5:32cm, J6:100cm.

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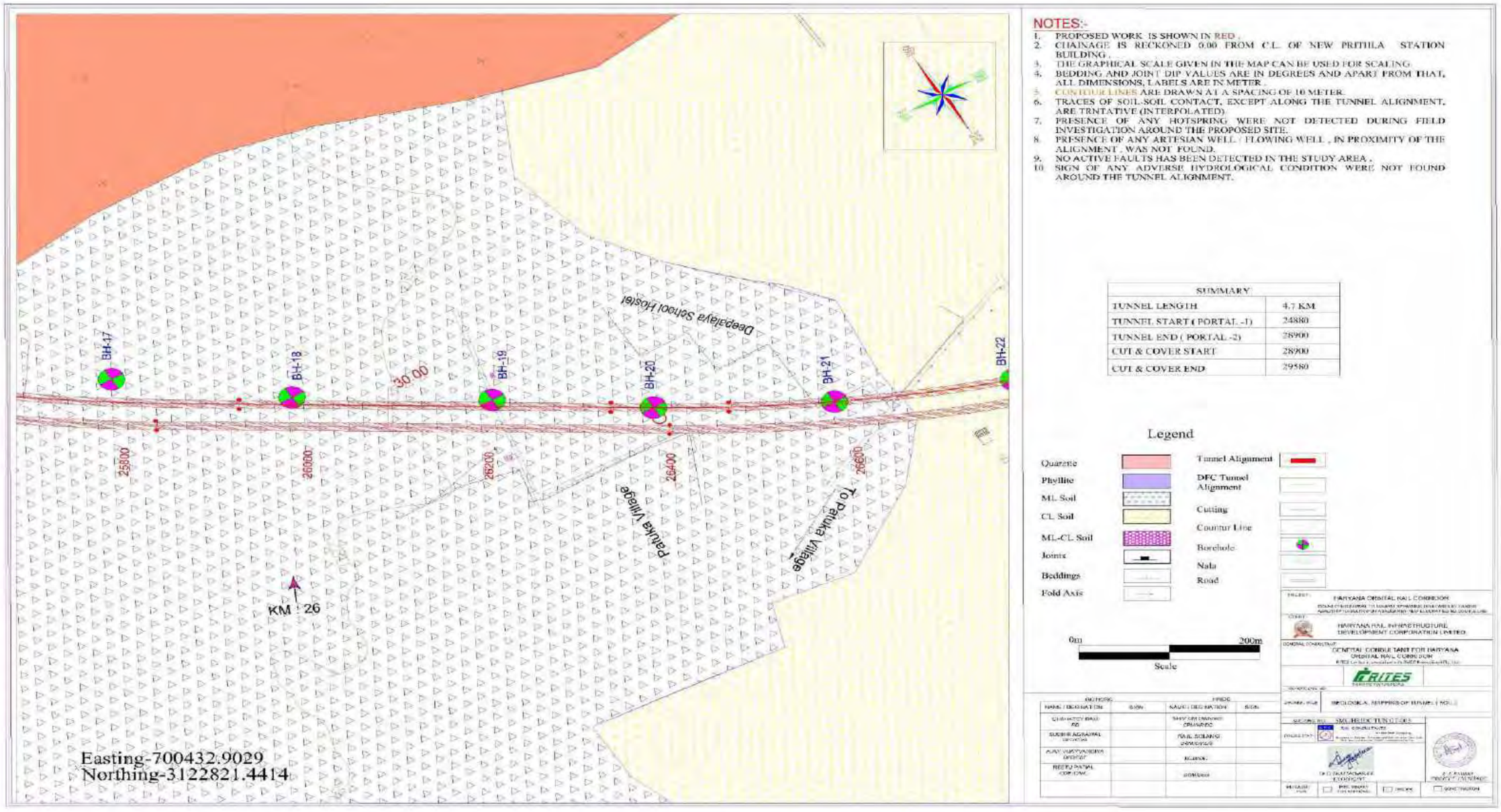

Figure 14: Detailed structural map of the major soil area at 1:2000 scale.

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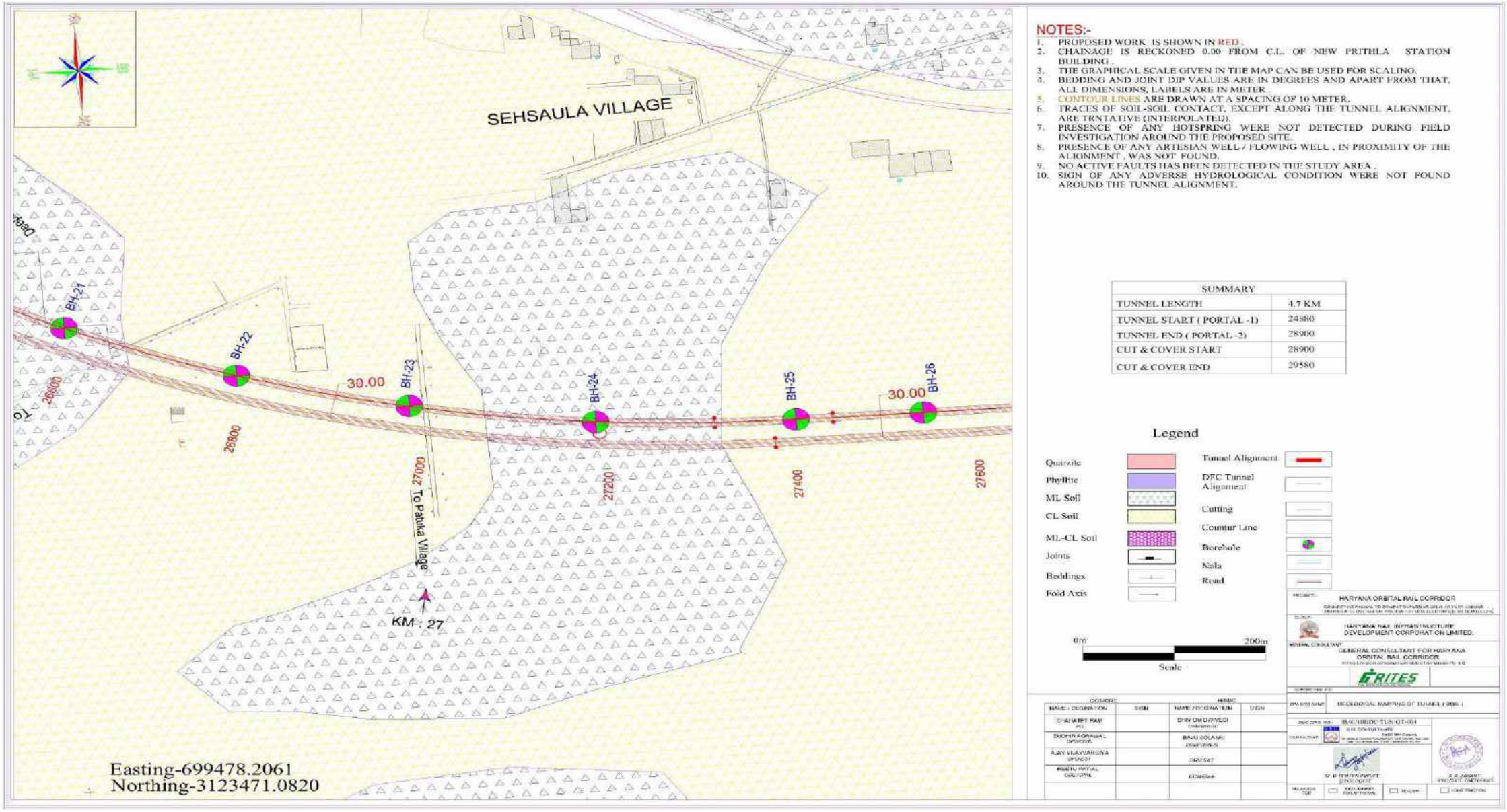

Figure 15: Detailed structural map of the major soil area at 1:2000 scale.

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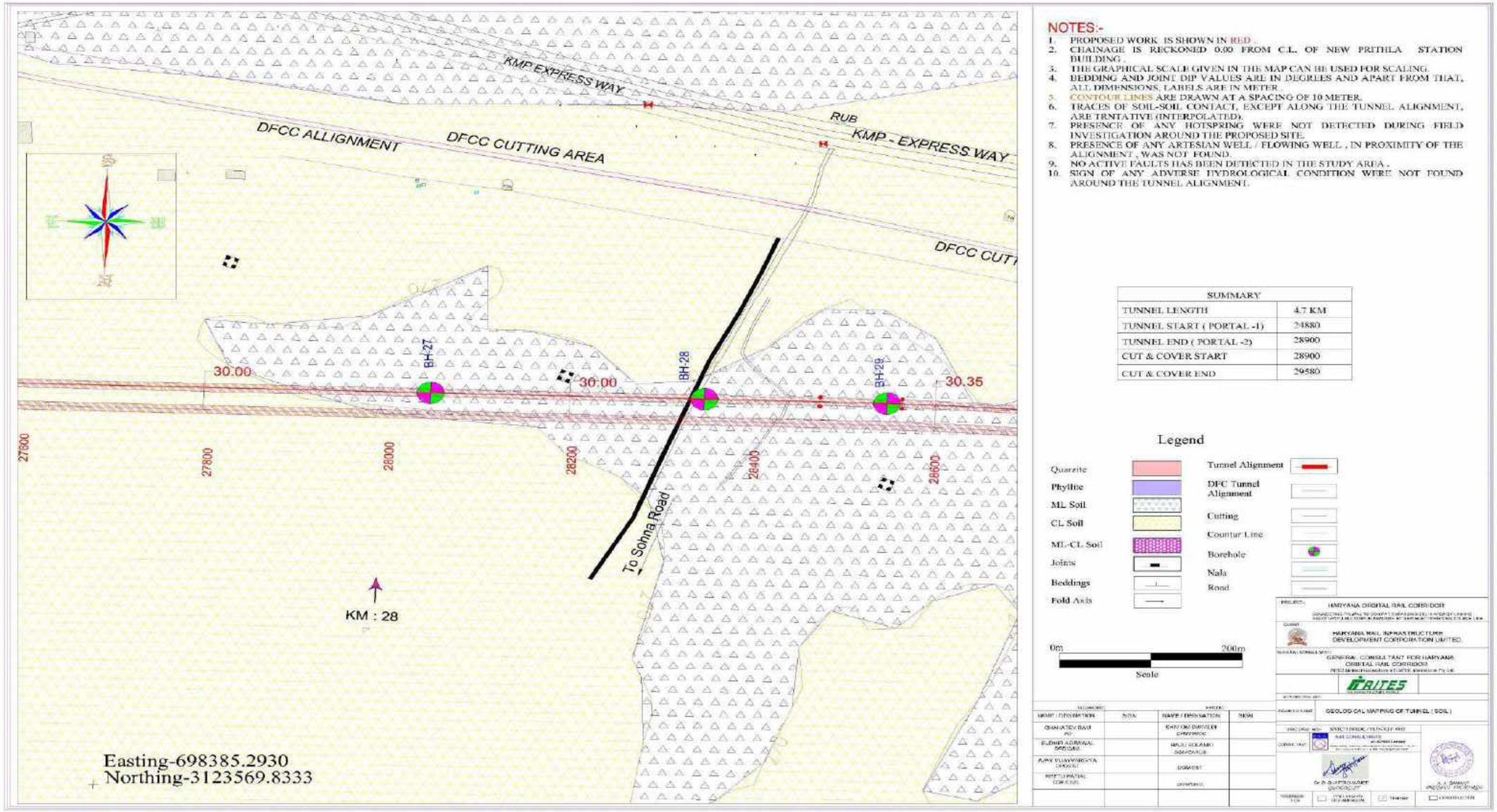

Figure 16: Detailed structural map of the major soil area at 1:2000 scale.

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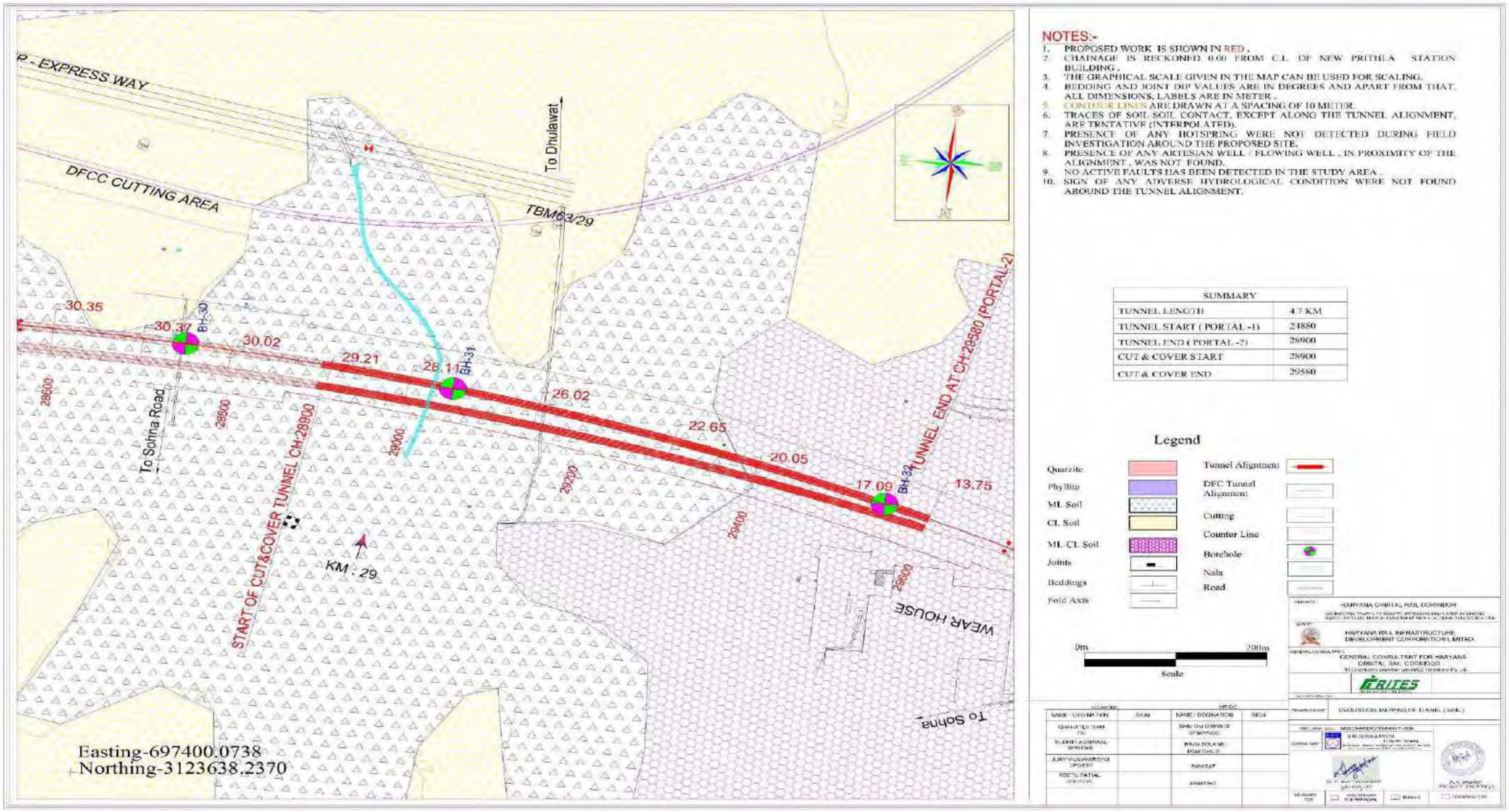

Figure 17: Detailed structural map of the major soil area at 1:2000 scale.

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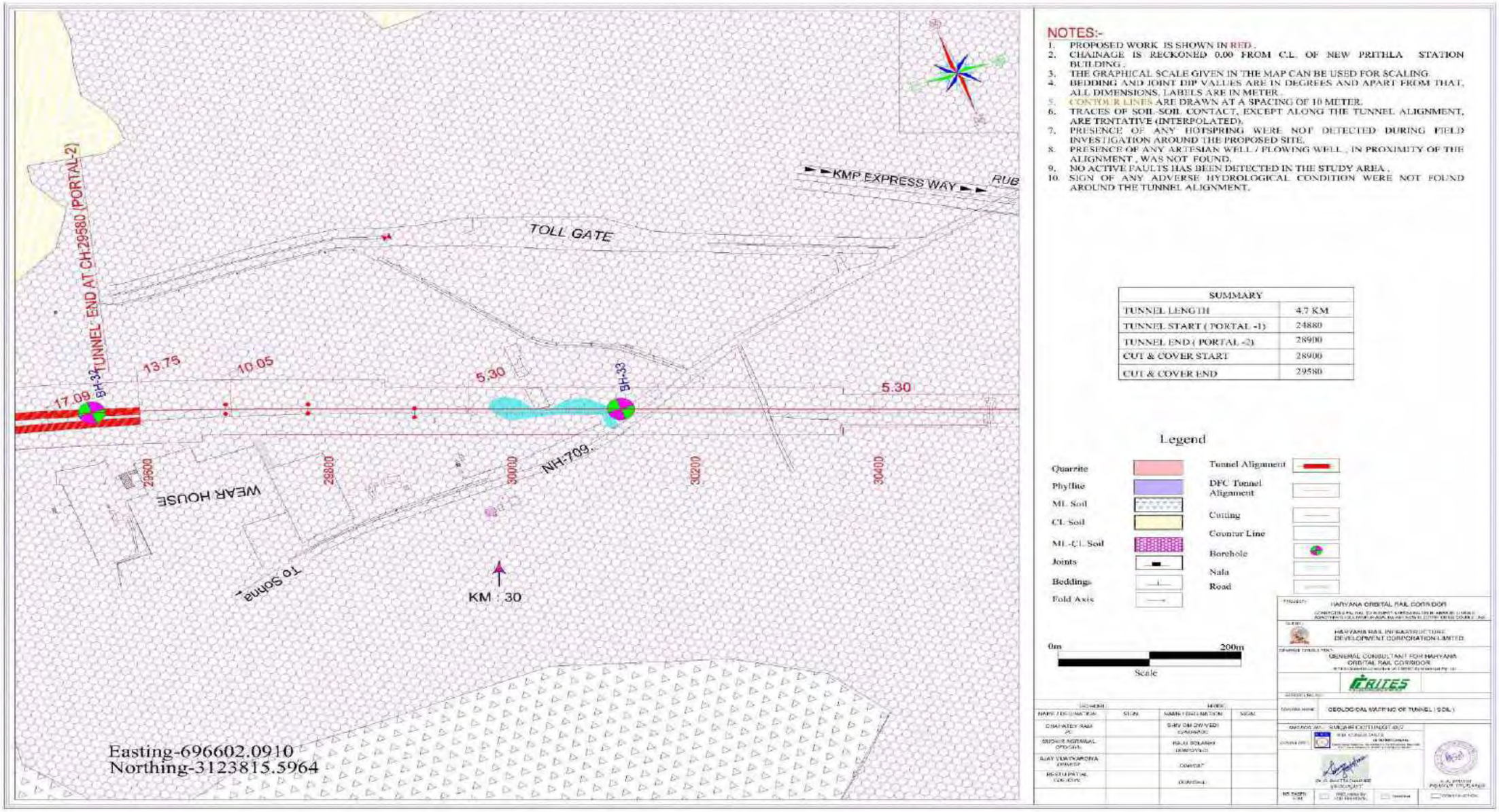

Figure 18: Detailed structural map of the major soil area at 1:2000 scale.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

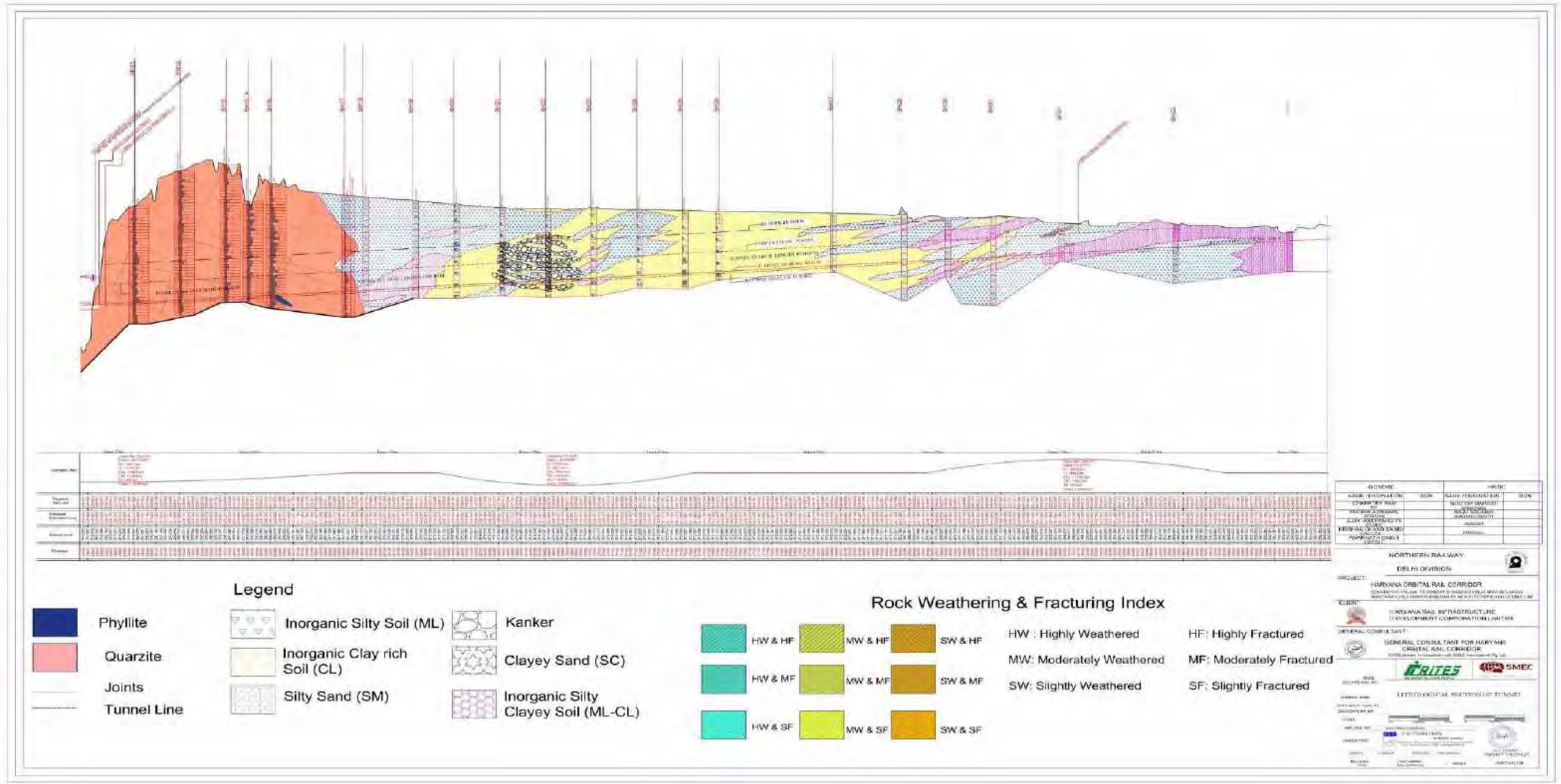

Figure 19: L-Section along the hilly terrain (1:25000 H and 1:2500 V). Joint sets are schematically drawn along their actual orientation.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

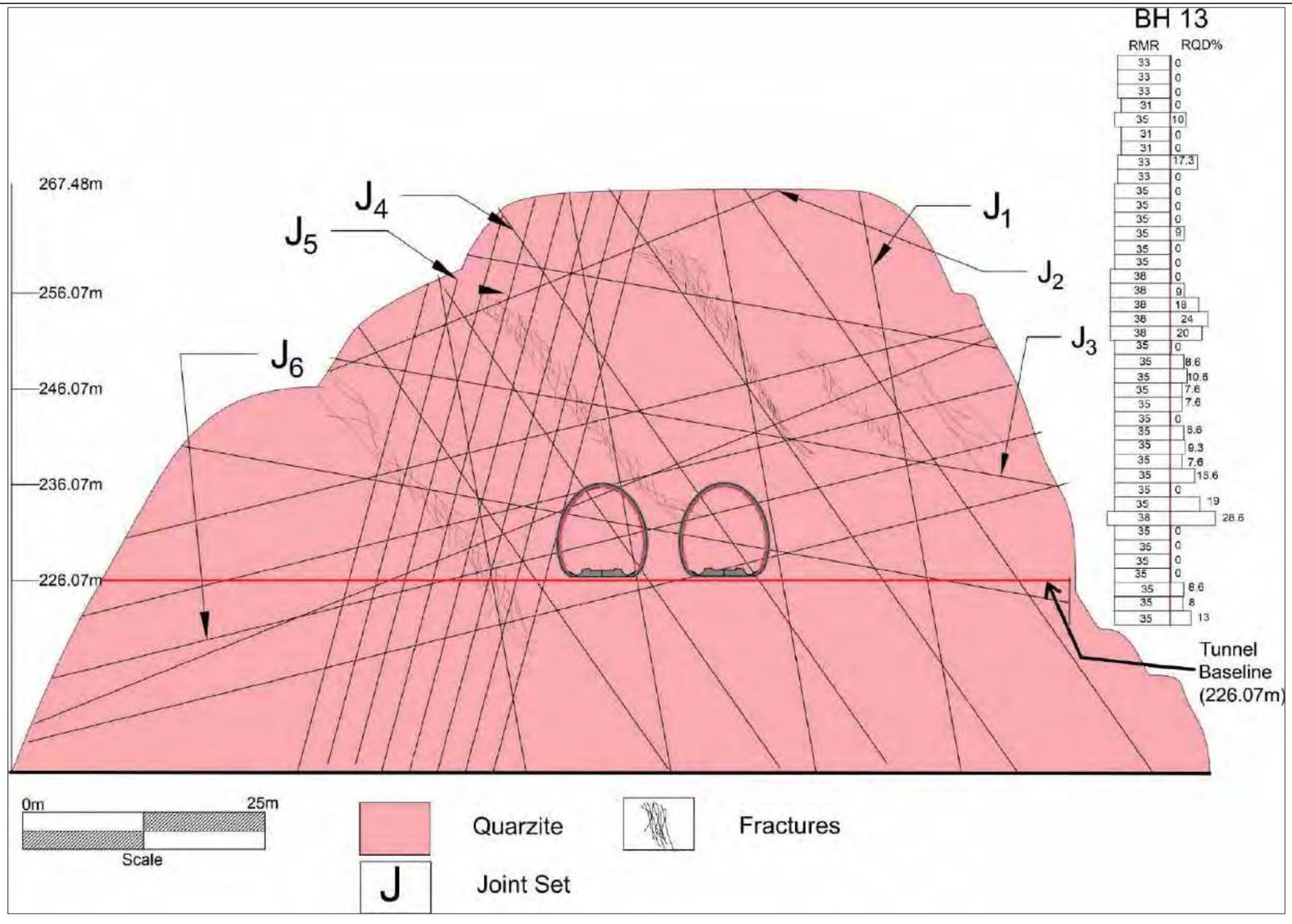

Figure 20: Detailed cross section of the portal face on the mountain front. Joint sets are schematically drawn along their actual orientation. Average spacing between the joints are as follows J1: 300 cm, J2:252.78cm, J3:160cm, J4:80cm,J5:32cm,J6:100cm.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

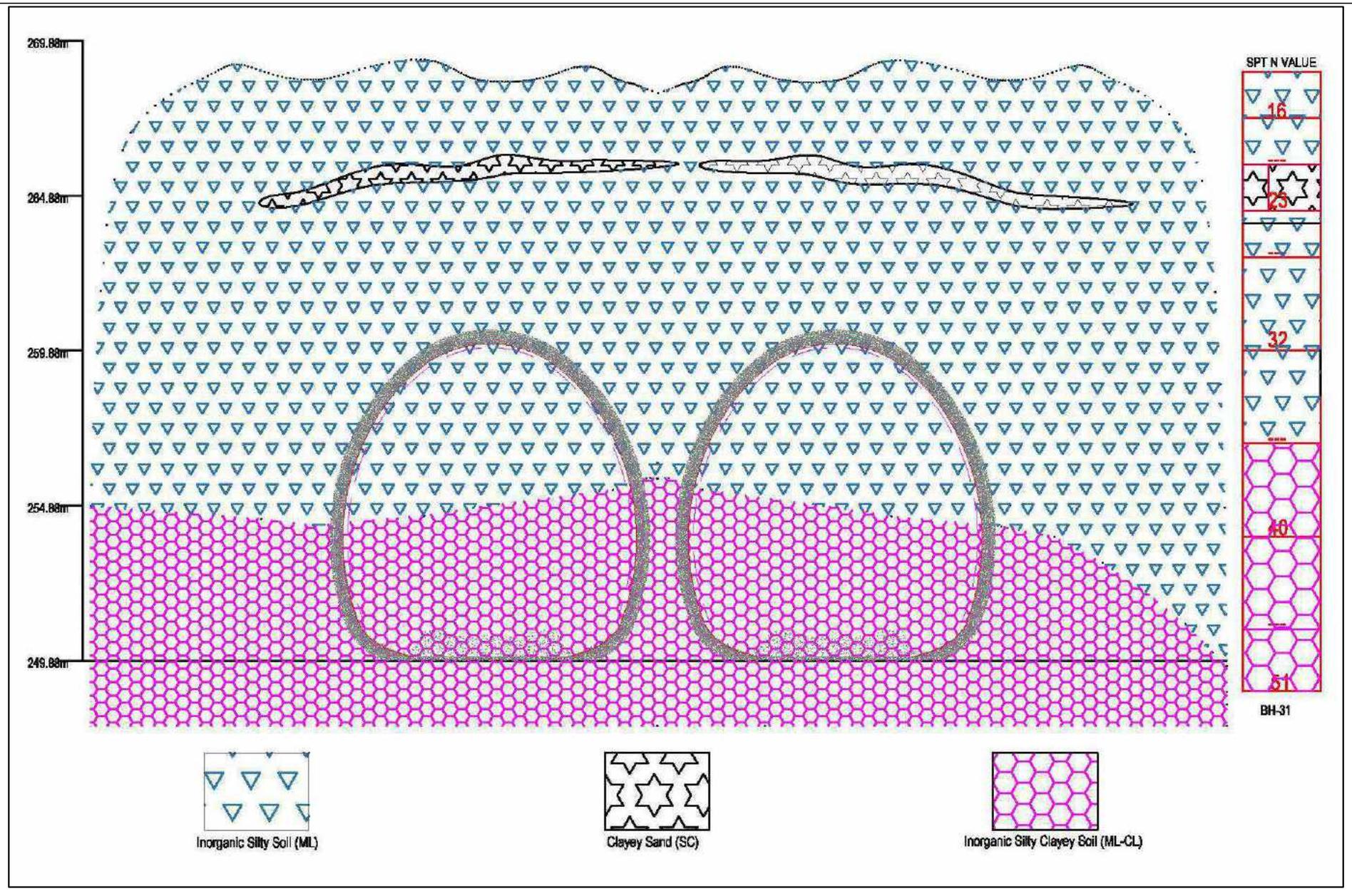

Figure 21: Detailed lithological cross section at the end of NATM Structure in soil (CH 28900).

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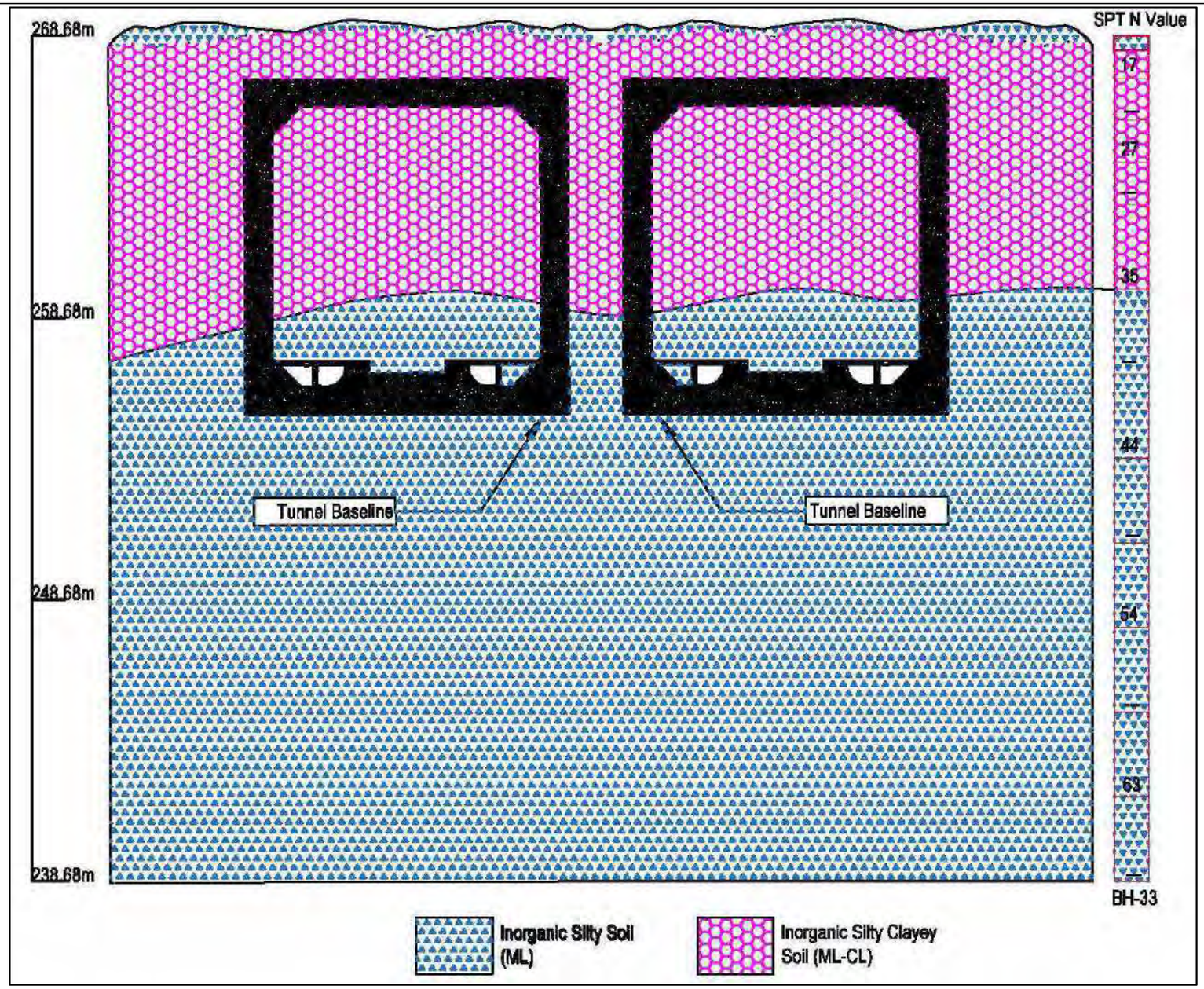

Figure 22: Cut and Cover structure at the end of tunnel – Portal II (CH29600).

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4 CHAPTER: EXPLORATORY DRILLING

As per the requirement of scope of work outlined in the terms of reference, 20 bore holes were drilled with a cumulative length of 4.6 Km (Approx) at different locations along the proposed alignment. Necessary care has been taken during drilling operations by deploying good quality diamond drill machines to obtain good core recovery to obtain RQD values. The locations of the boreholes were selected in such a way, so that these holes more or less intersect the envisaged ground/ strata conditions at different depths. The location and details of boreholes drilled; total depth of drillings is shown in table below.

Table 4: Boreholes Details

BH No.	Chainage No.	Ground Elevation, RL (m)	Total Depth (m)
BH-13	25000	276.867	60
BH-14	25195	294.218	75
BH-15	25380	295.532	70
BH-15A	25488	276.442	50
BH-16	25586	287.324	62
BH-17	25785	282.461	62
BH-18	25990	280.253	55
BH-19	26210	278.116	50
BH-20	26387	276.795	48
BH-21	26587	274.993	45
BH-22	26787	274.321	45
BH-23	26980	274.85	45
BH-24	27187	274.075	40

BH-25	27410	273.565	40
BH-26	27550	273.112	35
BH-27	28050	272.210	30
BH-28	28350	272.799	45
BH-29	28550	269.964	30
BH-30	28750	270.808	45
BH-31	29050	267.159	20
BH-32	29550	266.684	30
BH-33	30125	265.581	20

4.1 Borehole Core Details :

4.1.1 Borehole Core details from Rock Region;

The homogenous rock mass of quartzite is found in boreholes from BH13- BH17 up-to a maximum depth of 216m MSL. Rocks are weathered in a varying degree in this region. Only in BH16 at below 40m a very small amount of phyllitic rock was found.

4.1.2 Borehole Core details from Soil Region;

BH NO- 17

1. From N.G.L to 18.0.0 m depth, a low-plastic, stiff to hard consistency Inorganic silty clayey soil stratum exists from which three UDS were collected at 1.50 m, 4.5 m & 9.0 m depth. The field SPT N values were found to be 12,16,26,21,37 and greater than 50 at 3.0 m,6.0 m,12.0 m,15.0 m ,16.50 m & 18.0 m depth respectively
2. From 18.0 m to 35.0 m depth, rock stratum was encountered.
3. From 35.0 m to 39.50 m depth, a non-plastic, very dense compacted silty sand stratum exists. The field SPT N values were found to be greater than 50 at 36.50 m,38.0 m & 39.50 m depth
4. From 39.50 m to 62.0 m (max. explored) depth, rock stratum was encountered.

BH NO- 18

1. From N.G.L to 15.0.0 m depth, a non-plastic, medium compacted clayey silts with none to low plasticity stratum exists from which one DS & three UDS were collected at 0.5 m, 1.5 m, 4.50 m, & 9.0 m depth. The field SPT N values were found to be 11,20 & 24 at3.0 m,6.0 m, & 12.0 m depth.
2. From 15.0 m to 24.0 m depth, low plastic, hard consistency Inorganic silty clayey soil stratum exists. The field SPT N values were found to be 31,35 & 40 at 15.0 m,18.0 m, & 21.0 m depth.
3. From 24.0 m to 55.0 m (max. explored) depth, a non-plastic, dense to very dense compacted clayey silts with none to low plasticity stratum exists. The field SPT N values were found to be 47,49,57,64,69,77,84 and greater than 50 at 24.0m,27.0 m,30.0 m,33.0 m,36.0 m,39.0 m,42.0 m,45.0 m,47.0 m,50. 0 m,53.0 m & 55.0 m depth

BH NO- 19

1. From N.G.L to 33.0 m depth, a non-plastic, medium to dense compacted clayey silts with none to low plasticity stratum exists from which one DS & six UDS were collected at 0.5 m, 3.0 m, 6.0 m, 12.0 m, 18.0 m, 24.0 m & 30.0 m depth. The field SPT N values were found to be 17, 23, 30, 35, 35 & 39 at 1.50 m, 4.50 m, 9.0 m, 15.0 m, 21.0 m, & 27.0 m depth.
2. From 33.0 m to 50.0 m (max. explored) depth, a non-plastic, dense to very dense compacted Silty sand stratum exists.

BH NO- 20

1. From N.G.L to 12.0 m depth, a non-plastic, dense compacted clayey silts with none to low plasticity stratum exists from which one DS & two UDS were collected at 0.5 m, 3.0 m & 6.0 m depth. The field SPT N values were found to be 18, 32 & 48 at 1.50 m, 4.50 m & 9.0 m depth.
2. From 12.0 m to 15.0 m depth, a non-plastic, Silty sand stratum exists.
3. From 15.0 m to 18.0 m depth, a non-plastic, very dense compacted clayey silts with none to low plasticity stratum exists. The Field SPT N values was found to be 60 at 15.0 m Depth.
4. From 18.0 m to 21.0 m depth, a non-plastic, Silty sand stratum exists.

5. From 21.0 m to 27.0 m depth, non-plastic, very dense compacted clayey silts with none to low plasticity stratum exist. The Field SPT N values were found to be 67 & 76 at 21.0 m & 24.0 m Depth.
6. From 27.0 m to 48.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist from which four UDS sample were collected at 27.0 m, 33.0 m,39.0 m & 45.0 m depth. The field SPT N values were found to be 58, 67, 75 & 79 at 30.0 m, 36.0 m, 42.0 m & 48.0 m depth respectively

BH NO- 21

1. From N.G.L to 18.0 m depth, a non-plastic, medium to dense compacted clayey silts with none to low plasticity stratum exists from which one DS & three UDS were collected at 0.5 m, 3.0 m, 6.0 m & 12.0 m depth. The field SPT N values were found to be 14, 20, 31 & 38 at 1.50 m, 4.50 m 9.0 m & 15.0 m depth.
2. From 18.0 m to 39.0 m depth, fragmented rock stratum encountered.
3. From 39.0 m to 45.0 m (max. explored) depth, non-plastic, very dense compacted stratum exists from which two DS sample was collected at 39.0 m and 45.0 m depth. The field SPT N values was found to be 77 at 42.0 m depth respectively.

BH NO- 22

1. From N.G.L to 1.50 m depth, a medium-plastic silt & clay with low compressibility stratum exists from which one DS was collected at 0.5 m depth.
2. From 1.50 m to 12.0 m depth, a non-plastic, medium compacted clayey silts with none to low plasticity stratum exists from which two UDS were collected at 3.0 m & 6.0 m depth.
3. From 12.0 m to 42.0 m depth Fragmented Rock stratum encountered.
4. From 42.0 m to 45.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist. from which one DS sample was collected at 42.0 m depth. The field SPT N value was found to be 91 at 45.0 m depth.

BH NO- 23

1. From N.G.L to 9.0 m depth, a medium-plastic, stiff to very stiff consistency silt & clay with low compressibility stratum exists from which one DS & two UDS were collected at 0.5 m, 3.0 m & 6.0 m depth. The field SPT N values were found to be 16 & 23 at 1.50 m & 4.50 m depth.
2. From 9.0 m to 12.0 m depth, a non-plastic, dense compacted clayey silts with none to low plasticity stratum exists. The Field SPT N value was found to be 34 at 9.0 m Depth.
3. From 12.0 m to 21.0 m depth, a medium-plastic, hard consistency silt & clay with low compressibility stratum exists. The field SPT N value was found to be 38 at 21.0 m depth.
4. From 21.0 m to 24.0 m depth, a non-plastic, dense compacted Silty sand stratum exists. The field SPT N value was found to be 50 at 15.0 m depth.
5. From 24.0 m to 27.0 m depth, medium-plastic, silt & clay with low compressibility stratum exist from which one UDS was collected at 24.0 m depth.
6. From 27.0 m to 30.0 m depth, a non-plastic, very dense compacted Silty sand stratum exists. The field SPT N value was found to be 63 at 27.0 m depth.
7. From 30.0 m to 33.0 m depth, a non-plastic, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 30.0 m depth.
8. From 33.0 m to 36.0 m depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist. The field SPT N value was found to be 73 at 33.0 m depth.
9. From 36.0 m to 39.0 m depth, a non-plastic, Silty sand stratum exists from which one UDS was collected at 36.0 m depth.
10. From 39.0 m to 45.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist from which one UDS sample was collected at 42.0 m depth. The field SPT N values were found to be 77 & 85 at 39.0 m & 45.0 m depth respectively.

BH NO- 24

1. From N.G.L to 24.0 m depth, a non-plastic, medium compacted clayey silts with none to low plasticity stratum exists from which one DS & four UDS were collected at 0.5 m, 3.0 m, 6.0 m, 12.0 m & 18.0 m depth. The field SPT N values were found to be 14,21,27,33 & 43 at 1.50 m, 4.50 m, 9.0 m, 15.0 m & 21.0 m depth.

2. From 24.0 m to 40.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist from which four UDS sample were collected at 24.0 m,30.0 m,36.0 m & 40.0 m depth. The field SPT N values were found to be 58, 72 & 89 at 27.0 m, 33.0 m & 39.0 m depth respectively.

BH NO- 25

1. From N.G.L to 40.0 m (max. explored) depth, medium-plastic, stiff to hard consistency silt & clay with low compressibility stratum exist from which one DS & eight UDS sample were collected at 0.5 m,3.0 m,6.0 m,12.0 m,18.0 m,24.0 m,30.0 m,36.0 m & 40.0 m depth. T
2. The field SPT N values were found to be 13,20,30,31,33,48,68 & 81 at 1.50 m,4.50 m,9.0 m,15.0 m,21.0 m,27.0 m, 33.0 m & 39.0 m depth respectively.

BH NO- 26

1. From N.G.L to 35.0 m (max. explored) depth, medium-plastic, stiff to hard consistency silt & clay with low compressibility stratum exist from which one DS & seven UDS sample were collected at 3.0 m,6.0 m,12.0 m,18.0 m,24.0 m,30.0 m & 35.0 m depth.
2. The field SPT N values were found to be 11,19,28,34,41,53 & 65 at 1.50 m,4.50 m,9.0 m,15.0 m,21.0 m,27.0 m & 33.0 m depth respectively.

BH NO- 27

1. From N.G.L to 6.0 m depth, a medium-plastic, stiff to very stiff consistency, silt and clay with low compressibility stratum exists from which one DS & one UDS were collected at 0.5 m & 3.0 m, depth. The field SPT N values were found to be 14 & 24 at 1.50 m, & 4.50 m depth.
2. From 6.0 m to 9.0 m depth, non-plastic, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 6.0 m depth,
3. From 9.0 m to 18.0 m depth, a medium-plastic, very stiff to hard consistency, silt and clay with low compressibility stratum exists from which one UDS was collected at 12.0 m, depth. The field SPT N values were found to be 27 & 36 & 9.0 m, & 15.0 m depth.
4. From 18.0 m to 21.0 m depth, non-plastic, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 18.0 m depth,

5. From 21.0 m to 30.0 m (max. explored) depth, medium-plastic, hard consistency silt & clay with low compressibility stratum exist from which two UDS sample were collected at 24.0 m & 30.0 m depth. The field SPT N values were found to be 45 & 54 at 21.0 m & 27.0 m depth respectively.

BH NO- 28

1. From N.G.L to 1.50 m depth, non-plastic, clayey silts with none to low plasticity stratum exists from which one DS was collected at 0.5 m depth,
2. From 1.50 m to 3.0 m depth, a medium-plastic, medium consistency, silt and clay with low compressibility stratum exists. The field SPT N values was found to be 12 at 1.5 m depth.
3. From 3.0 to 6.0 m depth, non-plastic, medium compacted clayey silts with none to low plasticity stratum exists from which one UDS was collected at 3.0 m depth. The field SPT N Values Was found to be 21 & 4.50 m depth.
4. From 6.0 to 9.0 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 6.0 m depth.
5. From 9.0 to 18.0 m depth, non-plastic, medium to dense compacted clayey silts with none to low plasticity stratum exists from which one UDS was collected at 12.0 m depth. The field SPT N Values Was found to be 28 & 38 at 9.0 & 15.0 m depth.
6. From 18.0 m to 30.0 m depth, a medium-plastic, hard consistency, silt and clay with low compressibility stratum exists from which two UDS were collected at 18.0 m & 24.0 m depth. The field SPT N values were found to be 47 & 53 at 21.0 m & 27.0 m depth.
7. From 30.0 to 33.0 m depth, non-plastic, very dense compacted clayey silts with none to low plasticity stratum exists from which one UDS was collected at 30.0 m depth.
8. From 33.0 m to 39.0 m depth, a medium-plastic, hard consistency, silt and clay with low compressibility stratum exists from which one UDS was collected at 36.0 m depth. The field SPT N values were found to be 70 at 33.0 m depth.
9. From 39.0 m to 45.0 m (max. explored) depth, non-plastic very dense compacted clayey silts with none to low plasticity stratum exist from which one UDS sample was collected at 39.0 m depth. The field SPT N values were found to be 81 & 92 at 39.0 m & 45.0 m depth respectively.

BH NO- 29

1. From N.G.L to 3.0 m depth, non-plastic, medium compacted, clayey silts with none to low plasticity stratum exists from which one DS was collected at 0.5 m depth. The field SPT N value was found to be 12 at 1.5 m depth.
2. From 3.0 m to 12.0 m depth, a low-plastic, very stiff consistency, consistency Inorganic silty clayey stratum exists from which two UDS were collected at 3.0 m & 6.0 m depth. The field SPT N values were found to be 14 & 27 at 4.5 m & 9.0 m depth.
3. From 12.0 to 15.0 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 12.0 m depth.
4. From 15.0 to 24.0 m depth, non-plastic, dense compacted, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 18.0 m depth. The field SPT N Values were found to be 38 & 47 at 15.0 m & 21.0 m depth respectively.
5. From 24.0 to 27.0 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 24.0 m depth.
6. From 27.0 m to 30.0 m (max. explored) depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists from which one UDS was collected at 27.0 m depth. The field SPT N values was found to be 61 at 27.0 m depth.

BH NO- 30

1. From N.G.L to 4.5 m depth, non-plastic, medium compacted, clayey silts with none to low plasticity stratum exists from which one DS and one UDS was collected at 0.5 m & 3.0 m depth. The field SPT N value was found to be 17 at 1.5 m depth.
2. From 4.50 m to 12.0 m depth, a low-plastic, very stiff consistency, Inorganic silty clayey stratum exists from which two UDS were collected at 3.0 m & 6.0 m depth. The field SPT N values were found to be 22 & 30 at 4.5 m & 9.0 m depth.
3. From 12.0 to 18.0 m depth, medium-plastic, hard consistency, silt & clay with low compressibility stratum exists from which one UDS was collected at 12.0 m depth. The field SPT N values was found to be 38 at 15.0 m depth.
4. From 18.0 to 21.0 m depth, non-plastic, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 18.0 m depth.

5. From 21.0 to 24.0 m depth, medium-plastic, hard consistency, silt & clay with low compressibility stratum exists. The field SPT N values were found to be 44 at 21.0 m depth.
6. From 24.0 to 27.0 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 24.0 m depth.
7. From 27.0 to 45.0 m depth, non-plastic, very dense compacted, clayey silts with none to low plasticity stratum exists from which three UDS were collected at 30.0 m,36.0 m & 42.0 m depth respectively.
8. From 45.0 m (max. explored) depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists. The field SPT N values were found to be 84 at 45.0 m depth.

BH NO- 31

1. From N.G.L to 3.0 m depth, medium-plastic, stiff consistency, silt and clay with low compressibility stratum exists from which one DS was collected at 0.5 m depth. The field SPT N value was found to be 16 at 1.5 m depth.
2. From 3.0 to 4.50 m depth, non-plastic, silty sand stratum exists from which one UDS was collected at 3.0 m depth.
3. From 4.50 m to 12.0 m depth, a non-plastic, medium to dense compacted, clayey silts with none to low plasticity stratum exists from which one UDS was collected at 6.0 m depth. The field SPT N values were found to be 23 & 32 at 4.5 m & 9.0 m depth.
4. From 12.0 m to 20.0 m (max. explored) depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists from which two UDS were collected at 12.0 m & 18.0 m The field SPT N values were found to be 40 & 51 at 15.0 m & 20.0 m depth respectively.

BH NO-32

1. From N.G.L to 30 m depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists from which one DS was collected at 0.5 m depth and six UDS were collected at 3.0 m, 6.0 m, 12.0 m, 18.0 m, 24.0m & 30.0m.
2. The field SPT N values were found to be 17, 27, 35, 44, 54 & 63 at 1.5m, 4.5m, 9.0m, 15.0m, 21.0m & 27.0 m depth respectively.
3. The plasticity index of the soil throughout the borehole is ranging between 10% – 12 %.
4. The plastic limit of the soil throughout the borehole is ranging between 19% – 22 %.

BH NO-33

1. From N.G.L to 30 m depth, a low-plastic, hard consistency Inorganic silty clayey stratum exists from which one DS was collected at 0.5 m depth and four UDS were collected at 3.0 m, 6.0 m, 12.0 m & 18.0 m.
2. The field SPT N values were found to be 11, 28, 39, 50 & 63 at 1.5m, 4.5m, 9.0m, 15.0m & 20.0m depth respectively.
3. The plasticity index of the soil throughout the borehole is ranging between 9% – 13 %.
4. The plastic limit of the soil throughout the borehole is ranging between 18% – 20 %.

4.2 Permeability Test in Bed Rock

The packer test method was carried out as per IS 5529 (Part 2): 2006 to determine the permeability of the rock strata at site.

4.2.1 Packer test method:

In the packer method, water is pumped under pressure into the test section of bedrock through drill hole. The single and double packer methods are normally conducted in exploratory holes.

Single packer method:

In this method, one packer is used in the drill hole. The test section is between the bottom of the bore hole and the packer.

Double packer method:

In this method, two packers are used in the drill hole. The test section is between the two packers.

Procedure:

The procedure adopted consists of pumping water into the 'test section' and is therefore called 'pumping-in type'. Packers are employed for conducting these tests and depending upon the use of one packer or two packers the method is designated as single or

double packer method respectively. Examination of the drill cores and the results of water tests, obtained during drilling will usually indicate whether a double packer test in any isolated section or sections of the drill hole is required. The tests are based on measuring the amount of water accepted by the 'test section' (of the hole) confined by a packer/packer while water is pumped into it.

After completion of the full arrangement for the test, the water pumped in to the section under pressure. The pressure should be maintained until the readings of water intake at intervals of 5 min show a nearly constant reading of water intake for one particular pressure at the collar. The constant rate of water intake should be noted. It is recommended that the tests to be commenced with a low pressure at the collar and increased limited to the availability of suitable rock cover to prevent uplift or till a maximum pressure equivalent to H + x (where H is the hydraulic head to which the strata would be subjected to due to the contemplated structure and x is the loss due to the friction) is achieved. In our case, 1, 2 and 3 kg/cm2 pressure were applied in every case.

The water loss (due to permeability inside the rock) is expressed in Lugeons. A Lugeon is defined as the water loss in litre/min./m of the drill hole under is pressure of 10 atmospheres maintained for 10 min in a drill hole of 46 mm to 76 mm diameter.

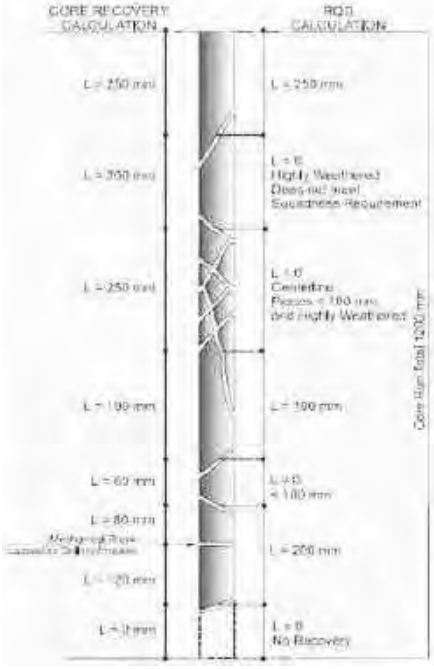
Table 5 Parker test results

BH No.	Packer test section 1		Lugeon Value	Packer test section 2		Lugeon Value
	Upper part (m)	Lower part (m)		Upper part (m)	Lower part (m)	
BH-13	**36**	**39**	**30.20**	**48**	**51**	**25.62**
BH-14	**54**	**57**	**24.46**	**63**	**66**	**21.88**
BG-15	**55**	**58**	**24.34**	**64**	**67**	**18.42**
BH-16	**44**	**47**	**27.38**	**56**	**59**	**21.14**
BH-17	**41**	**44**	**24.52**	**50**	**53**	**22.78**

5 CHAPTER: GEOMECHANICAL CLASSIFICATION OF GEOLOGICAL UNITS

5.1 Rock Quality Designation (RQD)

Rock Quality Designation (RQD) is a measure of quality of rock core taken from a borehole. RQD signifies the degree of jointing or fracture in a rock mass measured in percentage, where RQD of 75% or more shows good quality hard rock and less than 50% show low quality weathered rocks. RFQ is calculated by taking a rock core sample from a borehole and lengths of all sound rock pieces which are minimum 100 mm long are summed up and are divided by the length of the core run. Only those pieces of rocks are considered which are hard and good quality. Weathered rocks which do not meet soundness requirements and whose lengths are not greater than 100mm are not considered for calculation of RQD. The length of core pieces is measured along center line of the pieces. RFQ test provides assessment of soundness of the rock and damages caused due to weathering.



Rock Quality	RQD (%)
Very poor (Completely weathered rock)	<25%
Poor (weathered rocks)	25 to 50%
Fair (Moderately weathered rocks)	51 to 75%
Good (Hard Rock)	76 to 90%
Very Good (Fresh rocks)	91 to 100%

Table 6: Categories of rock with respect to their RQD value

5.1.1 Rocks Core Recovery and RQD Calculations:

Core recovery (CR) is calculated by following formula:

$$CR = \left[\frac{total\ length\ of\ rock\ recovered}{Total\ core\ run\ length} \times 100\right]\%$$

$$RQD = \left[\frac{Length\ of\ core\ pieces > 10cm}{Total\ core\ run\ length} \times 100\right]\%$$

ROCK CLASSIFICATION BASED ON RQD		Joint Frequency	RQD (%)
A	VERY POOR ROCK	>27 joints per m^3	0-25
B	POOR	20-27 joints per m^3	25-50
C	FAIR	13-19 joints per m^3	50-75
D	GOOD	8-12 joints per m^3	75-90
E	EXCELLENT	0-7 joints per m^3	90-100

Note:

i) Where RQD is reported or measured as ≤ 10 (including 0) the value 10 is used to evaluate the Q-value

ii) RQD-intervals of 5, i.e. 100, 95, 90, etc., are sufficiently accurate.

5.1.2 Methodology:

The drill cores (NX & NQ size) were properly logged and stored in the GI core boxes specifically designed as per the standard specifications. The cores are aligned systematically according to the core run and all the relevant information regarding the core recovery, Rock Quality Designation (RQD), fracture pattern was observed from the geotechnical logging of

the drilled holes. The details of the rock type obtained from each drill hole runs were systematically recorded and summarized in the standard Geotechnical logging format. Table, given below, summarized the percentage of RQD as obtained during the drilling of bore holes. For detail table refer Annexure.

Table 7: Average, Minimum & Maximum Value of RQD.

BH NO.	AVERAGE RQD, %	MINIMUM RQD, %	MAXIMUM RQD, %
BH-13	6.5	0	28.6
BH-14	5.9	0	24.0
BH-15	5.9	0	27.0
BH-15A	10.7	0	32.0
BH-16	16.0	0	51.3
BH-17	10.9	0	41.5

Core samples were collected from the drill holes at different depth intervals to represent the envisaged strata conditions of the proposed crown and invert portion of different tunnel types. These samples were sent to IIT, Banaras Hindu University (BHU) and NABL accredited Laboratory at New Delhi for testing the Physico-mechanical properties.

The assessment of rock mass has been carried out based on the geotechnical investigation, observation of the core logs, joint orientation with reference to the proposed tunnel orientation and physico -mechanical properties of rock cores. The rock mass is classified in to Q-classification system (Q tunnelling index) developed by Barton. N. (1976), Norwegian Geotechnical Institute and RMR Geo-mechanics Classification system.

The data, thus obtained from geotechnical inputs has been analysed by using both the standard Rock Mass Classification systems. Pre-investigations for underground excavations often include core-logging. The Q-parameters were evaluated with a relatively high degree of accuracy.

However, special attention has been addressed to the following aspects:

Only a small section of each joint surface will usually be available, particularly for joints intersecting the borehole at an obtuse angle. Evaluation of the roughness coefficient (Jr) may therefore be difficult. Particularly the large and medium scale undulation may be difficult to estimate. As water is used during drilling, fillings like clay minerals may be washed out, making it difficult to evaluate in some cases.

The drilling direction of the borehole influences the number of joints that are intersected by the borehole. Sub-parallel joints to the borehole will be under represented in the cores, and this will give too high RQD-values and too low Jn values. Whereas, RQD is often calculated for every meter, Jn must usually be estimated for sections of several meters.

In massive rock it is impossible to estimate SRF (Stress Reduction Factor) from drill cores. However, in rock intersected by weakness zones, it may be possible to give some suggestions about SRF. In massive rock, SRF can be estimated partially based on the overburden, height of a mountain side, stress measurements carried out in the borehole, or experiences from nearby construction sites.

In general, a core log should only contain data obtained from the cores or measurements carried out in the borehole itself. However, by using the log data combined with estimates of J_w and SRF, it will be possible to get a rough impression of the Q-values of the cores, and these could be helpful during planning phase. Water-loss tests are often carried out during core drilling. The results are normally given in Lugeon (Lugeon = the loss of water in litters per minute and per meter borehole at an over-pressure of 1 MPa), and form the basis for evaluation of the J_w-value. One also has to take into account whether the rock mass is going to be grouted or not in order to estimate the Q-value as a basis for rock support after excavation.

It is always important to evaluate how representative the cores are. Boreholes are often drilled just in order to investigate particular zones. It is then imperative to consider how much of the total rock masses these zones represent. If a borehole is orientated along a fracture zone, the parameter values for this zone will be determined.

5.2 Rock Mass Rating Index (RMR):

Bieniawski (1976) published the details of a rock mass classification called the Geomechanics Classification or the Rock Mass Rating (RMR) system. Over the years, this system has been successively re- fined as more case records have been examined and the reader should be aware that Bieniawski has made significant changes in the ratings assigned to different parameters. The discussion which follows is based upon the 1989 version of the classification (Bieniawski, 1989). The following six parameters are used to classify a rock mass using the RMR system:

i) Uniaxial compressive strength of rock material.
ii) Rock Quality Designation (RQD).
iii) Spacing of discontinuities.
iv) Condition of discontinuities.
    a) Length, persistence
    b) Separation
    c) Smoothness
    d) Infilling
    e) Alteration / weathering
v) Groundwater conditions.
vi) Orientation of discontinuities.

All of these are measurable in the field and can also be obtained from borehole data. The rating of each of these parameters is summarized to give a value of RMR. All parameters are measurable in the field and some of them may also be obtained from borehole data.

To apply the RMR classification, the rock mass along a tunnel route is divided into a number of structural regions, i.e., zones in which certain geological feature are more or less uniform. The above six classification parameters are determined for each structural region from measurements in the field. Once the classification parameters are determined, the ratings are assigned to each parameter according to Table 7.

Table 8: RMR Classification Parameters and Their Ratings

PARAMETER			Range of values // ratings						
1	Strength of intact rock material	Point-load strength index	> 10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range Uniaxial compr. strength is preferred		
		Uniaxial com- pressive strength	> 250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 -5 MPa	< 1 MPa
	RATING		**15**	**12**	**7**	**4**	**2**	**1**	**0**
2	Drill core quality RQD		90 - 100%	75 - 90%	50 - 75%	25 - 50%	< 25%		
	RATING		**20**	**17**	**13**	**8**	**5**		
3	Spacing of discontinuities		> 2 m	0.6 - 2 m	200 - 600 mm	60 - 200 mm	< 60 mm		
	RATING		**20**	**15**	**10**	**8**	**5**		
4	Condition of discontinuities	Length, persistence	< 1 m	1 - 3 m	3 - 10 m	10 - 20 m	> 20 m		
		Rating	**6**	**4**	**2**	**1**	**0**		
		Separation	None	< 0.1 mm	0.1 - 1 mm	1 - 5 mm	> 5 mm		
		Rating	**6**	**5**	**4**	**1**	**0**		
		Roughness	very rough	Rough	slightly rough	smooth	Slickensided		
		Rating	**6**	**5**	**3**	**1**	**0**		
		Infilling (gouge)	None	Hard filling		Soft filling			
			-	< 5 mm	> 5 mm	< 5 mm	> 5 mm		
		Rating	**6**	**4**	**2**	**2**	**0**		
		Weathering	unweathered	slightly w.	moderately w.	highly w.	Decomposed		
		Rating	**6**	**5**	**3**	**1**	**0**		
5	Ground water	Inflow per 10 m tunnel length	None	< 10 litres/min	10 - 25 litres/min	25 - 125 litres/min	> 125 litres /min		
		p_w /	0	0 - 0.1	0.1 - 0.2	0.2 - 0.5	> 0.5		
		General conditions	completely dry	Damp	Wet	dripping	Flowing		
	RATING		**15**	**10**	**7**	**4**	**0**		

p_w = joint water pressure; = major principal stress

In this respect the typical, rather than the worst conditions, are evaluated. Furthermore, it should be noted that the ratings, which are given for discontinuity spacing, apply to rock masses having three sets of discontinuities. Thus, when only two sets of discontinuities are present, a conservative assessment is obtained.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

Table 9: Rating Adjustment for Discontinuity Orientations

		Very favorable	Favorable	Fair	Unfavorable	Very unfavorable
RATINGS	Tunnels	**0**	**-2**	**-5**	**-10**	**-12**
	Foundations	**0**	**-2**	**-7**	**-15**	**-25**
	Slopes	**0**	**-5**	**-25**	**-50**	**-60**

Table 10: Rock Mass Classes Determined from Total Ratings

Rating	100 - 81	80 – 61	60 – 41	40 - 21	< 20
Class No.	I	II	III	IV	V
Description	VERY GOOD	GOOD	FAIR	POOR	VERY POOR

Table 10: Significance of Rock Mass Classes

Class No.	I	II	III	IV	V
Average stand-up time	10 years for 15 m span	6 months for 8 m span	1 week for 5 m span	10 hours for 2.5 m span	30 minutes for 1 m span
Cohesion of the rock mass	> 400 kPa	300 - 400 kPa	200 - 300 kPa	100 - 200 kPa	< 100 kPa
Friction angle of the rock mass	< 45°	35 - 45°	25 - 35°	15 - 25°	< 15°

Table 11: RMR Classification Guide for Excavation and Support in Rock Tunnels

Rock mass class	**Excavation**	**Support**		
		Rock bolts (20 mm diam., fully bonded)	Shotcrete	Steel sets
1. Very good rock RMR: 81-100	Full face: 3 m advance	Generally, no support required except for occasional spot bolting		
2. Good rock RMR: 61-80	Full face: 1.0-1.5 m advance; Complete support 20 m from face	Locally bolts in crown, 3 m long, spaced 2.5 m with occasional wire mesh	50 mm in crown where required	None
3. Fair rock RMR: 41-60	Top heading and bench: 1.5-3 m advance in top heading; Commence support after each blast; Commence support 10 m from face	Systematic bolts 4 m long, spaced 1.5-2 m in crown and walls with wire mesh in crown	50-100 mm in crown, and 30 mm in sides	None

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Rock mass class	Excavation	Support		
		Rock bolts (20 mm diam., fully bonded)	Shotcrete	Steel sets
4. Poor rock RMR: 21-40	Top heading and bench: 1.0-1.5 m advance in top heading; Install support concurrently with excavation - 10 m from face	Systematic bolts 4-5 m long, spaced 1-1.5 m in crown and walls with wire mesh	100-150 mm in crown and 100 mm in sides	Light ribs spaced 1.5 m where required
5. Very poor rock RMR < 21	Multiple drifts: 0.5-1.5 m advance in top heading; Install support concurrently with excavation; shotcrete as soon as possible after blasting	Systematic bolts 5-6 m long, spaced 1-1.5 m in crown and walls with wire mesh. Bolt invert	150-200 mm in crown, 150 mm in sides, and 50 mm on face	Medium to heavy ribs spaced 0.75 m with steel lagging and fore poling if required. Close invert

In applying this classification system, the rock mass is divided into a number of structural regions and each region is classified separately. The boundaries of the structural regions usually coincide with a major structural feature such as a fault or with a change in rock type. In some cases, significant changes in discontinuity spacing or characteristics, within the same rock type, may necessitate the division of the rock mass into a number of small structural regions or domains. The Rock Mass Rating system is presented in Table 12, giving the ratings for each of the six parameters listed above. These ratings are summed to give a value of RMR.

For detail table refer Annexure

Table 12 Average, Maximum, Minimum RMR of borehole (Follow Annexure -A for detailed information)

BH NO.	AVERAGE RMR VALUE	MAXIMUM RMR VALUE	MINIMUM RMR VALUE
BH-13	34.95	40	31
BH-14	34.18	38	31
BG-15	33.23404	40	24
BH-15A	29.47059	43	27
BH-16	37.61905	48	30
BH-17	41.2	47	32

Based on the average RMR value of the rock mass it falls into "Poor" category

5.3 The Unified Soil Classification System (USCS) :

Though RMR classification provide great insight to classify the different types hard rocks of with reference to the tunnel designing, but it loses its reliability in classification soil or highly weathered rock. The main problem with using RMR for weak rock mass classification is that ratings are not sensitive to changes in rock quality designation (RQD) when RQD <25% and and fracture spacing is <2.4 inch (60 mm). For example, the RQD and fracture frequency ratings for sound rock with 24 % RQD and fracture spacing of 2.3 in. (59 mm) would receive the same Bin-RMR89 ratings as clay, 3 and 5, respectively. Hence classification of soil is provided using The Unified Soil Classification System (USCS) [ASTM (2011, 2009) D2487 and D2488].

The USCS provides good insight into behavior of material especially in the presence of water; however, it gives no indication of the relative strength of the material. In addition to USCS soil classification, civil-geotechnical engineering investigations usually include

relative density or consistency estimates which are considered in the design process. (Parker 1996). However, in contrast to RMR system, USCS system uses letters to classify soil like material for general engineering purposes.

Figure 23: USCS Classification of coarse-grained soil.

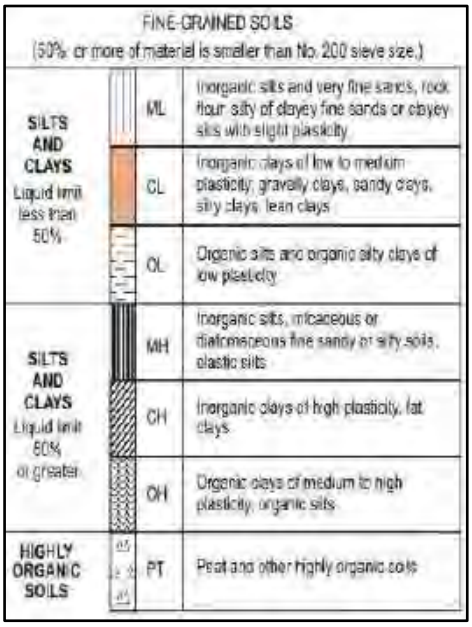

Figure 24: USCS Classification of fine-grained soil

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Soils are broadly classified into three divisions:

i. **Coarse grained soils:** 50% or more of the total material by weight is larger than 75 micron IS sieve size.

ii. **Fine grained soils:** 50% or more of the total material by weight is smaller than 75 micron IS sieve size.

iii. **Highly organic soils and other miscellaneous soil materials:** These soils contain large percentage of fibrous organic matter, such as peat, and the particles of decomposed vegetation. In addition, certain soils containing shells, cinders and other non-soil materials in sufficient quantities are also grouped in this division.

5.3.1 Coarse grained Soils

Coarse grained soils are further divided into two sub-divisions:

a) **Gravels (G)**: In these soils more than 50% of the coarse fraction (+75 micron) is larger than 4.75 mm sieve size. This sub-division includes gravels and gravelly soil, and is designated by symbol G.

b) **Sands (S)**: In these soils, more than 50% of the coarse fraction is smaller than 4.75mm IS sieve size. This sub-division includes sands and sandy soils.

Each of the above sub-divisions are further divided into four groups depending upon grading and inclusion of other materials.

1. W : Well Graded
2. C : Clay binder
3. P : Poorly graded
4. M : Containing fine materials not covered in other groups.

These symbols used in combination to designate the type of grained soils.

Example, GC: **C**layey **G**ravels.

5.3.2 Fine grained soils

Fine grained soils are further divided into three sub-divisions:

a) Inorganic silts and very fine sands: M

b) Inorganic clays: C

c) Organic silts and clays and organic matter: O.

The fine-grained soils are further divided into the following groups on the basis of the following arbitrarily selected values of liquid limit which is a good index of compressibility:

i) Silts and clays of low compressibility:

Having a liquid limit less than 35 and represented by symbol L.

ii) Silts and clays of medium compressibility:

Having a liquid limit greater than 35 and less than 50 and represented by symbol I.

iii) Silts and clays of high compressibility:

Having a liquid limit greater than 50 and represented by a symbol H.

Combination of these symbols indicates the type of fine-grained soil. For example, ML means inorganic silt with low to medium compressibility.

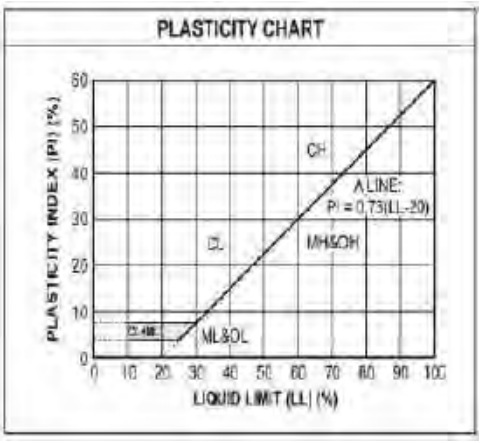

Figure 25 Relation between Liquid Limit and Plasticity Index of soil for USCS

5.4 USCS & RMR Correlation:

In spite of being an advantageous classification system, USCS also have some disadvantages due to its descriptive format of classification using letters. Any numerical and statistical analysis of materials classified in USCS using spreadsheets are really

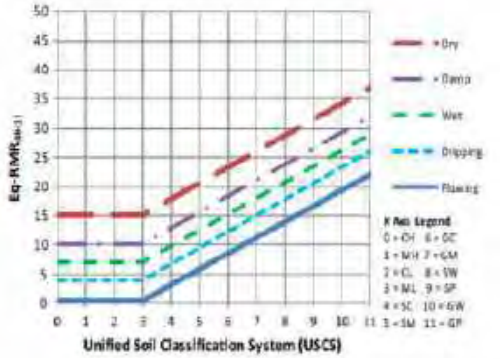

Figure 26 Graph showing correlation between USCS classification and RMR Classification. (Warren,2016)

difficult. Warren (2016) gives a numerical correlation between USCS and RMR which have been used to calculate equivalent RMR of soil in this report. Equivalent RMR is determined only by taking USCS Classification and ground water conditions of the soil material.

Table 11: Avg., Maximum, minimum of Eq-RMR for soil.

BH NO.	Average Eq-RMR value	Maximum Eq-RMR value	Minimum Eq-RMR value
BH-18	16.5	20	15
BH-19	16.75	20	15
BH-20	15.26	20	15
BH-21	15.6	20	15
BH-22	15.64	20	15
BH-23	15.789	20	15
BH-24	15	15	15
BH-25	15	15	15
BH-26	15	15	15
BH-27	15	15	15
BH-28	15.34	20	15
BH-29	15	15	15
BH-30	15	15	15
BH-31	15.34	20	15
BH-32	15	15	15
BH-33	15	15	15

Figure 26 Graph showing correlation between USCS classification and RMR Classification. (Warren,2016)

For other detailed soil properties like S.P.T N Value, Atterberg's Limit, Field Moisture Content, Natural density, Dry density, Cohesion, Angle of shearing resistance, Specific gravity, Void ratio along with results of Hydrometer Analysis, Grain size analysis, Triaxial test, Consolidation test please refer ANNEXURE –G.

5.5 Q System (NGI Tunneling Index):

The Q-system is developed to classify rock masses around an underground opening, as well as for field mapping. Based on estimation of six rock mass parameters, a Q-value for a rock mass can be calculated. This value gives a description of the rock mass quality. The Q-value depends on the underground opening and its geometry, and is therefore not an independent characterization of the rock mass. The Q-value in an undisturbed rock mass may be different.

The different Q-values are related to different types of permanent support by means of a schematic support chart. This means that by calculating the Q-value it is possible to find the type and quantity of support that has been applied previously in rock masses of the similar qualities. The Q-system can therefore be used as a guideline in rock support design decisions and for documentation of rock mass quality.

The Q-system was developed at NGI between 1971 and `74 (Barton et al. 1974). Since the introduction of the Q-system in 1974 there has been a considerable development within support philosophy and technology in underground excavations. Several new types of rock bolts have been introduced, and the continuous development of fibre reinforced technology has in many ways changed the support procedure. Application of sprayed concrete has gained acceptance even for good quality rocks masses due to demands for a higher level of safety during the recent years. Reinforced ribs of sprayed concrete have replaced cast concrete structures to a large extent.

Since the introduction of the system in 1974, two revisions of the support chart have been carried out and published in conference proceedings. An extensive updating in 1993 was based on 1050 examples mainly from Norwegian underground excavations (Grimstad and Barton, 1993). In 2002, an updating was made based on more than 900 new examples from

underground excavations in Norway, Switzerland and India. This update also included analytical research with respect to the thickness, spacing and reinforcement of reinforced ribs of sprayed concrete (RRS) as a function of the load and the rock mass quality (Grimstad et al. 2002).

Calculation of Q value:

Q index value can be calculated from RMR using different empirical equation proposed by different author (Bieniawski;1984, Rutledge and Preston;1978, Moreno Tallon; 1980, Cameron-Clarke and Budavari;1981, Abad J et all;1987). These equations provide rapid determination of Q index from RMR index of corresponding rock. In reference with these equations, Q index shares logarithmic relation with RMR index value

$$"\boldsymbol{RMR = a.LnQ + b}"$$

The value of *'a'* and *'b'* are different for different equation purposed by different author and they vary over a range of value.

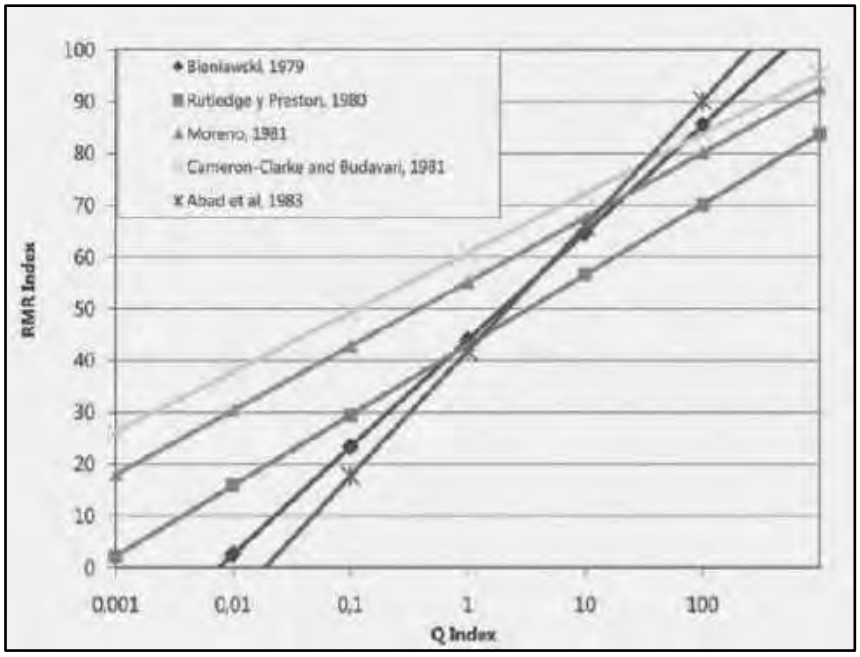

Figure 27: Graph showing correlation between different empirical equation for conversion between Q Index and RMR Index (adopted from Castro-fresno)

"$\boldsymbol{RMR = 9\,LnQ + 44}$" Bieniawski;1984

"$RMR = 5.9\,LnQ + 43$" Rutledge and Preston;1978

"$RMR = 5.4\,LnQ + 55.2$" Moreno Tallon; 1980

"$RMR = 10.5\,LnQ + 41$" Cameron-Clarke and Budavari;1981

"$RMR = 5\,LnQ + 60.8$" Abad J et all;1987

All of these equations tend to give similar result for conversion between Q and RMR for a median value of respective indexes, but at extreme end of the values of indexes, the conversion by these empirical equations is not reliable due to variation.

The true Q-value at the level of underground excavation can only be observed in the excavation itself, and Q-values obtained by above methods will be more uncertain. The number of joint sets may be underestimated from drill cores and estimations of the parameters Jw and SRF may be cumbersome without actual observations on site. From surface mapping it may be uncertain as joint filling may be washed out at the surface, and other joint parameters may be difficult to observe. In such cases it may be an advantage to use histograms to visualize variations in the data by using maximum and minimum values for each parameter.

LnQ	Classification
0-0.01	Exceptionally Poor
0.01-0.1	Extremely Poor
0.1-1	Very Poor
1-7	Poor
7-10	Fair
10-70	Good
70-100	Very Good
100-700	Extremely Good
700-1000	Exceptionally Good

Table 12: Rock Mass classification based on their Q Value on logarithm scale (after Bieniawski,1976)

Absolute value of Q index is determined based on a numerical assessment of the rock mass quality using six different parameters;

1. RQD.
2. Number of joint sets.
3. Roughness of the most unfavorable joint or discontinuity.
4. Degree of alteration or filling along the weakest joint.
5. Water inflow.
6. Stress condition.

These six parameters are grouped into three quotients to give the overall rock mass quality Q as follows:

$$Q = \frac{RQD}{j_n} \times \frac{j_r}{j_a} \times \frac{j_w}{SRF}$$

Where:

RQD = Rock Quality Designation

j_n = Joint set number

j_r = Joint roughness number

j_a = Joint alteration number

RQD/J_n= Degree of jointing (or block size)

J_r/J_a=Joint Friction (inter block shear strength)

J_w/SRF=Active Stress

The rock quality can range from Q = 0.001 to Q = 1000 on a logarithmic rock mass quality scale. The above equation gives absolute value of Q index for a rock mass by taking abovesaid 6 parameters in account.

Table 13: Description & Rating for Jn

2. Joint Set Number (J_n)		**Rating**
A	Massive, no or few joints	0.5-1.0
B	One joint set	2
C	One joint set plus random joint	3
D	Two joint sets	4
E	Two joint sets plus random joints	6
F	Three joint sets	9
G	Three joint sets plus random joints	12
H	Four or more joint sets, random heavily jointed “sugar cube”, etc	15
J	Crushed rock, earth like	20
Note: i) For tunnel intersections, use 3 x Jn ii) For portals, use 2 x Jn		

Table 14 Description &Rating for J_r

3. Joint Roughness Number (J_r)		**Rating**
Rock-wall contact, and Rock-wall contact before 10 cm of shear movement		
A	Discontinuous joints	4
B	Rough or irregular, undulating	3
C	Smooth, undulating	2
D	Slickensided, undulating	1.5
E	Rough, irregular, planar	1.5

F	Smooth, planar	1
G	Slickensided, planar	0.5
Note: i) Description refers to small scale features and intermediate scale features, in that order		
No rock-wall contact when sheared		
H	Zone containing clay minerals thick enough to prevent rock-wall contact when sheared	1
Note: ii) Add 1 if the mean spacing of the relevant joint set is greater than 3 m (dependent on the size of the underground opening) iii) Jr = 0.5 can be used for planar slickensided joints having lineation, provided the lineation are oriented in the estimated sliding direction		

Table 15 Description & Rating for J_a

Joint Alteration Number J_a		**Rating**
a) Rock-wall contact (no mineral fillings, only coatings)		
A	Tightly healed, hard, non-softening, impermeable filling, i.e., quartz or epidote.	0.75
B	Unaltered joint walls, surface staining only.	1
C	Slightly altered joint walls. Non-softening mineral coatings; sandy particles, clay-free disintegrated rock, etc.	2
D	Silty or sandy clay coatings, small clay fraction (non-softening).	3
E	Softening or low friction clay mineral coatings, i.e., kaolinite or mica. Also chlorite, talc gypsum, graphite, etc., and small quantities of swelling clays.	4
b) Rock-wall contact before 10 cm shear (thin mineral fillings)		

Joint Alteration Number J_a		Rating
F	Sandy particles, clay-free disintegrated rock, etc.	4
G	Strongly over-consolidated, non-softening, clay mineral fillings (continuous, but <5 mm thickness).	6
H	Medium or low over-consolidation, softening, clay mineral fillings (continuous, but <5 mm thickness).	8
J	Swelling-clay fillings, i.e., montmorillonite (continuous, but <5 mm thickness). Value of Ja depends on percent of swelling clay-size particles.	8-12
c) No rock-wall contact when sheared (thick mineral fillings)		
K	Zones or bands of disintegrated or crushed rock. Strongly over-consolidated.	6
L	Zones or bands of clay, disintegrated or crushed rock. Medium or low over-consolidation or softening fillings.	8
M	Zones or bands of clay, disintegrated or crushed rock. Swelling clay. Ja depends on percent of swelling clay-size particles.	8-12
N	Thick continuous zones or bands of clay. Strongly over-consolidated.	10
O	Thick, continuous zones or bands of clay. Medium to low over-consolidation.	13

Table 16 Description & Rating for J_w

Joint Water Reduction Factor J_w		Rating
A	Dry excavations or minor inflow (humid or a few drips)	1.0

B	Medium inflow, occasional out wash of joint fillings (many drips/"rain")	0.66
C	Jet inflow or high pressure in competent rock with unfilled joints	0.5
D	Large inflow or high pressure, considerable out wash of joint fillings	0.33
E	Exceptionally high inflow or water pressure decaying with time. Causes out wash of material and perhaps cave in.	0.2-0.1
F	Exceptionally high inflow or water pressure continuing without noticeable decay. Causes out wash of material and perhaps cave in.	0.1-0.05
Note: i) Factors C to F are crude estimates. Increase Jw if the rock is drained or grouting is carried out ii) Special problems caused by ice formation are not considered		

Table 17 Description & Rating for Stress Reducing Factor (SRF)

Stress Reduction Factor		**SRF**
a) Weak zones intersecting the underground opening, which may cause loosening of rock mass		
A	Multiple occurrences of weak zones within a short section containing clay or chemically disintegrated, very loose surrounding rock (any depth), or long sections within competent (weak) rock (any depth). For Squeezing conditions,	10
B	Multiple shear zones within a short section in competent clay-free rock with loose surrounding rock (any depth)	7.5
C	Single weak zones with or without clay or chemical disintegrated rock (depth ≤ 50m)	5
D	Loose, open joints, heavily jointed or "sugar cube", etc. (any depth)	5
E	Single weak zones with or without clay or chemical disintegrated rock (depth > 50m)	2.5
Note: i) Reduce these values of SRF by 25-50% if the weak zones only influence but do not intersect		

the underground opening.				
b) Competent, mainly massive rock, stress problems		σ_c/σ_1	σ_c/σ_2	SRF
F	Low stress, near surface, open joints	>200	<0.01	2.5
G	Medium stress, favourable stress condition	200-10	0.01-0.3	1
H	High stress, very tight structure. Usually favourable to stability. May also be unfavorable to stability dependent on the orientation of stresses compared to jointing / weakness planes*	10-5	0.3-0.4	0.5-2 2-5*
J	Moderate spalling and/or slabbing after > 1 hour in massive rock	5-3	0.5-0.65	5-50
K	Spalling or rock burst after a few minutes in massive rock	3-2	0.65-1	50-200
L	Heavy rock burst and immediate dynamic deformation in massive rock	<2	>1	200-400
Note: For strongly anisotropic virgin stress field (if measured): when $5 \leq \sigma1/\sigma3 \leq 10$, reduce σc to 0.75 σc. When $\sigma1/\sigma3 > 10$, reduce σc to 0.5 σ_c, where σ_c = unconfined compression strength, σ1 and σ3 are the major and minor principal stresses, and σ1σ2= maximum tangential stress (estimated from elastic theory) When the depth of the crown below the surface is less than the span; suggest SRF increase from 2.5 to 5 for such cases (see F)				
c) Squeezing rock: plastic deformation in incompetent rock under the influence of high pressure			σc	SRF
M	Mild squeezing rock pressure		1-5	5-10
N	Heavy squeezing rock pressure		>5	10-20
Note: iv) Determination of squeezing rock conditions must be made according to relevant literature (i.e., Singh et al., 1992 and Bhasin and Grimstad, 1996)				

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

d) Swelling rock: chemical swelling activity depending on the presence of water		SRF
O	Mild swelling rock pressure	5-10
P	Heavy swelling rock pressure	10-15

The individual parameters are determined during geological mapping using tables that give numerical values to be assigned to a described situation. Paired, the six parameters express the three main factors which describe the stability in underground openings

The Q values for the samples are given in table below. For detail table refer Annexure.

Table 18 Average, Maximum, and Minimum Q-Value from Borehole (Follow annexure A for detailed information)

BH NO.	AVERAGE Q VALUE	MAXIMUM Q VALUE	MINIMUM Q VALUE
BH-13	4.54	6.69	1.5
BH-14	1.74	3.6	1.5
BG-15	1.7	4.05	1.5
BH-15A	2.17	4.8	1.5
BH-16	2.7	7.69	1.5
BH-17	0.2	0.83	0.2

Based on the average Q value of the rock mass it falls into "Very Poor" to "Poor" category

6 CHAPTER: Engineering properties of the rock / soil

6.1 Laboratory Testing of Rock Mass

Laboratory tests were also carried out on rock samples, the details of different laboratory tests conducted as part of the project are given in the table below

Table 19: The laboratory tests conducted for rock.

Laboratory tests conducted for rock	1. Unconfined Compressive Strength,
	2. Point Load Index Test
	3. Tensile Strength
	4. Specific Gravity
	5. Modulus of elasticity
	6. Water absorption
	7. Poisons' ratio
	8. Triaxial Test
	9. Hardness test
	10. Abrasive test

6.1.1 Selection of Core Sample

Representative core samples (NX and NQ size) are collected for covering the crown and invert section and other portions above the crown. The samples were properly labelled and packed carefully and sent NABL accredited Bhubaneswar laboratory for determining the physico-mechanical properties.

The physico-mechanical properties like unit weight, water absorption, porosity, specific gravity, point load index, uniaxial compressive strength (UCS), tri-axial compressive strength, tensile strength (TS), modulus of elasticity, Poisson's ratio is determined. Simultaneously, the specific heat, thermal diffusivity, thermal conductivity, hydraulic conductivity and petrography tests are also conducted on the rock samples representing to the tunnel influence zone. The following laboratory tests have been conducted to determine intact rock properties.

6.1.2 Tensile Strength

Brazilian test is intended to measure the tensile strength of a rock sample in the form of specimens of regular geometry. The test is mainly intended for strength classification and characterization of intact rock. The test specimens are right circular cylinders having a length to diameter (L: D) ratio approximately equal to 0.5 and a diameter shall not be less than 45 mm. This method of determining tensile strength is an indirect method, and is popularly known as Brazilian method. The indirect tensile strength is calculated as follows:

$$\sigma_t = \frac{2P}{\pi D t}$$

Where:

σ_t = Brazilian tensile strength (MPa); D = Diameter of the core sample (mm);

P = Maximum failure load (N); t = Thickness or Length of the sample (mm)

Figure 28 and Table 20 below provides a summary of Tensile strength for the all the core samples from different boreholes.

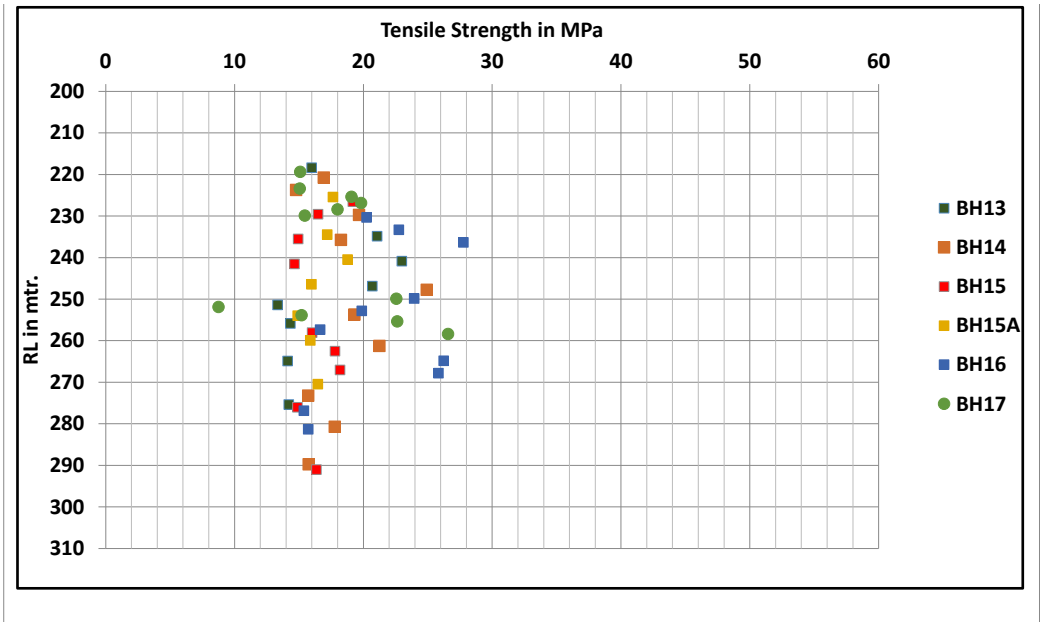

Figure 28: Tensile Strength of rock mass from entire borehole length vs RL. (Refer to Annexure B in Geotechnical Report for detail).

Table 20: Result of Tensile strength (Follow annexure B for detailed information)

BH NO.	Minimum tensile strength value (MPa)	Maximum tensile strength value (MPa)	Average tensile strength value (MPa)
BH-13	13.34	22.99	17.10
BH-14	14.78	24.93	18.44
BG-15	14.66	19.2	16.51
BH-15A	14.91	18.78	16.70
BH-16	15.39	27.77	21.67
BH-17	8.77	26.58	18.03

6.1.3 Unconfined Compressive Strength

UCS test is intended to determine the unconfined compressive strength of a rock sample in the form of specimens of regular geometry. The length to diameter ratio of cylindrical specimen shall preferably be 2 to 3. If the ratio is less than 2, usual correction shall be applied taking standard slenderness ratio as 2. Load on the specimen shall be applied continuously at a constant stress rate such that failure will take place in about 5 to 15 minutes of loading. Alternatively, the stress rate shall be within the limits of 0.5 MPa/s to 1 MPa/s. The unconfined compressive strength of the specimen has been calculated by dividing the maximum load carried by the specimen during the test, by the average original cross-sectional area.

Figure 29 and Table 21 below provides a summary of UCS values for the all the samples. For detail table refer Annexure.

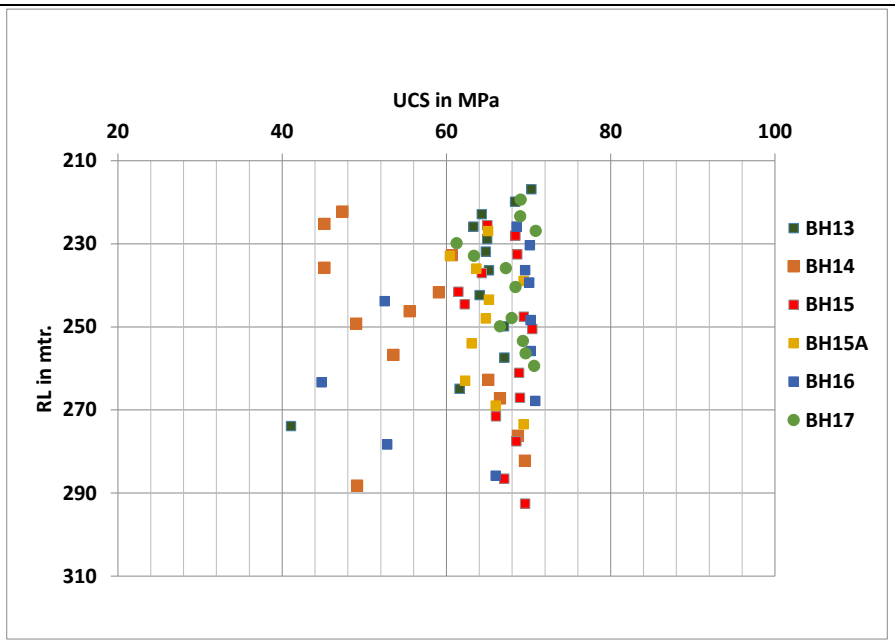

Figure 29: Unconfined Compressive Strength (UCS) of rock mass from entire borehole length vs RL (Refer to Annexure C in Geotechnical Report for detail).

Table 21: Result of UCS Test (Follow annexure C for detailed information)

BH NO.	Minimum UCS value (MPa)	Maximum UCS value (MPa)	Average UCS value (MPa)
BH-13	41.06	70.33	63.49
BH-14	45.15	69.54	56.49
BG-15	61.45	70.44	67.05
BH-15A	60.42	69.38	65.12
BH-16	44.8	70.8	64.16
BH-17	61.24	70.85	67.76

6.1.4 Density, Specific Gravity, Water Absorption

These tests are performed as per relevant standard. The Bulk volume is obtained by buoyancy technique and the pore volume is obtained by water saturation. It may also be applied to a sample in the form of specimen of irregular geometry.

Based on the tests conducted, the unit weight has been calculated

Specific gravity has been estimated for core samples picked up from different borehole. The true specific gravity has been expressed as a numerical value and shall be based on average of three determinations.

The table below provides set of values calculated for Density, specific gravity, water absorption. For detail table refer Annexure.

Table 22: Result of Density, Specific Gravity, Water absorption (Follow annexure D for detailed information).

BH NO.	Minimum Density value (kN/m^3)	Maximum Density value (kN/m^3)	Average Density value (kN/m^3)
BH-13	24.31	25.73	25.31
BH-14	25.67	26.09	25.88
BG-15	25.07	25.74	25.43
BH-15A	24.81	25.69	25.30
BH-16	25.3	26.52	25.97
BH-17	24.23	26.21	25.42

Table 23: Result of Specific Gravity (Follow annexure D for detailed information).

BH NO.	Minimum Specific gravity value	Maximum Specific gravity value	Average Specific gravity value
BH-13	2.47	2.61	2.57
BH-14	2.61	2.65	2.63

BH NO.	Minimum Specific gravity value	Maximum Specific gravity value	Average Specific gravity value
BG-15	2.54	2.61	2.58
BH-15A	2.52	2.60	2.57
BH-16	2.56	2.69	2.64
BH-17	2.45	2.67	2.58

Table 24: Result of Water absorption (Follow annexure D for detailed information).

BH NO.	Minimum Water absorption value %	Maximum Water absorption value %	Average Water absorption value %
BH-13	0.14	0.51	0.39
BH-14	0.15	0.57	0.32
BG-15	0.46	0.63	0.52
BH-15A	0.16	0.75	0.47
BH-16	0.25	0.70	0.50
BH-17	0	1.18	0.56

6.1.5 Point Load Strength Index

Point Load test is intended to determine the diametrical and axial point load strength index of rock core. The core specimens with length to diameter ratio of 0.3 to 1 are suitable for axial testing. The point load strength index shall be calculated from the following formula:

$$I_l(50) = \frac{P}{(Dd)^{0.75} \times \sqrt{D_{50}}}$$

Where: $I_l(50)$ = Point Load strength Index (MPa); D = Distance between the platen (mm);

P = Maximum failure load (N); d = Diameter of test specimen (mm);

D_{50} = Standard core diameter (mm)

Figure 30 and table below provides point load index value, for detail table refer Annexure.

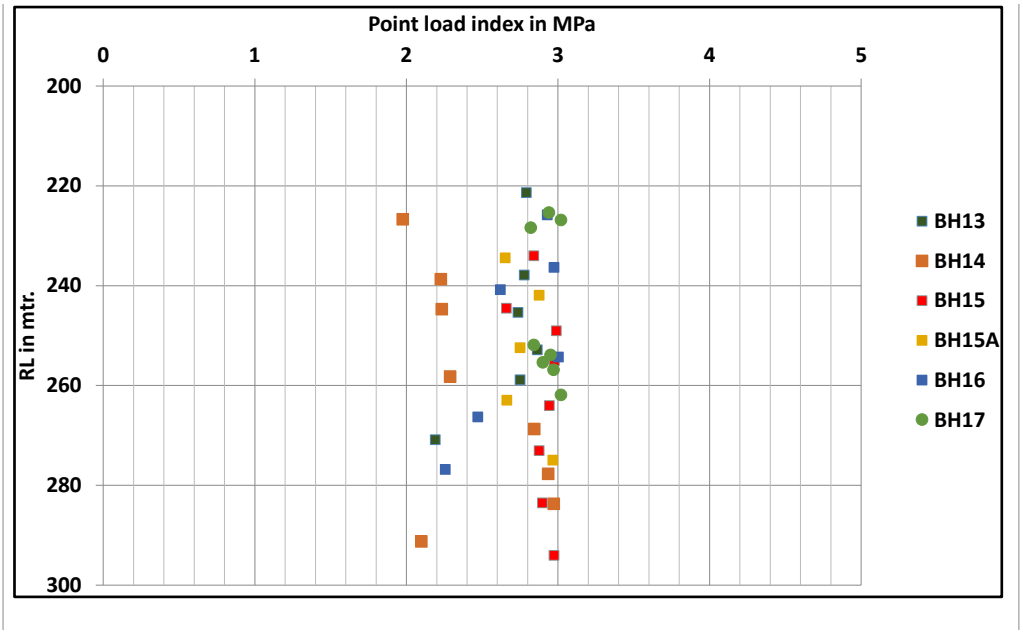

Figure 30: Point Load Index (PLI) of rock mass from entire borehole length vs RL. (Refer to Annexure E in Geotechnical Report for detail).

Table 25: Result of point load index test (Follow annexure E for detailed information).

BH NO.	Minimum Point load index value (MPa)	Maximum Point load index value (MPa)	Average Point load index value (MPa)
BH-13	1.01	3.20	2.18
BH-14	2.27	3.62	2.99
BG-15	2.53	3.85	3.37
BH-15A	2.86	3.40	3.14
BH-16	2.06	3.84	3.07

BH NO.	Minimum Point load index value (MPa)	Maximum Point load index value (MPa)	Average Point load index value (MPa)
BH-17	2.82	3.02	2.93

6.1.6 Modulus of Elasticity and Poisson's Ratio

This test is intended to determine the Modulus of Elasticity & Poisson's Ratio of cylindrical rock specimen in compression. Circumferential and axial deformations or strains may be determined from data obtained by electrical resistance strain gauges, compress meters, optical devices or other suitable means. The design of the measuring device shall be such that the average of at least two circumferential and two axial strain measurements can be determined for each increment of load. Measuring positions shall be equally spaced around the circumference of the specimens close to the mid height. They should not fall within D/2 of the specimen ends, where D is the diameter.

6.1.6.1 Calculation

The axial strain (Ɛa) and the diametric strain (Ɛd) may be recorded directly from strain indicating equipment or may be calculated from the measured deformation depending upon the type of apparatus or instrument used.

The axial (Ɛa) and diametric (Ɛd) strains shall be calculated as follows:

$$\varepsilon a = \Delta l / l$$

$$\varepsilon d = \Delta d / d$$

Where l = original axial length before deformation,

d = original diameter before the deformation,

Δl = change in measured axial length (positive for a decrease in length), and

Δd = change in diameter (positive for an in increase in diameter).

*NOTE - It may be noted that circumferentially applied electrical resistance strain gauges also reflect diametric strain, the value necessary for computing Poisson's ratio.

Since,

$$C = \pi d$$

$$\Delta c = \pi \Delta d$$

The circumferential and diametric strains are related as follows:

$$\varepsilon c = \Delta c / c$$

$$= \pi \Delta \mathrm{d} / \pi \mathrm{d}$$

$$= \Delta d / d$$

$$= \varepsilon d$$

Where, c and d are circumference and diameter of the specimen respectively. The compressive stress in the test specimen σ shall be calculated from compressive load P and the θ initially computed cross-sectional area A, as follows:

$$\sigma = \frac{P}{A}$$

The stress versus axial and lateral strain shall be plotted as a curve.

Figure 31 and table below shows Modulus of Elasticity values for all samples from boreholes.

Figure 31

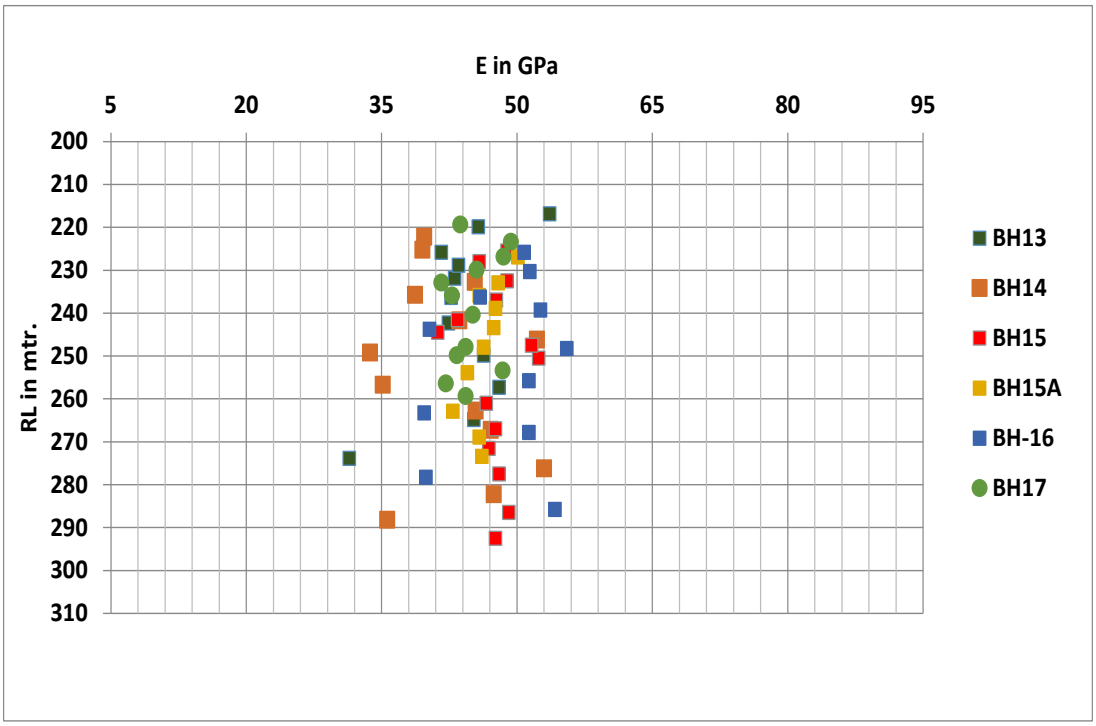

Figure 31: Modulus of Elasticity (E) of rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).

Table 26: Modulus of elasticity (Follow annexure F for detailed information).

BH NO.	Minimum Modulus of elasticity value (GPa)	Maximum Modulus of elasticity value (GPa)	Average Modulus of elasticity value (GPa)
BH-13	31.4	53.6	43.9
BH-14	33.7	53.0	42.8
BG-15	41.2	52.4	47.5
BH-15A	42.9	50.1	46.7
BH-16	39.7	55.5	48.4
BH-17	41.6	49.3	44.9

Poisson's Ratio (v) –

Poisson's ratio shall be calculated as the ratio of the total diametric strain εd to the total axial strain εa at any given stress level.

NOTE - When the terms 'Modulus' and 'Poisson's Ratio' are used without any qualification, they shall be taken to mean as the tangent modulus and the Poisson's ratio at 50percent of the ultimate stress.

Based on the tests conducted on core samples, the average Poisson's Ratio and Modulus of Elasticity has been estimated to be 0.13 and 45.89 GPa. Figure 32 and table below shows Poisson's ratio values for all samples, for detail table refer Annexure

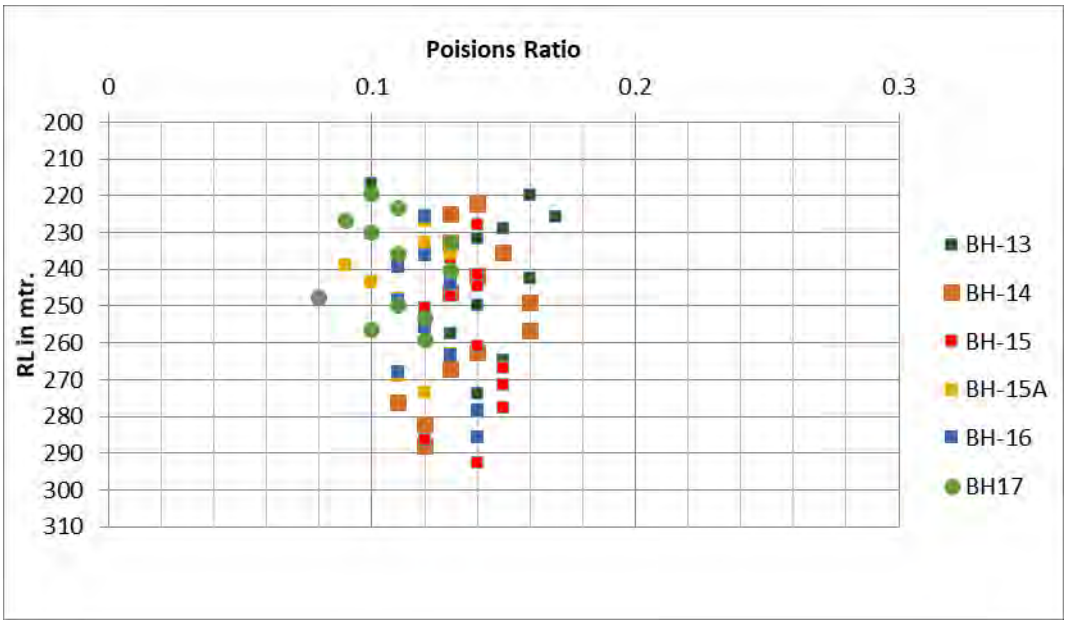

Figure 32: Poisson's Ratio distribution for the entire rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).

Table 27: Poisson's ratio (Follow annexure E for detailed information).

BH NO.	Minimum Poisson's ratio value	Maximum Poisson's ratio value	Average Poisson's ratio value
BH-13	0.10	0.17	0.14
BH-14	0.11	0.16	0.14
BG-15	0.12	0.15	0.14
BH-15A	0.09	0.13	0.11
BH-16	0.10	0.14	0.12
BH-17	0.08	0.13	0.11

6.1.7 Triaxial Test

Triaxial test is intended to determine the Cohesion and angle of internal friction of a rock sample in the form of specimens of regular geometry. The length to diameter ratio of cylindrical specimen shall preferably be 2 to 3. Load on the specimen shall be applied continuously at a constant stress rate such that failure will take place in about 5 to 15 minutes of loading. Alternatively, the stress rate shall be within the limits of 0.5 MPa/s to 1 MPa/s.

6.1.7.1 Calculation

Using Parameter m and b, the angle of internal friction ∅ and a value for the apparent cohesion C may be calculated using following formula.

$$\emptyset = \sin^{-1}\frac{m-1}{m+1}$$

$$C = b \times \frac{1-\sin\emptyset}{2\cos\emptyset}$$

Figure 33 and Table 28 below provides a summary of Triaxial Cohesion values for the all the samples. Figure 34 and Table 29 below provides a summary of phi values.

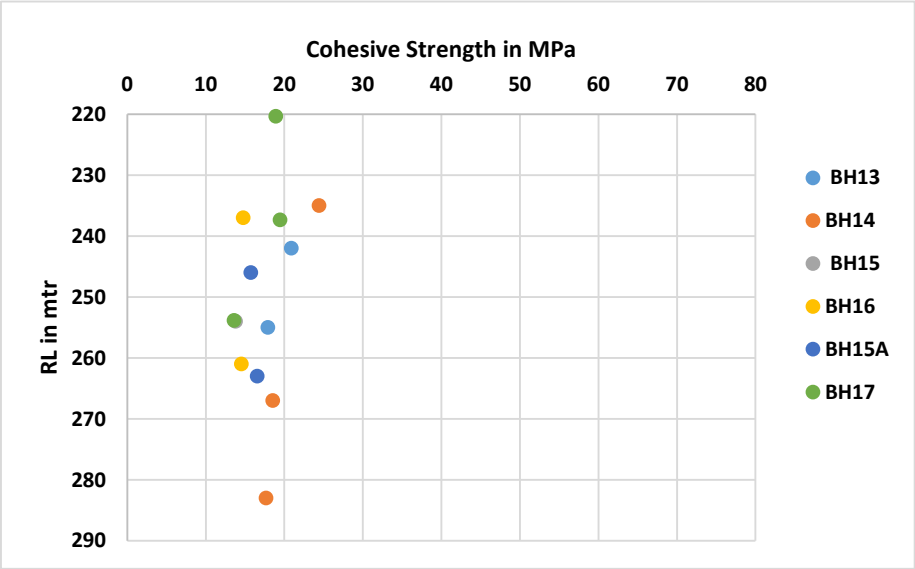

Figure 33: Cohesive strength of rock mass from entire borehole length vs RL (Refer to Annexure F in Geotechnical Report for detail).

Table 28: Result of Cohesive Strength test (Follow annexure F for detailed information)

BH NO.	Minimum C value (MPa)	Maximum C value (MPa)	Average C value (MPa)
BH-13	15.13	20.88	17.97
BH-14	17.66	24.39	20.19
BH-15	13.78	13.78	13.78
BH-15A	15.71	16.54	16.13
BH-16	14.50	14.75	14.63
BH-17	13.58	19.44	17.30

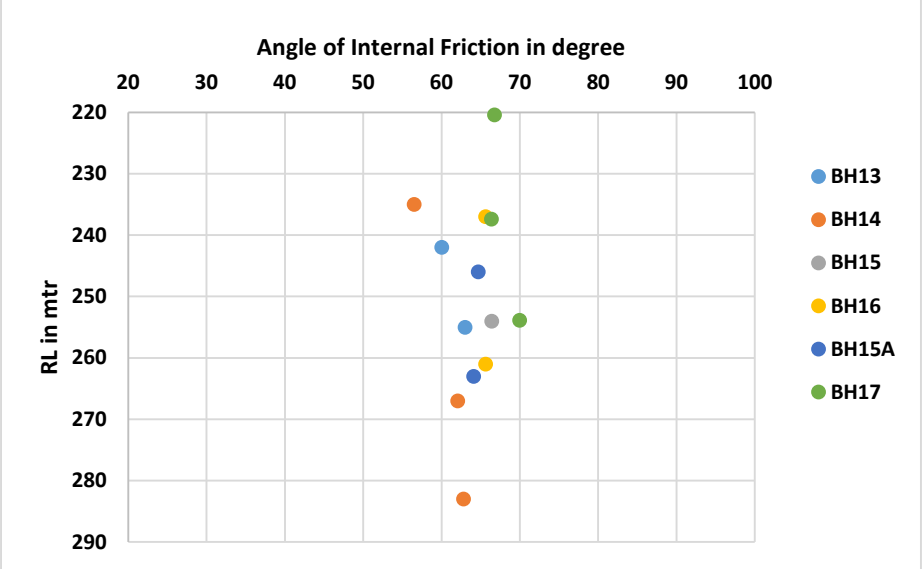

Figure 34: Angle of internal friction of rock mass from entire borehole length vs RL (Refer to Annexure G in Geotechnical Report for detail).

Table 29: Result of angle of internal friction (∅) Test (Follow annexure F for detailed information)

BH NO.	Minimum ∅ value in degree	Maximum ∅ value in degree	Average ∅ value in degree
BH-13	60.02	65.23	62.75
BH-14	56.48	62.80	60.45
BH-15	66.39	66.39	66.39
BH-15A	64.08	64.67	64.38
BH-16	65.63	65.63	65.63
BH-17	66.36	69.96	67.69

6.1.8 Hardness Test

Hardness test is intended to determine the hardness number of a rock sample. The length of the sample should be at least 60 mm. Test locations shall be separated by at least twice the diameter of the plunger.

6.1.8.1 Calculation

The correction factor is calculated as: Correction factor=

$$\frac{Specified\ standard\ value\ of\ the\ anvil}{Average\ of\ 10\ reading\ on\ calibration\ anvil}$$

The measured test values for the sample should be tabulated in descending order. The lower 50 percent of the values should be discarded and the average obtained of the upper 50 percent values. This average shall be multiplied by the correction factor

Figure 35 and Table 30 below provides a summary of Triaxial Cohesion values for the all the samples.

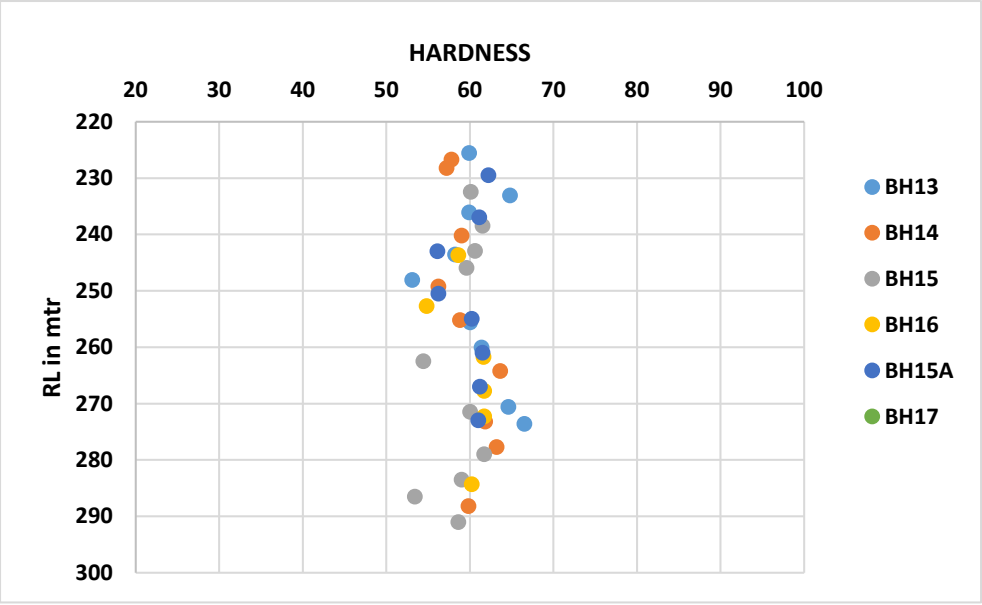

Figure 35: Hardness of rock mass from entire borehole length vs RL. (Refer to Annexure H in Geotechnical Report for detail).

Table 30: Result of Hardness Test (Follow Annexure G for detailed information).

BH NO.	Minimum Hardness value in Numbers	Maximum Hardness value in Numbers	Average Hardness value in Numbers
BH-13	53.1	66.5	60.9
BH-14	56.2	63.6	59.7
BH-15	53.4	61.7	58.9
BH-15A	56.1	62.2	59.9
BH-16	54.8	61.7	59.8
BH-17	22.1	50.6	32.6

6.1.9 Abrasiveness Test

Abrasiveness test is intended to determine the wear or loss of material which the rock produces on contact with another material.

6.1.9.1 Calculation

Abrasiveness is calculated by following formula

$$\text{CAI or CAIs}=\frac{1}{10\epsilon}\sum_{1}^{10} di$$

CAI or CAIs = Cerchar index for natural or saw cut surface respectively and d_i is diameter of the abraded flat area measured in units of 0.1 mm.

If Saw cut specimen is tested, then calculated CAIs of Eq. 1 it is advised to be normalized using Eq.2

CAI= 0.99 CAIs + 0.48

CAI = Cerchar index for natural surface; CAIs= Cerchar index for smooth surface

Table 31 and Figure 36below provides a summary of Triaxial Cohesion values for the all the samples

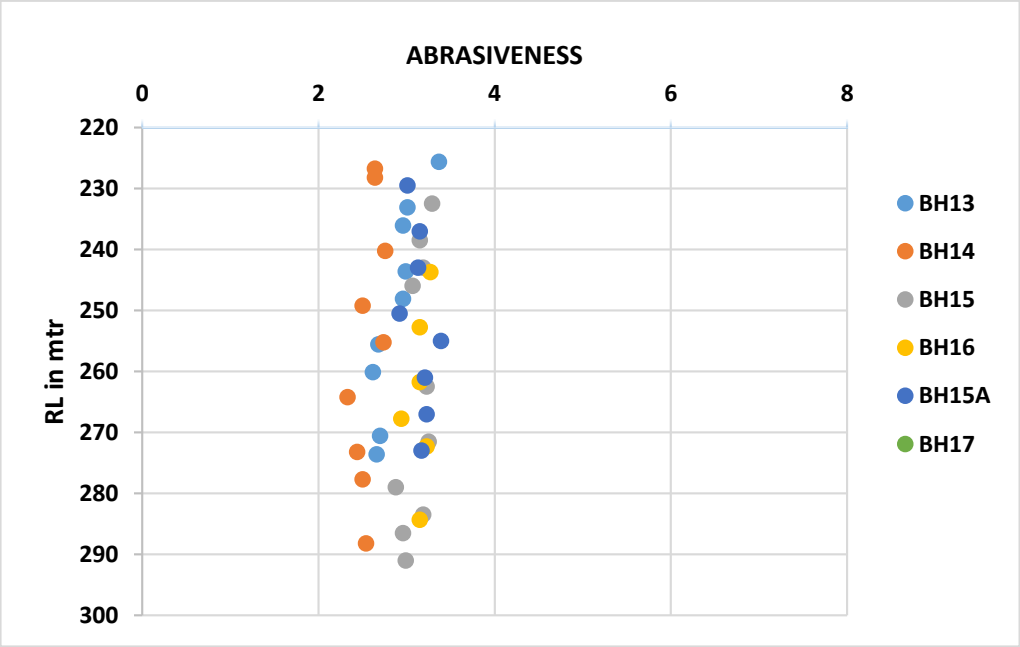

Figure 36: Abrasiveness of rock mass from entire borehole length vs RL. (Refer to Annexure I in Geotechnical Report for detail).

Table 31: Result of Abrasiveness test (Follow annexure G for detailed information)

BH NO.	Minimum Abrasiveness	Maximum Minimum Abrasiveness	Average Minimum Abrasiveness	Classification (HRC=55)
BH-13	2.62	3.37	2.88	High Abrasiveness
BH-14	2.33	2.76	2.55	High Abrasiveness
BH-15	2.88	3.43	3.15	High Abrasiveness
BH-15A	2.92	3.39	3.15	High Abrasiveness
BH-16	2.94	3.31	3.17	High Abrasiveness
BH-17	1.91	2.58	2.21	High Abrasiveness

6.1.10 Petrography Test

This test is performed to study the mineralogical, textural and micro-structural property of rock. The rock samples are cut up to 30-micron size and their optical properties are observed.

In the present test Grain size analysis is done to study the textural property of rock and the relative abundance of minerals are calculated to study the chemical and mineralogical property of the rock.

In order to get a holistic view, the samples are collected from different depth from each borehole as follows:

Table 32: Borehole wise details of collected sample for thin section.

BH ID	DEPTH
BH13	6
	10.5
	18
	24
	31.5
	39
	46.5
	52.5
	55.5
BH14	3
	10.5
	16.5
	25.5
	36
	49
	55.5

BH ID	DEPTH
	67.5
BH15	1.5
	12
	22.5
	31.5
	40.5
	51
	61.5
	67.5
BH15A	6
	10.5
	18
	22.5
	27
	33
	34.5
	45
BH16	10.5
	21
	33
	40.5
	46.5
	52
BH17	20.5
	25.0
	30.0
	31.5

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BH ID	DEPTH
	45.5
	51.5
	53.0
	61.0
	62.0

As per the grain size analysis of the rock the entire strata was found to be formed of Quartzite containing 80-90% quartz, only ≥20% of feldspar and very little mica, representing a mineralogically matured parent rock. This rock is almost equigranular with an average grain diameter of 0.25mm, indicating the textural maturity of its provenance. Only in BH16 at below 40m a very small amount of mica rich garnetiferrous phyllite was found. Photomicrographs of the thin sections and the results of the respective grain size and mineralogical analyses are presented below.

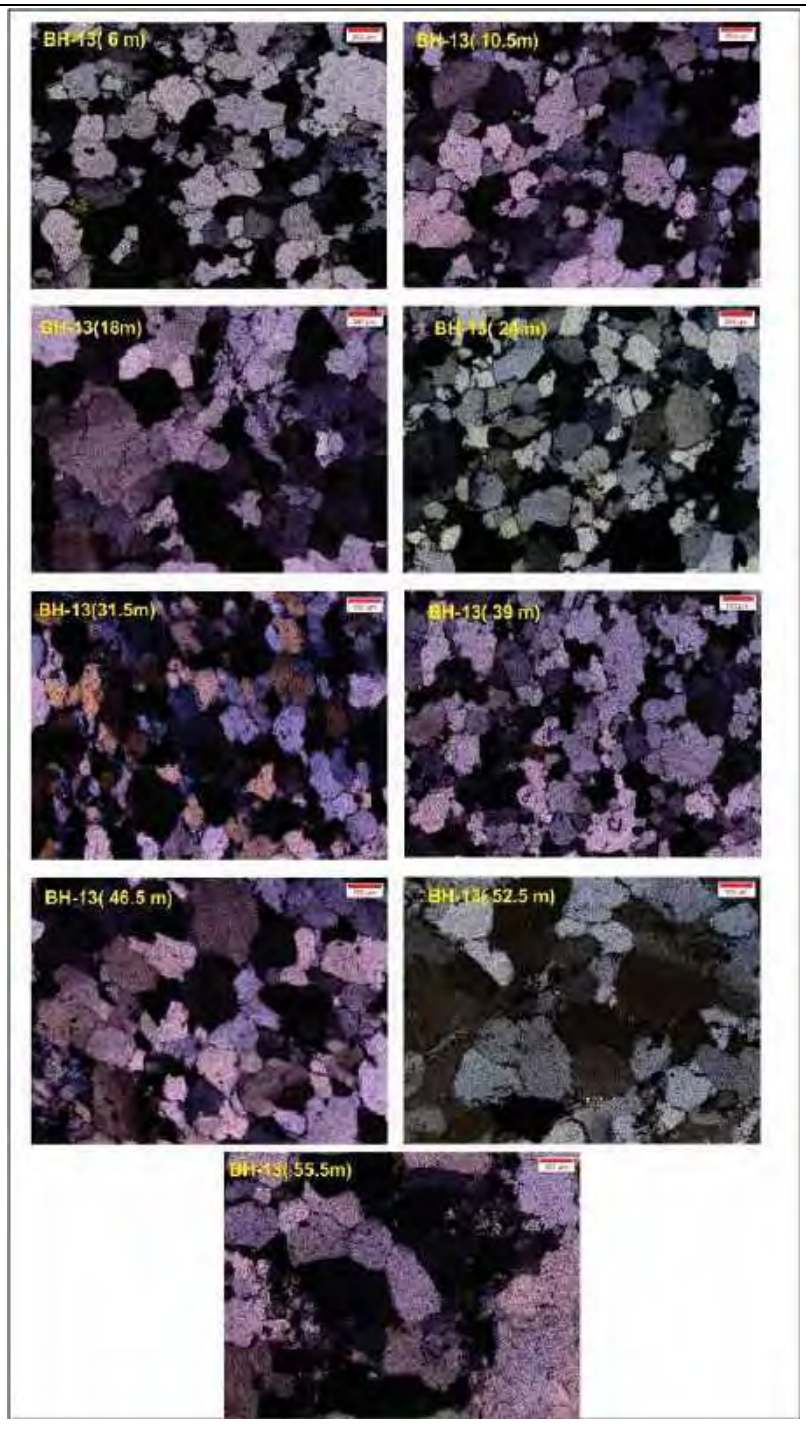

Figure 37: Borehole 13 sample under optical microscope (Cross polarized 5X)

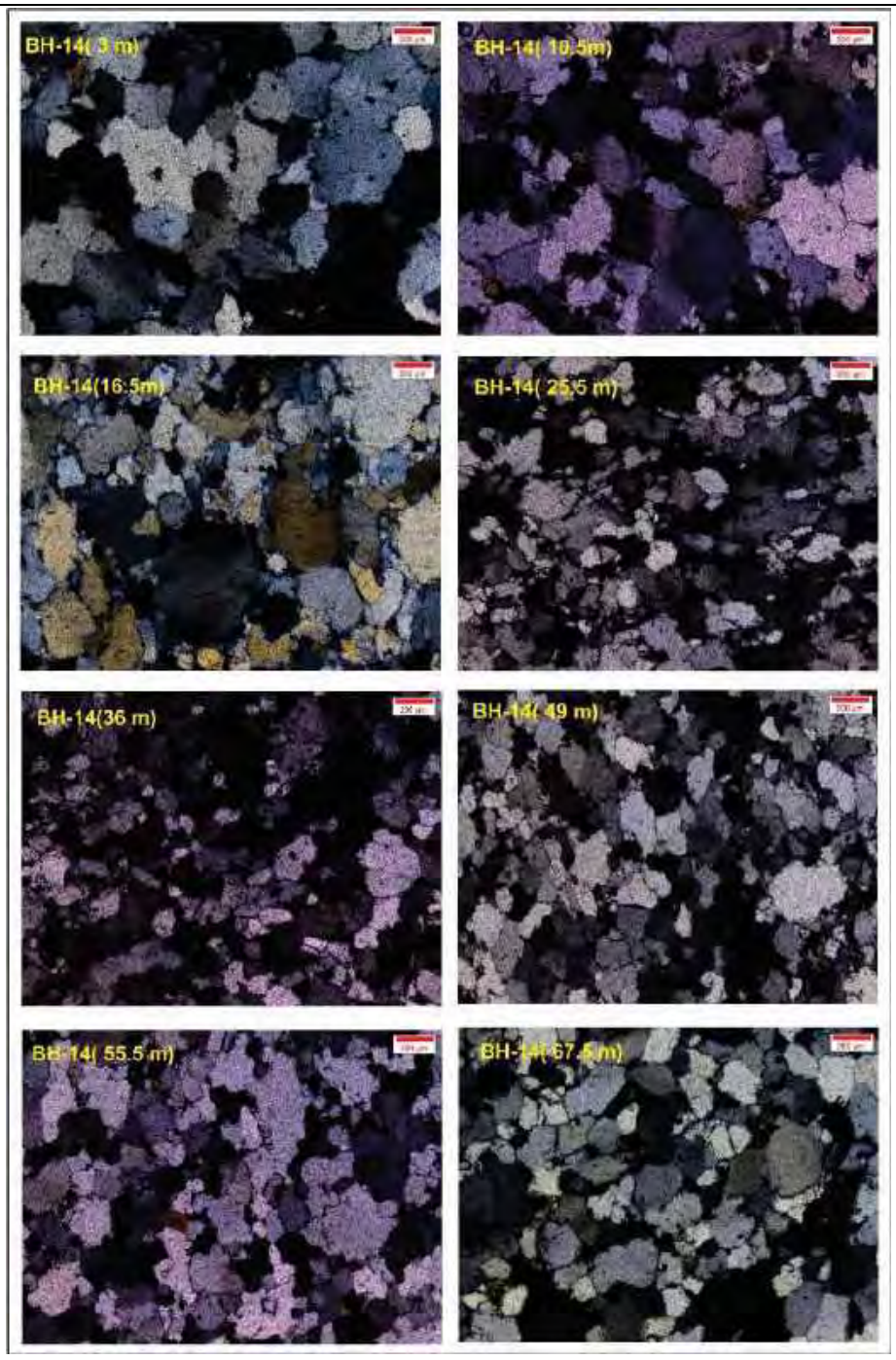

Figure 38: Borehole 14 samples under optical microscope (Cross polarized 5X)

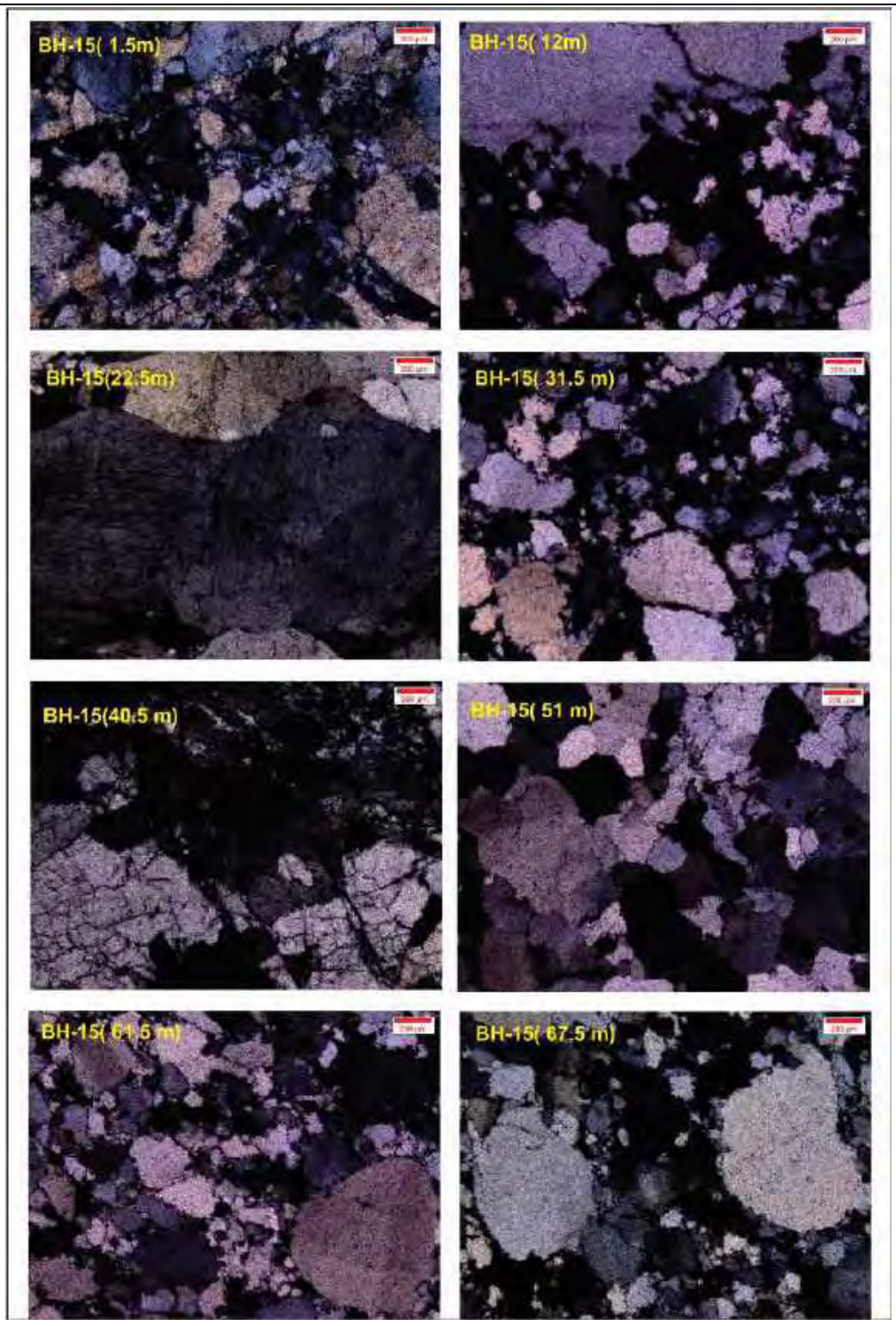

Figure 39: Borehole 15 Samples under optical microscope (cross polarized 5X).

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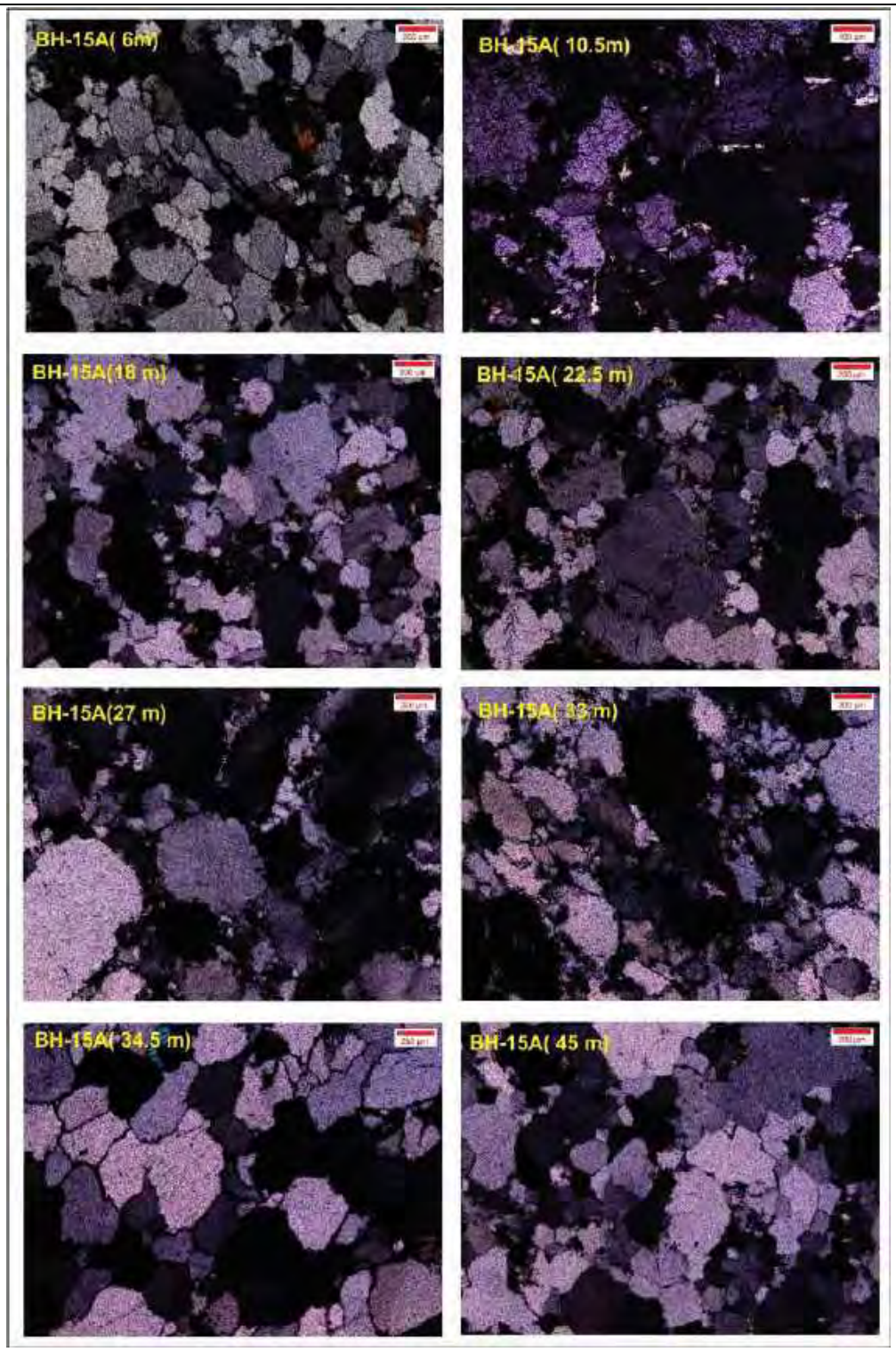

Figure 40: Borehole 15(A) Samples under optical microscope (cross polarized 5X).

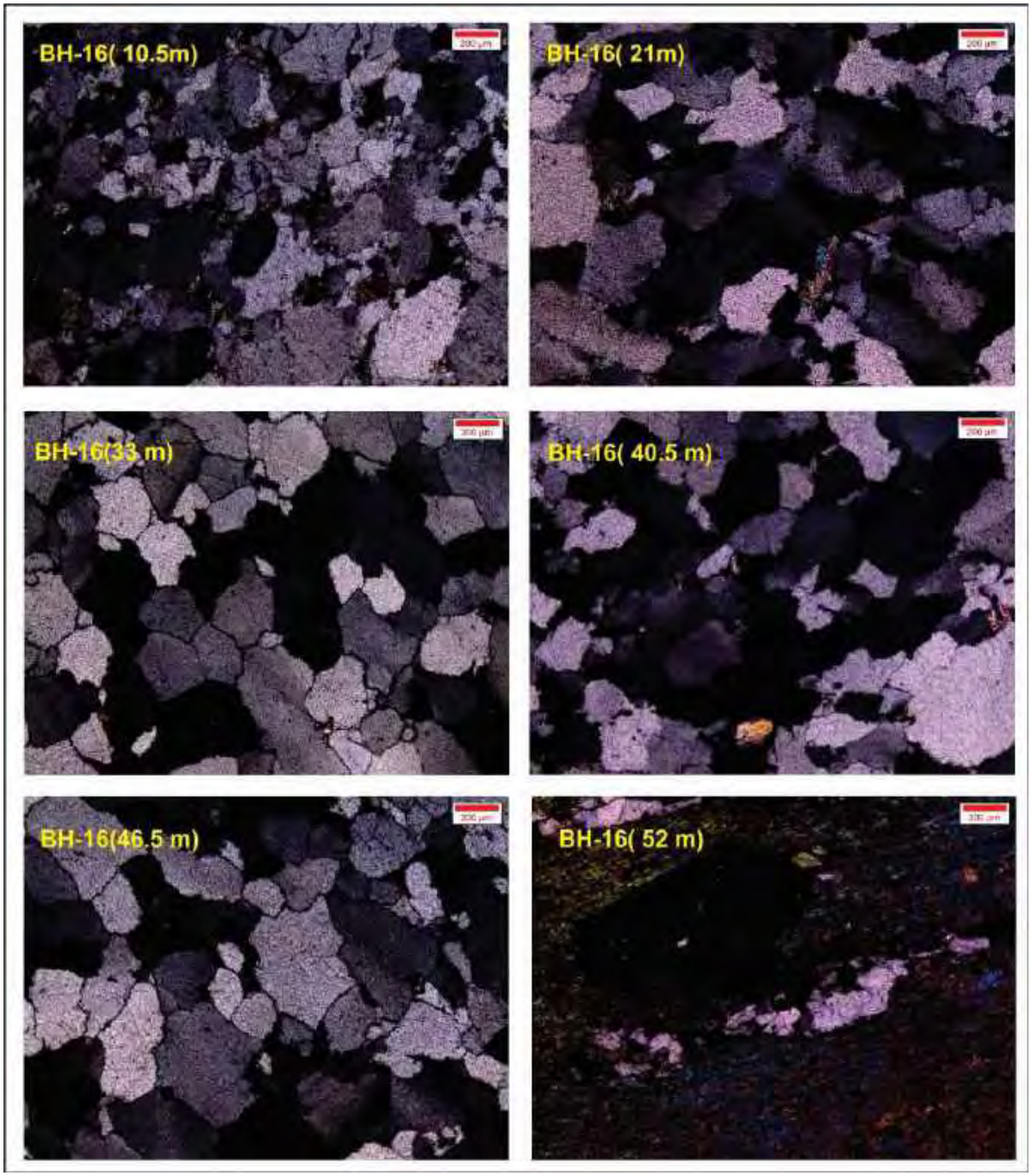

Figure 41: Borehole 16 sample under optical microscope (cross polarized 5X).

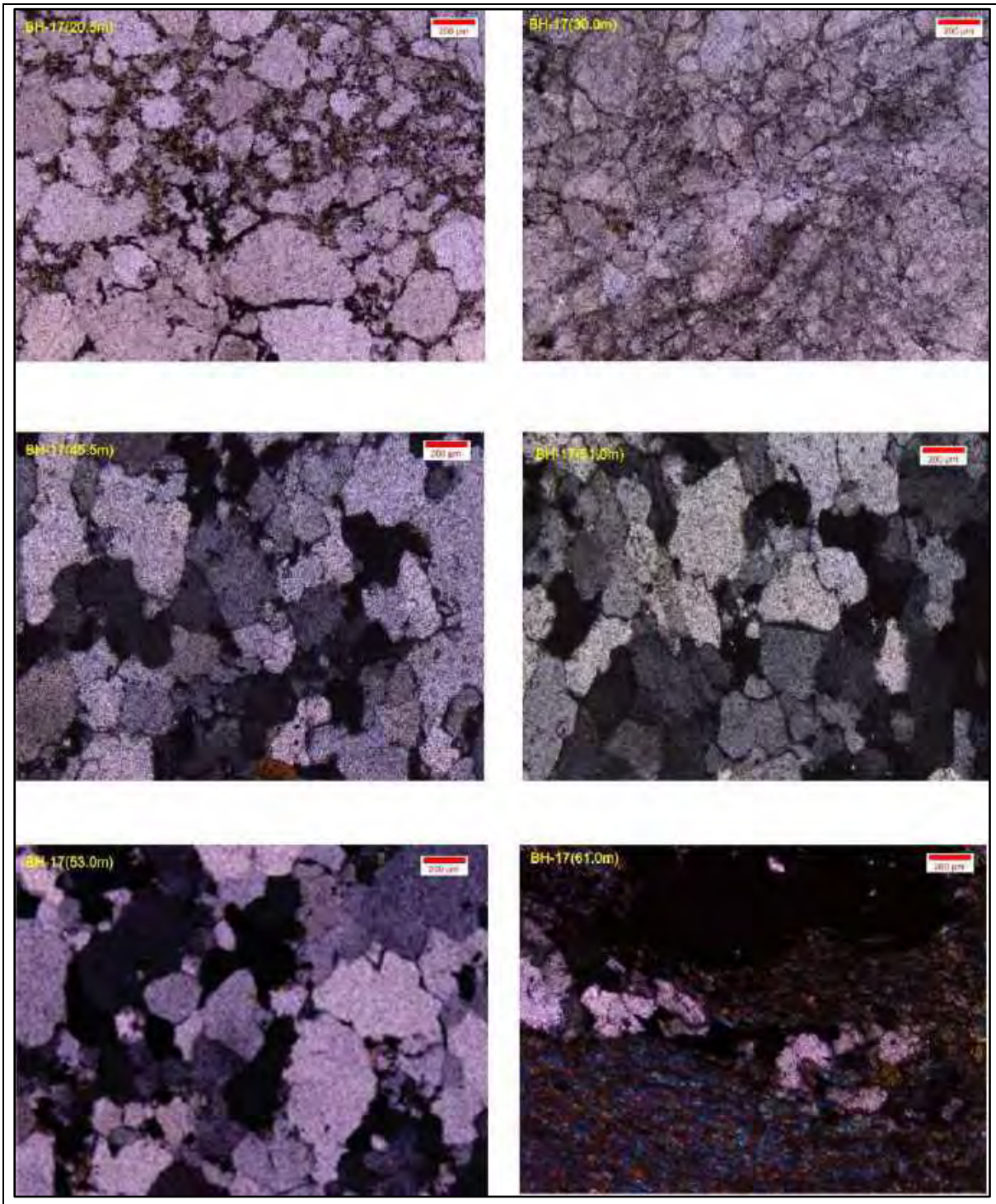

Figure 42: Borehole 17 sample under optical microscope

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6.1.11 Grain size analysis

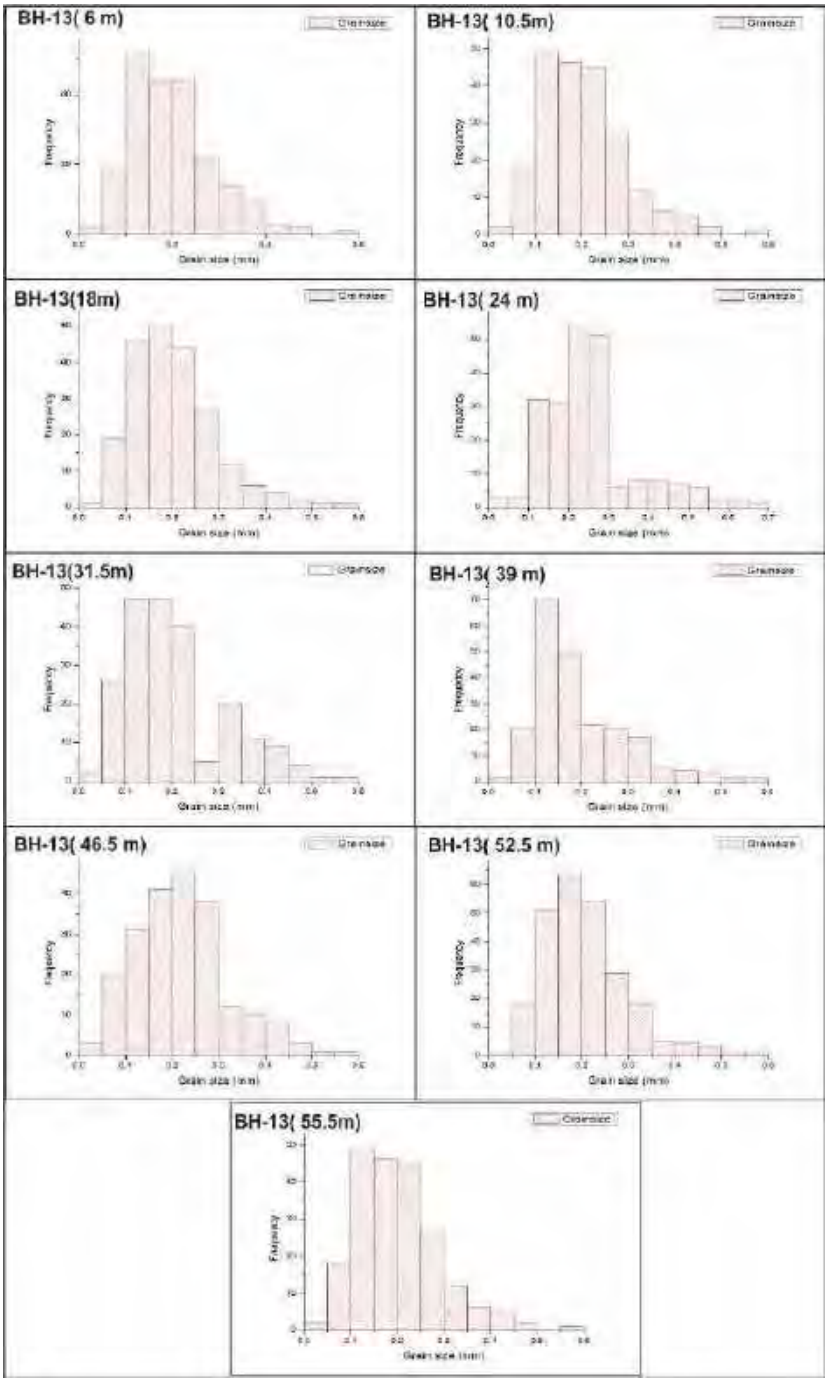

Figure 43: Borehole 13 Grain size analysis histogram.

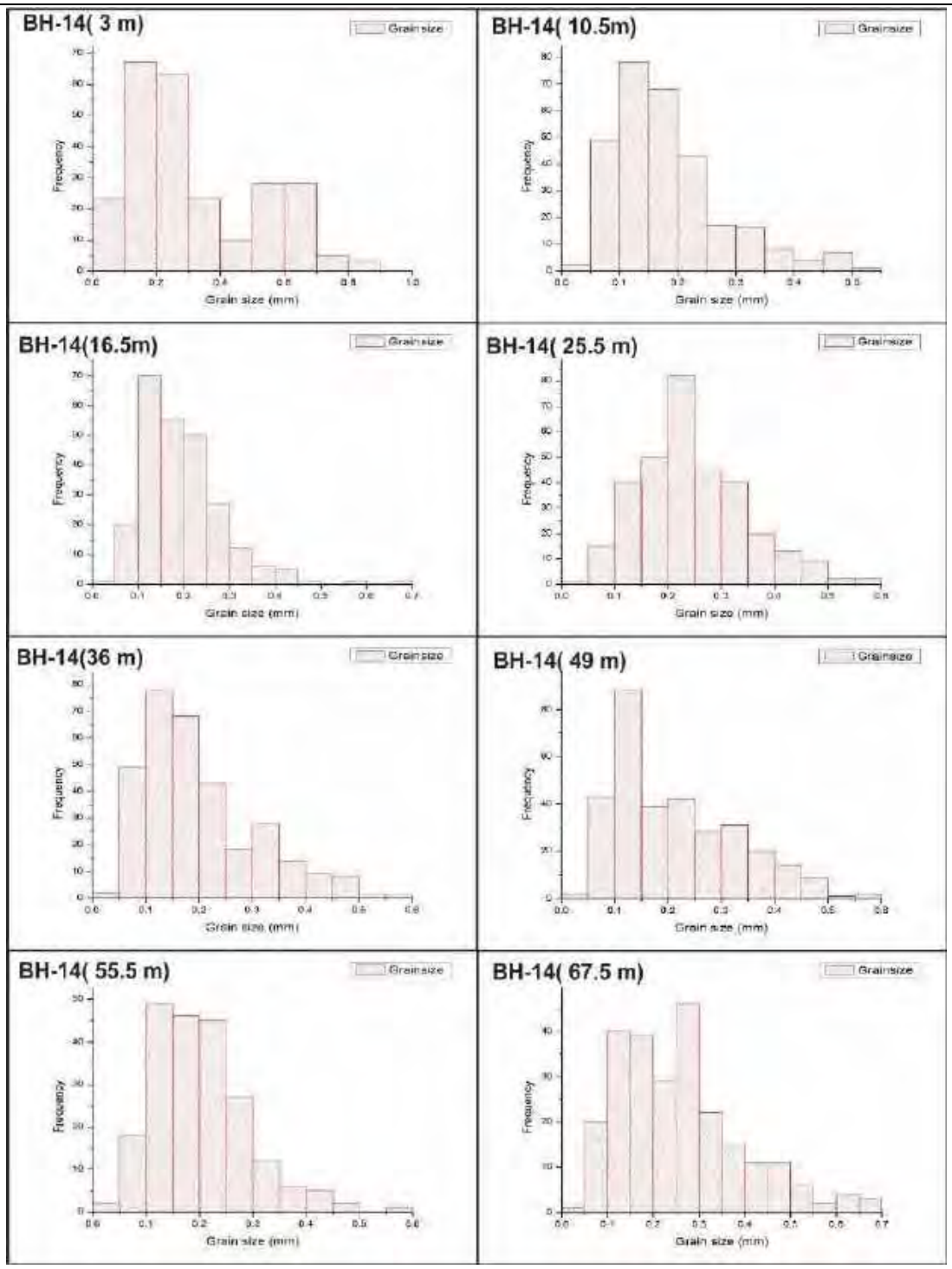

Figure 44: Borehole 14 Grain size analysis histogram

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

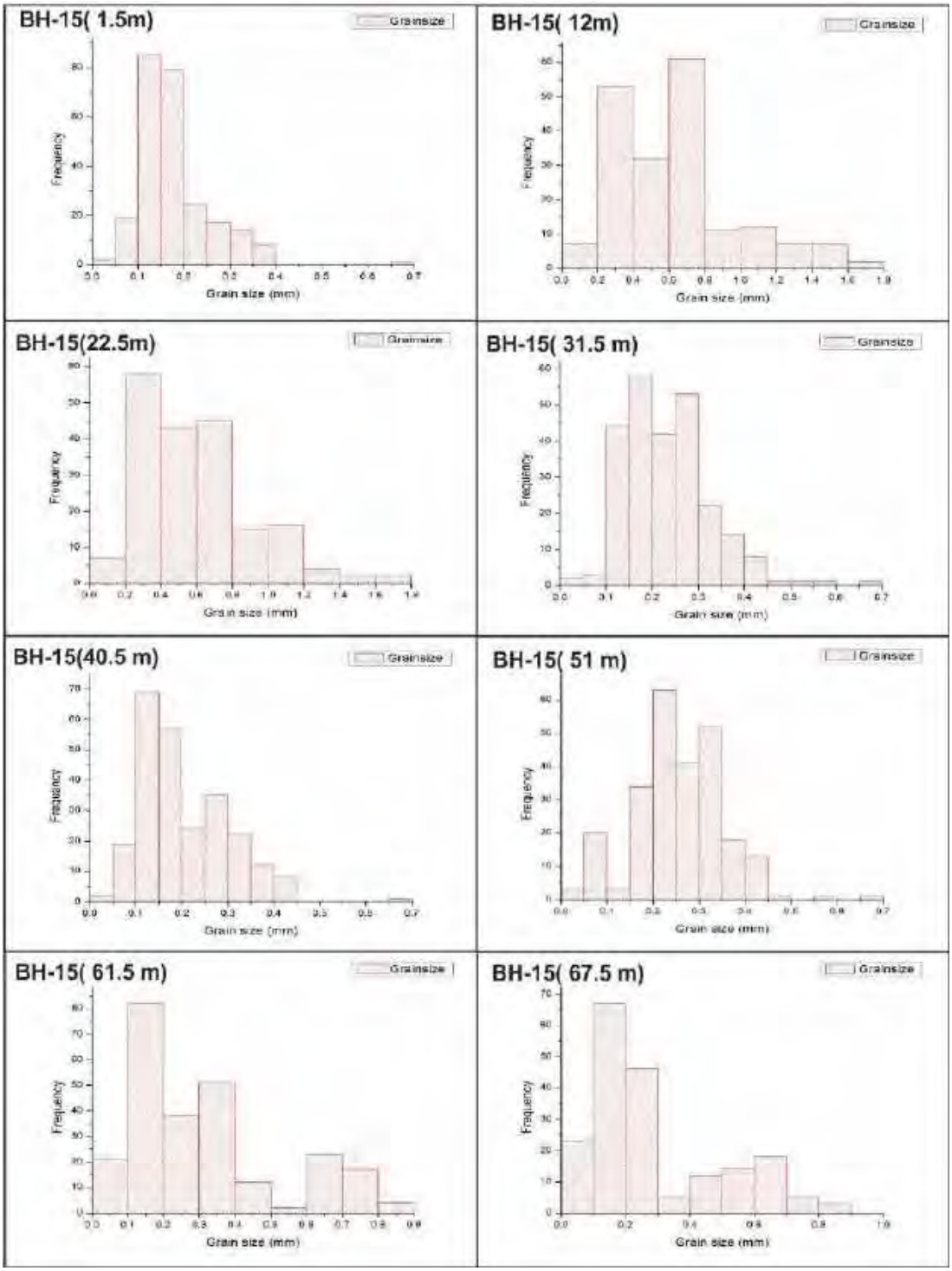

Figure 45: Borehole 15 Grain size analysis histogram

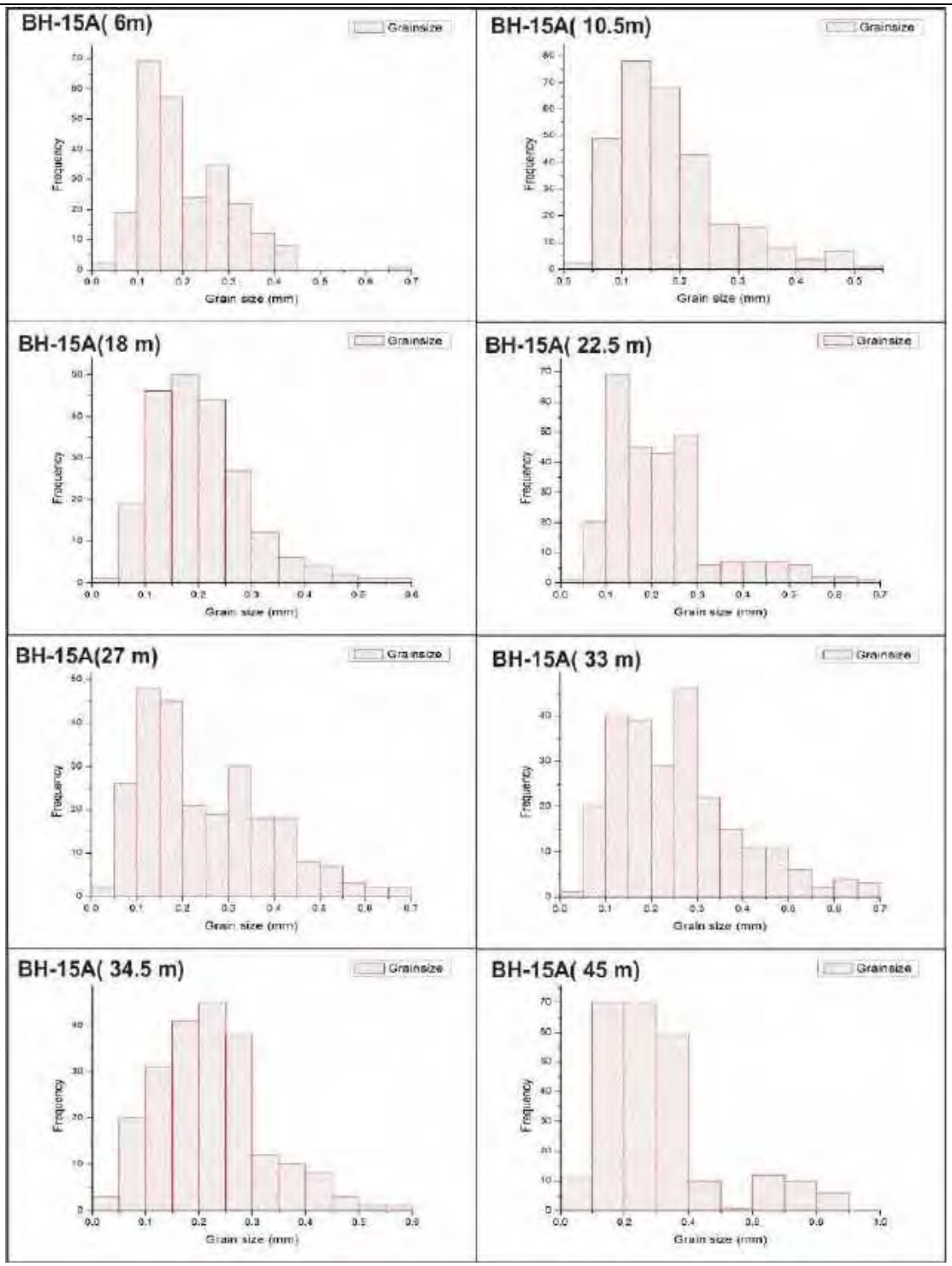

Figure 46: Borehole 15(A) Grain size analysis histogram.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

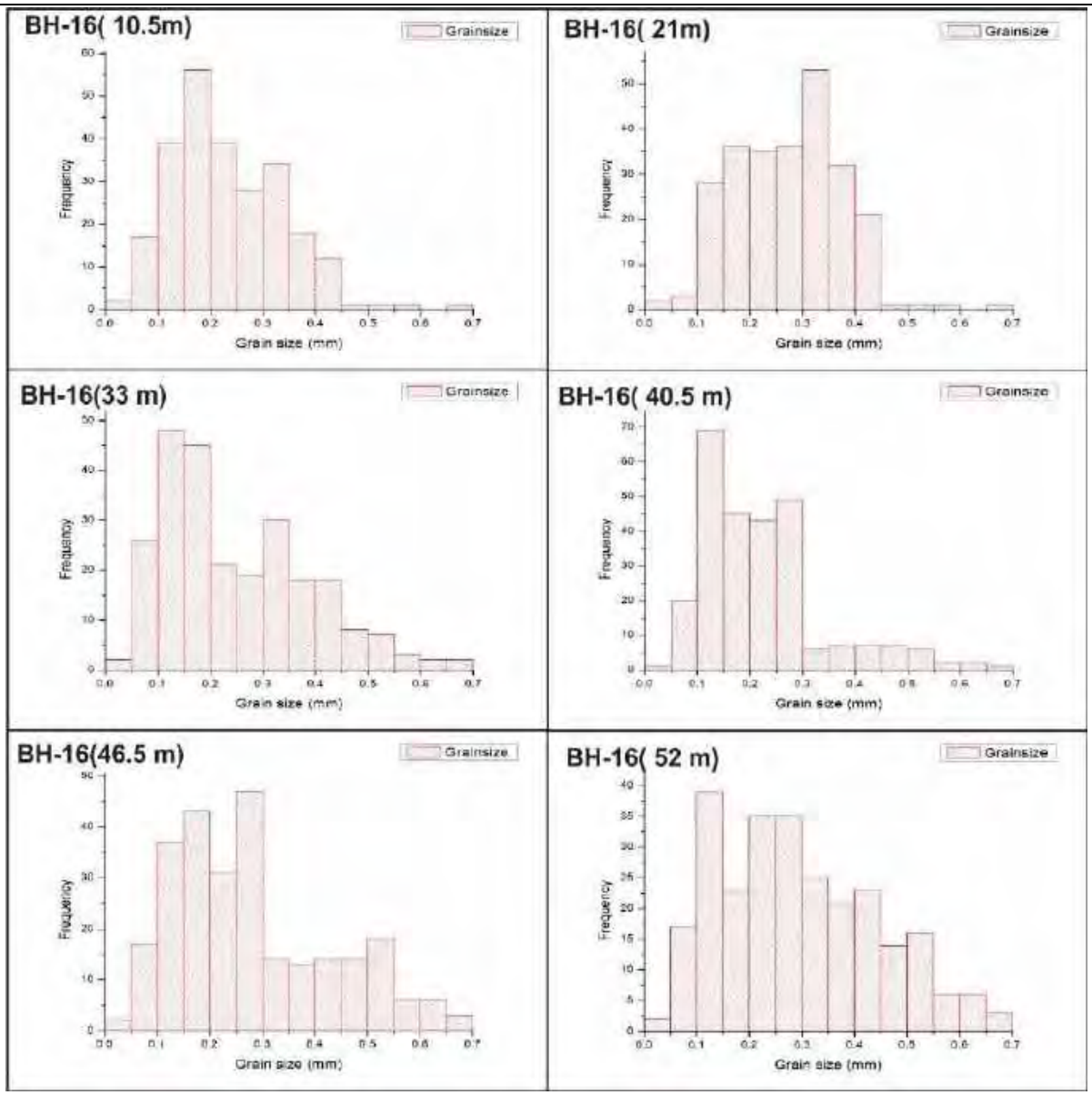

Figure 47: Borehole 16 Grain size analysis histogram.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

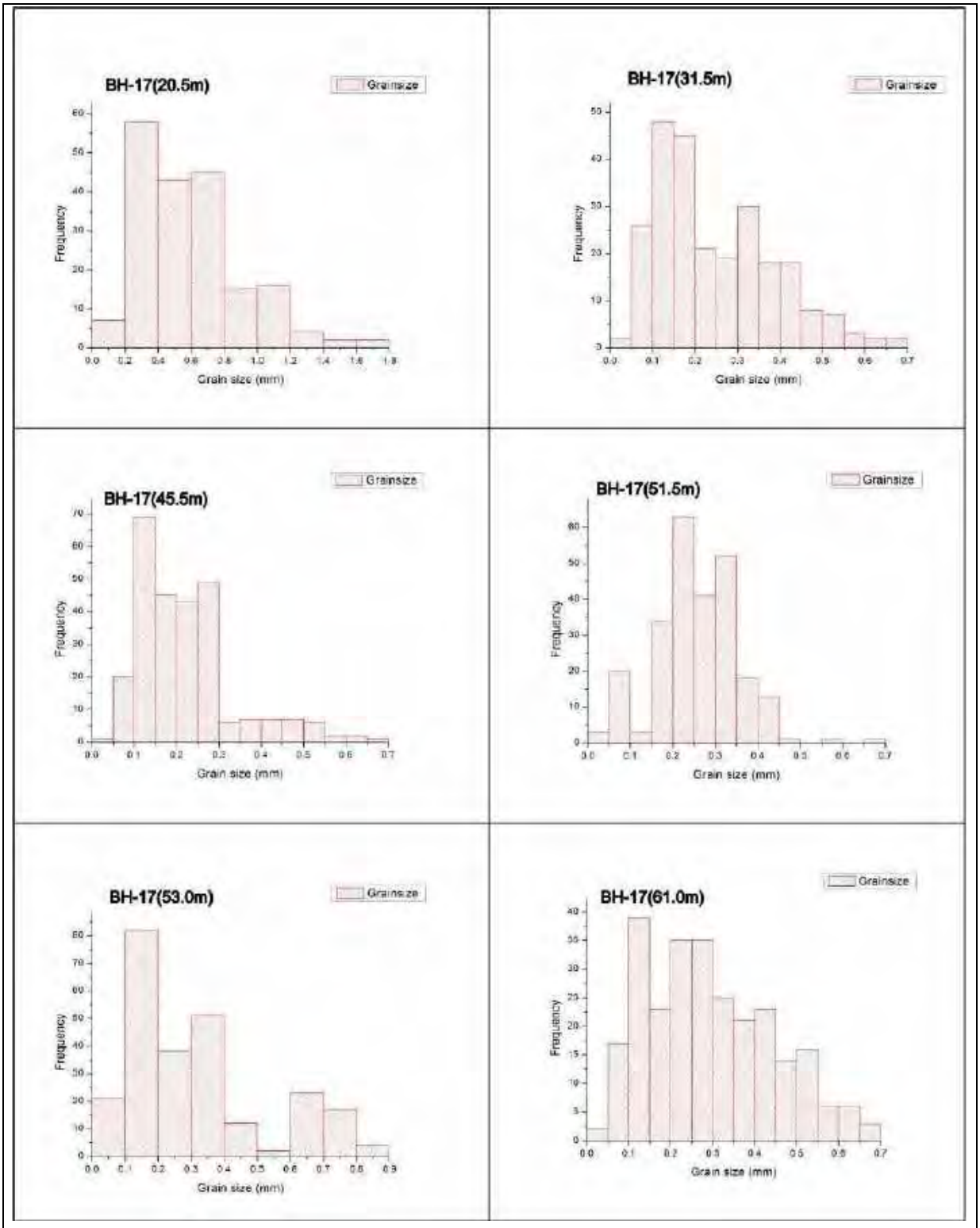

Figure 48: Borehole 17 Grain size analysis histogram.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

Table 33: Mean, Median, Mode value of grain size analysis

BH.ID	Depth(m)	Grain size(mm)		
		Mean	Median	Mode
BH13	4.50-6.00	0.199803	0.19	0.12
	9.00-10.50	0.201959	0.193	0.085
	16.50-18.00	0.205468	0.1915	0.129
	22.50-24.00	0.258223	0.241	0.273
	30.00-31.50	0.206205	0.182	0.093
	37.50-39.00	0.16483	0.1515	0.129
	45.00-46.50	0.206281	0.205	0.203
	51.00-52.50	0.212493	0.209	0.273
	54.00-52.50	0.201959	0.205	0.273
BH14	1.50-3.00	0.18256	0.17	0.12
	9.00-10.50	0.2053	0.193	0.128
	15.00-16.50	0.203155	0.183	0.12
	24.00-25.50	0.256	0.239	0.23
	34.50-36.00	0.26	0.23	0.129
	48.00-49.50	0.21	0.25	0.129
	54.00-55.50	0.25	0.26	0.11
	66.00-67.50	0.316289	0.26	0.26
BH15	0-1.5	0.177933	0.16	0.12
	10.50-12.0	0.708647	0.6635	0.203
	21.00-22.50	0.568245	0.436	0.375
	30.00-31.50	0.246856	0.25	0.273
	39.00-40.50	0.203155	0.183	0.12
	49.50-51.00	0.236961	0.23	0.191
	60.00-61.50	0.316289	0.1835	0.12
	66.00-67.50	0.311211	0.246	0.252
BH15A	4.50-6.00	0.201959	0.193	0.1

BH.ID	Depth(m)	Grain size(mm)		
		Mean	Median	Mode
	9.00-10.50	0.203155	0.183	0.12
	16.50-18.00	0.204089	0.2	0.23
	21.00-22.50	0.238725	0.222	0.129
	25.50-27.00	0.25	0.26	0.15
	31.50-33.00	0.213	0.224	0.23
	33.00-34.50	0.246253	0.243	0.222
	43.50-45.00	0.266062	0.2245	0.129
BH16	9.00-10.50	0.204089	0.1915	0.085
	19.50-21.00	0.238725	0.222	0.129
	31.50-33.00	0.219092	0.184	0.093
	39.00-40.50	0.218842	0.197	0.129
	45.00-46.50	0.246253	0.2	0.222
	52.00-53.50	0.316289	0.26	0.16
BH-17	20.50-22.00	0.238725	0.224	0.23
	25.00-26.50	0.21	0.25	0.129
	30.00-31.50	0.2456	0.23	0.191
	45.50-47.00	0.236961	0.23	0.191
	51.50-53.00	0.389	0.286	0.146
	61.00-62.00	0.311211	0.26	0.252

6.1.12 Mineralogical analysis

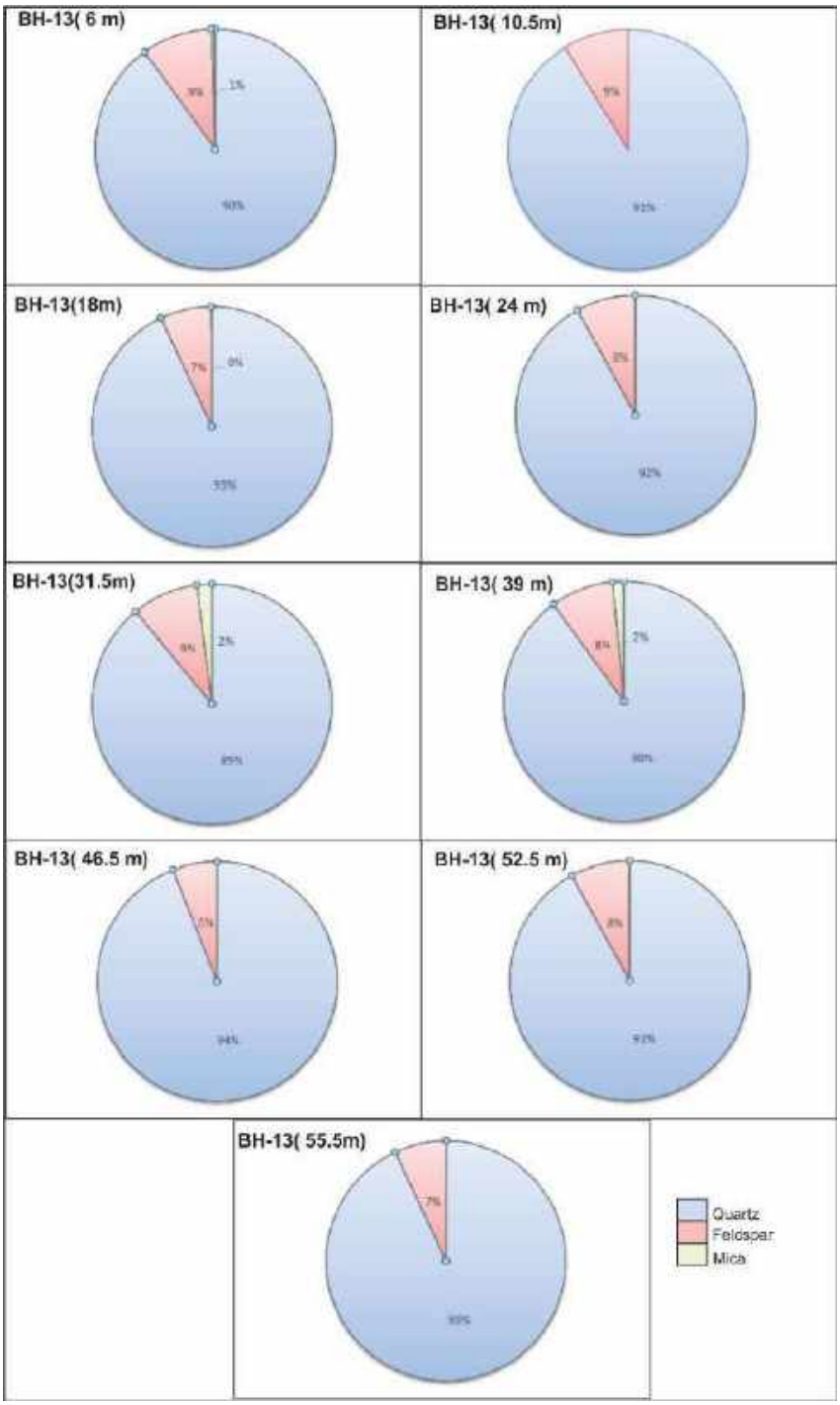

Figure 49: Borehole 13 Mineral percentage

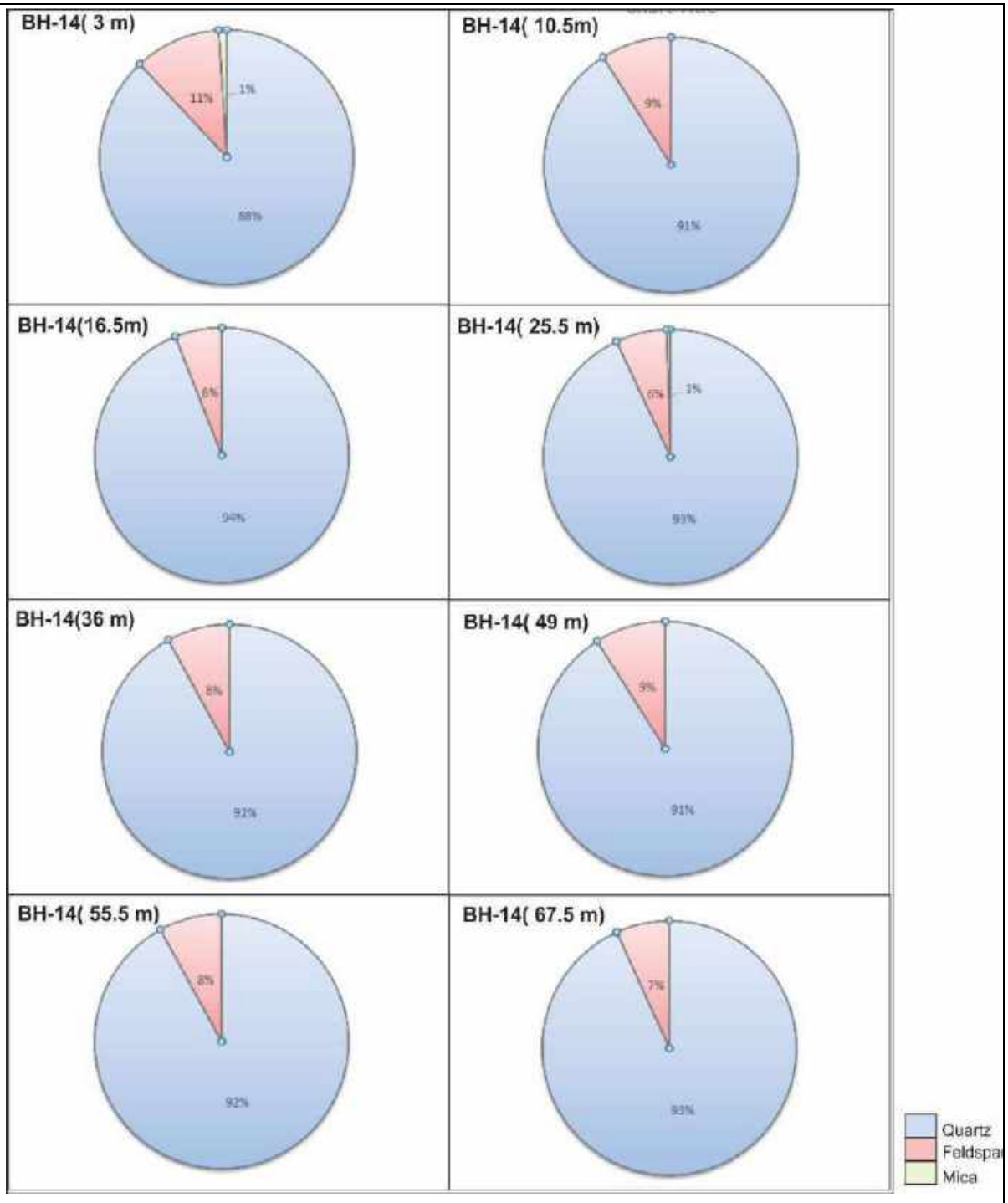

Figure 50: Borehole 14 Mineral percentage.

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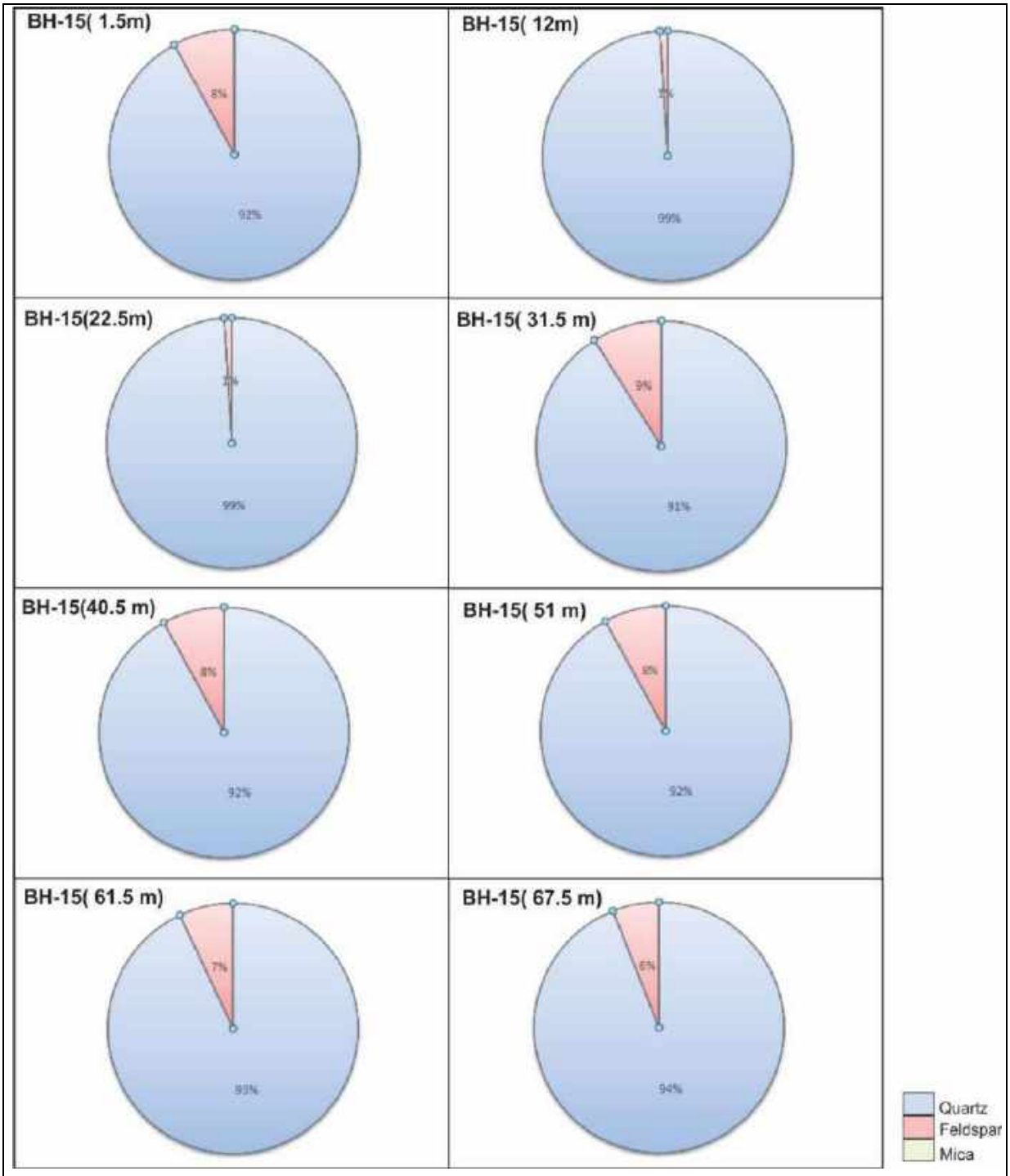

Figure 51: Borehole 15 Mineral percentage.

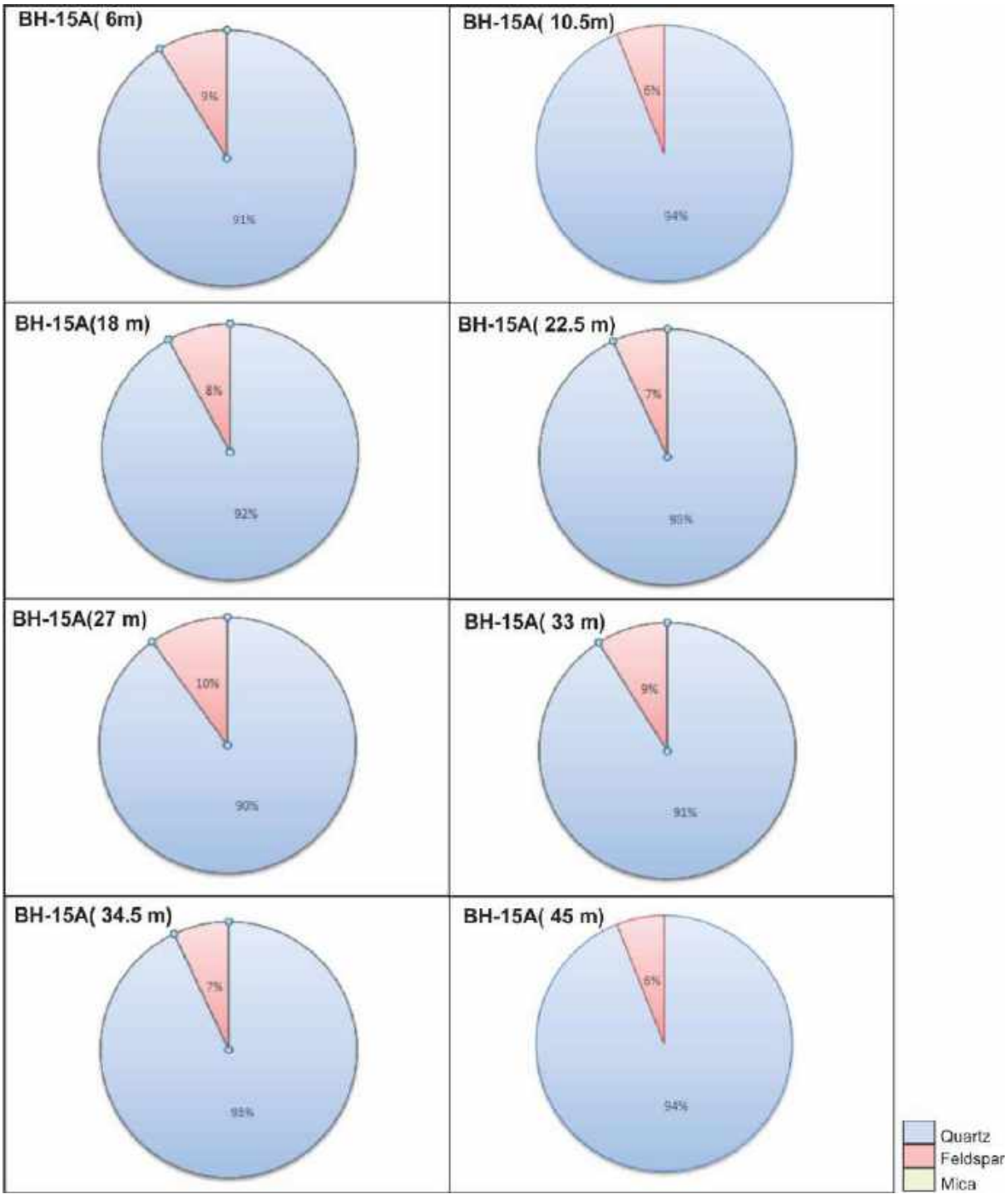

Figure 52: Borehole 15(A) Mineral percentage.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

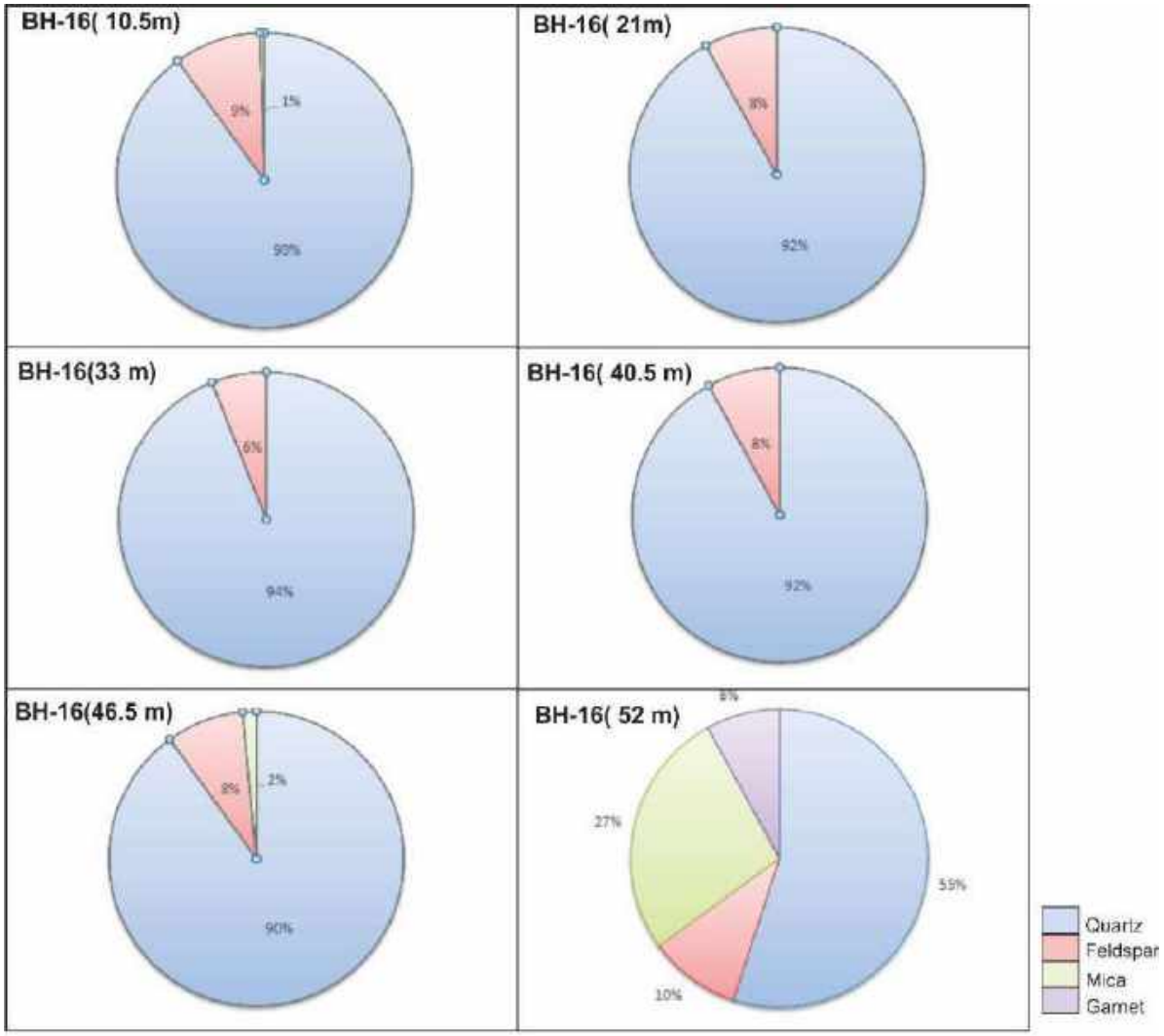

Figure 53: Borehole 16 Mineral percentage.

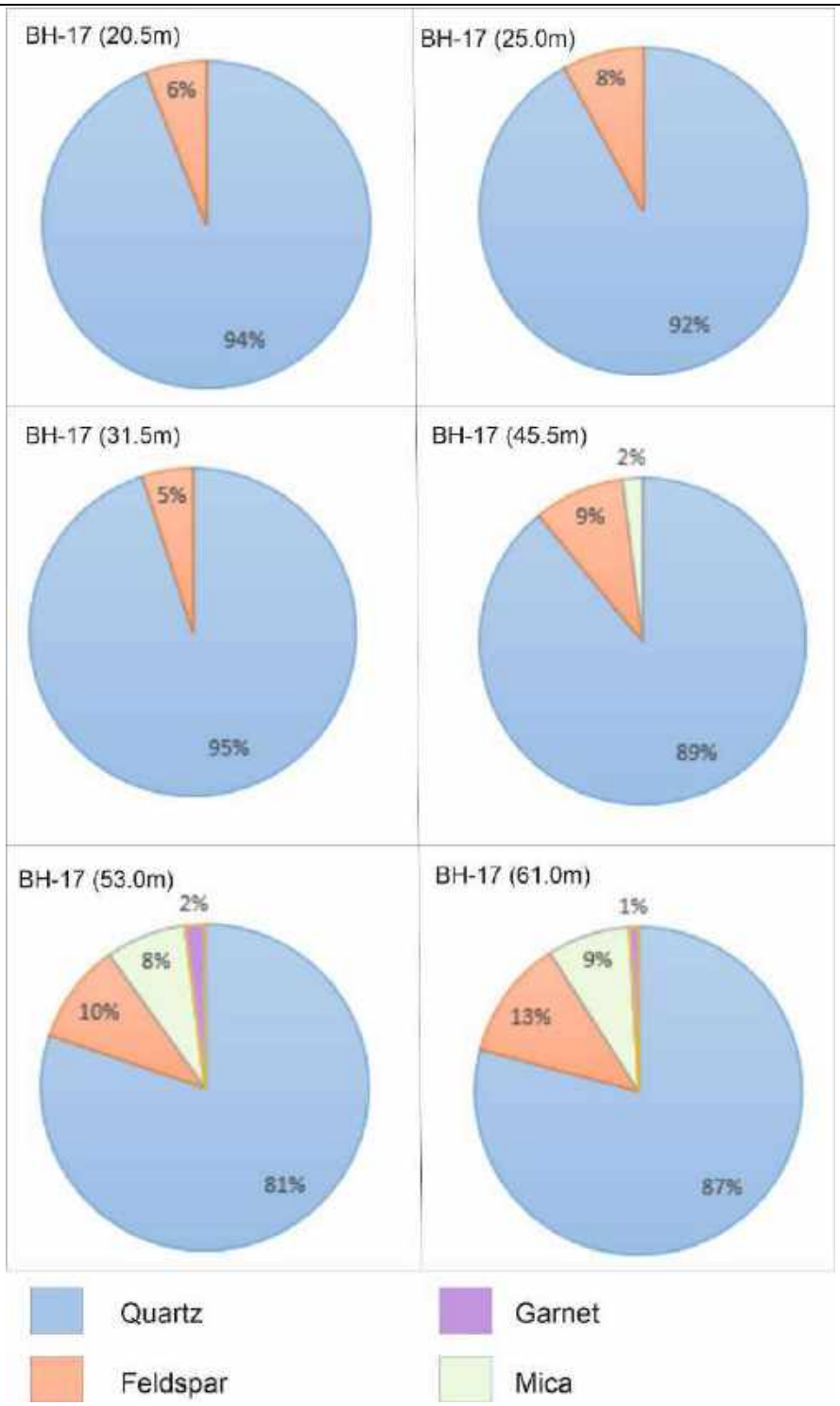

Figure 54: Borehole 17 Mineral percentage.

Name of Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project"

6.2 Soil Laboratory Test:

Laboratory tests were also carried out on soil samples taken from borehole BH18-BH33, the details of different laboratory tests conducted as part of the project are given in the table below.

Sl. No.	Laboratory tests	IS Codes
1	Preparation of soil sample	IS: 2720(part-1)-1983 (Reaffirmed 2015)
2	Moisture Content	IS: 2720(part-2)-1973 (Reaffirmed 2015)
3	Specific Gravity	IS: 2720(part-3)(sec-1)-1980 (Reaffirmed 2016)
4	Grain Size Analysis	IS: 2720(part-4)-1985 (Reaffirmed 2015)
5	Atterberg's Limits	IS: 2720(part-5)-1985 (Reaffirmed 2015)
6	Bulk Density	----
7	Triaxial Shear Strength	IS: 2720(part-11)-1993 (Reaffirmed 2016)
8	Direct Shear Strength	IS: 2720(part-13)-1986 (Reaffirmed 2016)
9	Consolidation Test	IS: 2720(part-15)-1986 (Reaffirmed 2016)

6.2.1 Soil Types:

Soil mass encountered along the tunnel alignment has been categorised in two group i.e., 1) Noncohesive Soil comprising Silty Sand (SM) and Inorganic Silt (ML) and 2) Cohesive Soil comprising Inorganic clay (CL).

6.2.2 Cohesion Test:

Cohesion values from all the all kinds of soil are found to 2 group. As shown in Figure 55 CL type soil mass has higher cohesion value (clustered green dots in graph) ranging between 25-35 kPa and other 3 types of soil are comprised of another group with values ranging from 4-12 kPa.

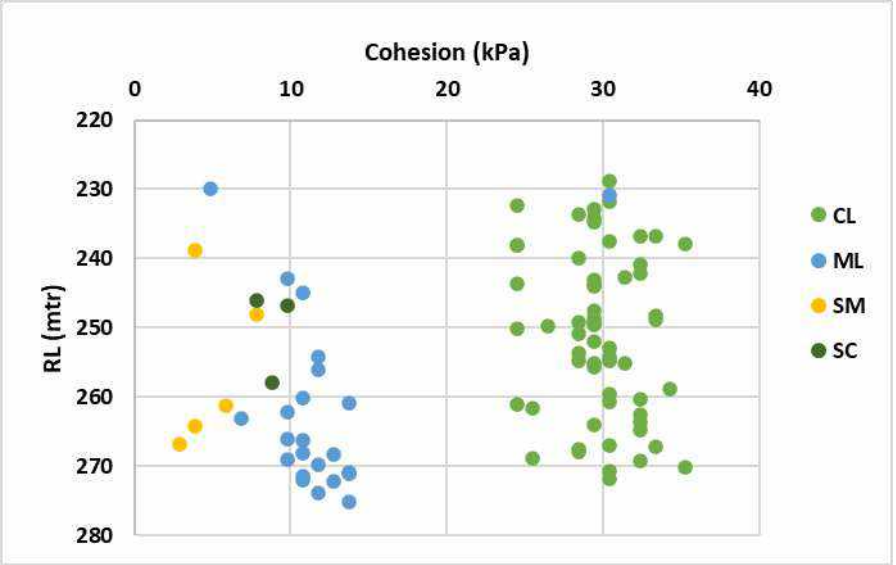

Figure 55: Variation in cohesion value of soil with RL.

Table 34: Summery of cohesion test results for soil.

Soil Types	Minimum Cohesion value	Maximum Cohesion value	Average Cohesion value
CL	23.54 kPa	35.30 kPa	25 kPa
ML	1.96 kPa	18.63 kPa	3 kPa
SC	7.85 kPa	19.61 kPa	3 kPa
SM	1.96 kPa	3.92 kPa	3 kPa

6.2.3 Angle of Internal Friction:

The figure below provides the summarized results of test conducted to determine the angle of internal friction of the soil sample taken from the boreholes.

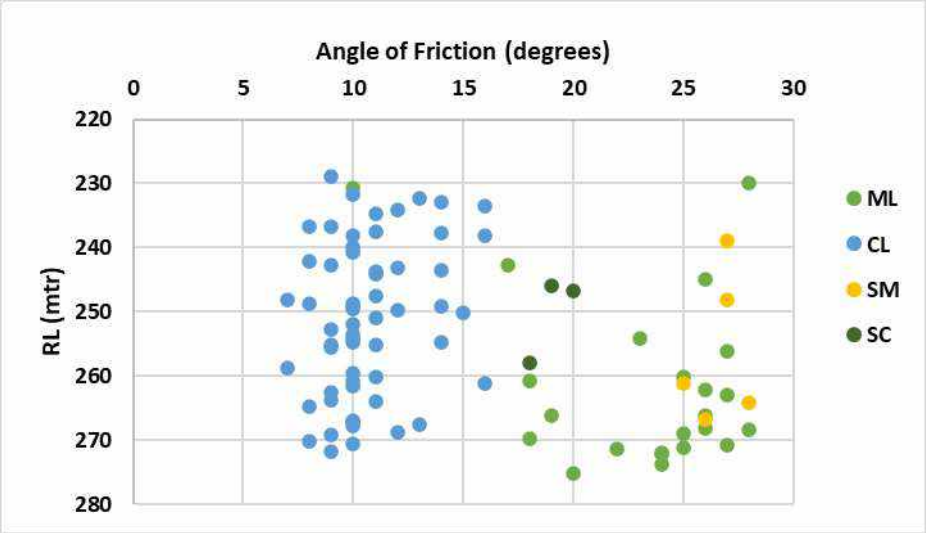

Figure 56: Variation in phi value of soil with RL

Table 35: Summery of angle of internal friction test results for soil.

Soil Types	Minimum Phi value	Maximum Phi value	Average Phi value
CL	9°	16°	12°
ML	28°	36°	32°
SC	29°	34°	32°
SM	29°	32°	32°

6.2.4 Natural Weight:

Density of all kind of soil found to be linearly increasing with depth. The trend of variation with depth is shown below in Figure 57.

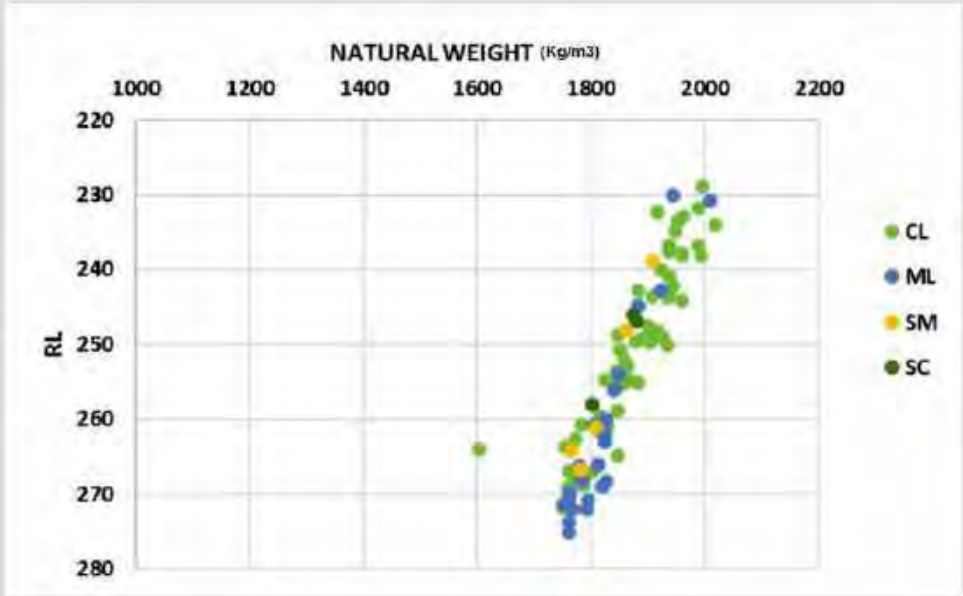

Figure 57: Variation in density value of soil with RL

Table 36: Summery of density test results for soil

Soil Types	Minimum Density value	Maximum Density value	Average Density value
CL	1604 kg/m^3	2018 kg/m^3	1852 kg/m^3
ML	1752 kg/m^3	2009 kg/m^3	1765 kg/m^3
SC	1802 kg/m^3	1879 kg/m^3	1851 kg/m^3
SM	1765 kg/m^3	1906 kg/m^3	1824 kg/m^3

6.2.5 Modulus of Elasticity (E):

The drained modulus (E') values are determined based on the corrected SPT N value –N_{60} as per CIRIA Report 143 for granular as well as cohesive soils. For cohesive soil– **$E' = 1.2\times N_{60}$ (MPa)**, and for cohesionless soil– **$E' = 1.0\times N_{60}$ (MPa). Modulus of elasticity** was found to be increasing from 10 MPa to 15 MPa with depth up-to first 15 meter from the surface, after which it falls within a constant range of value around 30±1 MPa up-to the floor of the tunnel.

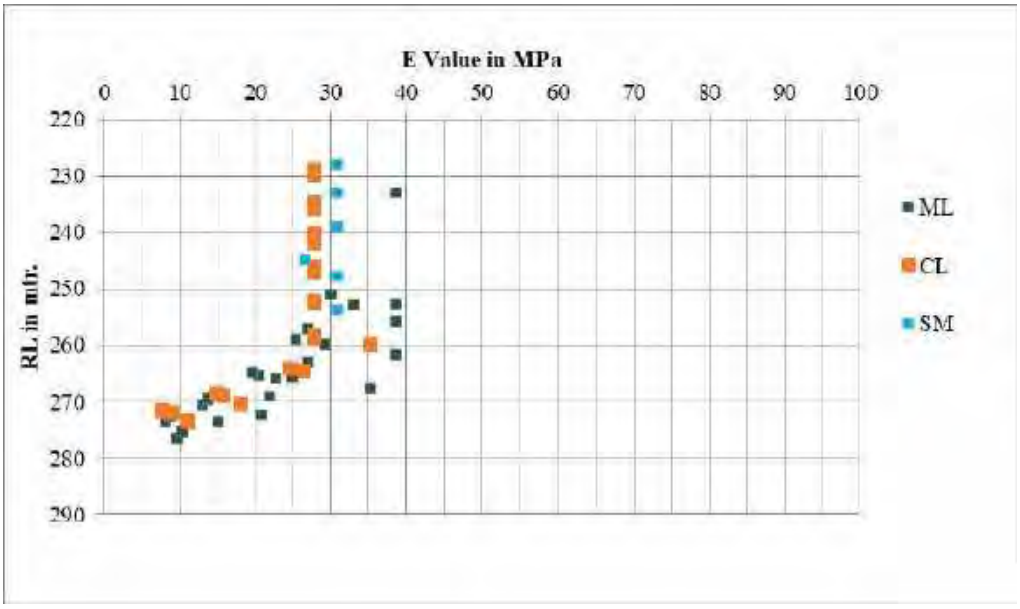

Figure 58: graph for Modulus of elasticity for soil vs RL.

Table 37: Summery of Modulus of E values for soil

Soil Types	Minimum E value	Maximum E value	Average E value
CL	7.64 MPa	35.19 MPa	24.10 MPa
ML	6.94 MPa	38.58 MPa	24.67 MPa
SM	26.54 MPa	30.87 MPa	30.14 MPa

7 CHAPTER: SUMMARY

The Geotechnical investigation is an integral part of the assessment of subsurface strata conditions before the commencement of underground excavation and design methodology. For this purpose, 20 nos. of bore holes (BH-13 to BH-33) were drilled at the site covering the entire area. The bore holes were planned in such a way to intersect the proposed tunnel layouts throughout its proposed alignment. Geological mapping has been carried out based on the surface exposure of different rock types. The attitude (strike and dip) of these different formations were measured in the field at appropriate places.

7.1 Structure

Based on the available surface information and close observation of the drilled cores from the litho-logs, it has been observed that after crossing the soil the tunnel will enter into a folded rock mass where the axis of the tunnel will be perpendicular to the fold axis, thus favourably oriented with respect to the folded bedding planes. However, the folded rock layer has suffered extreme level of later brittle fracturing, which has been testified by the presence of 6 sets of joints of different orientation and a few late brittle discrete shear zones (which is certainly not active in nature). These joints and the fractures have significantly reduced the strength of the otherwise sufficiently cohesive metamorphic rock mass.

7.2 Lithology

Out of 4.26 km length of the tunnel it was found that 1.1 km of tunnel will be within the quartzite rock mass of Delhi Supergroup and rest of the 3.16 km will run through soil.

7.2.1 Rock Mass

The rock core samples extracted from the drilled holes, at regular intervals along depth, were utilized for the estimation of strength parameters, rock mass characterization, basic support design, and prediction of envisaged strata conditions. The testing of cores for

the determination of strength properties performed at NABL recognized laboratories. The tests include uniaxial compressive test, triaxial strength test, tensile strength, permeability, porosity, Point Load strength index, hardness, abrasiveness, petrographic analysis. The test results regarding the engineering properties for the rock mass are given in Annexures.

7.2.2 Soil

Geotechnical Investigation were carried out by drilling 15 no of boreholes i.e., BH No-18 to 33. The subsoil predominantly consists of silt of low plasticity to clay of low plasticity. The ranges of engineering properties such as, cohesive strength, phi value, natural weight, Modulus of elasticity for **CL** type soil is 23.54-35.30 kPa, 9°-16°, 1604-2018 kg/m3, 7.64 MPa; for **ML** type Soil is 1.96-18.36 kPa, 28°-36°, 1752-2009 kg/m3, 6,94-38.58 MPa; for **SM** type soil is 1.96-3.92 kPa, 29°-32°, 1765-1906 kg/m3, 26.54-30.87 MPa respectively

7.3 Hydrogeological Conditions

None of the boreholes reached the ground water table. Therefore, based on the preliminary survey, it can be predicted that the tunnel will not face any difficulty due to encounter of ground water table during the construction. However, the overlying rock strata having significant nos. of joint set is quite capable of percolating rain waters during the rainy seasons. There is also a ditch around CH 24800, which is situated almost 31.87m above the roof of the tunnel. This ditch may be connected to a perched water table with a limited water resource. The joint sets and the ditch could act as efficient path ways of rainwater recharge into the tunnel during the rainy season. Therefore, it is recommended that suitable drainage system should be designed along with the tunnel to drain out that percolated water to avoid water logging during and after the construction of the tunnel.

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9 ANNEXURES

ANNEXURE –A
Geological Log, RQD, Q value

BH No.	**Chainage No.**	**Ground Elevation, RL (m)**	**Total Depth (m)**
BH-13	25000	276.867	60
BH-14	25195	294.218	75
BH-15	25380	295.532	70
BH-15A	25488	276.442	50
BH-16	25586	287.324	62
BH-17	25785	282.461	62
BH-18	25990	280.253	55
BH-19	26210	278.116	50
BH-20	26387	276.795	48
BH-21	26587	274.993	45
BH-22	26787	274.321	45
BH-23	26980	274.85	45
BH-24	27187	274.075	40
BH-25	27410	273.565	40
BH-26	27550	273.112	35
BH-27	28050	272.210	30
BH-28	28350	272.799	45
BH-29	28550	269.964	30
BH-30	28750	270.808	45
BH-31	29050	267.159	20
BH-32	29550	266.684	30
BH-33	30125	265.581	20

project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**13**	**LONGITUDE**	**77°2'41.397"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25000**	**LATTITUDE**	**28°12'25.991"N**		**TOTAL DEPTH:**	**60m**		
START DATE	**25-08-2021**	**GROUND ELEVATION MSL :**	**276.867**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**06-09-2021**	**ANGLE WITH HORIZONT: 90°**			**DEPTH OF WATER TABLE**	**Not Found**	**CASING**	**NX up to 3.0 m**
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**07-09-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Bh-13; Total Depth 60m

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Type of Sample Collected	Q VALUE
280	0	1.5	Slightly Weathered, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	18	0	33	CLASS 3(FAIR ROCK)	0.00-1.50	Core Rock	1.5
278	1.5	3	Slightly Weathered,Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Moderately Fractured and Jointed	28.6	0	33	CLASS 3(FAIR ROCK)	1.50-3.00	Core Rock	1.5

Bh-13; Total Depth 60m											
Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
277	3	4.5	Slightly Weathered, Light Grey to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	44.6	0	33	CLASS 3(FAIR ROCK)	3.00-4.50	Core Rock	6.69
275	4.5	6	Highly Weathered, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	21.33	0	31	CLASS 3(FAIR ROCK)	4.50-6.00	Core Rock	3.1995
274	6	7.5	Slightly Weathered, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	25.33	10	35	CLASS 3(FAIR ROCK)	6.00-7.50	Core Rock	3.7995
272	7.5	9	Highly Weathered, Highly Fractured, Highly Jointed, White to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	37.33	0	31	CLASS 3(FAIR ROCK)	7.50-9.00	Core Rock	5.5995
271	9	11		Highly Fractured and Jointed	34	0	31	CLASS 3(FAIR ROCK)	9.00-10.50	Core Rock	5.1

Bh-13; Total Depth 60m

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Type of Sample Collected	Q VALUE
269	11	12	Moderately Weathered, Highly Fractured, Highly Jointed, Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	28	17	33	CLASS 3(FAIR ROCK)	10.50-12.00	Core Rock	4.2
268	12	14	Highly Weathered, White to Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	21.33	0	33	CLASS 3(FAIR ROCK)	12.00-13.50	Core Rock	3.1995
266	14	15		Highly Fractured and Jointed	34	0	35	CLASS 3(FAIR ROCK)	13.50-15.00	Core Rock	5.1
265	15	17	Slightly Weathered, Reddish Brown to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	32	0	35	CLASS 3(FAIR ROCK)	15.00-16.50	Core Rock	4.2
263	17	18	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	32.85	0	35	CLASS 3(FAIR ROCK)	16.50-18.00	Core Rock	3.1995
262	18	20	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron	Highly Fractured and Jointed	30	9	35	CLASS 3(FAIR ROCK)	18.00-19.50	Core Rock	5.1

Bh-13; Total Depth 60m

Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
260	20	21	Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	39.33	0	35	CLASS 3(FAIR ROCK)	19.50-21.00	Core Rock	4.8
259	21	23		Highly Fractured and Jointed	33.33	0	35	CLASS 3(FAIR ROCK)	21.00-22.50	Core Rock	4.9275
257	23	24		Highly Fractured and Jointed	39.33	0	38	CLASS 3(FAIR ROCK)	22.50-24.00	Core Rock	4.5
256	24	26	Slightly Weathered,Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	28.66	9	38	CLASS 3(FAIR ROCK)	24.00-25.50	Core Rock	5.8995
254	26	27		Highly Fractured and Jointed	34	18	38	CLASS 3(FAIR ROCK)	25.50-27.00	Core Rock	4.9995
253	27	29		Highly Fractured and Jointed	34	24	38	CLASS 3(FAIR ROCK)	27.00-28.50	Core Rock	5.8995
251	29	30		Highly Fractured and Jointed	40	20	38	CLASS 3(FAIR ROCK)	28.50-30.00	Core Rock	4.299
250	30	32		Highly Fractured and Jointed	31.33	0	35	CLASS 3(FAIR ROCK)	30.00-31.50	Core Rock	5.1

Bh-13; Total Depth 60m

Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
248	32	33		Highly Fractured and Jointed	33.33	9	35	CLASS 3(FAIR ROCK)	31.50-33.00	Core Rock	5.1
247	33	35		Highly Fractured and Jointed	24	11	35	CLASS 3(FAIR ROCK)	33.00-34.50	Core Rock	6
245	35	36	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	35.33	8	35	CLASS 3(FAIR ROCK)	34.50-36.00	Core Rock	4.6995
244	36	38		Highly Fractured and Jointed	32.6	8	35	CLASS 3(FAIR ROCK)	36.00-37.50	Core Rock	4.9995
242	38	39		Highly Fractured and Jointed	26.66	0	35	CLASS 3(FAIR ROCK)	37.50-39.00	Core Rock	3.6
241	39	41		Highly Fractured and Jointed	32	9	35	CLASS 3(FAIR ROCK)	39.00-40.50	Core Rock	5.2995
239	41	42	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	43.33	9	35	CLASS 3(FAIR ROCK)	40.50-42.00	Core Rock	4.89
238	42	44		Highly Fractured and Jointed	26	8	35	CLASS 3(FAIR ROCK)	42.00-43.50	Core Rock	3.999

Bh-13; Total Depth 60m

Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
236	44	45	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	33.33	16	35	CLASS 3(FAIR ROCK)	43.50-45.00	Core Rock	4.8
235	45	47		Highly Fractured and Jointed	30	0	35	CLASS 3(FAIR ROCK)	45.00-46.50	Core Rock	6.4995
233	47	48		Highly Fractured and Jointed	22.66	19	35	CLASS 3(FAIR ROCK)	46.50-48.00	Core Rock	3.9
232	48	50		Highly Fractured and Jointed	34	29	40	CLASS 3(FAIR ROCK)	48.00-49.50	Core Rock	4.9995
230	50	51		Highly Fractured and Jointed	27.33	0	35	CLASS 3(FAIR ROCK)	49.50-51.00	Core Rock	4.5
229	51	53		Highly Fractured and Jointed	26	0	35	CLASS 3(FAIR ROCK)	51.00-52.50	Core Rock	3.399
227	53	54		Highly Fractured and Jointed	34	0	35	CLASS 3(FAIR ROCK)	52.50-54.00	Core Rock	5.1
226	54	56		Highly Fractured and Jointed	34	0	35	CLASS 3(FAIR ROCK)	54.00-55.50	Core Rock	4.0995

Bh-13; Total Depth 60m											
Elevation (m)	Depth (m)		Lithological Description	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
224	56	57	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	26.66	9	35	CLASS 3(FAIR ROCK)	55.50-57.00	Core Rock	3.9
223	57	59		Highly Fractured and Jointed	28	8	35	CLASS 3(FAIR ROCK)	57.00-58.50	Core Rock	5.1
221	59	60		Highly Fractured and Jointed	22	13	35	CLASS 3(FAIR ROCK)	58.50-60.00	Core Rock	5.1

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**14**	**LONGITUDE**	**77°2'37.427"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25195**	**LATTITUDE**	**28°12'31.483"N**		**TOTAL DEPTH:**	**75m**		
START DATE	**11-08-2021**	**GROUND ELEVATION MSL :**	**294.218**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**23-08-2021**	**ANGLE WITH HORIZONT: 90º**			**DEPTH OF WATER TABLE**	**Not found**	**CASING**	**NX up to 3.0 m**
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**24-08-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
294.218	0.0	1.5	Moderately Weathered, , Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	30	0	33	CLASS 3(FAIR ROCK)	0.00-1.50	Core Rock	1.5
292.718	1.5	3.0		Highly Fractured and Jointed	48	0	33	CLASS 3(FAIR ROCK)	1.50-3.00	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
291.218	3.0	4.5	Highly Weathered Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Moderately Fractured and Jointed	38	0	33	CLASS 3(FAIR ROCK)	3.00-4.50	Core Rock	1.5
289.718	4.5	6.0	Quartz vein Slightly Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	66	24	33	CLASS 3(FAIR ROCK)	4.50-6.00	Core Rock	3.6
288.218	6.0	7.5	Highly Weathered Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Moderatley Fractured and Jointed	45	0	35	CLASS 3(FAIR ROCK)	6.00-7.50	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
286.718	7.5	9.0	Slightly Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (fine grain muscovite)	Highly Fractured and Jointed	50	18	35	CLASS 3(FAIR ROCK)	7.50-9.00	Core Rock	2.7
285.218	9.0	10.5	Slightly to Moderately Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Moderately Fractured and Jointed	51	0	33	CLASS 3(FAIR ROCK)	9.00-10.50	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
283.718	10.5	12.0	Moderately Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	40	21	38	CLASS 3(FAIR ROCK)	10.50-12.00	Core Rock	3.15
282.218	12.0	13.5		Highly Fractured and Jointed	34	15	33	CLASS 3(FAIR ROCK)	12.00-13.50	Core Rock	2.25
280.718	13.5	15.0		Highly Fractured and Jointed	21	0	31	CLASS 3(FAIR ROCK)	13.50-15.00	Core Rock	1.5
279.218	15.0	16.5		Highly Fractured and Jointed	29	0	31	CLASS 3(FAIR ROCK)	15.00-16.50	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
277.718	16.5	18.0	Moderately Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	28	9	31	CLASS 3(FAIR ROCK)	16.50-18.00	Core Rock	1.5
276.218	18.0	19.5	Slightly Weathered, Light Grey, Fine Grained, Interlocking Texture,	Highly Fractured and Jointed	34	6	35	CLASS 3(FAIR ROCK)	18.00-19.50	Core Rock	1.5
274.718	19.5	21.0		Highly Fractured and Jointed	23	0	35	CLASS 3(FAIR ROCK)	19.50-21.00	Core Rock	1.5
273.218	21.0	22.5		Highly Fractured and Jointed	28	13	35	CLASS 3(FAIR ROCK)	21.00-22.50	Core Rock	1.95

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
271.718	22.5	24.0	Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	23	6	35	CLASS 3(FAIR ROCK)	22.50-24.00	Core Rock	1.5
270.218	24.0	25.5		Highly Fractured and Jointed	20	0	35	CLASS 3(FAIR ROCK)	24.00-25.50	Core Rock	1.5
268.718	25.5	27.0		Highly Fractured and Jointed	25	9	35	CLASS 3(FAIR ROCK)	25.50-27.00	Core Rock	1.5
267.218	27.0	28.5		Highly Fractured and Jointed	28	0	38	CLASS 3(FAIR ROCK)	27.00-28.50	Core Rock	1.5
265.718	28.5	30.0		Highly Fractured and Jointed	25	18	35	CLASS 3(FAIR ROCK)	28.50-30.00	Core Rock	2.7
264.218	30.0	31.5	Slightly Weathered, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	28	14	35	CLASS 3(FAIR ROCK)	30.00-31.50	Core Rock	2.1

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
262.718	31.5	33.0	Moderately Weathered, , Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Moderately Fractured and Jointed	28	18	33	CLASS 3(FAIR ROCK)	31.50-33.00	Core Rock	2.7
261.218	33.0	34.5	Moderately Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	22	6	31	CLASS 3(FAIR ROCK)	33.00-34.50	Core Rock	1.5
259.718	34.5	36.0		Highly Fractured and Jointed	25	0	31	CLASS 3(FAIR ROCK)	34.50-36.00	Core Rock	1.5
258.218	36.0	37.5		Highly Fractured and Jointed	29	10	31	CLASS 3(FAIR ROCK)	36.00-37.50	Core Rock	1.5
256.718	37.5	39.0		Highly Fractured and Jointed	28	7	31	CLASS 3(FAIR ROCK)	37.50-39.00	Core Rock	1.5
255.218	39.0	40.5		Highly Fractured and Jointed	30	0	31	CLASS 3(FAIR ROCK)	39.00-40.50	Core Rock	1.5
253.718	40.5	42.0	Moderately	Highly Fractured and Jointed	28	7	31	CLASS 3(FAIR ROCK)	40.50-42.00	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
252.218	42.0	43.5	Weathered, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	25	0	35	CLASS 3(FAIR ROCK)	42.00-43.50	Core Rock	1.5
250.718	43.5	45.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	26	6	35	CLASS 3(FAIR ROCK)	43.50-45.00	Core Rock	1.5
249.218	45.0	46.5		Highly Fractured and Jointed	24	0	35	CLASS 3(FAIR ROCK)	45.00-46.50	Core Rock	1.5
247.718	46.5	48.0		Highly Fractured and Jointed	26	0	35	CLASS 3(FAIR ROCK)	46.50-48.00	Core Rock	1.5
246.218	48.0	49.5		Highly Fractured and Jointed	27	18	35	CLASS 3(FAIR ROCK)	48.00-49.50	Core Rock	2.7
244.718	49.5	51.0		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	49.50-51.00	Core Rock	1.5
243.218	51.0	52.5		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	51.00-52.50	Core Rock	1.5

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
241.718	52.5	54.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	52.50-54.00	Core Rock	1.5
240.218	54.0	55.5		Highly Fractured and Jointed	26	0	35	CLASS 3(FAIR ROCK)	54.00-55.50	Core Rock	1.5
238.718	55.5	57.0		Highly Fractured and Jointed	26	0	35	CLASS 3(FAIR ROCK)	55.50-57.00	Core Rock	1.5
237.218	57.0	58.5		Highly Fractured and Jointed	22	10	35	CLASS 3(FAIR ROCK)	57.00-58.50	Core Rock	1.5
235.718	58.5	60.0		Highly Fractured and Jointed	21	0	35	CLASS 3(FAIR ROCK)	58.50-60.00	Core Rock	1.5
234.218	60.0	61.5		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	60.00-61.50		1.5
232.718	61.5	63.0		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	61.50-63.00		1.5
231.218	63.0	64.5		Highly Fractured and Jointed	25	13	35	CLASS 3(FAIR ROCK)	63.05-64.55		1.95
229.718	64.5	66.0		Highly Fractured and Jointed	28	11	35	CLASS 3(FAIR ROCK)	64.50-66.00		1.65

Elevation (m)	Depth (m)			Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom	Lithology				Rating	Class	Depth of sample (m)	Type of Sample Collected	
228.218	66.0	67.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	28	0	35	CLASS 3(FAIR ROCK)	66.05-67.55		1.5
226.718	67.5	69.0		Highly Fractured and Jointed	28	0	35	CLASS 3(FAIR ROCK)	67.50-69.00		1.5
225.218	69.0	70.5		Highly Fractured and Jointed	26	8	35	CLASS 3(FAIR ROCK)	69.05-70.55		1.5
223.718	70.5	72.0		Highly Fractured and Jointed	27	14	35	CLASS 3(FAIR ROCK)	70.50-72.00		2.1
222.218	72.0	73.5		Highly Fractured and Jointed	26	14	38	CLASS 3(FAIR ROCK)	72.05-73.55		2.1
220.718	73.5	75.0		Highly Fractured and Jointed	22	0	35	CLASS 3(FAIR ROCK)	73.50-75.00		1.5

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**15**	**LONGITUDE**	**77°2'32.878"E**	**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25380**	**LATTITUDE**	**28°12'36.141"N**	**TOTAL DEPTH:**	**70m**		
START DATE	**12-08-2021**	**GROUND ELEVATION MSL :**	**295.532**	**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**28-08-2021**	**ANGLE WITH HORIZONT: 90º**		**DEPTH OF WATER TABLE**	**61.0m**	**CASING**	**NX up to 3.0 m**
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**		**WATER TABLE RECORD DATE**	**29-08-2021**		
				NAME OF GEOLOGIST	**Gaurav Chunekar**		

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Sample Collected	Q VALUE
295.532	0.0	1.5	HighlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	26	0	33	CLASS 4 (POOR ROCK)	0.00-1.50	Core Rock	1.5
294.03	1.5	3.0		Highly Fractured and Jointed	28	7	33	CLASS 4 (POOR ROCK)	1.50-3.00	Core Rock	1.5
292.528	3.0	4.5		Highly Fractured and Jointed	42	7	33	CLASS 4 (POOR ROCK)	3.00-4.50	Core Rock	1.5
291.026	4.5	6.0	SightlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	36	0	33	CLASS 4 (POOR ROCK)	4.50-6.00	Core Rock	1.5
289.524	6.0	7.5		Highly Fractured and Jointed	46	0	33	CLASS 4 (POOR ROCK)	6.00-7.50	Core Rock	1.5

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Collected	Q VALUE
288.022	7.5	9.0		Highly Fractured and Jointed	24	7	33	CLASS 4 (POOR ROCK)	7.50-9.00	Core Rock	1.5
286.52	9.0	10.5		Highly Fractured and Jointed	34	14	33	CLASS 4 (POOR ROCK)	9.00-10.50	Core Rock	2.1
285.018	10.5	12.0	SightlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite (Quartz vein)	Highly Fractured and Jointed	20	0	33	CLASS 4 (POOR ROCK)	10.50-12.00	Core Rock	1.5
283.516	12.0	13.5	HighlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	23	0	33	CLASS 4 (POOR ROCK)	12.00-13.50	Core Rock	1.5
282.014	13.5	15.0		Highly Fractured and Jointed	16	0	33	CLASS 4 (POOR ROCK)	13.50-15.00	Core Rock	1.5

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
280.512	15.0	16.5	SightlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite (Quartz vein)	Highly Fractured and Jointed	16	0	35	CLASS 4 (POOR ROCK)	15.00-16.50	Core Rock	1.5
279.01	16.5	18.0	HighlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	22	0	35	CLASS 4 (POOR ROCK)	16.50-18.00	Core Rock	1.5
277.508	18.0	19.5	HighlyWeathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	41	17	35	CLASS 4 (POOR ROCK)	18.00-19.50	Core Rock	2.55

Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Sample Collected	
276.006	19.5	21.0	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	28	0	35	CLASS 4 (POOR ROCK)	19.50-21.00	Core Rock	1.5
274.504	21.0	22.5	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	26	0	35	CLASS 4 (POOR ROCK)	21.00-22.50	Core Rock	1.5
273.002	22.5	24.0		Highly Fractured and Jointed	36	18	35	CLASS 4 (POOR ROCK)	22.50-24.00	Core Rock	2.7
271.5	24.0	25.5		Highly Fractured and Jointed	27	0	35	CLASS 4 (POOR ROCK)	24.00-25.50	Core Rock	1.5
269.998	25.5	27.0		Highly Fractured and Jointed	36	0	35	CLASS 4 (POOR ROCK)	25.50-27.00	Core Rock	1.5
268.496	27.0	28.5		Highly Fractured and Jointed	33	8	35	CLASS 4 (POOR ROCK)	27.00-28.50	Core Rock	1.5
266.994	28.5	30.0		Highly Fractured and Jointed	20	0	35	CLASS 4 (POOR ROCK)	28.50-30.00	Core Rock	1.5
265.492	30.0	31.5		Highly Fractured and Jointed	23	0	35	CLASS 4 (POOR ROCK)	30.00-31.50	Core Rock	1.5

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Sample Collected	Q VALUE
263.99	31.5	33.0	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Moderately Fractured and Jointed	21	0	35	CLASS 4 (POOR ROCK)	31.50-33.00	Core Rock	1.5
262.488	33.0	34.5		Highly Fractured and Jointed	30	7	35	CLASS 4 (POOR ROCK)	33.00-34.50	Core Rock	1.5
260.986	34.5	36.0		Highly Fractured and Jointed	32	0	35	CLASS 4 (POOR ROCK)	34.50-36.00	Core Rock	1.5
259.484	36.0	37.5		Highly Fractured and Jointed	31	0	35	CLASS 4 (POOR ROCK)	36.00-37.50	Core Rock	1.5
257.982	37.5	39.0		Highly Fractured and Jointed	30	6	35	CLASS 4 (POOR ROCK)	37.50-39.00	Core Rock	1.5
256.48	39.0	40.5		Highly Fractured and Jointed	25	0	38	CLASS 4 (POOR ROCK)	39.00-40.50	Core Rock	1.5
254.978	40.5	42.0		Highly Fractured and Jointed	40	22	38	CLASS 4 (POOR ROCK)	40.50-42.00	Core Rock	3.3
253.476	42.0	43.5		Highly Fractured and Jointed	28	8	38	CLASS 4 (POOR ROCK)	42.00-43.50	Core Rock	1.5
251.974	43.5	45.0		Highly Fractured and Jointed	30	6	35	CLASS 4 (POOR ROCK)	43.50-45.00	Core Rock	1.5

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Sample Collected	Q VALUE
250.472	45.0	46.5	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	26	0	35	CLASS 4 (POOR ROCK)	45.00-46.50	Core Rock	1.5
248.97	46.5	48.0		Highly Fractured and Jointed	38	27	40	CLASS 4 (POOR ROCK)	46.50-48.00	Core Rock	4.05
247.468	48.0	49.5		Highly Fractured and Jointed	29	10	35	CLASS 4 (POOR ROCK)	48.00-49.50	Core Rock	1.5
245.966	49.5	51.0		Highly Fractured and Jointed	22	0	35	CLASS 4 (POOR ROCK)	49.50-51.00	Core Rock	1.5
244.464	51.0	52.5		Highly Fractured and Jointed	26	15	35	CLASS 4 (POOR ROCK)	51.00-52.50	Core Rock	2.25
242.962	52.5	54.0		Highly Fractured and Jointed	20	10	35	CLASS 4 (POOR ROCK)	52.50-54.00	Core Rock	1.5
241.46	54.0	55.5		Highly Fractured and Jointed	26	0	35	CLASS 4 (POOR ROCK)	54.00-55.50	Core Rock	1.5
239.958	55.5	57.0		Highly Fractured and Jointed	20	0	35	CLASS 4 (POOR ROCK)	55.50-57.00	Core Rock	1.5
238.456	57.0	58.5		Highly Fractured and Jointed	25	0	35	CLASS 4 (POOR ROCK)	57.00-58.50	Core Rock	1.5

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Collected	Q VALUE
236.954	58.5	60.0	Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	Highly Fractured and Jointed	34	0	35	CLASS 4 (POOR ROCK)	58.50-60.00	Core Rock	1.5
235.452	60.0	61.5		Highly Fractured and Jointed	28	24	24	CLASS 4 (POOR ROCK)	60.00-61.50		3.6
233.95	61.5	63.0		Highly Fractured and Jointed	20	8	24	CLASS 4 (POOR ROCK)	61.50-63.00		1.5
232.448	63.0	64.5		Highly Fractured and Jointed	32	16	24	CLASS 4 (POOR ROCK)	63.00-64.50		2.4
230.946	64.5	66.0		Highly Fractured and Jointed	31	14	24	CLASS 4 (POOR ROCK)	64.50-66.00		2.1
229.444	66.0	67.5		Highly Fractured and Jointed	27	9	24	CLASS 4 (POOR ROCK)	66.00-67.50		1.5
227.942	67.5	69.0		Highly Fractured and Jointed	28	8	24	CLASS 4 (POOR ROCK)	67.50-69.00		1.5
226.44	69.0	70.0		Highly Fractured and Jointed	57	10	24	CLASS 4 (POOR ROCK)	69.00-70.00		1.5

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**15(A)**	**LONGITUDE**	**77°2'30.032"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25488**	**LATTITUDE**	**28°12'38.555"N**		**TOTAL DEPTH:**	**50.0m**		
START DATE	**15-09-2021**	**GROUND ELEVATION MSL :**	**276.442**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**01-10-2021**	**ANGLE WITH HORIZONT: 90º**			**DEPTH OF WATER TABLE**	**10.0 m**	**CASING**	
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**02-10-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Bh-15(A) Ch. No. 24820 Total Depth 50m

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Type of sample Collected	Q VALUE
276.442	0.0	1.5	Moderately Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	28	0	36	CLASS 3(FAIR ROCK)	0.00-1.50	Core Rock	1.5
274.94	1.5	3.0		Highly Fractured and Jointed	39	10	36	CLASS 3(FAIR ROCK)	1.50-3.00	Core Rock	1.5
273.438	3.0	4.5		Highly Fractured and Jointed	32	21	36	CLASS 3(FAIR ROCK)	3.00-4.50	Core Rock	3.15
271.936	4.5	6.0		Highly Fractured and Jointed	35	0	36	CLASS 3(FAIR ROCK)	4.50-6.00	Core Rock	1.5

Consultant:	**Geotechnical Investigation Report**		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Bh-15(A) Ch. No. 24820 Total Depth 50m											
Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of sample Collected	
270.434	6.0	7.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	45	28	43	CLASS 3(FAIR ROCK)	6.00-7.50	Core Rock	4.2
268.932	7.5	9.0		Highly Fractured and Jointed	21	0	38	CLASS 3(FAIR ROCK)	7.50-9.00	Core Rock	1.5
267.43	9.0	10.5		Highly Fractured and Jointed	50	30	43	CLASS 3(FAIR ROCK)	9.00-10.50	Core Rock	4.5
265.928	10.5	12.0		Highly Fractured and Jointed	35	22	27	CLASS 3(FAIR ROCK)	10.50-12.00	Core Rock	3.3
264.426	12.0	13.5		Highly Fractured and Jointed	32	8	27	CLASS 3(FAIR ROCK)	12.00-13.50	Core Rock	1.5
262.924	13.5	15.0		Highly Fractured and Jointed	47	32	32	CLASS 3(FAIR ROCK)	13.50-15.00	Core Rock	4.8
261.422	15.0	16.5		Highly Fractured and Jointed	28	8	27	CLASS 3(FAIR ROCK)	15.00-16.50	Core Rock	1.5
259.92	16.5	18.0		Highly Fractured and Jointed	41	7	27	CLASS 3(FAIR ROCK)	16.50-18.00	Core Rock	1.5

Bh-15(A) Ch. No. 24820 Total Depth 50m											
Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
258.418	18.0	19.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	36	16	27	CLASS 3(FAIR ROCK)	18.00-19.50	Core Rock	2.4
256.916	19.5	21.0		Highly Fractured and Jointed	45	20	27	CLASS 3(FAIR ROCK)	19.50-21.00	Core Rock	3
255.414	21.0	22.5		Highly Fractured and Jointed	30	15	27	CLASS 3(FAIR ROCK)	21.00-22.50	Core Rock	2.25
253.912	22.5	24.0		Highly Fractured and Jointed	36	0	27	CLASS 3(FAIR ROCK)	22.50-24.00	Core Rock	1.5
252.41	24.0	25.5		Highly Fractured and Jointed	27	0	27	CLASS 3(FAIR ROCK)	24.00-25.50	Core Rock	1.5
250.908	25.5	27.0		Highly Fractured and Jointed	40	15	27	CLASS 3(FAIR ROCK)	25.50-27.00	Core Rock	2.25
249.406	27.0	28.5		Highly Fractured and Jointed	32	23	27	CLASS 3(FAIR ROCK)	27.00-28.50	Core Rock	3.45
247.904	28.5	30.0		Highly Fractured and Jointed	34	0	27	CLASS 3(FAIR ROCK)	28.50-30.00	Core Rock	1.5

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Bh-15(A) Ch. No. 24820 Total Depth 50m											
Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
246.402	30.0	31.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	34	22	27	CLASS 3(FAIR ROCK)	30.00-31.50	Core Rock	3.3
244.9	31.5	33.0		Highly Fractured and Jointed	30	15	27	CLASS 3(FAIR ROCK)	31.50-33.00	Core Rock	2.25
243.398	33.0	34.5		Highly Fractured and Jointed	30	8	27	CLASS 3(FAIR ROCK)	33.00-34.50	Core Rock	1.5
241.896	34.5	36.0		Highly Fractured and Jointed	36	0	27	CLASS 3(FAIR ROCK)	34.50-36.00	Core Rock	1.5
240.394	36.0	37.5		Highly Fractured and Jointed	37	23	27	CLASS 3(FAIR ROCK)	36.00-37.50	Core Rock	3.45
238.892	37.5	39.0		Highly Fractured and Jointed	40	7	27	CLASS 3(FAIR ROCK)	37.50-39.00	Core Rock	1.5
237.39	39.0	40.5		Highly Fractured and Jointed	50	10	27	CLASS 3(FAIR ROCK)	39.00-40.50	Core Rock	1.5
235.888	40.5	42.0		Highly Fractured and Jointed	34	0	27	CLASS 3(FAIR ROCK)	40.50-42.00	Core Rock	1.5

Bh-15(A) Ch. No. 24820 Total Depth 50m

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Type of Sample Collected	Q VALUE
234.386	42.0	43.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	Highly Fractured and Jointed	32	8	27	CLASS 3(FAIR ROCK)	42.00-43.50	Core Rock	1.5
232.884	43.5	45.0		Highly Fractured and Jointed	35	0	27	CLASS 3(FAIR ROCK)	43.50-45.00	Core Rock	1.5
231.382	45.0	46.5		Highly Fractured and Jointed	30	0	27	CLASS 3(FAIR ROCK)	45.00-46.50	Core Rock	1.5
229.88	46.5	48.0		Highly Fractured and Jointed	36	7	27	CLASS 3(FAIR ROCK)	46.50-48.00	Core Rock	1.5
228.378	48.0	49.5		Highly Fractured and Jointed	40	8	27	CLASS 3(FAIR ROCK)	48.00-49.50	Core Rock	1.5
226.876	49.5	50.0		Highly Fractured and Jointed	40	0	27	CLASS 3(FAIR ROCK)	49.50-50.00	Core Rock	1.5

nments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**16**	**LONGITUDE**	**77°2'27.239"E**		**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25586**	**LATTITUDE**	**28°12'40.66"N**		**TOTAL DEPTH:**	**62m**		
START DATE	**26-08-2021**	**GROUND ELEVATION MSL :**	**287.324**		**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**10-09-2021**	**ANGLE WITH HORIZONT: 90º**			**DEPTH OF WATER TABLE**	**50.0m**	**CASING**	**NX up to 3.0 m**
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**			**WATER TABLE RECORD DATE**	**11-09-2021**		
					NAME OF GEOLOGIST	**Gaurav Chunekar**		

Bh-16 ;Total Depth 62m

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Type of Sample Collected	Q VALUE
287.324	0.0	1.5	Moderately Weathered, , Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite (DS and DS Wash Collected)	Highly Fractured and Jointed	16	0	33	CLASS 3(FAIR ROCK)	0.00-1.50	Core Rock	1.5
285.82	1.5	3.0	Moderately Weathered, , Grey , Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	25	0	33	CLASS 3(FAIR ROCK)	1.50-3.00	Core Rock	1.5
284.316	3.0	4.5		Highly Fractured and Jointed	32	0	33	CLASS 3(FAIR ROCK)	3.00-4.50	Core Rock	1.5
282.812	4.5	6.0		Highly Fractured and Jointed	32	0	33	CLASS 3(FAIR ROCK)	4.50-6.00	Core Rock	1.5

Bh-16 ;Total Depth 62m											
Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
281.308	6.0	7.5	Moderately Weathered, , Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	30	0	33	CLASS 3(FAIR ROCK)	6.00-7.50	Core Rock	1.5
279.804	7.5	9.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	31	10	35	CLASS 3(FAIR ROCK)	7.50-9.00	Core Rock	1.5
278.3	9.0	10.5		Highly Fractured and Jointed	30	0	35	CLASS 3(FAIR ROCK)	9.00-10.50	Core Rock	1.5
276.796	10.5	12.0		Highly Fractured and Jointed	34	0	35	CLASS 3(FAIR ROCK)	10.50-12.00	Core Rock	1.5
275.292	12.0	13.5		Highly Fractured and Jointed	31	15	38	CLASS 3(FAIR ROCK)	12.00-13.50	Core Rock	2.2995
273.788	13.5	15.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	27	10	38	CLASS 3(FAIR ROCK)	13.50-15.00	Core Rock	1.5
272.284	15.0	16.5		Highly Fractured and Jointed	36	19	38	CLASS 3(FAIR ROCK)	15.00-16.50	Core Rock	2.85
270.78	16.5	18.0		Highly Fractured and Jointed	28	15	38	CLASS 3(FAIR ROCK)	16.50-18.00	Core Rock	2.295

Bh-16 ;Total Depth 62m											
Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
269.276	18.0	19.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	46	36	43	CLASS 3(FAIR ROCK)	18.00-19.50	Core Rock	5.445
267.772	19.5	21.0		Highly Fractured and Jointed	48	0	38	CLASS 3(FAIR ROCK)	19.50-21.00	Core Rock	1.5
266.268	21.0	22.5		Highly Fractured and Jointed	44	14	38	CLASS 3(FAIR ROCK)	21.00-22.50	Core Rock	2.1
264.764	22.5	24.0		Highly Fractured and Jointed	43	11	38	CLASS 3(FAIR ROCK)	22.50-24.00	Core Rock	1.65
263.26	24.0	25.5		Highly Fractured and Jointed	42	28	43	CLASS 3(FAIR ROCK)	24.00-25.50	Core Rock	4.2
261.756	25.5	27.0		Highly Fractured and Jointed	34	15	38	CLASS 3(FAIR ROCK)	25.50-27.00	Core Rock	2.25
260.252	27.0	28.5		Highly Fractured and Jointed	53	47	43	CLASS 3(FAIR ROCK)	27.00-28.50	Core Rock	7.05
258.748	28.5	30.0		Highly Fractured and Jointed	31	8	38	CLASS 3(FAIR ROCK)	28.50-30.00	Core Rock	1.5

Bh-16 ;Total Depth 62m

Elevation (m)	Depth (m) Top	Depth (m) Bottom	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR Rating	RMR Class	Samples Depth of sample (m)	Samples Type of Sample Collected	Q VALUE
257.244	30.0	31.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	39	34	43	CLASS 3(FAIR ROCK)	30.00-31.50	Core Rock	5.1
255.74	31.5	33.0		Highly Fractured and Jointed	30	14	38	CLASS 3(FAIR ROCK)	31.50-33.00	Core Rock	2.1
254.236	33.0	34.5		Highly Fractured and Jointed	36	25	43	CLASS 3(FAIR ROCK)	33.00-34.50	Core Rock	3.75
252.732	34.5	36.0		Highly Fractured and Jointed	30	22	38	CLASS 3(FAIR ROCK)	34.50-36.00	Core Rock	3.3
251.228	36.0	37.5		Highly Fractured and Jointed	37	22	38	CLASS 3(FAIR ROCK)	36.00-37.50	Core Rock	3.3
249.724	37.5	39.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	30	8	38	CLASS 3(FAIR ROCK)	37.50-39.00	Core Rock	1.5
248.22	39.0	40.5		Highly Fractured and Jointed	34	20	38	CLASS 3(FAIR ROCK)	39.00-40.50	Core Rock	3
246.716	40.5	42.0	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	36	0	38	CLASS 3(FAIR ROCK)	40.50-42.00	Core Rock	1.5

Bh-16 ;Total Depth 62m											
Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
245.212	42.0	43.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	42	17	38	CLASS 3(FAIR ROCK)	42.00-43.50	Core Rock	2.49
243.708	43.5	45.0		Highly Fractured and Jointed	44	44	43	CLASS 3(FAIR ROCK)	43.50-45.00	Core Rock	6.6
242.204	45.0	46.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	37	0	38	CLASS 3(FAIR ROCK)	45.00-46.50	Core Rock	1.5
240.7	46.5	48.0	Slightly Weathered, , Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	53	51	48	CLASS 3(FAIR ROCK)	46.50-48.00	Core Rock	7.695
239.196	48.0	49.5		Highly Fractured and Jointed	45	15	38	CLASS 3(FAIR ROCK)	48.00-49.50	Core Rock	2.295
237.692	49.5	51.0		Highly Fractured and Jointed	38	27	43	CLASS 3(FAIR ROCK)	49.50-51.00	Core Rock	3.99
236.188	51.0	52.5	Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very	Highly Fractured and Jointed	40	29	43	CLASS 3(FAIR ROCK)	51.00-52.50		4.395

Bh-16 ;Total Depth 62m											
Elevation (m)	Depth (m)		Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples		Q VALUE
	Top	Bottom					Rating	Class	Depth of sample (m)	Type of Sample Collected	
234.684	52.5	54.0	Hard, Quartzite (Weathered Medium Grained Garnet Grains, Contact of Phyllite Band Noticed)	Highly Fractured and Jointed	43	16	38	CLASS 3(FAIR ROCK)	52.50-54.00		2.445
233.18	54.0	55.5	Slightly Weathered, , Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Highly Fractured and Jointed	43	21	38	CLASS 3(FAIR ROCK)	54.00-55.50		3.15
231.676	55.5	57.0		Highly Fractured and Jointed	31	8	38	CLASS 3(FAIR ROCK)	55.50-57.00		1.5
230.172	57.0	58.5		Highly Fractured and Jointed	30	18	30	CLASS 3(FAIR ROCK)	57.00-58.50		2.64
228.668	58.5	60.0		Highly Fractured and Jointed	25	20	30	CLASS 3(FAIR ROCK)	58.50-60.00		3
227.164	60.0	61.5		Highly Fractured and Jointed	32	24	30	CLASS 3(FAIR ROCK)	60.00-61.50		3.645
225.66	61.5	62.0		Highly Fractured and Jointed	66	9	30	CLASS 3(FAIR ROCK)	61.50-62.00		1.5

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Project: Exploring alternate alignments, final location survey, geological mapping, geo-technical investigation, detail design of tunnel & its approaches including Viaduct if any and other ancillary work in Sohna-Manesar Section of HORC project.

BORE HOLE ID :	**BH 17**	**LONGITUDE**	**77°2'30.032"E**	**LOCATION:**	**Sohna**	**STRUCTURE**	**Tunnel**
CHAINAGE (Km)	**25785**	**LATTITUDE**	**28°12'38.555"N**	**TOTAL DEPTH:**	**50.0m**		
START DATE	**15-09-2021**	**GROUND ELEVATION MSL :**	**276.442**	**TYPE OF CORE BARREL:**	**Double Tube Core Barrel**	**TYPE OF BIT**	**Diamond Bit**
COMPLETED DATE	**01-10-2021**	**ANGLE WITH HORIZONT: 90º**		**DEPTH OF WATER TABLE**	**10.0 m**	**CASING**	
BORING TYPE&SIZE:		**DRILLING AGENCY S.M Consultants**		**WATER TABLE RECORD DATE**	**02-10-2021**		
				NAME OF GEOLOGIST	**Gaurav Chunekar**		

Bh-17 ;Total Depth 75m

Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
282.46	0			0	0	NA	NA		0
280.961	1.5	Brown colour, very fine to fine grained, clayey silt deposit	very fine to fine grained, clayey silt deposit	0	0	NA	NA		0
279.461	3	Brown colour, very fine to fine grained, clayey silt deposit	very fine to fine grained, clayey silt deposit	0	0	NA	NA		0
277.96	4.5			0	0	NA	NA		0
276.46	6			0	0	NA	NA		0
274.96	9			0	0	NA	NA		0
273.461	12	Brown colour, very fine to fine grained, clayey silt with gravels..	very fine to fine grained, clayey silt with gravels..	0	0	NA	NA		0

Bh-17 ;Total Depth 75m									
Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
271.96	15			0	0	NA	NA		0
270.46	16.5			0	0	NA	NA		0
268.961	18	Brown colour, very fine to fine grained, sub angular to sub rounded pebbels with clayey silt.	It shows very fine to fine grained, sub angular to sub rounded pebbels clayey silt.	0	0	NA	NA		0
267.461	19.5	Highly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Hard Quartzite.	Joints of 0°,45°	17	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
265.961	20.5		Closed Joint of 10°	22	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
264.461	22		It shows highly fractured weathered rock	25	11.6	47	CLASS 3(FAIR ROCK)	Core Rock	0
262.961	23			32	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
261.461	24.5			33	0	40	CLASS 4 (POOR ROCK)	Core Rock	0

Consultant:	**Geotechnical Investigation Report**		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Bh-17 ;Total Depth 75m									
Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
259.961	25	Moderately Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite.	Joints of 0°,10°,15°	48	25	47	CLASS 3(FAIR ROCK)	Core Rock	1
258.461	26		Joints of 0°, 15°,80°	59	32.6	43	CLASS 3(FAIR ROCK)	Core Rock	1
256.961	27.5		Joints of 0°,10°,15°,20°	44	12.66	40	CLASS 4 (POOR ROCK)	Core Rock	0
255.461	28			68	25.8	43	CLASS 3(FAIR ROCK)	Core Rock	1
253.961	29.5	Highly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Hard Quartzite.	It shows highly fractured weathered rock	58	7.6	40	CLASS 4 (POOR ROCK)	Core Rock	0
252.461	30	Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	Joints of 0°,10°,15°, 70°	70	0	47	CLASS 3(FAIR ROCK)	Core Rock	0
250.961	31		It shows highly angular fractured and jointed, weak strength	47	17.13	40	CLASS 4 (POOR ROCK)	Core Rock	0

Bh-17 ;Total Depth 75m									
Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
249.461	32.5			64	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
247.961	33.5	Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite		54	15.53	40	CLASS 4 (POOR ROCK)		0
246.461	35	Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite.(crushed zone)		34.66	0	40	CLASS 4 (POOR ROCK)		0
244.961	36.5	Light Brown colour, Coarse grained, Sand. (SPT Rebounded)	Coarse grained, Sand. (SPT Rebounded)	0	0	0	CLASS 5 (VERY POOR ROCK)		0
243.461	38			0	0	0	CLASS 5 (VERY POOR ROCK)	Core Rock	0
241.961	39.5			0	0	0	CLASS 5 (VERY POOR ROCK)	Core Rock	0

Bh-17 ;Total Depth 75m

Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
240.461	41	Moderatey to Slightly Weathered, Moderately to Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite		32	11	47	CLASS 3(FAIR ROCK)	Core Rock	0
238.961	42.5			41.33	19.33	40	CLASS 4 (POOR ROCK)	Core Rock	0
237.461	44			54	41.53	43	CLASS 3(FAIR ROCK)	Core Rock	1
235.961	45.5			30	16.66	47	CLASS 3(FAIR ROCK)	Core Rock	0
234.461	47			37.33	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
232.961	48.5			41.33	21.06	47	CLASS 3(FAIR ROCK)	Core Rock	0
231.461	50			30	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
229.961	51.5			36.66	0	40	CLASS 4 (POOR ROCK)	Core Rock	0
228.461	53			34.66	12	40	CLASS 4 (POOR ROCK)	Core Rock	0
226.961	54.5			33.33	6.8	47	CLASS 3(FAIR ROCK)	Core Rock	0

Bh-17 ;Total Depth 75m									
Elevation (m)	Depth (m)	Lithology	Structural conditions	% of Core-Recovery	% RQD	RMR		Samples	Q VALUE
						Rating	Class	Type of Sample Collected	
225.461	56			28	6.73	32	CLASS 4 (POOR ROCK)	Core Rock	0
223.961	58			38	8	32	CLASS 4 (POOR ROCK)	Core Rock	0
222.461	59.5			38.33	0	39	CLASS 4 (POOR ROCK)	Core Rock	0
220.961	61			40.6	27.66	35	CLASS 4 (POOR ROCK)	Core Rock	1

ANNEXURE –B
Tensile Strength

Tensile Strength

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
1	BH-13	0.50	1.50	14.21
2		1.50	3.00	
3		3.00	4.50	
4		4.50	6.00	
5		6.00	7.50	
6		7.50	9.00	
7		9.00	10.50	
8		10.50	12.00	14.12
9		15.00	16.50	
10		16.50	18.00	
11		18.00	19.50	
12		19.50	21.00	14.34
13		21.00	22.50	
14		22.50	24.00	
15		24.00	25.50	13.34
16		25.50	27.00	
17		27.00	28.50	
18		28.50	30.00	20.71
19		30.00	31.50	
20		31.50	33.00	
21		33.00	34.50	
22		34.50	36.00	22.99
23		36.00	37.50	
24		37.50	39.00	
25		39.00	40.50	
26		40.50	42.00	21.08
27		42.00	43.50	
28		43.50	45.00	
29		45.00	46.50	
30		46.50	48.00	
31		48.00	49.50	
32		49.50	51.00	
33		51.00	52.50	

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
34		52.50	54.00	
35		54.00	55.50	
36		55.50	57.00	
37		57.00	58.50	16
38		58.50	60.00	
			Min.	13.34
			Max.	22.99
			Avg.	17.10
39	BH-14	1.50	3.00	
40		3.00	4.50	15.77
41		4.50	6.00	
42		6.00	7.50	
43		7.50	9.00	
44		9.00	10.50	
45		10.50	12.00	
46		12.00	13.50	17.78
47		15.00	16.50	
48		16.50	18.00	
49		18.00	19.50	
50		19.50	21.00	15.72
51		21.00	22.50	
52		22.50	24.00	
53		24.00	25.50	
54		25.50	27.00	
55		27.00	28.50	
56		28.50	30.00	
57		30.00	31.50	
58		31.50	33.00	21.25
59		33.00	34.50	
60		34.50	36.00	
61		36.00	37.50	
62		37.50	39.00	
63		39.00	40.50	19.31
64		40.50	42.00	
65		42.00	43.50	
66		43.50	45.00	
67		45.00	46.50	24.93

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
68		46.50	48.00	
69		48.00	49.50	
70		49.50	51.00	
71		51.00	52.50	
72		52.50	54.00	
73		54.00	55.50	
74		57.00	58.50	18.27
75		58.50	60.00	
76		60.00	61.50	
77		63.00	64.50	19.68
78		64.50	66.00	
79		66.00	67.50	
80		67.50	69.00	
81		69.00	70.50	14.78
82		70.50	72.00	
83		72.00	73.50	16.94
	Min.			14.78
	Max.			24.93
	Avg.			18.44
84	BH-15	0.00	1.50	
85		1.50	3.00	
86		3.00	4.50	16.36
87		4.50	6.00	
88		6.00	7.50	
89		7.50	9.00	
90		9.00	10.50	
91		10.50	12.00	
92		12.00	13.50	
93		15.00	16.50	
94		16.50	18.00	
95		18.00	19.50	14.89
96		19.50	21.00	
97		21.00	22.50	
98		22.50	24.00	
99		24.00	25.50	
100		25.50	27.00	
101		27.00	28.50	18.2

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
102		28.50	30.00	
103		30.00	31.50	
104		31.50	33.00	17.81
105		33.00	34.50	
106		34.50	36.00	
107		36.00	37.50	16.03
108		37.50	39.00	
109		39.00	40.50	
110		40.50	42.00	
111		42.00	43.50	
112		43.50	45.00	
113		45.00	46.50	
114		46.50	48.00	
115		48.00	49.50	
116		49.50	51.00	
117		51.00	52.50	
118		52.50	54.00	14.66
119		54.00	55.50	
120		57.00	58.50	
121		58.50	60.00	14.94
122		60.00	61.50	
123		61.50	63.00	
124		64.50	66.00	16.49
125		66.00	67.50	
126		67.50	69.00	19.2
127		69.00	70.00	
	Min.			14.66
	Max.			19.2
	Avg.			16.51
128	BH-15A	0.00	1.50	
129		1.50	3.00	
130		3.00	4.50	
131		4.50	6.00	16.47
132		6.00	7.50	

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
133		7.50	9.00	
138		9.00	10.50	
139		10.50	12.00	
140		12.00	13.50	
141		13.50	15.00	
142		15.00	16.50	15.89
143		16.50	18.00	
144		18.00	19.50	
145		19.50	21.00	
146		21.00	22.50	14.91
147		22.50	24.00	
148		25.50	27.00	
149		27.00	28.50	
150		28.50	30.00	15.97
151		30.00	31.50	
152		31.50	33.00	
153		33.00	34.50	
154		34.50	36.00	18.78
155		36.00	37.50	

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
156		37.50	39.00	
157		39.00	40.50	
158		40.50	42.00	17.21
159		42.00	43.50	
160		43.50	45.00	
161		46.50	48.00	
162		48.00	49.50	
163		49.50	51.00	17.64
	Min.			14.91
	Max.			18.78
	Avg.			16.70
164	BH-16	0.00	1.50	
165		1.50	3.00	
166		3.00	4.50	
167		4.50	6.00	15.72
168		4.50	6.00	
169		7.50	9.00	
170		9.00	10.50	15.39
171		10.50	12.00	
172		12.00	13.50	
173		13.50	15.00	
174		18.00	19.50	25.83
175		19.50	21.00	
176		21.00	22.50	26.24
177		22.50	24.00	
178		24.00	25.50	
179		25.50	27.00	
180		27.00	28.50	
181		28.50	30.00	16.65
182		30.00	31.50	
183		31.50	33.00	

Sr.No.	BH NO.	Depth		Tensile Strength Test
		From	To	(MPa)
184		33.00	34.50	19.89
185		33.00	34.50	
186		36.00	37.50	23.96
187		37.50	39.00	
188		39.00	40.50	
189		40.50	42.00	23.86
190		42.00	43.50	
191		45.00	46.50	
192		46.50	48.00	
193		48.00	49.50	
194		49.50	51.00	27.77
195		52.50	54.00	22.76
196		54.00	55.50	
197		55.50	57.00	20.25
198		58.50	60.00	
199		60.00	61.50	
200		61.50	62.00	
	Min.			15.39
	Max.			27.77
	Avg.			21.67

BH 17		
Depth	Sample Number	Tensile Strength Test
		(Mpa)
19.50	BH17/1221/R/01	
20.50	BH17/1221/R/03	
22.00	BH17/1221/R/05	
23.00	BH17/1221/R/06	26.58
24.50	BH17/1221/R/07	

BH 17		
Depth	**Sample Number**	**Tensile Strength Test**
	BH17/1221/R/08	
25.00	BH17/0122/R/09	
	BH17/0122/R/10	
26.00	BH17/0122/R/11	22.64
	BH17/0122/R/12	
	BH17/0122/R/13	
27.50	BH17/0122/R/14	
	BH17/0122/R/15	
	BH17/0122/R/16	
	BH17/0122/R/17	15.21
28.00	BH17/0122/R/18	
	BH17/0122/R/19	
	BH17/0122/R/20	
29.50	BH17/0122/R/21	8.77
	BH17/0122/R/22	
	BH17/0122/R/23	
30.00	BH17/0122/R/24	
	BH17/0122/R/25	
31.50	BH17/0122/R/26	
	BH17/0122/R/27	
	BH17/0122/R/28	
	BH17/0122/R/29	22.57
32.50	BH17/0122/R/30	
	BH17/0122/R/31	
33.50	BH17/0122/R/32	
	BH17/0122/R/33	

BH 17		
Depth	**Sample Number**	**Tensile Strength Test**
	BH17/0122/R/34	
	BH17/0122/R/35	
35.00	BH17/0122/R/37	
	BH17/0122/R/38	
41.00	BH17/0122/R/40	
	BH17/0122/R/41	
42.50	BH17/0122/R/42	
	BH17/0122/R/43	
44.00	BH17/0122/R/44	
	BH17/0122/R/45	
	BH17/0122/R/46	
	BH17/0122/R/47	
45.50	BH17/1221/R/48	
	BH17/1221/R/49	
	BH17/1221/R/50	
	BH17/1221/R/51	
47.00	BH17/1221/R/52	
	BH17/1221/R/53	
48.50	BH17/1221/R/54	
	BH17/1221/R/55	
	BH17/1221/R/56	
	BH17/1221/R/57	
50.00	BH17/1221/R/58	
	BH17/1221/R/59	
	BH17/1221/R/60	
	BH17/1221/R/61	

BH 17		
Depth	**Sample Number**	**Tensile Strength Test**
	BH17/1221/R/65	15.46
53.00	BH17/1221/R/69	18.01
54.50	BH17/1221/R/74	
	BH17/1221/R/75	
	BH17/1221/R/76	19.83
	BH17/1221/R/77	
56.00	BH17/1221/R/78	
	BH17/1221/R/79	19.09
58.00	BH17/1221/R/80	
	BH17/1221/R/81	15.07
59.50	BH17/1221/R/82	
62.00	BH17/1221/R/87	
	BH17/1221/R/88	
	BH17/1221/R/89	15.1
	BH17/1221/R/90	
	BH17/1221/R/91	
	BH17/1221/R/92	
	Min.	**8.77**
	Max.	**26.58**
	Average.	**18.03**

ANNEXURE –C
Unconfined Compressive strength

Unconfined Compressive Strength

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
1	BH-13	0.50	1.50	
2		1.50	3.00	41.06
3		3.00	4.50	
4		4.50	6.00	
5		6.00	7.50	
6		7.50	9.00	
7		9.00	10.50	
8		10.50	12.00	61.6
9		15.00	16.50	
10		16.50	18.00	
11		18.00	19.50	67.07
12		19.50	21.00	
13		21.00	22.50	
14		22.50	24.00	
15		24.00	25.50	
16		25.50	27.00	67.01
17		27.00	28.50	
18		28.50	30.00	
19		30.00	31.50	
20		31.50	33.00	
21		33.00	34.50	64.01
22		34.50	36.00	
23		36.00	37.50	
24		37.50	39.00	
25		39.00	40.50	65.17
26		40.50	42.00	
27		42.00	43.50	
28		43.50	45.00	64.79
29		45.00	46.50	
30		46.50	48.00	64.94
31		48.00	49.50	
32		49.50	51.00	63.23
33		51.00	52.50	

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
34		52.50	54.00	64.29
35		54.00	55.50	
36		55.50	57.00	68.34
37		57.00	58.50	
38		58.50	60.00	70.33
			Min.	41.06
			Max.	70.33
			Avg.	63.49
39	BH-14	1.50	3.00	
40		3.00	4.50	
41		4.50	6.00	49.1
42		6.00	7.50	
43		7.50	9.00	
44		9.00	10.50	
45		10.50	12.00	69.54
46		12.00	13.50	
47		15.00	16.50	
48		16.50	18.00	68.69
49		18.00	19.50	
50		19.50	21.00	
51		21.00	22.50	
52		22.50	24.00	
53		24.00	25.50	
54		25.50	27.00	66.51
55		27.00	28.50	
56		28.50	30.00	
57		30.00	31.50	65.1
58		31.50	33.00	
59		33.00	34.50	
60		34.50	36.00	
61		36.00	37.50	53.54
62		37.50	39.00	
63		39.00	40.50	
64		40.50	42.00	
65		42.00	43.50	
66		43.50	45.00	49.01
67		45.00	46.50	

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
68		46.50	48.00	55.52
69		48.00	49.50	
70		49.50	51.00	
71		51.00	52.50	59.06
72		52.50	54.00	
73		54.00	55.50	
74		57.00	58.50	45.15
75		58.50	60.00	
76		60.00	61.50	60.66
77		63.00	64.50	
78		64.50	66.00	
79		66.00	67.50	
80		67.50	69.00	45.15
81		69.00	70.50	
82		70.50	72.00	47.33
83		72.00	73.50	
	Min.			45.15
	Max.			69.54
	Avg.			56.49
84		0.00	1.50	
85		1.50	3.00	69.58
86		3.00	4.50	
87		4.50	6.00	
88	BH-15	6.00	7.50	
89		7.50	9.00	67.04
90		9.00	10.50	
91		10.50	12.00	
92		12.00	13.50	
93		15.00	16.50	
94		16.50	18.00	68.52
95		18.00	19.50	
96		19.50	21.00	
97		21.00	22.50	
98		22.50	24.00	66.01
99		24.00	25.50	
100		25.50	27.00	
101		27.00	28.50	68.94

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
102		28.50	30.00	
103		30.00	31.50	
104		31.50	33.00	
105		33.00	34.50	68.84
106		34.50	36.00	
107		36.00	37.50	
108		37.50	39.00	
109		39.00	40.50	
110		40.50	42.00	
111		42.00	43.50	
112		43.50	45.00	70.44
113		45.00	46.50	
114		46.50	48.00	69.4
115		48.00	49.50	
116		49.50	51.00	62.21
117		51.00	52.50	
118		52.50	54.00	61.45
119		54.00	55.50	
120		57.00	58.50	64.29
121		58.50	60.00	
122		60.00	61.50	
123		61.50	63.00	68.63
124		64.50	66.00	
125		66.00	67.50	68.41
126		67.50	69.00	
127		69.00	70.00	64.97
	Min.			61.45
	Max.			70.44
	Avg.			67.05
128	BH-15A	0.00	1.50	
129		1.50	3.00	69.38
130		3.00	4.50	
131		4.50	6.00	
132		6.00	7.50	

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
				66
133		7.50	9.00	
138		9.00	10.50	
139		10.50	12.00	
140		12.00	13.50	
				62.28
141		13.50	15.00	
142		15.00	16.50	
143		16.50	18.00	
144		18.00	19.50	
145		19.50	21.00	
146		21.00	22.50	
				63.06
147		22.50	24.00	
148		25.50	27.00	
149		27.00	28.50	
				64.78
150		28.50	30.00	
151		30.00	31.50	
152		31.50	33.00	65.17
				67.2
153		33.00	34.50	

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
154		34.50	36.00	
155		36.00	37.50	69.38
156		37.50	39.00	
157		39.00	40.50	63.64
158		40.50	42.00	
159		42.00	43.50	60.42
160		43.50	45.00	
161		46.50	48.00	
162		48.00	49.50	65.05
163		49.50	51.00	
	Min.			60.42
	Max.			69.38
	Avg.			65.12
164	BH-16	0.00	1.50	66
165		1.50	3.00	
166		3.00	4.50	
167		4.50	6.00	
168		4.50	6.00	
169		7.50	9.00	52.79
170		9.00	10.50	
171		10.50	12.00	
172		12.00	13.50	
173		13.50	15.00	
174		18.00	19.50	70.8
175		19.50	21.00	
176		21.00	22.50	
177		22.50	24.00	44.8
178		24.00	25.50	
179		25.50	27.00	
180		27.00	28.50	

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		UCS Test
		From	To	(MPa)
181		28.50	30.00	
182		30.00	31.50	70.27
183		31.50	33.00	
184		33.00	34.50	
185		33.00	34.50	
186		36.00	37.50	
187		37.50	39.00	70.23
188		39.00	40.50	
189		40.50	42.00	
190		42.00	43.50	52.49
191		45.00	46.50	
192		46.50	48.00	70.08
193		48.00	49.50	
194		49.50	51.00	69.57
195		52.50	54.00	
196		54.00	55.50	
197		55.50	57.00	70.16
198		58.50	60.00	
199		60.00	61.50	68.55
200		61.50	62.00	
	Min.			44.8
	Max.			70.8
	Avg.			64.16

BH 17		
Depth	**Sample Number**	**UCS (Mpa)**
19.50	BH17/1221/R/01	
20.50	BH17/1221/R/03	
22.00	BH17/1221/R/05	70.68
23.00	BH17/1221/R/06	
24.50	BH17/1221/R/07	
	BH17/1221/R/08	
25.00	BH17/0122/R/09	69.63
	BH17/0122/R/10	
26.00	BH17/0122/R/11	
	BH17/0122/R/12	
	BH17/0122/R/13	
27.50	BH17/0122/R/14	
	BH17/0122/R/15	
	BH17/0122/R/16	
	BH17/0122/R/17	
28.00	BH17/0122/R/18	69.31
	BH17/0122/R/19	
	BH17/0122/R/20	
29.50	BH17/0122/R/21	
	BH17/0122/R/22	
	BH17/0122/R/23	
30.00	BH17/0122/R/24	
	BH17/0122/R/25	
31.50	BH17/0122/R/26	
	BH17/0122/R/27	66.51
	BH17/0122/R/28	
	BH17/0122/R/29	
32.50	BH17/0122/R/30	
	BH17/0122/R/31	
33.50	BH17/0122/R/32	
	BH17/0122/R/33	
	BH17/0122/R/34	
	BH17/0122/R/35	
	BH17/0122/R/36	67.94
35.00	BH17/0122/R/37	
	BH17/0122/R/38	

BH 17		
Depth	**Sample Number**	**UCS (Mpa)**
41.00	BH17/0122/R/40	
	BH17/0122/R/41	68.41
42.50	BH17/0122/R/42	
	BH17/0122/R/43	
44.00	BH17/0122/R/44	
	BH17/0122/R/45	
	BH17/0122/R/46	
	BH17/0122/R/47	
45.50	BH17/1221/R/49	67.23
47.00	BH17/1221/R/52	
	BH17/1221/R/53	
48.50	BH17/1221/R/54	
	BH17/1221/R/55	
	BH17/1221/R/56	
	BH17/1221/R/57	63.34
50.00	BH17/1221/R/58	
51.50	BH17/1221/R/62	
	BH17/1221/R/63	
	BH17/1221/R/64	
	BH17/1221/R/65	
	BH17/1221/R/66	61.24
	BH17/1221/R/67	
53.00	BH17/1221/R/69	
	BH17/1221/R/70	
	BH17/1221/R/71	
	BH17/1221/R/72	
	BH17/1221/R/73	
54.50	BH17/1221/R/74	
	BH17/1221/R/75	70.85
	BH17/1221/R/76	
	BH17/1221/R/77	
56.00	BH17/1221/R/78	
	BH17/1221/R/79	
58.00	BH17/1221/R/80	68.97
	BH17/1221/R/81	
59.50	BH17/1221/R/82	
62.00	BH17/1221/R/87	69.04
	BH17/1221/R/88	

BH 17		
Depth	**Sample Number**	**UCS (Mpa)**
	BH17/1221/R/89	
	BH17/1221/R/90	
	BH17/1221/R/91	
	BH17/1221/R/92	
Min.		**61.24**
Max.		**70.85**
Average.		**67.76**

ANNEXURE –D
Specific Gravity, Water absorption, Density

Specific Gravity, Water absorption, Density

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
1	BH-13	0.50	1.50	24.31	2.47	0.4
2		1.50	3.00			
3		3.00	4.50			
4		4.50	6.00			
5		6.00	7.50	25.15	2.55	0.45
6		7.50	9.00			
7		9.00	10.50			
8		10.50	12.00			
9		15.00	16.50	25.26	2.57	0.32
10		16.50	18.00			
11		18.00	19.50			
12		19.50	21.00			
13		21.00	22.50	25.65	2.6	0.44
14		22.50	24.00			
15		24.00	25.50			
16		25.50	27.00			
17		27.00	28.50			
18		28.50	30.00	25.08	2.55	0.4
19		30.00	31.50			
20		31.50	33.00			
21		33.00	34.50			
22		34.50	36.00	25.35	2.58	0.14
23		36.00	37.50			
24		37.50	39.00	25.47	2.58	0.47
25		39.00	40.50			
26		40.50	42.00	25.23	2.56	0.3
27		42.00	43.50			
28		43.50	45.00	25.47	2.58	0.47
29		45.00	46.50			
30		46.50	48.00	25.73	2.61	0.39
31		48.00	49.50			
32		49.50	51.00	25.43	2.58	0.38
33		51.00	52.50			
34		52.50	54.00			

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
35		54.00	55.50	25.64	2.6	0.51
36		55.50	57.00			
37		57.00	58.50			
38		58.50	60.00			
			Min.	24.31	2.47	0.14
			Max.	25.73	2.61	0.51
			Avg.	25.31	2.57	0.39
39	BH-14	1.50	3.00			
40		3.00	4.50			
41		4.50	6.00			
42		6.00	7.50	25.67	2.61	0.41
43		7.50	9.00			
44		9.00	10.50			
45		10.50	12.00			
46		12.00	13.50	25.8	2.63	0.16
47		15.00	16.50			
48		16.50	18.00			
49		18.00	19.50	25.83	2.62	0.35
50		19.50	21.00			
51		21.00	22.50			
52		22.50	24.00	25.78	2.62	0.3
53		24.00	25.50			
54		25.50	27.00			
55		27.00	28.50			
56		28.50	30.00			
57		30.00	31.50			
58		31.50	33.00			
59		33.00	34.50	26.09	2.65	0.43
60		34.50	36.00			
61		36.00	37.50			
62		37.50	39.00	25.99	2.65	0.15
63		39.00	40.50			
64		40.50	42.00			
65		42.00	43.50	25.92	2.63	0.41
66		43.50	45.00			
67		45.00	46.50			
68		46.50	48.00			

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
69		48.00	49.50			
70		49.50	51.00	25.82	2.62	0.57
71		51.00	52.50			
72		52.50	54.00			
73		54.00	55.50			
74		57.00	58.50	25.96	2.64	0.23
75		58.50	60.00			
76		60.00	61.50			
77		63.00	64.50			
78		64.50	66.00	25.94	2.64	0.28
79		66.00	67.50			
80		67.50	69.00	25.82	2.63	0.23
81		69.00	70.50	25.91	2.63	0.29
82		70.50	72.00			
83		72.00	73.50			
	Min.			25.67	2.61	0.15
	Max.			26.09	2.65	0.57
	Avg.			25.88	2.63	0.32
84	BH-15	0.00	1.50			
85		1.50	3.00			
86		3.00	4.50			
87		4.50	6.00	25.66	2.6	0.51
88		6.00	7.50			
89		7.50	9.00			
90		9.00	10.50			
91		10.50	12.00			
92		12.00	13.50			
93		15.00	16.50	25.33	2.57	0.51
94		16.50	18.00			
95		18.00	19.50			
96		19.50	21.00	25.53	2.59	0.5
97		21.00	22.50			
98		22.50	24.00			
99		24.00	25.50			
100		25.50	27.00	25.38	2.57	0.63
101		27.00	28.50			
102		28.50	30.00			

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
103		30.00	31.50			
104		31.50	33.00	25.5	2.59	0.49
105		33.00	34.50			
106		34.50	36.00			
107		36.00	37.50			
108		37.50	39.00			
109		39.00	40.50			
110		40.50	42.00			
111		42.00	43.50	25.2	2.55	0.6
112		43.50	45.00			
113		45.00	46.50			
114		46.50	48.00			
115		48.00	49.50	25.36	2.57	0.47
116		49.50	51.00			
117		51.00	52.50			
118		52.50	54.00			
119		54.00	55.50	25.5	2.59	0.47
120		57.00	58.50			
121		58.50	60.00			
122		60.00	61.50			
123		61.50	63.00			
124		64.50	66.00	25.74	2.61	0.53
125		66.00	67.50			
126		67.50	69.00			
127		69.00	70.00	25.07	2.54	0.46
	Min.			25.07	2.54	0.46
	Max.			25.74	2.61	0.63
	Avg.			25.43	2.58	0.52
128	BH-15A	0.00	1.50			
129		1.50	3.00			
130		3.00	4.50	25.44	2.59	0.16
131		4.50	6.00			
132		6.00	7.50			

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
133		7.50	9.00			
138		9.00	10.50	25.55	2.59	0.47
139		10.50	12.00			
140		12.00	13.50			
141		13.50	15.00			
142		15.00	16.50			
143		16.50	18.00			
144		18.00	19.50	25.35	2.57	0.75
145		19.50	21.00			
146		21.00	22.50			
147		22.50	24.00	25.69	2.6	0.55
148		25.50	27.00			
149		27.00	28.50			
150		28.50	30.00			
				25.17	2.56	0.2
151		30.00	31.50			
152		31.50	33.00			
				25.45	2.58	0.72
153		33.00	34.50			
154		34.50	36.00			
155		36.00	37.50			
				24.81	2.52	0.46

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
156		37.50	39.00			
157		39.00	40.50			
				25.01	2.54	0.45
158		40.50	42.00			
159		42.00	43.50	25.58	2.6	0.38
160		43.50	45.00	25.02	2.54	0.57
161		46.50	48.00			
162		48.00	49.50			
163		49.50	51.00			
	Min.			24.81	2.52	0.16
	Max.			25.69	2.6	0.75
	Avg.			25.307	2.57	0.47
164		0.00	1.50			
165		1.50	3.00	25.43	2.59	0.25
166		3.00	4.50			
167		4.50	6.00			
168		4.50	6.00			
169		7.50	9.00			
170		9.00	10.50			
171	BH-16	10.50	12.00	25.3	2.56	0.62
172		12.00	13.50			
173		13.50	15.00	25.51	2.58	0.7
174		18.00	19.50			
175		19.50	21.00			
176		21.00	22.50			
177		22.50	24.00	26.39	2.68	0.57
178		24.00	25.50			
179		25.50	27.00			
180		27.00	28.50			
181		28.50	30.00			
182		30.00	31.50	26.33	2.67	0.48
183		31.50	33.00			

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		Weight Density	Specific Gravity	Water Absorption
		From	To	(kN/m³)		(%)
184		33.00	34.50			
185		33.00	34.50			
186		36.00	37.50			
187		37.50	39.00	26.52	2.69	0.51
188		39.00	40.50			
189		40.50	42.00			
190		42.00	43.50			
191		45.00	46.50			
192		46.50	48.00	25.54	2.63	0.63
193		48.00	49.50	26.24	2.67	0.3
194		49.50	51.00			
195		52.50	54.00			
196		54.00	55.50			
197		55.50	57.00			
198		58.50	60.00	26.36	2.67	0.46
199		60.00	61.50	26.1	2.65	0.51
200		61.50	62.00			
	Min.			25.3	2.56	0.25
	Max.			26.52	2.69	0.7
	Avg.			25.97	2.64	0.50

BH 17				
Depth	Sample Number	Weight Density	Specific Gravity	Water Absorption
		(kN/m³)		(%)
19.50	BH17/1221/R/01	26.21	2.67	0
20.50	BH17/1221/R/03			
22.00	BH17/1221/R/05			
23.00	BH17/1221/R/06	25.73	2.61	0.36
24.50	BH17/1221/R/07			
	BH17/1221/R/08			
25.00	BH17/0122/R/09			
	BH17/0122/R/10			
26.00	BH17/0122/R/11	25.7	2.61	0.38

BH 17				
Depth	Sample Number	Weight Density	Specific Gravity	Water Absorption
	BH17/0122/R/12			
	BH17/0122/R/13			
27.50	BH17/0122/R/14			
	BH17/0122/R/15			
	BH17/0122/R/16	24.79	2.5	0.95
	BH17/0122/R/17			
28.00	BH17/0122/R/18			
	BH17/0122/R/19			
	BH17/0122/R/20			
29.50	BH17/0122/R/21	25.21	2.54	1.18
	BH17/0122/R/22			
	BH17/0122/R/23			
30.00	BH17/0122/R/24			
	BH17/0122/R/25	25.79	2.63	0.16
31.50	BH17/0122/R/26			
	BH17/0122/R/27			
	BH17/0122/R/28			
	BH17/0122/R/29	25.82	2.62	0.36
32.50	BH17/0122/R/30			
	BH17/0122/R/31			
33.50	BH17/0122/R/32			
	BH17/0122/R/33			
	BH17/0122/R/34			
	BH17/0122/R/35	26.2	2.66	0.21
	BH17/0122/R/36			
35.00	BH17/0122/R/37			
	BH17/0122/R/38			
41.00	BH17/0122/R/40	24.96	2.52	1.1
	BH17/0122/R/41			
42.50	BH17/0122/R/42			
	BH17/0122/R/43			
45.50	BH17/1221/R/48	25.48	2.59	0.39
	BH17/1221/R/49			
	BH17/1221/R/50			
	BH17/1221/R/51			
47.00	BH17/1221/R/52			
	BH17/1221/R/53			
48.50	BH17/1221/R/54	24.23	2.45	0.9

BH 17				
Depth	**Sample Number**	**Weight Density**	**Specific Gravity**	**Water Absorption**
	BH17/1221/R/55			
	BH17/1221/R/56			
	BH17/1221/R/57			
50.00	BH17/1221/R/58			
	BH17/1221/R/59			
	BH17/1221/R/62			
	BH17/1221/R/63	25.13	2.54	0.81
	BH17/1221/R/64			
51.50	BH17/1221/R/65			
	BH17/1221/R/66			
	BH17/1221/R/67			
	BH17/1221/R/69			
	BH17/1221/R/70			
53.00	BH17/1221/R/71	25.73	2.62	0.2
	BH17/1221/R/72			
	BH17/1221/R/73			
	BH17/1221/R/74			
	BH17/1221/R/75			
54.50	BH17/1221/R/76			
	BH17/1221/R/77	25.51	2.59	0.21
56.00	BH17/1221/R/78			
	BH17/1221/R/79			
58.00	BH17/1221/R/80			
	BH17/1221/R/81	25.54	2.58	0.72
59.50	BH17/1221/R/82	25.25	2.55	0.78
	BH17/1221/R/83			
	BH17/1221/R/84			
61.00	BH17/1221/R/85	25.31	2.57	0.45
	BH17/1221/R/86			
	BH17/1221/R/87			
	BH17/1221/R/88	25.68	2.61	0.42
62.00	BH17/1221/R/89			
	BH17/1221/R/90			
	BH17/1221/R/91			
	BH17/1221/R/92			
Min.		**24.23**	**2.45**	**0**
Max.		**26.21**	**2.67**	**1.18**
Average.		**25.42**	**2.58**	**0.56**

ANNEXURE –E
Point load index

Consultant:	Geotechnical Investigation Report		Client:
S.M. CONSULTANTS BHUBANESWAR	Job No.:	830	Haryana Rail Infrastructure Development Corporation Ltd
	Report No.:	SMC/2050	

Point load index Test

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
1	BH-13	0.50	1.50	
2		1.50	3.00	
3		3.00	4.50	
4		4.50	6.00	3.73
5		6.00	7.50	
6		7.50	9.00	
7		9.00	10.50	
8		10.50	12.00	
9		15.00	16.50	
10		16.50	18.00	2.61
11		18.00	19.50	
12		19.50	21.00	
13		21.00	22.50	
14		22.50	24.00	2.39
15		24.00	25.50	
16		25.50	27.00	
17		27.00	28.50	
18		28.50	30.00	
19		30.00	31.50	1.01
20		31.50	33.00	
21		33.00	34.50	
22		34.50	36.00	
23		36.00	37.50	
24		37.50	39.00	2.30
25		39.00	40.50	
26		40.50	42.00	
27		42.00	43.50	
28		43.50	45.00	
29		45.00	46.50	
30		46.50	48.00	
31		48.00	49.50	
32		49.50	51.00	
33		51.00	52.50	
34		52.50	54.00	

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
35		54.00	55.50	1.6
36		55.50	57.00	
37		57.00	58.50	
38		58.50	60.00	
			Min.	1.01
			Max.	3.20
			Avg.	2.18
39	BH-14	1.50	3.00	21.83
40		3.00	4.50	
41		4.50	6.00	
42		6.00	7.50	
43		7.50	9.00	
44		9.00	10.50	3.2
45		10.50	12.00	
46		12.00	13.50	
47		15.00	16.50	3.23
48		16.50	18.00	
49		18.00	19.50	
50		19.50	21.00	
51		21.00	22.50	
52		22.50	24.00	
53		24.00	25.50	3.62
54		25.50	27.00	
55		27.00	28.50	
56		28.50	30.00	
57		30.00	31.50	
58		31.50	33.00	
59		33.00	34.50	
60		34.50	36.00	3.08
61		36.00	37.50	
62		37.50	39.00	
63		39.00	40.50	
64		40.50	42.00	
65		42.00	43.50	
66		43.50	45.00	
67		45.00	46.50	
68		46.50	48.00	

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
69		48.00	49.50	3.16
70		49.50	51.00	
71		51.00	52.50	
72		52.50	54.00	
73		54.00	55.50	2.37
74		57.00	58.50	
75		58.50	60.00	
76		60.00	61.50	
77		63.00	64.50	
78		64.50	66.00	
79		66.00	67.50	2.26
80		67.50	69.00	
81		69.00	70.50	
82		70.50	72.00	
83		72.00	73.50	
	Min.			2.27
	Max.			3.62
	Avg.			2.99
84	BH-15	0.00	1.50	3.15
85		1.50	3.00	
86		3.00	4.50	
87		4.50	6.00	
88		6.00	7.50	
89		7.50	9.00	
90		9.00	10.50	
91		10.50	12.00	3.66
92		12.00	13.50	
93		15.00	16.50	
94		16.50	18.00	
95		18.00	19.50	
96		19.50	21.00	
97		21.00	22.50	2.53
98		22.50	24.00	
99		24.00	25.50	
100		25.50	27.00	
101		27.00	28.50	
102		28.50	30.00	

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
103		30.00	31.50	3.21
104		31.50	33.00	
105		33.00	34.50	
106		34.50	36.00	
107		36.00	37.50	
108		37.50	39.00	
109		39.00	40.50	3.66
110		40.50	42.00	
111		42.00	43.50	
112		43.50	45.00	
113		45.00	46.50	3.35
114		46.50	48.00	
115		48.00	49.50	
116		49.50	51.00	3.53
117		51.00	52.50	
118		52.50	54.00	
119		54.00	55.50	
120		57.00	58.50	
121		58.50	60.00	
122		60.00	61.50	3.85
123		61.50	63.00	
124		64.50	66.00	
125		66.00	67.50	
126		67.50	69.00	
127		69.00	70.00	
	Min.			2.5
	Max.			3.8
	Avg.			3.37
128	BH-15A	0.00	1.50	2.86
129		1.50	3.00	
130		3.00	4.50	
131		4.50	6.00	
132		6.00	7.50	

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
133		7.50	9.00	
138		9.00	10.50	
139		10.50	12.00	
140		12.00	13.50	3.02
141		13.50	15.00	
142		15.00	16.50	
143		16.50	18.00	
144		18.00	19.50	
145		19.50	21.00	
146		21.00	22.50	
147		22.50	24.00	3.15
148		25.50	27.00	
149		27.00	28.50	
150		28.50	30.00	
151		30.00	31.50	
152		31.50	33.00	
153		33.00	34.50	3.4
154		34.50	36.00	

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
155		36.00	37.50	
156		37.50	39.00	
157		39.00	40.50	
158		40.50	42.00	3.3
159		42.00	43.50	
160		43.50	45.00	
161		46.50	48.00	
162		48.00	49.50	
163		49.50	51.00	
	Min.			2.86
	Max.			3.4
	Avg.			3.14
164	BH-16	0.00	1.50	
165		1.50	3.00	
166		3.00	4.50	
167		4.50	6.00	
168		4.50	6.00	
169		7.50	9.00	
170		9.00	10.50	2.16
171		10.50	12.00	
172		12.00	13.50	
173		13.50	15.00	
174		18.00	19.50	
175		19.50	21.00	2.06
176		21.00	22.50	
177		22.50	24.00	
178		24.00	25.50	
179		25.50	27.00	
180		27.00	28.50	
181		28.50	30.00	
182		30.00	31.50	

Sr.No.	BH NO.	Depth		Point load index
		From	To	(MPa)
183		31.50	33.00	3.47
184		33.00	34.50	
185		33.00	34.50	
186		36.00	37.50	
187		37.50	39.00	
188		39.00	40.50	
189		40.50	42.00	
190		42.00	43.50	
191		45.00	46.50	3.84
192		46.50	48.00	
193		48.00	49.50	
194		49.50	51.00	3.32
195		52.50	54.00	
196		54.00	55.50	
197		55.50	57.00	
198		58.50	60.00	
199		60.00	61.50	3.60
200		61.50	62.00	
	Min.			2.06
	Max.			3.84
	Avg.			3.07

BH 17		
Depth	**Sample Number**	**Point load index (Mpa)**
19.50	BH17/1221/R/01	3.02
20.50	BH17/1221/R/03	
22.00	BH17/1221/R/05	
23.00	BH17/1221/R/06	
24.50	BH17/1221/R/07	
	BH17/1221/R/08	2.97
25.00	BH17/0122/R/09	
	BH17/0122/R/10	
26.00	BH17/0122/R/11	

BH 17		
Depth	**Sample Number**	**Point load index (Mpa)**
	BH17/0122/R/12	2.9
	BH17/0122/R/13	
27.50	BH17/0122/R/14	
	BH17/0122/R/15	2.95
	BH17/0122/R/16	
	BH17/0122/R/17	
28.00	BH17/0122/R/18	
	BH17/0122/R/19	
	BH17/0122/R/20	
29.50	BH17/0122/R/21	
	BH17/0122/R/22	
	BH17/0122/R/23	2.84
30.00	BH17/0122/R/24	
	BH17/0122/R/25	
31.50	BH17/0122/R/26	
	BH17/0122/R/27	
	BH17/0122/R/28	
	BH17/0122/R/29	
32.50	BH17/0122/R/30	
	BH17/0122/R/31	
33.50	BH17/0122/R/32	
	BH17/0122/R/33	
	BH17/0122/R/34	
	BH17/0122/R/35	
	BH17/0122/R/36	
35.00	BH17/0122/R/37	
	BH17/0122/R/38	
41.00	BH17/0122/R/40	
	BH17/0122/R/41	
42.50	BH17/0122/R/42	
	BH17/0122/R/43	
44.00	BH17/0122/R/44	
	BH17/0122/R/45	
	BH17/0122/R/46	
	BH17/0122/R/47	
45.50	BH17/1221/R/48	
	BH17/1221/R/49	
	BH17/1221/R/50	
	BH17/1221/R/51	
47.00	BH17/1221/R/52	
	BH17/1221/R/53	

BH 17		
Depth	**Sample Number**	**Point load index (Mpa)**
48.50	BH17/1221/R/54	
	BH17/1221/R/55	
	BH17/1221/R/56	
	BH17/1221/R/57	
50.00	BH17/1221/R/58	
	BH17/1221/R/59	
	BH17/1221/R/60	
	BH17/1221/R/61	
51.50	BH17/1221/R/62	
	BH17/1221/R/63	
	BH17/1221/R/64	
	BH17/1221/R/65	
	BH17/1221/R/66	
	BH17/1221/R/67	
53.00	BH17/1221/R/69	
	BH17/1221/R/70	
	BH17/1221/R/71	
	BH17/1221/R/72	
	BH17/1221/R/73	2.82
54.50	BH17/1221/R/74	
	BH17/1221/R/75	
	BH17/1221/R/76	
	BH17/1221/R/77	3.02
56.00	BH17/1221/R/78	
	BH17/1221/R/79	2.94
58.00	BH17/1221/R/80	
	BH17/1221/R/81	
59.50	BH17/1221/R/82	
61.00	BH17/1221/R/83	
	BH17/1221/R/84	
	BH17/1221/R/85	
	BH17/1221/R/86	
Min.		**2.82**
Max.		**3.02**
Average.		**2.9325**

ANNEXURE –F
Modulus of elasticity and Poisson's ratio

Modulus of elasticity and Poisson's ratio

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
1	BH-13	0.50	1.50		
2		1.50	3.00	31.4	0.14
3		3.00	4.50		
4		4.50	6.00		
5		6.00	7.50		
6		7.50	9.00		
7		9.00	10.50		
8		10.50	12.00	45.2	0.15
9		15.00	16.50		
10		16.50	18.00		
11		18.00	19.50	48	0.13
12		19.50	21.00		
13		21.00	22.50		
14		22.50	24.00		
15		24.00	25.50		
16		25.50	27.00	46.3	0.14
17		27.00	28.50		
18		28.50	30.00		
19		30.00	31.50		
20		31.50	33.00		
21		33.00	34.50	42.4	0.16
22		34.50	36.00		
23		36.00	37.50		
24		37.50	39.00		
25		39.00	40.50	42.7	0.15
26		40.50	42.00		
27		42.00	43.50		
28		43.50	45.00	43.1	0.14
29		45.00	46.50		
30		46.50	48.00	43.5	0.15
31		48.00	49.50		
32		49.50	51.00	41.6	0.17
33		51.00	52.50		
34		52.50	54.00		

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
35		54.00	55.50		
36		55.50	57.00	45.7	0.16
37		57.00	58.50		
38		58.50	60.00	53.6	0.1
			Min.	31.4	0.1
			Max.	53.6	0.17
			Avg.	43.95	0.14
39	BH-14	1.50	3.00		
40		3.00	4.50		
41		4.50	6.00	35.6	0.12
42		6.00	7.50		
43		7.50	9.00		
44		9.00	10.50		
45		10.50	12.00	47.4	0.12
46		12.00	13.50		
47		15.00	16.50		
48		16.50	18.00	53	0.11
49		18.00	19.50		
50		19.50	21.00		
51		21.00	22.50		
52		22.50	24.00		
53		24.00	25.50		
54		25.50	27.00	47.1	0.13
55		27.00	28.50		
56		28.50	30.00		
57		30.00	31.50	45.4	0.14
58		31.50	33.00		
59		33.00	34.50		
60		34.50	36.00		
61		36.00	37.50	35.1	0.16
62		37.50	39.00		
63		39.00	40.50		
64		40.50	42.00		
65		42.00	43.50		
66		43.50	45.00	33.7	0.16
67		45.00	46.50		

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
68		46.50	48.00	52.2	0.13
69		48.00	49.50		
70		49.50	51.00		
71		51.00	52.50	43.6	0.14
72		52.50	54.00		
73		54.00	55.50		
74		57.00	58.50	38.7	0.15
75		58.50	60.00		
76		60.00	61.50	45.3	0.13
77		63.00	64.50		
78		64.50	66.00		
79		66.00	67.50		
80		67.50	69.00	39.5	0.13
81		69.00	70.50		
82		70.50	72.00	39.7	0.14
83		72.00	73.50		
	Min.			33.7	0.11
	Max.			53	0.16
	Avg.			42.79	0.14
84		0.00	1.50		
85		1.50	3.00	47.6	0.14
86		3.00	4.50		
87		4.50	6.00		
88		6.00	7.50		
89		7.50	9.00	49.1	0.12
90		9.00	10.50		
91		10.50	12.00		
92	BH-15	12.00	13.50		
93		15.00	16.50		
94		16.50	18.00	48	0.15
95		18.00	19.50		
96		19.50	21.00		
97		21.00	22.50		
98		22.50	24.00	46.9	0.15
99		24.00	25.50		
100		25.50	27.00		

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
101		27.00	28.50	47.6	0.15
102		28.50	30.00		
103		30.00	31.50		
104		31.50	33.00		
105		33.00	34.50	46.6	0.14
106		34.50	36.00		
107		36.00	37.50		
108		37.50	39.00		
109		39.00	40.50		
110		40.50	42.00		
111		42.00	43.50		
112		43.50	45.00	52.4	0.12
113		45.00	46.50		
114		46.50	48.00	51.6	0.13
115		48.00	49.50		
116		49.50	51.00	41.2	0.14
117		51.00	52.50		
118		52.50	54.00	43.4	0.14
119		54.00	55.50		
120		57.00	58.50	47.7	0.13
121		58.50	60.00		
122		60.00	61.50		
123		61.50	63.00	48.9	0.13
124		64.50	66.00		
125		66.00	67.50	45.8	0.14
126		67.50	69.00		
127		69.00	70.00	48.9	0.12
	Min.			41.2	0.12
	Max.			52.4	0.15
	Avg.			47.55	0.14
128	BH-15A	0.00	1.50		
129		1.50	3.00	46.1	0.12
130		3.00	4.50		
131		4.50	6.00		

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
132		6.00	7.50		
				45.8	0.11
133		7.50	9.00		
138		9.00	10.50		
139		10.50	12.00		
140		12.00	13.50		
				42.9	0.13
141		13.50	15.00		
142		15.00	16.50		
143		16.50	18.00		
144		18.00	19.50		
145		19.50	21.00		
146		21.00	22.50		
				44.5	0.12
147		22.50	24.00		
148		25.50	27.00		
149		27.00	28.50		
				46.3	0.11
150		28.50	30.00		
151		30.00	31.50		
152		31.50	33.00	47.4	0.11
				49.8	0.1

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
153		33.00	34.50		
154		34.50	36.00		
155		36.00	37.50	47.6	0.09
156		37.50	39.00		
157		39.00	40.50	45.8	0.13
158		40.50	42.00		
159		42.00	43.50		
				47.9	0.12
160		43.50	45.00		
161		46.50	48.00		
162		48.00	49.50	50.1	0.12
163		49.50	51.00		
	Min.			42.9	0.09
	Max.			50.1	0.13
	Avg.			46.75	0.11
164	BH-16	0.00	1.50	54.2	0.14
165		1.50	3.00		
166		3.00	4.50		
167		4.50	6.00		
168		4.50	6.00		
169		7.50	9.00	39.9	0.14
170		9.00	10.50		
171		10.50	12.00		
172		12.00	13.50		
173		13.50	15.00		
174		18.00	19.50	51.3	0.11
175		19.50	21.00		
176		21.00	22.50		
177		22.50	24.00	39.7	0.13
178		24.00	25.50		
179		25.50	27.00		

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	Report No.:	SMC/2050	

Sr.No.	BH NO.	Depth		Modulus of Elasticity (GPa)	Poisson's Ratio
		From	To		
180		27.00	28.50		
181		28.50	30.00		
182		30.00	31.50	51.3	0.12
183		31.50	33.00		
184		33.00	34.50		
185		33.00	34.50		
186		36.00	37.50		
187		37.50	39.00	55.5	0.11
188		39.00	40.50		
189		40.50	42.00		
190		42.00	43.50	40.3	0.13
191		45.00	46.50		
192		46.50	48.00	52.6	0.11
193		48.00	49.50		
194		49.50	51.00	45.9	0.12
195		52.50	54.00		
196		54.00	55.50		
197		55.50	57.00	51.4	0.1
198		58.50	60.00		
199		60.00	61.50	50.8	0.12
200		61.50	62.00		
	Min.			39.7	0.1
	Max.			55.5	0.14
	Avg.			48.45	0.12

	BH 17		
Depth	Sample Number	Modulus of Elasticity (GPa)	Poisson's Ratio
19.50	BH17/1221/R/01		
20.50	BH17/1221/R/03		
22.00	BH17/1221/R/05	44.3	0.12
23.00	BH17/1221/R/06		

	BH 17		
Depth	Sample Number	Modulus of	Poisson's Ratio
24.50	BH17/1221/R/07		
	BH17/1221/R/08		
25.00	BH17/0122/R/09	42.1	0.1
	BH17/0122/R/10		
26.00	BH17/0122/R/11		
	BH17/0122/R/12		
	BH17/0122/R/13		
27.50	BH17/0122/R/14		
	BH17/0122/R/15		
	BH17/0122/R/16		
	BH17/0122/R/17		
28.00	BH17/0122/R/18	48.4	0.12
	BH17/0122/R/19		
	BH17/0122/R/20		
29.50	BH17/0122/R/21		
	BH17/0122/R/22		
	BH17/0122/R/23		
30.00	BH17/0122/R/24		
	BH17/0122/R/25		
31.50	BH17/0122/R/26		
	BH17/0122/R/27	43.3	0.11
	BH17/0122/R/28		
	BH17/0122/R/29		
32.50	BH17/0122/R/30		
	BH17/0122/R/31		
33.50	BH17/0122/R/32		
	BH17/0122/R/33		
	BH17/0122/R/34		
	BH17/0122/R/35		
	BH17/0122/R/36	44.3	0.08
35.00	BH17/0122/R/37		
	BH17/0122/R/38		
41.00	BH17/0122/R/40		
	BH17/0122/R/41	45.1	0.13
42.50	BH17/0122/R/42		
	BH17/0122/R/43		
44.00	BH17/0122/R/44		
	BH17/0122/R/45		
	BH17/0122/R/46		
	BH17/0122/R/47		
45.50	BH17/1221/R/48		
	BH17/1221/R/49	42.8	0.11
	BH17/1221/R/50		
	BH17/1221/R/51		

	BH 17		
Depth	**Sample Number**	**Modulus of**	**Poisson's Ratio**
47.00	BH17/1221/R/52		
	BH17/1221/R/53		
48.50	BH17/1221/R/54		
	BH17/1221/R/55		
	BH17/1221/R/56		
	BH17/1221/R/57	41.6	0.13
50.00	BH17/1221/R/58		
	BH17/1221/R/59		
	BH17/1221/R/60		
	BH17/1221/R/61		
51.50	BH17/1221/R/62		
	BH17/1221/R/63		
	BH17/1221/R/64		
	BH17/1221/R/65		
	BH17/1221/R/66	45.5	0.1
	BH17/1221/R/67		
54.50	BH17/1221/R/74		
	BH17/1221/R/75	48.5	0.09
	BH17/1221/R/76		
	BH17/1221/R/77		
56.00	BH17/1221/R/78		
	BH17/1221/R/79		
58.00	BH17/1221/R/80	49.3	0.11
	BH17/1221/R/81		
59.50	BH17/1221/R/82		
61.00	BH17/1221/R/83		
	BH17/1221/R/84		
	BH17/1221/R/85		
	BH17/1221/R/86		
62.00	BH17/1221/R/87	43.7	0.1
	BH17/1221/R/88		
	Min.	**41.6**	**0.08**
	Max.	**49.3**	**0.13**
	Average.	**44.91**	**0.11**

ANNEXURE –G
Triaxial Test

Sr No.	BH No.	Depth		Triaxial Test	
		From	To	Cohesion	Angle of Internal Friction
1	**BH-13**	**27.00**	**30.00**	**17.9**	**63**
2		**40.50**	**43.50**	**20.88**	**60.02**
3		**48.00**	**49.50**	**15.13**	**65.23**
	Min.			**15.13**	**60.02**
	Max.			**20.88**	**65.23**
	Avg.			**17.97**	**62.75**
4	**BH-14**	**10.50**	**13.50**	**17.66**	**62.8**
5		**28.50**	**31.50**	**18.53**	**62.06**
6		**63.00**	**66.00**	**24.39**	**56.48**
	Min.			**17.66**	**56.48**
	Max.			**24.39**	**62.8**
	Avg.			**20.19**	**60.45**
7	**BH-15**	**40.50**	**43.50**	**13.78**	**66.39**
	Min.			**13.78**	**66.39**
	Max.			**13.78**	**66.39**
	Avg.			**13.78**	**66.39**

Sr No.	BH No.	Depth		Triaxial Test	
		From	To	Cohesion	Angle of Internal Friction
8	**BH-15A**	**13.50**	**15.00**	**16.54**	**64.08**
9		**30.00**	**31.50**	**15.71**	**64.67**
	Min.			**15.71**	**64.08**
	Max.			**16.54**	**64.67**
	Avg.			**16.13**	**64.38**
10	**BH-16**	**27.00**	**30.00**	**14.50**	**65.63**
11		**52.50**	**54.00**	**14.75**	**65.63**
	Min.			**14.50**	**65.63**
	Max.			**14.75**	**65.63**
	Avg.			**14.63**	**65.63**
12	**BH-17**	**25.0**	**27.5**	**13.58**	**69.96**
13		**42.5**	**44.0**	**19.44**	**66.36**
14		**59.5**	**61.0**	**18.89**	**66.76**
	Min.			**13.58**	**66.36**
	Max.			**19.44**	**69.96**
	Avg.			**17.30**	**67.69**

ANNEXURE –H
Hardness

Sr No.	BH No.	Depth		Hardness Number
		From	To	
1	**BH-13**	**3.00**	**4.50**	**66.5**
2		**6.00**	**7.50**	**64.6**
3		**19.50**	**21.00**	**61.4**
4		**24.00**	**25.50**	**60**
5		**31.50**	**33.00**	**53.1**
6		**36.00**	**37.50**	**58.2**
7		**43.50**	**45.00**	**59.9**
8		**46.50**	**48.00**	**64.8**
9		**57.00**	**58.50**	**59.9**
	Min.			**53.1**
	Max.			**66.5**
	Avg.			**60.93**
10	**BH-14**	**6.00**	**7.50**	**59.8**
11		**18.00**	**19.50**	**63.2**
12		**22.50**	**24.00**	**61.8**
13		**31.50**	**33.00**	**63.6**
14		**40.50**	**42.00**	**58.8**
15		**46.50**	**48.00**	**56.2**
16		**57.00**	**58.50**	**59.00**
17		**70.50**	**72.00**	**57.2**
18		**72.00**	**73.50**	**57.8**
	Min.			**56.2**
	Max.			**63.6**
	Avg.			**59.71**

Sr No.	BH No.	Depth		Hardness Number
		From	To	
19	**BH-15**	**4.50**	**6.00**	**58.6**
20		**9.00**	**10.50**	**53.4**
21		**12.00**	**13.50**	**59**
22		**18.00**	**19.50**	**61.7**
23		**25.50**	**27.00**	**60**
24		**34.50**	**36.00**	**54.4**
25		**51.00**	**52.50**	**59.6**
26		**54.00**	**55.50**	**60.6**
27		**60.00**	**61.50**	**61.5**
28		**67.50**	**69.00**	**60.1**
	Min.			**53.4**
	Max.			**61.7**
	Avg.			**58.89**
29	**BH-15A**	**3.00**	**4.50**	**61**
30		**9.00**	**10.50**	**61.2**
31		**15.00**	**16.50**	**61.5**
32		**21.00**	**22.50**	**60.2**
33		**25.50**	**27.00**	**56.2**
34		**33.00**	**34.50**	**56.1**
35		**39.00**	**40.50**	**61.1**
36		**46.50**	**48.00**	**62.2**
	Min.			**56.1**
	Max.			**62.2**
	Avg.			**59.94**

Sr No.	BH No.	Depth		Hardness Number
		From	To	
37	**BH-16**	**3.00**	**4.50**	**60.2**
38		**13.50**	**15.00**	**61.7**
39		**21.00**	**22.50**	**61.7**
40		**27.00**	**28.50**	**61.6**
41		**36.00**	**37.50**	**54.8**
42		**46.50**	**48.00**	**58.6**
43		**55.50**	**57.00**	**60.2**
		Min.		**54.8**
		Max.		**61.7**
		Avg.		**59.83**
44	**BH-17**	**20.5**	**22.0**	**27.4**
45		**26.0**	**27.5**	**25.5**
46		**27.5**	**28.0**	**30.2**
47		**29.5**	**30.0**	**31.8**
48		**31.5**	**32.5**	**22.1**
49		**32.5**	**33.5**	**50.6**
50		**33.5**	**35.0**	**34.5**
51		**41.0**	**42.5**	**34.1**
52		**44.0**	**45.5**	**40.0**
53		**47**	**48.5**	**24.5**
54		**51.5**	**53.0**	**28.6**
55		**54.5**	**56**	**33.9**
56		**61.0**	**62.0**	**36.3**
	Min.			**22.1**
	Max.			**50.6**
	Avg.			**32.65**

ANNEXURE –I
Abrasiveness Test

Sr No.	BH No.	Depth		Abrasiveness	Classification
		From	To		(HRC=55)
1	**BH-13**	**3.00**	**4.50**	**2.66**	**High Abrasiveness**
2		**6.00**	**7.50**	**2.7**	**High Abrasiveness**
3		**19.50**	**21.00**	**2.62**	**High Abrasiveness**
4		**24.00**	**25.50**	**2.68**	**High Abrasiveness**
5		**31.50**	**33.00**	**2.96**	**High Abrasiveness**
6		**36.00**	**37.50**	**2.99**	**High Abrasiveness**
7		**43.50**	**45.00**	**2.96**	**High Abrasiveness**
8		**46.50**	**48.00**	**3.01**	**High Abrasiveness**
9		**57.00**	**58.50**	**3.37**	**High Abrasiveness**
	Min.			**2.62**	**High Abrasiveness**
	Max.			**3.37**	**High Abrasiveness**
	Avg.			**2.88**	**High Abrasiveness**
10	**BH-14**	**6.00**	**7.50**	**2.54**	**High Abrasiveness**
		10.50	**12.00**	**2.38**	**High Abrasiveness**
11		**18.00**	**19.50**	**2.5**	**High Abrasiveness**
12		**22.50**	**24.00**	**2.44**	**High Abrasiveness**
13		**31.50**	**33.00**	**2.33**	**High Abrasiveness**
14		**40.50**	**42.00**	**2.74**	**High Abrasiveness**
15		**46.50**	**48.00**	**2.5**	**High Abrasiveness**
16		**57.00**	**58.50**	**2.76**	**High Abrasiveness**
17		**70.50**	**72.00**	**2.64**	**High Abrasiveness**
18		**72.00**	**73.50**	**2.64**	**High Abrasiveness**
	Min.			**2.33**	**High Abrasiveness**
	Max.			**2.76**	**High Abrasiveness**
	Avg.			**2.55**	**High Abrasiveness**

Sr No.	BH No.	Depth		Abrasiveness	Classification
		From	To		(HRC=55)
19	**BH-15**	**4.50**	**6.00**	**2.99**	**High Abrasiveness**
20		**9.00**	**10.50**	**2.96**	**High Abrasiveness**
21		**12.00**	**13.50**	**3.19**	**High Abrasiveness**
22		**18.00**	**19.50**	**2.88**	**High Abrasiveness**
23		**25.50**	**27.00**	**3.25**	**High Abrasiveness**
24		**34.50**	**36.00**	**3.23**	**High Abrasiveness**
		43.50	**45.00**	**3.43**	**High Abrasiveness**
25		**51.00**	**52.50**	**3.07**	**High Abrasiveness**
26		**54.00**	**55.50**	**3.19**	**High Abrasiveness**
27		**60.00**	**61.50**	**3.15**	**High Abrasiveness**
28		**67.50**	**69.00**	**3.29**	**High Abrasiveness**
	Min.			**2.88**	**High Abrasiveness**
	Max.			**3.43**	**High Abrasiveness**
	Avg.			**3.15**	**High Abrasiveness**
29	**BH-15A**	**3.00**	**4.50**	**3.17**	**High Abrasiveness**
30		**9.00**	**10.50**	**3.23**	**High Abrasiveness**
31		**15.00**	**16.50**	**3.21**	**High Abrasiveness**
32		**21.00**	**22.50**	**3.39**	**High Abrasiveness**
33		**25.50**	**27.00**	**2.92**	**High Abrasiveness**
34		**33.00**	**34.50**	**3.13**	**High Abrasiveness**
35		**39.00**	**40.50**	**3.15**	**High Abrasiveness**
36		**46.50**	**48.00**	**3.01**	**High Abrasiveness**
	Min.			**2.92**	**High Abrasiveness**
	Max.			**3.39**	**High Abrasiveness**
	Avg.			**3.15**	**High Abrasiveness**

Sr No.	BH No.	Depth		Abrasiveness	Classification
		From	To		(HRC=55)
37	**BH-16**	**3.00**	**4.50**	**3.15**	**High Abrasiveness**
38		**13.50**	**15.00**	**3.23**	**High Abrasiveness**
39		**21.00**	**22.50**	**2.94**	**High Abrasiveness**
40		**27.00**	**28.50**	**3.15**	**High Abrasiveness**
41		**36.00**	**37.50**	**3.15**	**High Abrasiveness**
42		**46.50**	**48.00**	**3.27**	**High Abrasiveness**
43		**55.50**	**57.00**	**3.31**	**High Abrasiveness**
	Min.			**2.94**	
	Max.			**3.31**	
	Avg.			**3.17**	
44	**BH-17**	**20.5**	**22.0**	**1.95**	**Medium Abrasiveness**
45		**26.0**	**27.5**	**1.91**	**Medium Abrasiveness**
46		**27.5**	**28.0**	**2.38**	**High Abrasiveness**
47		**29.5**	**30.0**	**2.58**	**High Abrasiveness**
48		**31.5**	**32.5**	**2.18**	**High Abrasiveness**
49		**32.5**	**33.5**	**2.36**	**High Abrasiveness**
50		**33.5**	**35.0**	**2.46**	**High Abrasiveness**
51		**41.0**	**42.5**	**2.12**	**High Abrasiveness**
52		**44.0**	**45.5**	**2.28**	**High Abrasiveness**
53		**47**	**48.5**	**2.16**	**High Abrasiveness**
54		**51.5**	**53.0**	**2.08**	**High Abrasiveness**
55		**54.5**	**56**	**2.24**	**High Abrasiveness**
56		**61.0**	**62.0**	**1.97**	**Medium Abrasiveness**
	Min.			**1.91**	
	Max.			**2.58**	
	Avg.			**2.21**	

TEST RESULTSHEET

ANNEXURE –G
SOIL TEST Results

*** The SPT N values illustrated in the tables below are raw values (without correction factor) collected directly from field.**
*** The phi values represented in the tables are measured in laboratory, they do not illustrate the phi values in the insitu condition.**

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TEST RESULTSHEET

BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of Shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**From 0.0 m to 1.50 m depth**	UDS		6.23	1.87	4.63	37.26	37.56	12.45	25	19	6	10.56	1.754	1.586	0.09	27	DS	2.66	0.68	0.136	ML-CL
2	**From 1.50 m to 3.0 m depth**	SPT	12	11.53	2.21	5.3	29.63	38.70	12.63	25	20	5	---	---	---	---	---	---	2.66		---	ML-CL
3	**From 3.0 m to 4.50 m depth**	UDS	---	5.23	3.14	4.87	6.85	65.06	14.85	26	20	6	12.45	1.816	1.615	0.15	14	UU	2.67	0.65	0.129	ML-CL
4	**From 4.50 m to 6.0 m depth**	SPT	16	4.21	1.35	4.58	7.59	65.88	16.39	27	20	7	---	---	---	---	---	---	2.67		---	ML-CL
5	**From 6.0 m to 9.0 m depth**	UDS	---	3.15	2.84	6.47	9.66	63.26	14.62	25	20	5	13.82	1.853	1.628	0.15	12	UU	2.66	0.63	0.139	ML-CL
6	**From 9.0 m to 12.0 m depth**	SPT	26	7.14	0.73	1.12	5.69	68.56	16.76	26	19	7	---	---	---	---	---	---	2.68	---	---	ML-CL
7	**From 12.0 m to 15.0 m depth**	SPT	21	6.02	1.06	2.48	7.03	67.55	15.86	25	19	6	---	---	---	---	---	---	2.67	---	---	ML-CL

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TEST RESULTSHEET

Contd… BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm	Medium Sand in % (2.0mm To 0.425mm	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
8	**From 15.0 m to 16.50 m depth**	SPT	37	6.97	3.25	2.28	3.29	68.29	15.92	25	20	5	---	---	---	---	---	---	2.67	---	---	ML-CL
9	**From 16.50 m to 18.00 m depth**	SPT	>50	26	0.87	0.9	3.67	56.10	12.46	24	18	6	---	---	---	---	---	---	2.66	---	---	ML-CL
10	**From 18.0 m to 19.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=17%, R.Q.D=NIL)																		
11	**From 19.50 m to 20.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=22%, R.Q.D=NIL)																		
12	**From 20.50m to 22.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=25%, R.Q.D=11.6%)																		
13	**From 22.0 m to 23.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=32%, R.Q.D=NIL)																		
14	**From 23.0 m to 24.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=33%, R.Q.D=NIL)																		
15	**From 24.50 m to 25.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=48%, R.Q.D=25%)																		

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TEST RESULTSHEET

Contd… BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis					Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)		Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
16	**From 25.00 m to 26.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=59%, R.Q.D=32.6%)																			
17	**From 26.00 m to 27.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=44%, R.Q.D=12.66%)																			
18	**From 27.50 m to 28.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=68%, R.Q.D=25.8%)																			
19	**From 28.0 m to 29.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=58%, R.Q.D=7.6%)																			
20	**From 29.50 m to 30.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=70%, R.Q.D=NIL)																			
21	**From 30.00m to 31.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=47%, R.Q.D=17.13%)																			
22	**From 31.0 m to 32.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=64%, R.Q.D=NIL)																			

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TEST RESULTSHEET

Contd… BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
23	**From 32.50 m to 33.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=54%, R.Q.D=15.53%)																		
24	**From 33.50 m to 35.0 m depth**	ROCK	---	ROCK (CORE RECOVERY=34.66%, R.Q.D=NIL)																		
25	**From 35.00 m to 36.50 m depth**	SPT	>50	2.16	1.51	3.55	67.09	25.69	0.00	21	---	NP	---	---	---	---	---	---	2.65	---	---	SM
26	**From 36.50 m to 38.00 m depth**	SPT	>50	3.41	1.61	9.75	71.60	13.63	0.00	20	---	NP	---	---	---	---	---	---	2.64	---	---	SM
27	**From 38.00 m to 39.50 m depth**	SPT	>50	4.10	1.37	2.57	5.31	71.41	15.24	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
28	**From 39.50 m to 41.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=32%, R.Q.D=11%)																		
29	**From 41.00 m to 42.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=41.33%, R.Q.D=19.33%)																		

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TEST RESULTSHEET

Contd… BH-17, (CH-25785 M)

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
30	**From 42.50m to 44.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=54%, R.Q.D=41.53%)																		
31	**From 44.0 m to 45.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=30%, R.Q.D=NIL)																		
32	**From 45.50 m to 47.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=37.33%, R.Q.D=NIL)																		
33	**From 47.00 m to 48.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=41.33%, R.Q.D=21.06%)																		
34	**From 48.50 m to 50.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=30%, R.Q.D=NIL)																		
35	**From 50.00 m to 51.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=36.66%, R.Q.D=NIL)																		
36	**From 51.50 m to 53.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=34.66%, R.Q.D=12%)																		

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TEST RESULTSHEET

Contd… BH-17, (CH-25785 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis: Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Hydrometer Analysis: Silt in %	Clay in %	Atterberg's Limit: Liquid Limit In %	Plastic Limit In %	Plasticity Index in %	Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU)	Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
37	**From 53.00 m to 54.50 m depth**	ROCK	---	ROCK (CORE RECOVERY=33.33%, R.Q.D=6.8%)																			
38	**From 54.50 m to 56.00m depth**	ROCK	---	ROCK (CORE RECOVERY=28%, R.Q.D=6.73%)																			
39	**From 56.00m to 58.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=38%, R.Q.D=8%)																			
40	**From 58.00 m to 59.50m depth**	ROCK	---	ROCK (CORE RECOVERY=38.33%, R.Q.D=NIL)																			
41	**From 59.50 m to 61.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=40.6%, R.Q.D=27.66%)																			
42	**From 61.00 m to 62.00 m depth**	ROCK	---	ROCK (CORE RECOVERY=70%, R.Q.D=12.66%)																			

***Note: From 35.0 m to 39.5m depth, highly weathered soft rock stratum exists from which core sample couldn't be collected only washed out sample has been collected.**

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TEST RESULTSHEET

BH-18, (CH-25990)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	2.77	21.85	66.69	8.69	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
2	**At 1.5 m depth**	UDS	---	0	0.09	0.54	34.22	58.61	6.54	24	---	NP	11.42	1.765	1.584	0.13	17	UU	2.66	0.68	0.132	ML
3	**At 3.0 m depth**	SPT	11	1.21	0.16	1.49	7.87	80.01	9.26	25	---	NP				---	---	---	2.68	---	---	ML
4	**At 4.5 m depth**	UDS	---	0	0.13	0.53	35.77	55.94	7.63	25	---	NP	12.63	1.803	1.601	0.12	19	UU	2.66	0.66	0.128	ML
5	**At 6.0 m depth**	SPT	20	0.75	1.12	1.02	11.01	76.63	9.47	26	---	NP				---	---	---	2.68	---	---	ML
6	**At 9.0 m depth**	UDS	---	0	0	0.64	22.85	67.82	8.69	26	---	NP	14.63	1.853	1.617	0.16	14	UU	2.67	0.65	0.125	ML
7	**At 12.0 m depth**	SPT	24	0	0	0.41	17.66	71.47	10.46	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
8	**At 15.0 m depth**	SPT	31	0	0	0.65	13.25	70.87	15.23	27	21	6	---	---	---	---	---	---	2.70	---	---	ML-CL
9	**At 18.0 m depth**	SPT	35	1.12	3.05	3.21	12.74	65.99	13.89	25	20	5	---	---	---	---	---	---	2.69	---	---	ML-CL

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-18, (CH-25990)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	40	0	4.27	4.28	12.73	66.51	12.21	26	20	6	---	---	---	---	---	---	2.69	---	---	ML-CL
11	**At 24.0 m depth**	SPT	47	2.08	5.39	4.35	10.17	70.32	7.69	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
12	**At 27.00 m depth**	SPT	49	2.77	5.59	4.54	7.57	71.08	8.45	24	---	NP	---	---	---	---	---	---	2.67	---	---	ML
13	**At 30.00 m depth**	SPT	57	6.59	2.30	2.13	11.62	70.87	6.49	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
14	**At 33.00 m depth**	SPT	64	2.29	3.32	2.72	20.65	64.68	6.34	24	---	NP	---	---	---	---	---	---	2.65	---	---	ML
15	**At 36.00 m depth**	SPT	69	1.21	3.92	2.72	20.65	64.94	6.56	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML
16	**At 39.00 m depth**	SPT	77	1.21	3.92	5.48	13.20	68.82	7.37	26	---	NP	---	---	---	---	---	---	2.66	---	---	ML
17	**At 42.00 m depth**	SPT	84	0	0.29	4.69	14.85	70.53	9.64	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
18	**At 45.00 m depth**	SPT	>50	0.86	1.29	2.47	21.77	66.35	7.26	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
19	**At 47.00 m depth**	SPT	>50	1.01	0.95	1.68	21.22	67.29	7.85	25	---	NP	---	---	---	---	---	---	2.65	---	---	ML

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-18, (CH-25990)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear test Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
20	**At 50.0 m depth**	SPT	>50	0	0	0.38	36.92	56.16	6.54	24	---	NP	---	---	---	---	---	---	2.68	---	---	ML
21	**At 53.0 m depth**	SPT	>50	5.50	1.11	0.98	17.76	66.76	7.89	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
22	**At 55.00 m depth**	SPT	>50	4.29	1.92	1.75	16.29	67.63	8.12	26	---	NP	---	---	---	---	---	---	2.66	---	---	ML

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

BH-19, (CH-26210 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 197

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.52	31.8	46.32	21.36	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	17	0	0	0.35	29.33	47.89	22.43	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	0.78	33.46	45.28	20.48	24	---	NP	10.59	1.761	1.592	0.14	20	DS	2.66	0.67	0.123	ML
4	**At 4.5 m depth**	SPT	23	13.54	1.59	3.96	10.02	49.93	20.96	24	---	NP	---	---	---	---	---	---	2.65	---	---	ML
5	**At 6.0 m depth**	UDS	---	6.24	2.85	4.39	13.62	49.46	23.44	27	---	NP	11.36	1.792	1.609	0.13	24	DS	2.67	0.66	0.118	ML
6	**At 9.0 m depth**	SPT	30	5.8	0.24	3.24	9.08	54.79	26.85	26	---	NP	---	---	---	---	---	---	2.68	--	---	ML
7	**At 12.0 m depth**	UDS	---	3.15	0.46	1.79	13.63	56.03	24.94	26	---	NP	11.85	1.813	1.621	0.10	26	DS	2.68	0.65	0.114	ML
8	**At 15.0 m depth**	SPT	35	1.01	0.3	0.8	17.77	55.86	24.26	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-19, (CH-26210 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	5.26	0.96	1.45	14.96	54.50	22.87	26	---	NP	12.64	1.826	1.621	0.11	25	DS	2.66	0.64	0.111	ML
10	**At 21.0 m depth**	SPT	35	8.28	0.81	2.77	12.82	55.69	19.63	24	---	NP	---	---	---	---	---	---	2.65	---	---	ML
11	**At 24.0 m depth**	UDS	---	3.45	0.69	1.75	21.82	51.85	20.44	25	---	NP	13.76	1.849	1.625	0.12	23	DS	2.66	0.64	0.115	ML
12	**At 27.00 m depth**	SPT	39	0.55	0.29	1.08	27.15	51.39	19.54	24	---	NP	---	---	---	---	---	---	2.65	---	---	ML
13	**At 30.00 m depth**	UDS	---	0.63	0.45	1.69	24.85	50.75	21.63	25	---	NP	14.24	1.863	1.631	0.08	27	DS	2.66	0.63	0.116	ML
14	**At 33.00 m depth**	SPT	43	2.3	3.3	12.85	60.05	21.50	0.00	19	---	NP	---	---	---	---	---	---	2.65	---	---	SM
15	**At 36.00 m depth**	DS	---	0.53	3.24	13.83	62.42	19.98	0.00	18	---	NP	---	---	---	---	---	---	2.63	---	---	SM
16	**At 39.00 m depth**	SPT	52	0	0	11.29	43.73	44.98	0.00	21	---	NP	---	---	---	---	---	---	2.65	---	---	SM
17	**At 42.00 m depth**	DS	---	0.14	1.64	12.89	50.37	34.96	0.00	20	---	NP	---	---	---	---	---	---	2.64	---	---	SM
18	**At 45.00 m depth**	SPT	65	0.62	0.82	10.3	43.26	45.00	0.00	21	---	NP	---	---	---	---	---	---	2.65	---	---	SM

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-19, (CH-26210 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
19	**At 48.00 m depth**	DS	---	1.01	2.08	12.23	52.69	31.99	0.00	20	---	NP	---	---	---	---	---	---	2.64	---	---	SM
20	**At 50.00 m depth**	SPT	80	0.22	0.92	11.98	51.54	35.34	0.00	21	---	NP	---	---	---	---	--	---	2.63	---	----	SM

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

BH-20, (CH-26387M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	1.04	38.61	54.08	6.27	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
2	**At 1.5 m depth**	SPT	18	0	0	2.56	45.72	46.58	5.14	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
3	**At 3.0 m depth**	UDS	---	1.8	0.78	1.42	39.52	50.44	6.04	26	---	NP	11.58	1.761	1.578	0.12	24	DS	2.66	0.69	0.118	ML
4	**At 4.5 m depth**	SPT	32	0	0	1.13	39.71	53.23	5.93	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
5	**At 6.0 m depth**	UDS	---	0	0	0.67	40.58	52.93	5.82	25	---	NP	12.43	1.795	1.597	0.14	27	DS	2.66	0.67	0.112	ML
6	**At 9.0 m depth**	SPT	48	8.24	0.8	1.32	4.08	77.09	8.47	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	DS	---	14.74	5.96	3.44	37.78	38.08	0.00	21	---	NP	---	---	---	---	---	---	2.64	---	---	SM
8	**At 15.0 m depth**	SPT	60	13.83	3.05	4.49	14.01	57.77	6.85	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
9	**At 18.0 m depth**	DS	---	15.72	10.44	3.33	15.53	49.18	5.80	22	---	NP	---	---	---	---	---	---	2.65	---	---	ML

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-20, (CH-26387 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	67	4.2	2.21	2.11	28.52	56.46	6.50	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML
11	**At 24.0 m depth**	SPT	76	0	0	1.81	13.06	76.83	8.30	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
12	**At 27.00 m depth**	UDS	---	3.38	2.51	7.06	7.7	64.85	14.50	31	20	11	14.21	1.902	1.665	0.27	12	UU	2.70	0.62	0.134	CL
13	**At 30.00 m depth**	SPT	58	0	0	0.21	11.23	71.36	17.20	33	21	12	---	---	---	---	---	---	2.71	---	---	CL
14	**At 33.00 m depth**	UDS	---	0.76	1.71	3.61	6.07	71.05	16.80	33	20	13	14.85	1.935	1.685	0.30	11	UU	2.71	0.61	0.136	CL
15	**At 36.00 m depth**	SPT	67	1.2	0.77	4.01	17.67	62.15	14.20	31	21	10	---	---	---	---	---	---	2.70	---	---	CL
16	**At 39.00 m depth**	UDS	---	0	0.63	1.08	7.44	72.35	18.50	34	22	12	15.38	1.958	1.697	0.36	14	UU	2.72	0.60	0.138	CL
17	**At 42.00 m depth**	SPT	75	3.12	1.63	3.72	9.71	64.92	16.90	32	21	11	---	---	---	---	---	---	2.71	---	---	CL
18	**At 45.00 m depth**	UDS	---	0	0	1.11	24.18	60.71	14.00	30	18	12	16.47	1.988	1.707	0.31	10	UU	2.70	0.58	0.133	CL
19	**At 48.00 m depth**	SPT	79	0	0.69	0.18	8.39	72.34	18.40	34	23	11	---	---	---	---	---	---	2.72	---	---	CL

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

BH-21, (CH-26587 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.98	29.34	63.28	6.40	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	14	0	0	0.8	27.92	64.38	6.90	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	0.78	23.87	67.85	7.50	27	---	NP	10.28	1.768	1.603	0.11	24	DS	2.67	0.67	0.112	ML
4	**At 4.5 m depth**	SPT	20	0	0	1.02	26.12	65.76	7.10	26	---	NP	---	---	---	---	---	---	2.66	---	---	ML
5	**At 6.0 m depth**	UDS	---	10.23	0.57	2.52	8.02	70.86	7.80	27	---	NP	11.47	1.819	1.632	0.10	25	DS	2.68	0.64	0.116	ML
6	**At 9.0 m depth**	SPT	31	8.31	1.47	2.56	10.42	69.94	7.30	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	UDS	---	22.85	4.06	2.15	19.18	45.06	6.70	25	---	NP	12.16	1.824	1.626	0.07	27	DS	2.64	0.62	0.109	ML
8	**At 15.0 m depth**	SPT	38	0	1.06	3.7	6.73	80.11	8.40	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
9	**At 18.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY = 6.0%, R.Q.D=4.5%)																		

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-21, (CH-26587 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=3.5%, R.Q.D=NIL)																		
11	**At 24.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=4.0%, R.Q.D=NIL)																		
12	**At 27.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=6.0%, R.Q.D=NIL)																		
13	**At 30.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=9.0%, R.Q.D=NIL)																		
14	**At 33.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=6.0%, R.Q.D=NIL)																		
15	**At 36.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=4.6%, R.Q.D=NIL)																		
16	**At 39.00 m depth**	DS	---	1.59	1.05	1.79	9.41	77.76	8.40	28	---	NP	---	---	---	---	---	---	2.68	---	---	ML
17	**At 42.00 m depth**	SPT	77	0	0.12	2.98	19.55	69.85	7.50	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
18	**At 45.00 m depth**	26600	---	0	0	3.56	22.62	66.62	7.20	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-22, (CH-26787 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.2	20.81	60.79	18.20	31	20	11	---	---	---	---	---	---	2.70	---	---	CL
2	**At 1.5 m depth**	SPT	15	0	0	0.29	29.32	62.89	7.50	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0.39	0.16	0.32	29.83	63.00	6.30	26	---	NP	11.58	1.752	1.570	0.11	22	DS	2.66	0.69	0.116	ML
4	**At 4.5 m depth**	SPT	21	19.14	0.52	3.9	11.46	58.38	6.60	25	---	NP	---	---	---	---	---	---	2.65	---	---	ML
5	**At 6.0 m depth**	UDS	---	0	0.2	0.14	24.82	67.64	7.20	27	---	NP	13.57	1.826	1.608	0.13	28	DS	2.67	0.66	0.112	ML
6	**At 9.0 m depth**	SPT	28	16.76	2.29	7.05	8.02	59.08	6.80	26	---	NP	---	---	---	---	---	---	2.66	---	---	ML
7	**At 12.0 m depth**	PEBBLE	---	PEBBLE PIECES WERE COLLECTED																		
8	**At 15.0 m depth**	PEBBLE	---	PEBBLE PIECES WERE COLLECTED																		
9	**At 18.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=3.0%, R.Q.D=NIL)																		

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-22, (CH-26787 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=2.3%, R.Q.D=NIL)																		
11	**At 24.0 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=3.0%, R.Q.D=NIL)																		
12	**At 27.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=2.0%, R.Q.D=NIL)																		
13	**At 30.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=3.0%, R.Q.D=NIL)																		
14	**At 33.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=2.3%, R.Q.D=NIL)																		
15	**At 36.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=4.0%, R.Q.D=NIL)																		
16	**At 39.00 m depth**	ROCK	---	FRAGMENTED ROCK (CORE RECOVERY=4.0%, R.Q.D=NIL)																		
17	**At 42.00 m depth**	DS	---	0	0.3	1.58	33.52	44.10	20.50	30	20	10	---	---	---	---	---	---	2.71	---	---	CL
18	**At 45.00 m depth**	SPT	91	6.44	0.88	1.4	32.90	38.78	19.60	28	19	9	---	---	---	---	---	---	2.70	---	---	CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

BH-23, (CH-26980 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0	32.85	53.65	13.50	30	18	12	---	---	---	---	---	---	2.70	---	---	CL
2	**At 1.5 m depth**	SPT	16	0	0	0.2	20.45	64.55	14.80	32	19	13	---	---	---	---	---	---	2.71	---	---	CL
3	**At 3.0 m depth**	UDS	---	0	0	0.2	20.32	64.58	14.90	32	20	12	10.62	1.752	1.584	0.31	9	UU	2.71	0.71	0.130	CL
4	**At 4.5 m depth**	SPT	23	12.8	0.7	1.67	9.92	60.71	14.20	31	18	13	---	---	---	---	---	---	2.70	---	---	CL
5	**At 6.0 m depth**	UDS	---	0	0	1.37	15.52	67.91	15.20	33	20	13	11.35	1.785	1.603	0.26	12	UU	2.72	0.70	0.132	CL
6	**At 9.0 m depth**	SPT	34	0	0	0	23.15	70.65	6.20	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
7	**At 12.0 m depth**	DS	---	6.27	1.67	7.71	9.26	60.89	14.20	32	19	13	---	---	---	---	---	---	2.70	---	---	CL
8	**At 15.0 m depth**	SPT	38	2.31	2.23	15.61	8.32	57.63	13.90	30	17	13	---	---	---	---	---	---	2.69	---	---	CL
9	**At 18.0 m depth**	DS	---	0	0	0.2	19.19	65.81	14.80	33	19	14	---	---	---	---	---	---	2.71	---	---	CL

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-23, (CH-26980 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	50	5.71	0.9	0.99	49.32	43.08	0.00	20	---	NP	---	---	---	---	---	---	2.65	---	---	SM
11	**At 24.0 m depth**	UDS	---	3.47	1.7	1.54	31.5	48.59	13.20	30	17	13	13.45	1.851	1.632	0.29	11	UU	2.69	0.65	0.126	CL
12	**At 27.00 m depth**	SPT	63	1.03	0.51	0.23	61.61	36.62	0.00	19	---	NP	---	---	---	---	---	---	2.64	---		SM
13	**At 30.00 m depth**	UDS	---	4.84	1.61	1.35	18.75	67.65	5.80	26	---	NP	14.62	1.883	1.643	0.11	26	DS	2.67	0.63	0.117	ML
14	**At 33.00 m depth**	SPT	73	2.64	1.21	1.95	10.36	68.54	15.30	33	19	14	---	---	---	---	---	---	2.72	---	---	CL
15	**At 36.00 m depth**	UDS	---	7.71	0.7	1.56	42.4	47.63	0.00	21	---	NP	15.48	1.906	1.651	0.04	27	DS	2.66	0.61	---	SM
16	**At 39.00 m depth**	SPT	77	0	0	0.2	1.39	79.11	19.30	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
17	**At 42.00 m depth**	UDS	---	0	2.74	7.74	11.98	62.64	14.90	31	20	11	16.21	1.961	1.687	0.30	14	UU	2.70	0.60	0.132	CL
18	**At 45.00 m depth**	SPT	85	0	0	0.49	1.74	78.57	19.20	34	22	12	---	---	---	---	---	---	2.72	---	---	CL

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

BH-24, (CH-27187 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.36	23.48	68.86	7.30	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
2	**At 1.5 m depth**	SPT	14	0	0	0.42	18.62	73.16	7.80	26	---	NP	---	---	---	---	---	---	2.68	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	0.82	13.57	77.41	8.20	27	---	NP	10.82	1.761	1.589	0.14	25	DS	2.68	0.69	0.113	ML
4	**At 4.5 m depth**	SPT	21	0	0	0.72	16.82	74.46	8.00	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
5	**At 6.0 m depth**	UDS	---	0.82	0.36	1.42	23.27	67.63	6.50	26	---	NP	11.48	1.784	1.600	0.11	26	DS	2.66	0.66	0.108	ML
6	**At 9.0 m depth**	SPT	27	0.34	0.68	0.95	17.43	72.9	7.70	26	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	UDS	---	0	0	0.17	25.49	67.74	6.60	25	---	NP	12.44	1.824	1.622	0.10	26	DS	2.67	0.65	0.109	ML
8	**At 15.0 m depth**	SPT	33	0	0	0.48	21.46	70.46	7.60	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
9	**At 18.0 m depth**	UDS	---	0.12	1.26	5.87	10.44	74.31	8.00	26	---	NP	13.28	1.839	1.623	0.12	27	DS	2.67	0.64	0.117	ML

Consultant:	Geotechnical Investigation Report		*Client:*
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TEST RESULTSHEET

Contd… BH-24, (CH-27187 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	43	0	0	12.62	15.87	65.21	6.30	25	---	NP	---	---	---	---	---	---	2.66	---	---	ML
11	**At 24.0 m depth**	UDS	---	0	0	8.47	11.49	64.44	15.60	32	20	12	15.47	1.935	1.676	0.25	15	UU	2.71	0.62	0.137	CL
12	**At 27.00 m depth**	SPT	58	0.43	0.82	5.44	8.79	68.32	16.20	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
13	**At 30.00 m depth**	UDS	---	0.29	0.45	3.28	16.74	64.14	15.10	30	20	10	15.89	1.958	1.690	0.30	11	UU	2.70	0.60	0.132	CL
14	**At 33.00 m depth**	SPT	72	0	0.17	2.62	21.53	60.88	14.80	30	19	11	---	---	---	---	---	---	2.70	---	---	CL
15	**At 36.00 m depth**	UDS	---	0	0	4.51	11.43	67.46	16.60	33	21	12	16.52	1.992	1.710	0.25	10	UU	2.72	0.59	0.136	CL
16	**At 39.00 m depth**	SPT	89	0	0	0.32	18.84	65.04	15.80	31	20	11	---	---	---	---	---	---	2.71	---	---	CL
17	**At 40.00 m depth**	UDS	---	1.23	4.62	7.38	12.56	59.61	14.60	30	21	9	17.24	2.018	1.721	0.30	12	UU	2.70	0.57	0.128	CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

BH-25, (CH-27410 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.42	19.2	64.18	16.20	31	19	12	---	---	---	---	---	---	2.71	---	---	CL
2	**At 1.5 m depth**	SPT	13	0	0	0.28	5.96	74.26	19.50	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
3	**At 3.0 m depth**	UDS	---	9.16	1.88	10.4	7.00	56.36	15.20	29	17	12	12.14	1.758	1.568	0.31	10	UU	2.70	0.72	0.138	CL
4	**At 4.5 m depth**	SPT	20	0	0	0.56	20.8	62.64	16.00	30	17	13	---	---	---	---	---	---	2.70	---	---	CL
5	**At 6.0 m depth**	UDS	---	24.64	0.24	0.18	11.95	48.39	14.60	28	18	10	12.58	1.779	1.580	0.29	13	UU	2.69	0.70	0.134	CL
6	**At 9.0 m depth**	SPT	30	0	0	0.82	20.36	62.72	16.10	30	18	12	---	---	---	---	---	---	2.70	---	---	CL
7	**At 12.0 m depth**	UDS	---	0	0	0.08	21.46	62.66	15.80	30	17	13	13.42	1.816	1.601	0.26	10	UU	2.70	0.69	0.136	CL
8	**At 15.0 m depth**	SPT	31	18.06	0	0.42	18.4	48.42	14.70	29	18	11	---	---	---	---	---	---	2.69	---	---	CL
9	**At 18.0 m depth**	UDS	---	0	4.3	7.84	9.5	62.66	15.70	31	19	12	14.34	1.846	1.614	0.30	9	UU	2.70	0.67	0.134	CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

Contd… BH-25, (CH-27410 M)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	33	1.16	1.15	23.2	8.81	50.88	14.80	28	16	12	---	---	---	---	---	---	2.69	---	---	CL
11	**At 24.0 m depth**	UDS	---	0	0	26.28	5.92	52.9	14.90	29	17	12	15.32	1.878	1.629	0.30	10	UU	2.69	0.65	0.129	CL
12	**At 27.00 m depth**	SPT	48	9.1	1.82	18.91	7.42	48.25	14.50	28	17	11	---	---	---	---	---	---	2.69	---	---	CL
13	**At 30.00 m depth**	UDS	---	0	0	8.74	12.18	63.28	15.80	30	17	13	15.86	1.906	1.645	0.25	14	UU	2.70	0.64	0.131	CL
14	**At 33.00 m depth**	SPT	68	0	0	0.32	16.1	66.78	16.80	31	19	12	---	---	---	---	---	---	2.71	---	---	CL
15	**At 36.00 m depth**	UDS	---	4.24	5.46	10	5.02	59.98	15.30	30	17	13	16.38	1.936	1.664	0.31	11	UU	2.70	0.62	0.128	CL
16	**At 39.00 m depth**	SPT	81	0	0	0.54	14.4	68.36	16.70	32	20	12	---	---	---	---	---	---	2.71	---	---	CL
17	**At 40.00 m depth**	UDS	---	7	3.42	20.7	7.68	47.3	13.90	28	17	11	16.69	1.952	1.673	0.29	16	UU	2.69	0.61	0.125	CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

BH-26, (CH-27550)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance(φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0	1.17	79.33	19.50	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
2	**At 1.5 m depth**	SPT	11	0	0	0.10	1.20	79.50	19.20	34	22	12	---	---	---	---	---	---	2.72	---	---	CL
3	**At 3.0 m depth**	UDS	---	0	0	0	1.07	79.33	19.60	34	21	13	10.89	1.763	1.590	0.36	8	UU	2.72	0.71	0.140	CL
4	**At 4.5 m depth**	SPT	19	0	0	0.36	20.4	62.74	16.50	32	21	12	---	---	---	---	---	---	2.70	---	---	CL
5	**At 6.0 m depth**	UDS	---	0	0	0.46	16.4	65.94	17.20	33	22	11	11.62	1.801	1.614	0.34	10	UU	2.71	0.68	0.132	CL
6	**At 9.0 m depth**	SPT	28	0	0	0.42	14.4	67.58	17.60	33	23	10	---	---	---	---	---	---	2.71	---	---	CL
7	**At 12.0 m depth**	UDS	---	0	0.24	0.36	17.92	64.38	17.10	32	20	12	12.62	1.829	1.624	0.25	16	UU	2.70	0.66	0.130	CL
8	**At 15.0 m depth**	SPT	34	0	2.3	21.32	8.68	52.50	15.20	30	20	10	---	---	---	---	---	---	2.69	---	---	CL
9	**At 18.0 m depth**	UDS	---	1.6	1.13	8.97	7.83	63.67	16.80	31	21	10	13.54	1.859	1.637	0.30	11	UU	2.70	0.65	0.128	CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

Contd… BH-26, (CH-27550)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (φ) in degree	Type of shear test (Triaxial test (UU) / Direct shear test (DS))	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	41	2.2	5.4	9.62	3.64	62.64	16.50	31	21	10	---	---	---	---	---	---	2.71	---	---	CL
11	**At 24.0 m depth**	UDS	---	30.22	3.28	1.12	11.78	39.40	14.20	28	19	9	14.86	1.892	1.647	0.29	14	UU	2.69	0.63	0.125	CL
12	**At 27.00 m depth**	SPT	53	16.38	0	0.56	10.63	56.73	15.70	30	19	11	---	---	---	---	---	---	2.71	---	---	CL
13	**At 30.00 m depth**	UDS	---	11.84	0	0.24	9.2	62.42	16.30	31	20	11	15.42	1.936	1.677	0.30	12	UU	2.71	0.62	0.128	CL
14	**At 33.00 m depth**	SPT	65	28.78	0	0.22	13.00	43.60	14.40	29	19	10	---	---	---	---	---	---	2.69	---	---	CL
15	**At 35.00 m depth**	UDS	---	0	0	0.38	21.96	61.56	16.10	31	20	11	16.38	1.958	1.682	0.25	16	UU	2.70	0.60	0.127	CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-27, (CH-28050m)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.7	21.45	57.65	20.20	31	20	11	---	---	---	---	---	---	2.70	---	---	CL
2	**At 1.5 m depth**	SPT	14	0	0	0.4	16.2	66.60	16.80	32	21	11	---	---	---	---	---	---	2.72	---	---	CL
3	**At 3.0 m depth**	UDS	---	0	0	0.4	36.03	49.97	13.60	30	18	12	11.45	1.758	1.577	0.26	10	UU	2.69	0.71	0.126	CL
4	**At 4.5 m depth**	SPT	24	0	0	1.52	18.64	64.24	15.60	31	19	12	---	---	---	---	---	---	2.70	---	---	CL
5	**At 6.0 m depth**	UDS	---	0	0	0.2	48.27	45.93	5.60	24	---	NP	12.63	1.779	1.580	0.16	14	UU	2.67	0.69	0.109	ML
6	**At 9.0 m depth**	SPT	27	6.66	0.51	1.88	6.69	66.96	17.30	31	19	12	---	---	---	---	---	---	2.72	---	---	CL
7	**At 12.0 m depth**	UDS	---	12.22	0.58	1.43	7.42	62.95	15.40	30	19	11	13.21	1.825	1.612	0.24	12	UU	2.70	0.67	0.132	CL
8	**At 15.0 m depth**	SPT	36	0	0	0.81	16.98	65.91	16.30	31	18	13	---	---	---	---	---	---	2.71	---	---	CL

Consultant:	**Geotechnical Investigation Report**		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

Contd… BH-27, (CH-28050m)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	0	0	0.23	32.2	58.07	9.50	26	---	NP	14.45	1.854	1.620	0.18	13	UU	2.69	0.66	0.118	ML
10	**At 21.0 m depth**	SPT	45	0	0	4.68	4.92	71.80	18.60	33	20	13	---	---	---	---	---	---	2.72	---	---	CL
11	**At 24.0 m depth**	UDS	---	0	0.37	1.08	7.36	71.79	19.40	34	20	14	15.63	1.916	1.657	0.29	9	UU	2.72	0.64	0.136	CL
12	**At 27.00 m depth**	SPT	54	1.36	0.25	0.75	3.35	73.69	20.60	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
13	**At 30.00 m depth**	UDS	---	0	0	0.48	6.68	73.04	19.80	33	21	12	16.48	1.942	1.667	0.30	9	UU	2.72	0.63	0.138	CL

Consultant:	**Geotechnical Investigation Report**		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

BH-28, (CH-28350)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.35	36.45	57.00	6.20	24	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	12	0	0.44	34.2	4.36	47.6	13.40	28	18	10	---	---	---	---	---	---	2.69	---	---	CL
3	**At 3.0 m depth**	UDS	---	0	0	0.66	27.56	65.18	6.60	25	---	NP	11.82	1.763	1.577	0.12	18	UU	2.67	0.69	0.108	ML
4	**At 4.5 m depth**	SPT	21	7.06	0.67	0.91	11.1	73.16	7.10	25	---	NP	---	---	---	---	---	---	2.68	---	---	ML
5	**At 6.0 m depth**	UDS	---	0	1.29	2.21	55.64	40.86	0.00	20	---	NP	12.47	1.782	1.584	0.03	26	DS	2.64	0.67	---	SM
6	**At 9.0 m depth**	SPT	28	0	0	1.6	8.52	82.08	7.80	25	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	UDS	---	16.98	0.76	1.3	6.54	67.62	6.80	25	---	NP	12.86	1.806	1.600	0.14	18	UU	2.66	0.66	0.110	ML
8	**At 15.0 m depth**	SPT	38	4.65	7.39	16.02	5.62	60.02	6.30	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
9	**At 18.0 m depth**	UDS	---	2.89	1.51	2.82	15.3	62.18	15.30	32	19	13	13.27	1.866	1.647	0.28	10	UU	2.70	0.64	0.136	CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

Contd… BH-28, (CH-28350)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
10	**At 21.0 m depth**	SPT	47	1.53	3.64	20.64	7.17	52.52	14.50	29	17	12	---	---	---	---	---	---	2.69	---	---	CL
11	**At 24.0 m depth**	UDS	---	1.52	0.39	1.78	2.39	74.32	19.60	34	20	14	14.43	1.901	1.661	0.25	10	UU	2.72	0.64	0.138	CL
12	**At 27.00 m depth**	SPT	53	0	0	2.72	3.54	74.44	19.30	34	21	13	---	---	---	---	---	---	2.72	---	---	CL
13	**At 30.00 m depth**	UDS	---	0	0	0.68	22.58	68.94	7.80	25	---	NP	15.62	1.923	1.663	0.17	14	UU	2.66	0.60	0.109	ML
14	**At 33.00 m depth**	SPT	70	0	0.68	1.27	2.97	74.58	20.50	35	22	13	---	---	---	---	---	---	2.72	---	---	CL
15	**At 36.00 m depth**	UDS	---	0	0	3.74	3.44	73.42	19.40	33	21	12	16.45	1.987	1.706	0.26	9	UU	2.72	0.59	0.136	CL
16	**At 39.00 m depth**	SPT	81	33.16	1.42	2.18	10.64	48.00	4.60	24	---	NP	---	---	---	---	---	---	2.66	---	---	ML
17	**At 42.00 m depth**	UDS	---	0	0	2.2	16.4	73.20	8.20	25	---	NP	17.61	2.009	1.708	0.19	13	UU	2.66	0.56	0.112	ML
18	**At 45.00 m depth**	SPT	92	0	0	2.7	15.36	73.64	8.30	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-29, (CH-28550m)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	(ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.48	20.15	67.97	9.40	27	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	12	0	0	0.56	37.26	54.88	7.30	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	1.07	36.44	48.09	14.40	26	---	NP	11.45	1.761	1.580	0.20	11	UU	2.70	0.71	0.126	ML-CL
4	**At 4.5 m depth**	SPT	24	0	0	0.27	41.98	43.85	13.90	26	---	NP	---	---	---	---	---	---	2.69	---	---	ML-CL
5	**At 6.0 m depth**	UDS	---	8.04	17.4	7.97	3.10	48.89	14.60	27	20	7	11.89	1.795	1.604	0.18	14	UU	2.70	0.68	0.131	ML-CL
6	**At 9.0 m depth**	SPT	27	0	0	0.62	33.02	51.46	14.90	27	21	6	---	---	---	---	---	---	2.70	---	---	ML-CL
7	**At 12.0 m depth**	UDS	---	0	0.18	0.17	57.05	42.60	0.00	21	---	NP	12.63	1.802	1.600	0.02	25	DS	2.66	0.66	---	SM
8	**At 15.0 m depth**	SPT	38	3.91	14.98	8.17	3.37	60.77	8.80	26	---	NP	---	---	---	---	---	---	2.69	---	---	ML

Consultant:	**Geotechnical Investigation Report**		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
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TEST RESULTSHEET

Contd… BH-29, (CH-28550m)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial tes(UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	5.72	15.44	9.61	5.28	49.45	8.50	26	---	NP	13.48	1.857	1.636	0.14	19	UU	2.69	0.64	0.128	ML
10	**At 21.0 m depth**	SPT	47	0	0	0.34	23.87	65.69	10.10	27	---	NP	---	---	---	---	---	---	2.70	---	---	ML
11	**At 24.0 m depth**	UDS	---	0	0	0.98	56.73	42.29	0.00	19	---	NP	14.69	1.874	1.634	0.03	25	DS	2.66	0.63	---	SM
12	**At 27.00 m depth**	SPT	61	26.98	0.17	6.66	14.33	41.06	10.80	26	19	7	---	---	---	---	---	---	2.67	---	---	ML-CL
13	**At 30.00 m depth**	UDS	---	0	0	0.76	43.32	42.12	13.80	26	20	6	15.27	1.923	1.668	0.18	16	UU	2.69	0.61	0.127	ML-CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-30, (CH-28750)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	0	0.88	47.65	42.67	8.80	24	---	NP	---	---	---	---	---	---	2.66	---	---	ML
2	**At 1.5 m depth**	SPT	17	0	0	0.41	42.88	47.51	9.20	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
3	**At 3.0 m depth**	UDS	---	0	0	0.94	43.45	47.51	8.10	26	---	NP	12.62	1.768	1.570	0.17	19	UU	2.67	0.71	0.123	ML
4	**At 4.5 m depth**	SPT	22	0	1.05	2.58	8.25	68.52	19.60	27	22	5	---	---	---	---	---	---	2.69	---	---	ML-CL
5	**At 6.0 m depth**	UDS	---	0	0	0.27	11.1	69.73	18.90	28	22	6	13.47	1.816	1.600	0.19	14	UU	2.69	0.69	0.132	ML-CL
6	**At 9.0 m depth**	SPT	30	0	0	0.31	16.49	66.80	16.40	26	20	6	---	---	---	---	---	---	2.68	---	---	ML-CL
7	**At 12.0 m depth**	UDS	---	0	0.5	0.98	2.4	72.52	23.60	34	23	11	13.86	1.847	1.622	0.25	10	UU	2.72	0.68	0.146	CL
8	**At 15.0 m depth**	SPT	38	0	0	0.66	10.22	66.22	22.90	33	22	11	---	---	---	---	---	---	2.72	---	---	CL
9	**At 18.0 m depth**	UDS	---	0	0	1.69	24.57	64.54	10.20	25	---	NP	14.43	1.864	1.629	0.19	14	UU	2.68	0.66	0.125	ML

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

Contd… BH-30, (CH-28750)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Type of shear testTriaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %											
10	**At 21.0 m depth**	SPT	44	0	0	0.47	8.56	66.57	24.40	34	22	12	---	---	---	---	---	---	2.72	---	---	CL
11	**At 24.0 m depth**	UDS	---	2.75	10.44	31.23	7.20	48.38	0.00	22	---	NP	15.17	1.879	1.632	0.03	25	DS	2.67	0.64	---	SM
12	**At 27.00 m depth**	SPT	56	18.53	0.57	1.46	5.54	63.20	10.70	24	---	NP	---	---	---	---	---	---	2.70	---	---	ML
13	**At 30.00 m depth**	UDS	---	0	0	2.11	15.18	71.41	11.30	26	---	NP	16.21	1.936	1.666	0.18	15	UU	2.71	0.63	0.126	ML
14	**At 33.00 m depth**	SPT	64	0	0	0.47	35.50	54.83	9.20	25	---	NP	---	---	---	---	---	---	2.68	---	---	ML
15	**At 36.00 m depth**	UDS	---	0	0	1.72	36.52	52.16	9.60	24	---	NP	16.72	1.947	1.668	0.14	17	UU	2.69	0.61	0.128	ML
16	**At 39.00 m depth**	SPT	73	0	9.34	6.6	23.74	52.12	8.20	24	---	NP	---	---	---	---	---	---	2.67	---	---	ML
17	**At 42.00 m depth**	UDS	---	0	1.88	6.24	13.57	68.11	10.20	26	---	NP	17.62	1.995	1.696	0.16	13	UU	2.71	0.60	0.122	ML
18	**At 45.00 m depth**	SPT	84	10.2	14.44	7.44	13.61	38.31	16.00	27	20	7	---	---	---	---	---	---	2.69	---	---	ML-CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-31, (CH-29050)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII, & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	(ϕ) in degree	Triaxial test (UU)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	4.09	1.33	3.53	31.98	45.07	14.00	29	18	11	---	---	---	---	---	---	2.69	---	---	CL
2	**At 1.5 m depth**	SPT	16	5.72	2.18	4.08	21.64	51.18	15.20	30	18	12	---	---	---	---	---	---	2.69	---	---	CL
3	**At 3.0 m depth**	UDS	---	27.54	2.16	2.2	37.7	30.40	0.00	21	---	NP	12.24	1.765	1.573	0.02	27	DS	2.65	0.69	---	SM
4	**At 4.5 m depth**	SPT	23	5.46	1.94	3.82	24.96	53.02	10.80	27	---	NP	---	---	---	---	---	---	2.67	---	---	ML
5	**At 6.0 m depth**	UDS	---	0	0	0.2	42.13	47.27	10.40	25	---	NP	13.47	1.808	1.593	0.04	29	DS	2.66	0.67	0.123	ML
6	**At 9.0 m depth**	SPT	32	0	0	0.86	45.22	40.02	13.90	26	---	NP	---	---	---	---	---	---	2.69	---	---	ML
7	**At 12.0 m depth**	UDS	---	0.92	1.86	11.96	5.42	63.64	16.20	26	20	6	14.61	1.882	1.642	0.17	12	UU	2.71	0.65	0.132	ML-CL
8	**At 15.0 m depth**	SPT	40	0	0	0.44	18.47	64.19	16.90	27	21	6	---	---	---	---	---	---	2.72	---	---	ML-CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

Contd… BH-31, (CH-29050)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis				Hydrometer Analysis		Atterberg's Limit			Field Moisture Content in %	Natural density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To 0.075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	8.32	6.4	5.86	13.56	50.76	15.10	25	20	5	15.37	1.926	1.669	0.14	15	UU	2.70	0.62	0.130	ML-CL
10	**At 20.0 m depth**	SPT	51	1.65	2.91	6.1	11.29	61.95	16.10	27	20	7	---	---	---	---	---	---	2.69	---	---	ML-CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-32, (CH-29550)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	(ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %											
1	**At 0.5 m depth**	DS	---	2.18	0.46	3.88	17.28	61.30	14.90	26	20	6	---	---	---	---	---	---	2.69	---	---	ML-CL
2	**At 1.5 m depth**	SPT	17	1.56	2.2	1.92	17.08	61.94	15.30	27	21	6	---	---	---	---	---	---	2.68	---	---	ML-CL
3	**At 3.0 m depth**	UDS	---	0	0.24	0.32	29	56.14	14.30	25	20	5	10.69	1.754	1.585	0.16	15	UU	2.69	0.70	0.141	ML-CL
4	**At 4.5 m depth**	SPT	27	0	3.54	3.6	16.4	61.36	15.10	27	20	7	---	---	---	---	---	---	2.67	---	---	ML-CL
5	**At 6.0 m depth**	UDS	---	0	0	2.36	27.14	55.90	14.60	26	21	5	11.58	1.784	1.599	0.15	14	UU	2.69	0.68	0.136	ML-CL
6	**At 9.0 m depth**	SPT	35	0	0	0.26	18.4	72.54	8.80	25	---	NP	---	---	---	---	---	---	2.68	---	---	ML
7	**At 12.0 m depth**	UDS	---	25.98	8.4	6.38	8.46	43.28	7.50	24	---	NP	12.18	1.824	1.626	0.02	30	DS	2.68	0.65	0.118	ML
8	**At 15.0 m depth**	SPT	44	0	0	0.64	18.06	72.60	8.70	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

Contd… BH-32, (CH-29550)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %											
9	**At 18.0 m depth**	UDS	---	0	0	1.36	33.9	57.24	7.50	25	---	NP	12.87	1.847	1.636	0.03	27	DS	2.68	0.64	0.122	ML
10	**At 21.0 m depth**	SPT	54	0	0	0.42	30.4	60.38	8.80	26	---	NP	---	---	---	---	---	---	2.67	---	---	ML
11	**At 24.0 m depth**	UDS	---	0	0	0.54	33.06	57.80	8.60	26	---	NP	13.68	1.882	1.656	0.04	26	DS	2.67	0.61	0.124	ML
12	**At 27.00 m depth**	SPT	63	0	0	1.22	16.54	72.84	9.40	27	---	NP	---	---	---	---	---	---	2.68	---	---	ML
13	**At 30.00 m depth**	UDS	---	0	0	0.82	17.96	72.02	9.20	27	---	NP	14.57	1.937	1.691	0.16	17	UU	2.68	0.59	0.132	ML

Consultant:	**Geotechnical Investigation Report**		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

BH-33, (CH-30125)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII,& Pt. XV) AND IS: 1498 – 1970

Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of Shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				[illegible]	Coarse Sand in % (4.75mm To 2.00 mm)	Medium Sand in % (2.0mm To 0.425mm)	Fine Sand in % (0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
1	**At 0.5 m depth**	DS	---	0	1.94	0.77	36.88	52.61	7.80	25	---	NP	---	---	---	---	---	---	2.67	---	---	ML
2	**At 1.5 m depth**	SPT	11	0	0	1.94	33.44	50.42	14.20	26	20	6	---	---	---	---	---	---	2.68	---	---	ML-CL
3	**At 3.0 m depth**	UDS	---	0	0	0.79	9.79	73.02	16.40	28	22	6	11.62	1.772	1.588	0.16	14	UU	2.68	0.69	0.137	ML-CL
4	**At 4.5 m depth**	SPT	28	0	0	0.42	33.62	51.36	14.60	26	21	5	---	---	---			---	2.67	---	---	ML-CL
5	**At 6.0 m depth**	UDS	---	0	0	3.19	20.06	61.45	15.30	27	22	5	12.47	1.814	1.613	0.14	13	UU	2.68	0.66	0.131	ML-CL
6	**At 9.0 m depth**	SPT	39	0	0	0.25	24.59	60.06	15.10	27	21	6	---	---	---			---	2.67	---	---	ML-CL
7	**At 12.0 m depth**	UDS	---	0	0	0.42	25.78	59.00	14.80	26	20	6	13.27	1.843	1.627	0.09	27	DS	2.68	0.65	0.128	ML-CL
8	**At 15.0 m depth**	SPT	50	0	0	0.32	40.18	45.90	13.60	25	20	5	---	---	---	---	---	---	2.67	---	---	ML-CL

Consultant:	Geotechnical Investigation Report		*Client:*
S.M. CONSULTANTS BHUBANESWAR	**Job No.:**	830	**Haryana Rail Infrastructure Development Corporation Ltd**
	REPORT. No.:	SMC/2050	

TEST RESULTSHEET

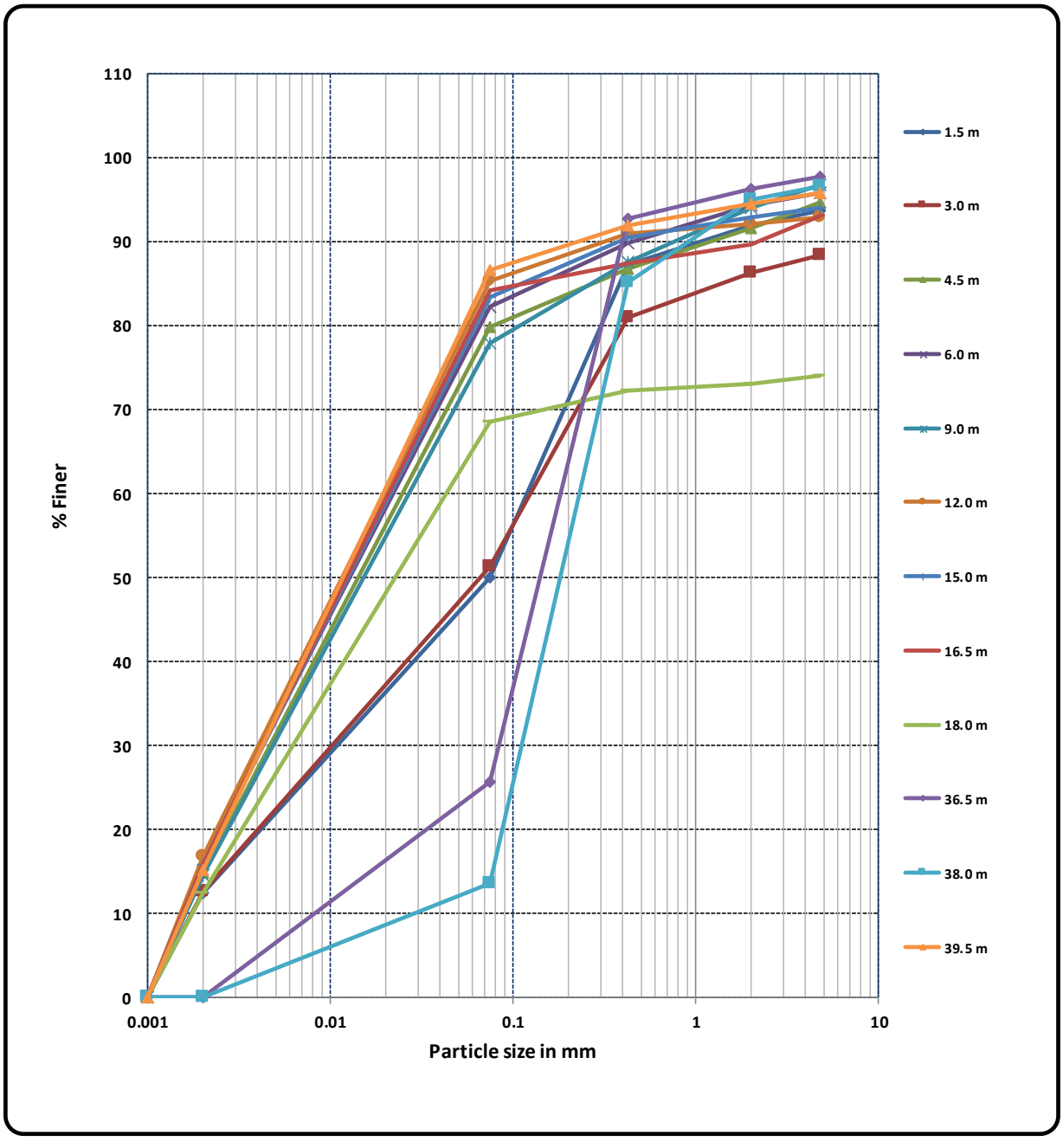
Contd… BH-33, (CH-30125)

TEST CONDUCTED AS PER IS: 2720 (Pt. II, Pt. III, Pt. IV, Pt. V, Pt. X, Pt. XI / Pt. XIII & Pt. XV) AND IS: 1498 – 1970

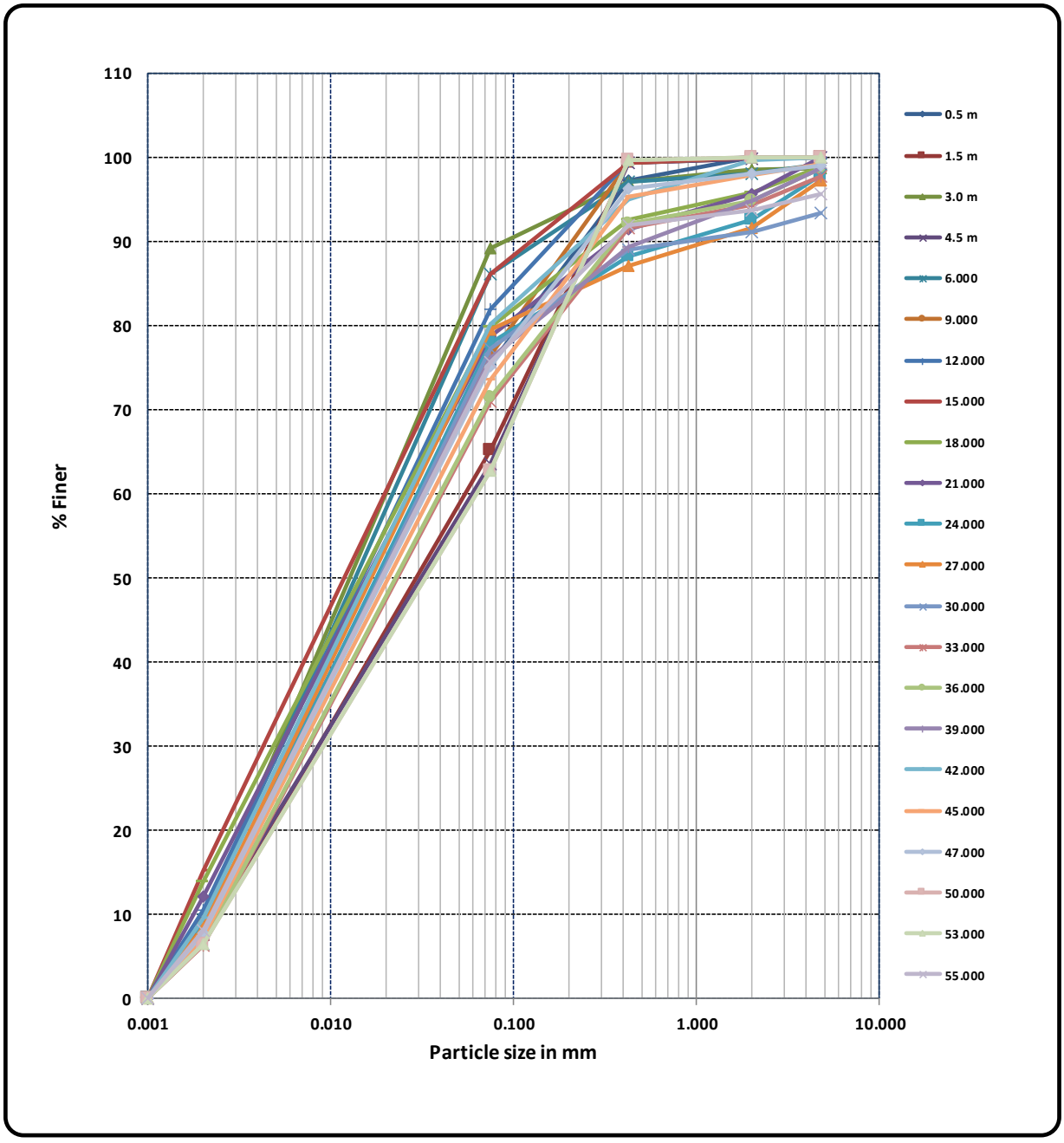
Sl. No.	Sample Collected at	Type of soil collected	S.P.T N Value	Grain size analysis						Atterberg's Limit			Field Moisture Content in %	Bulk density in gm/cc.	Dry density in gm/cc	Cohesion (C) Kgf/cm^2	Angle of shearing resistance (ϕ) in degree	Triaxial test (UU) Direct shear test (DS)	Specific gravity	Void ratio	Consolidation test (Compression Index, Cc)	Group of soil
				Fine Gravel in % (20mm To 4.75mm)	Medium Sand in % (4.75mm To 2.00 mm)	Fine Sand in % (2.0mm To 0.425mm)	(0.425mm To .075mm)	Silt in %	Clay in %	Liquid Limit In %	Plastic Limit In %	Plasticity Index in %										
9	**At 18.0 m depth**	UDS	---	0	0	1.56	28.53	55.11	14.80	25	20	5	14.65	1.901	1.658	0.08	26	DS	2.68	0.62	0.126	ML-CL
10	**At 20.0 m depth**	SPT	63	0	0	3.23	20.48	61.29	15.00	26	21	5	---	---	---	---	---	---	2.67	---	---	ML-CL

ANNEXURE –H
GRAIN SIZE DISTRIBUTION CURVE

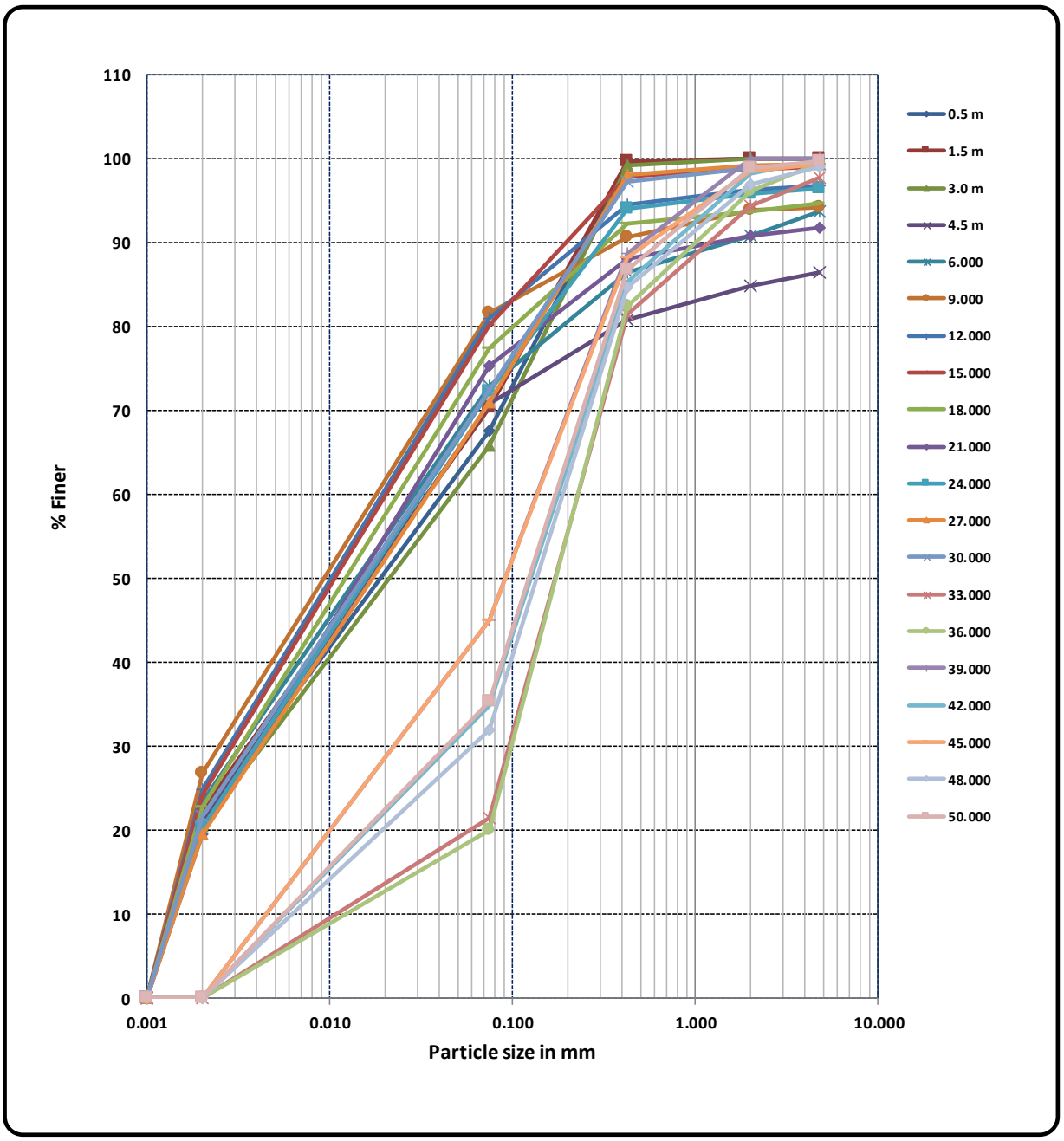
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-17



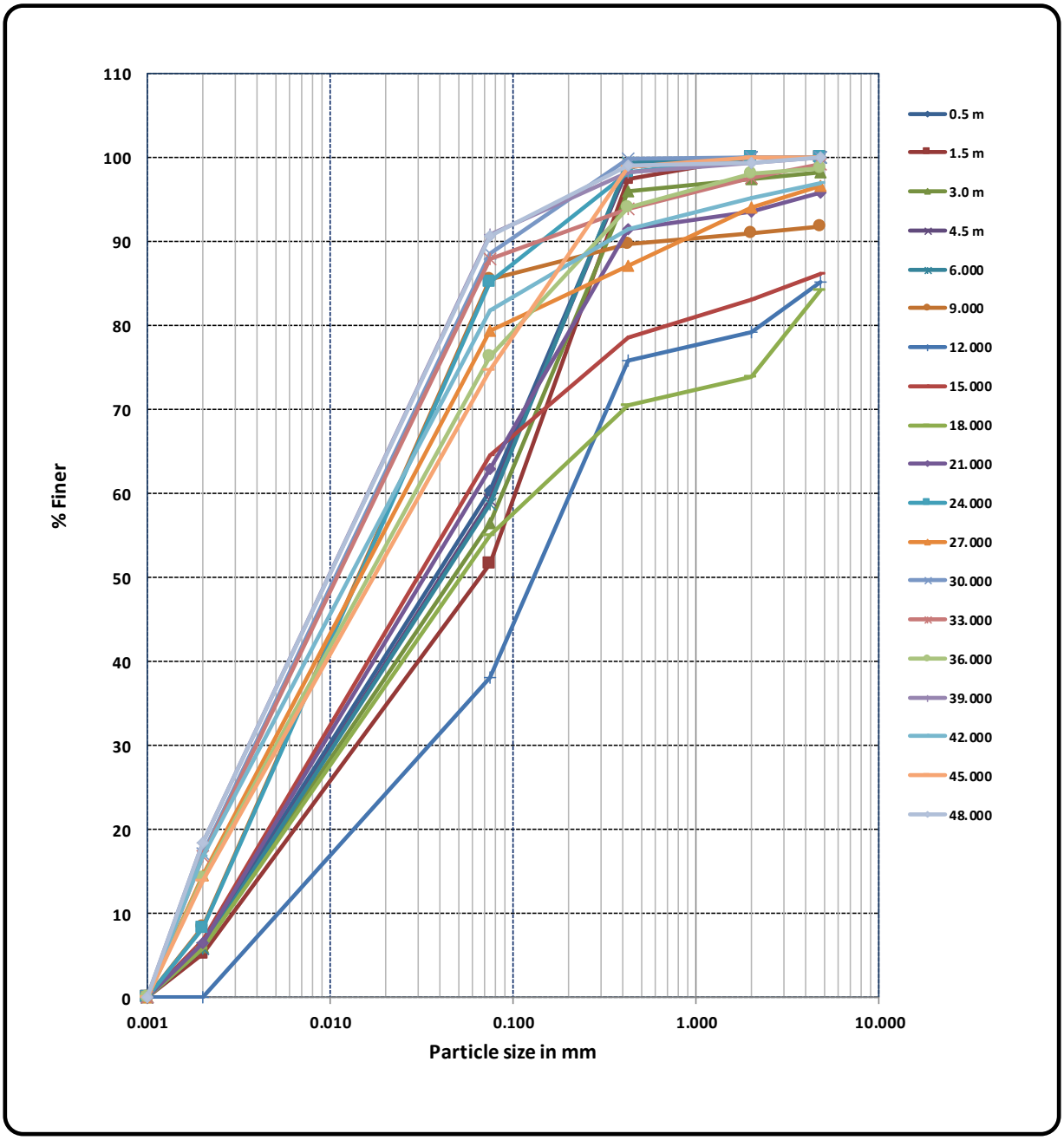
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-18



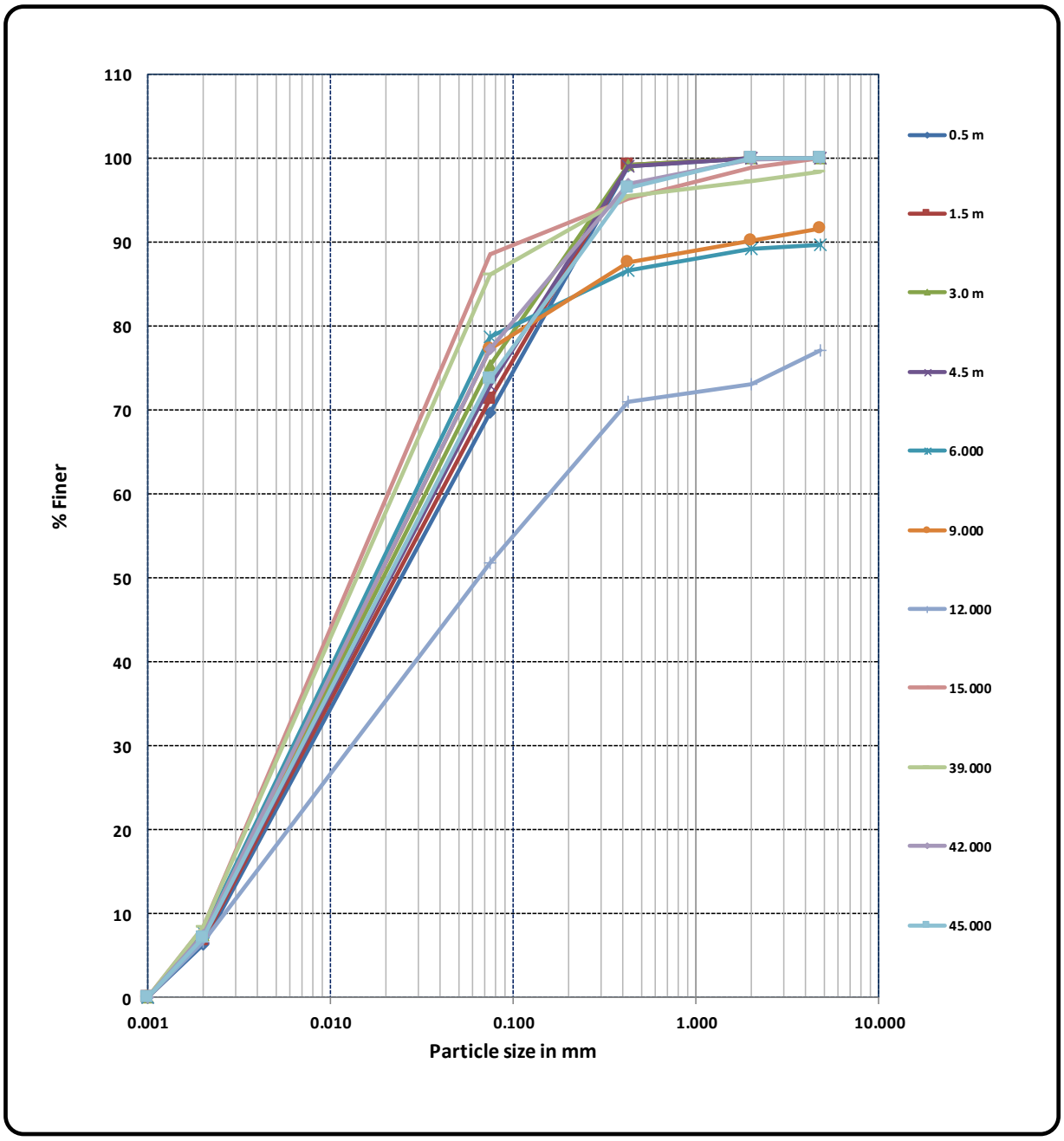
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-19



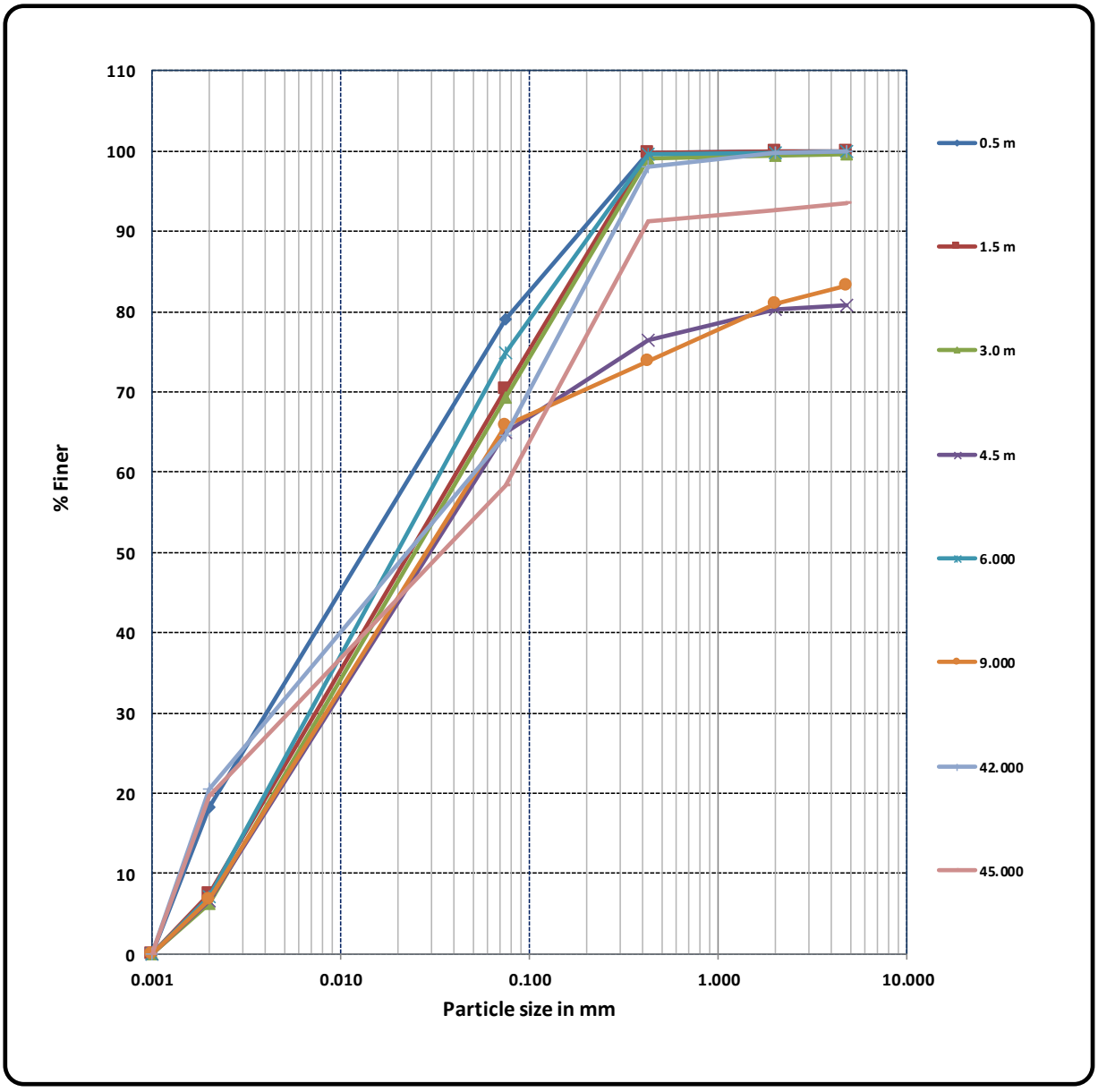
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-20



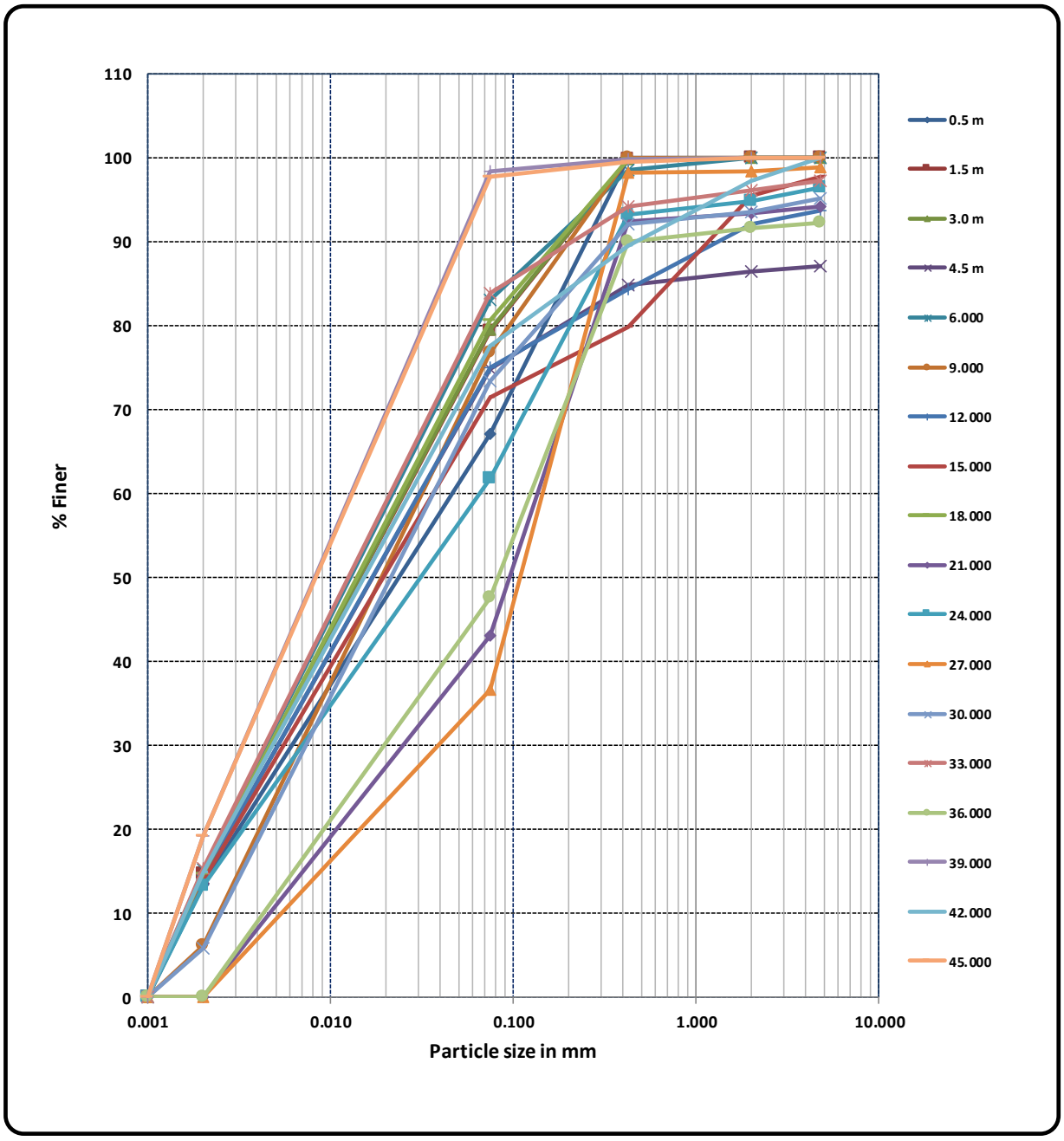
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-21



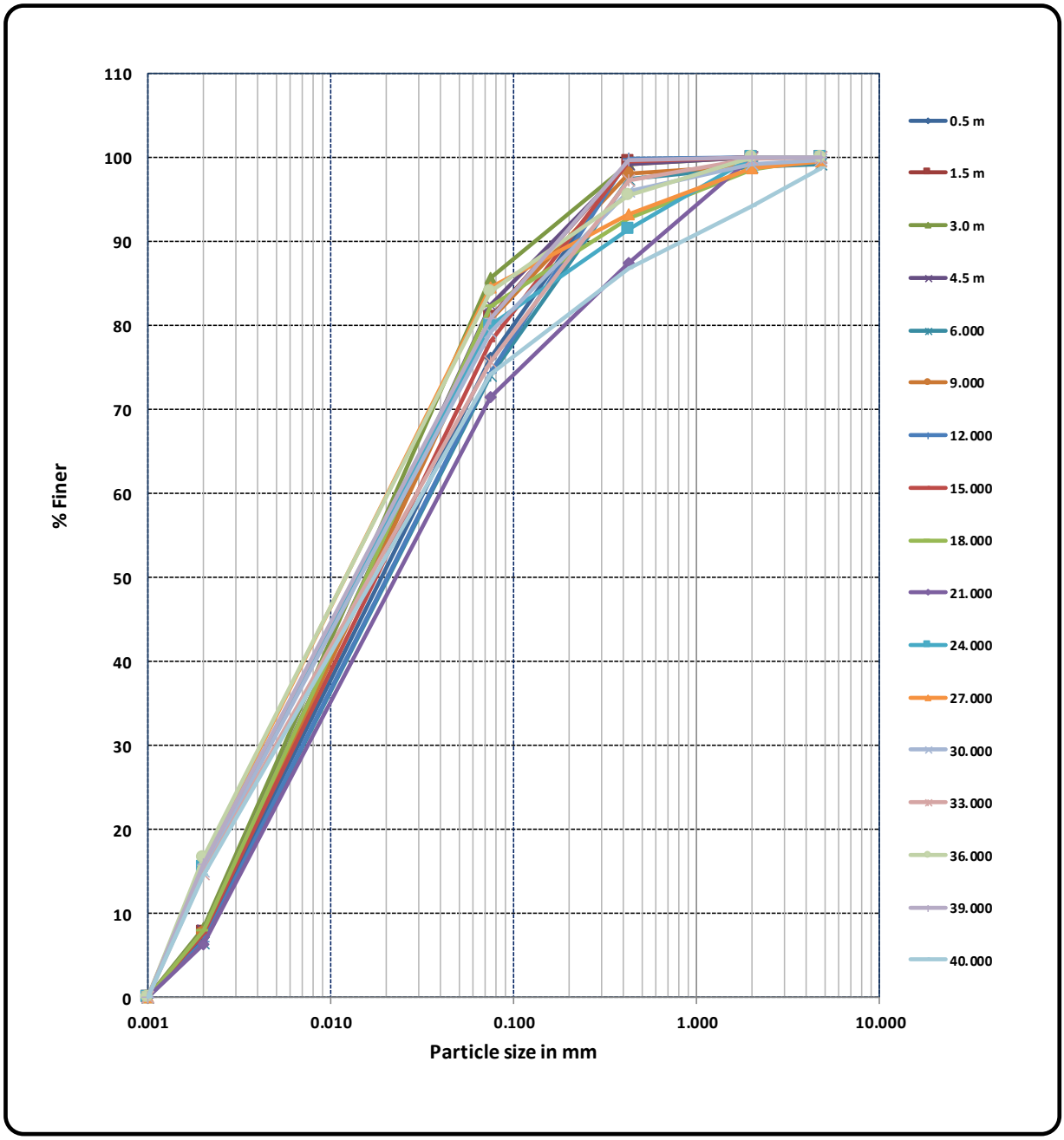
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-22



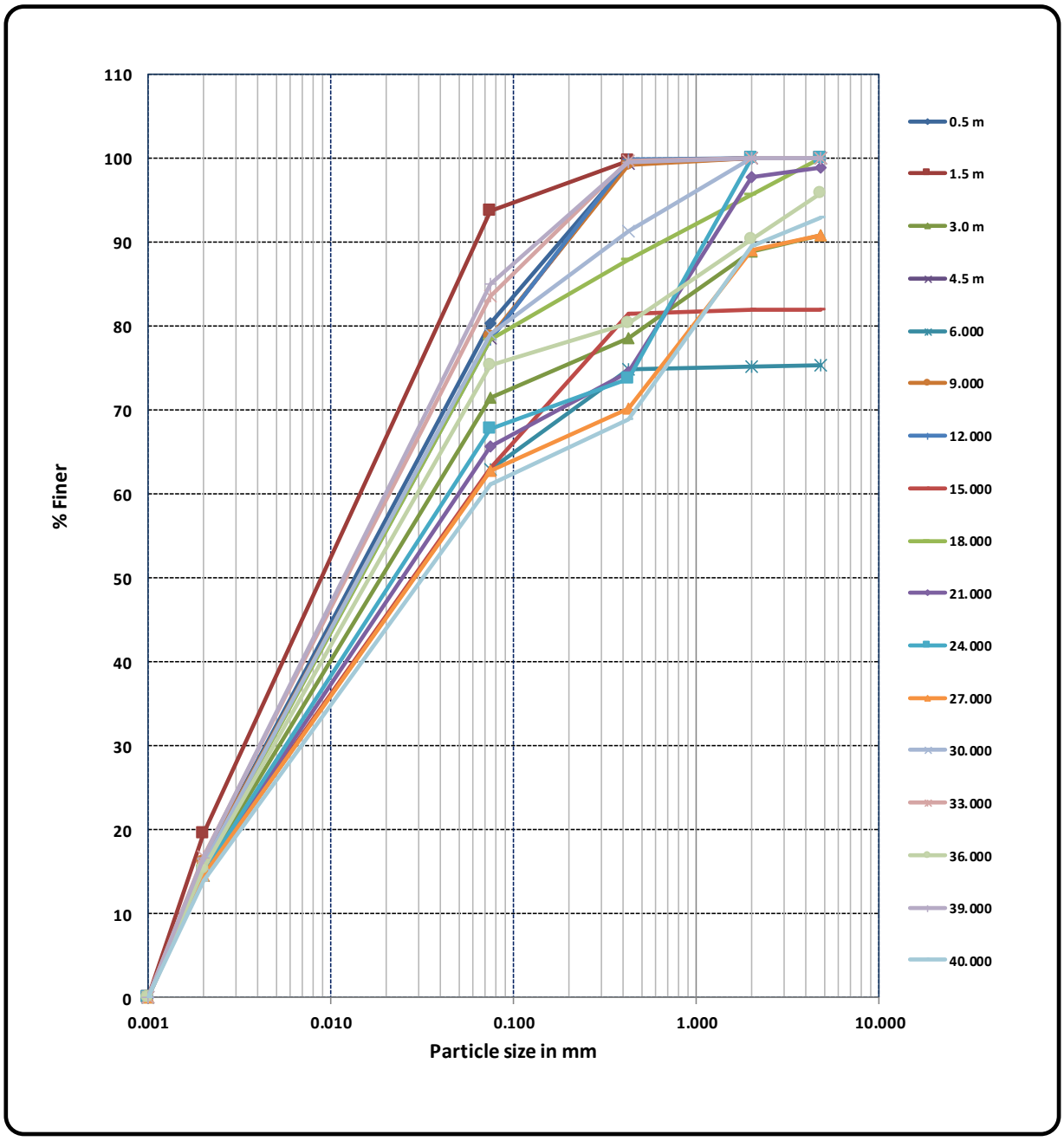
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-23



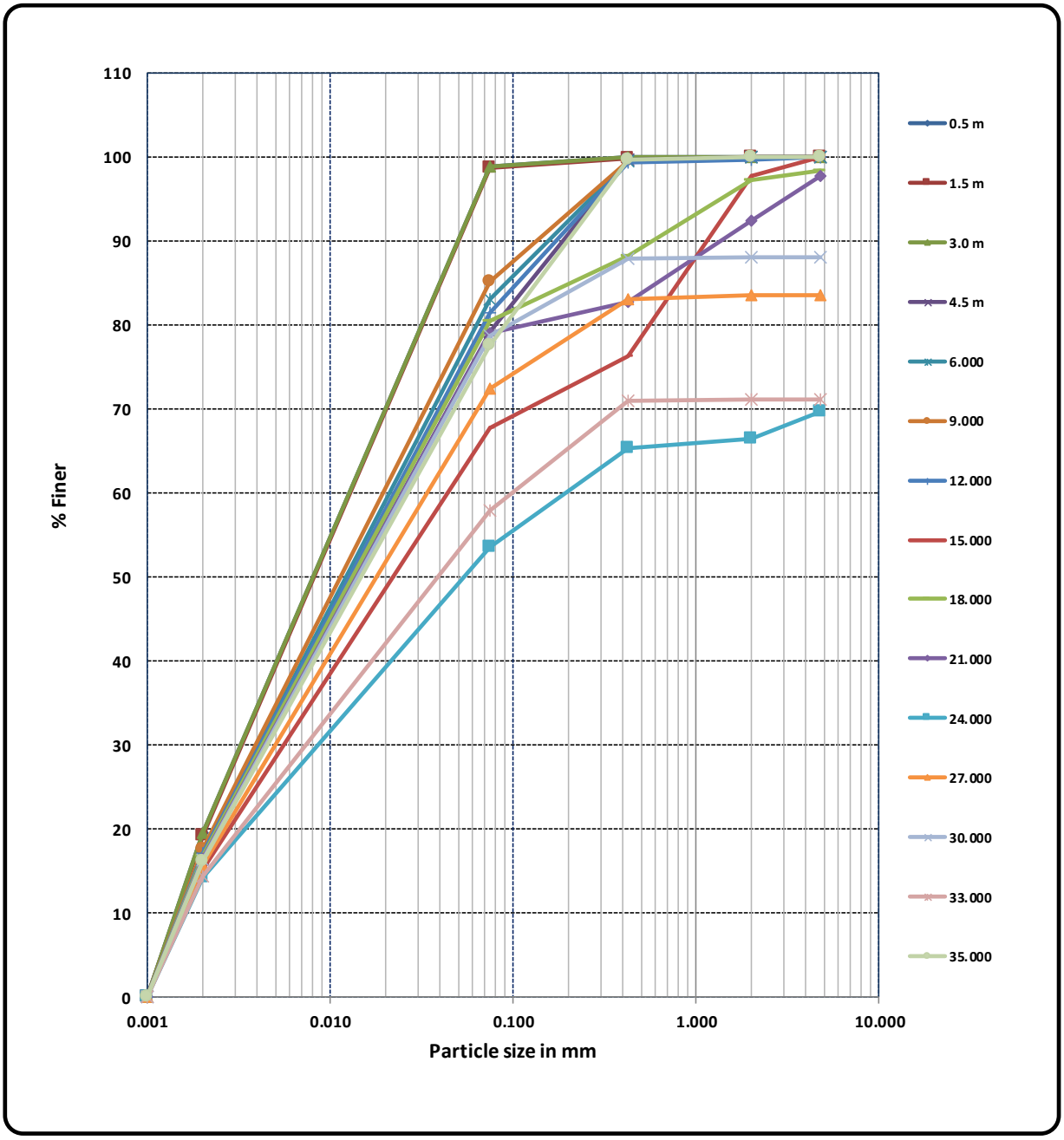
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-24



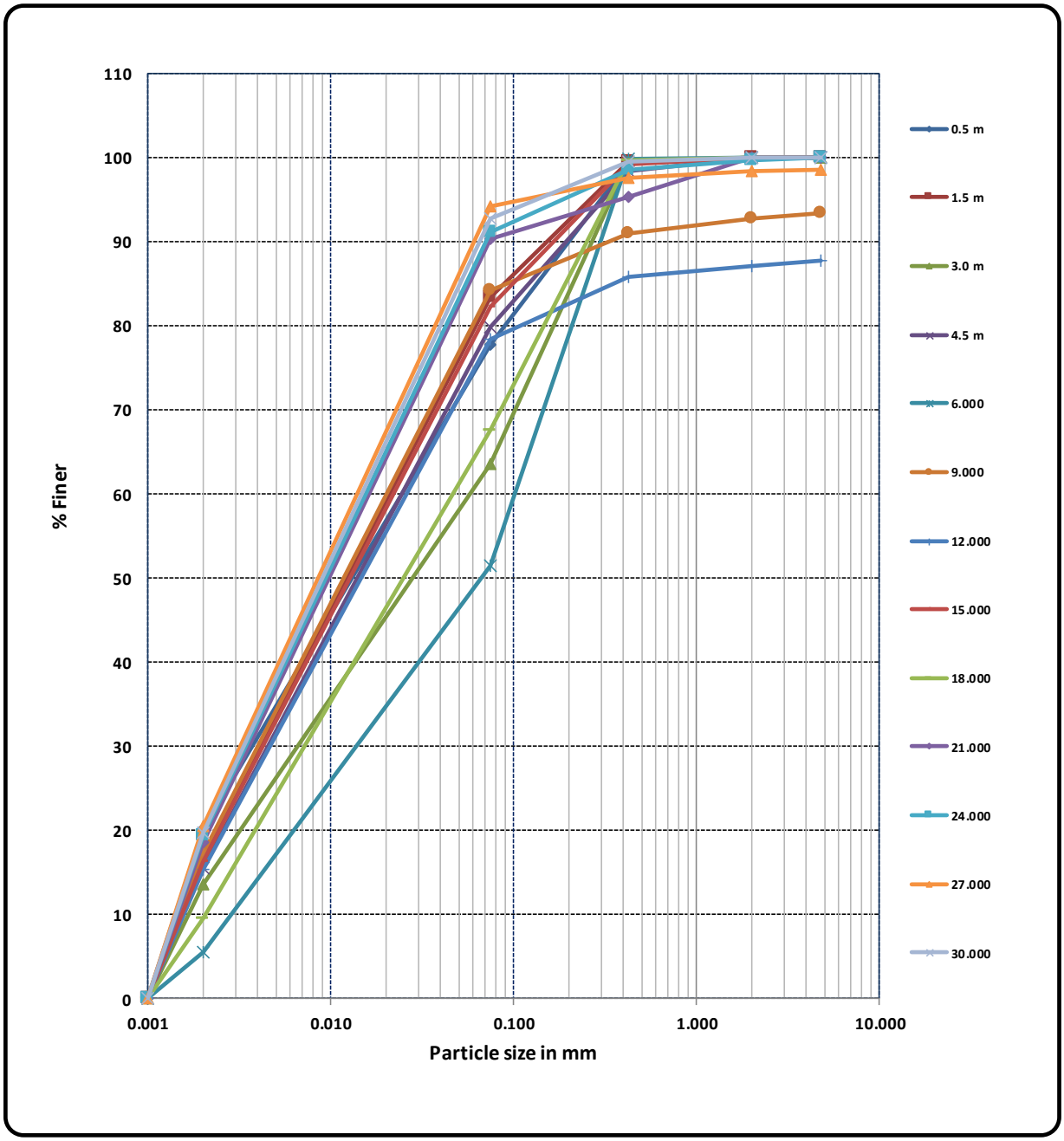
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-25



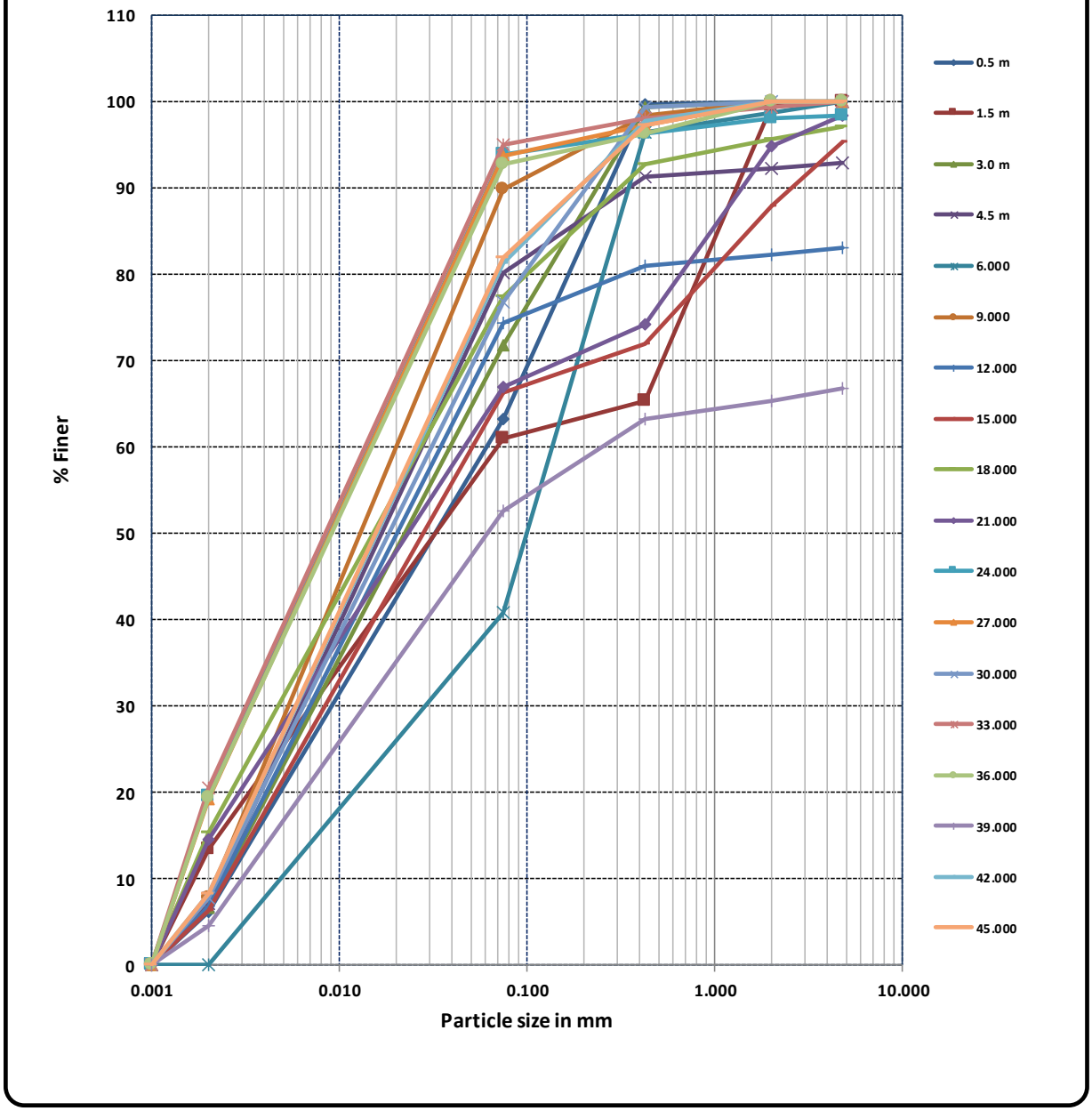
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-26



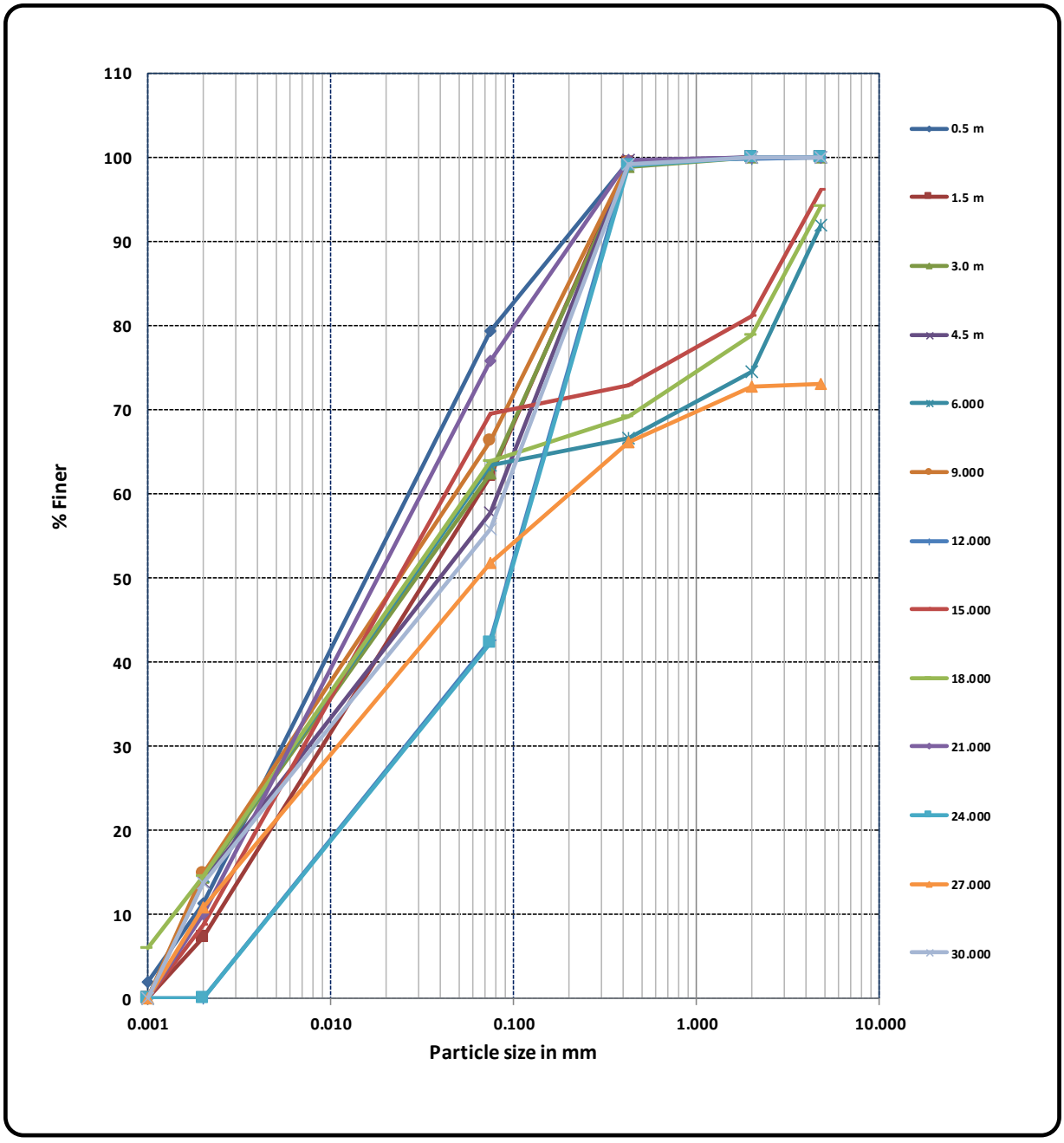
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-27



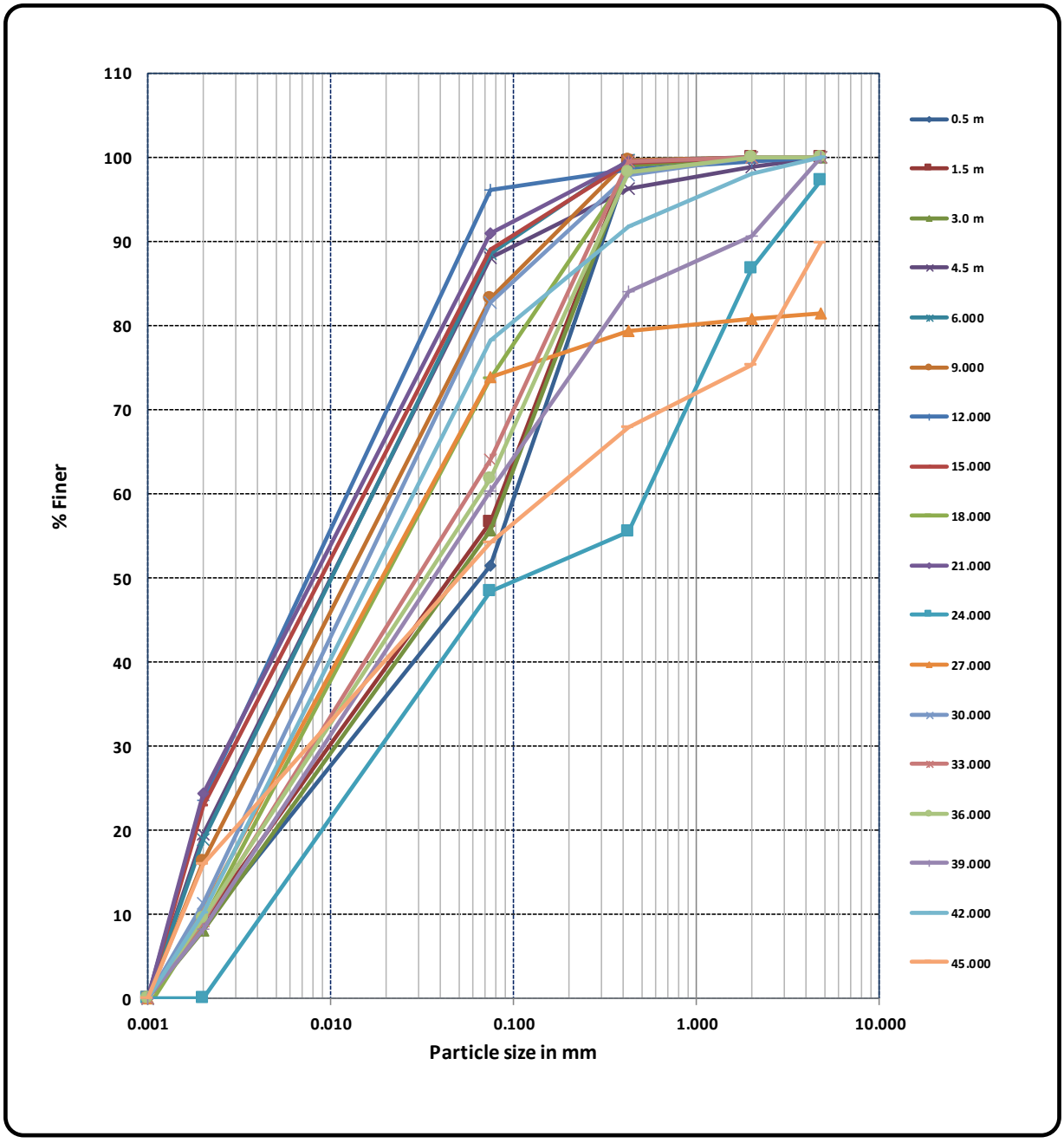
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-28



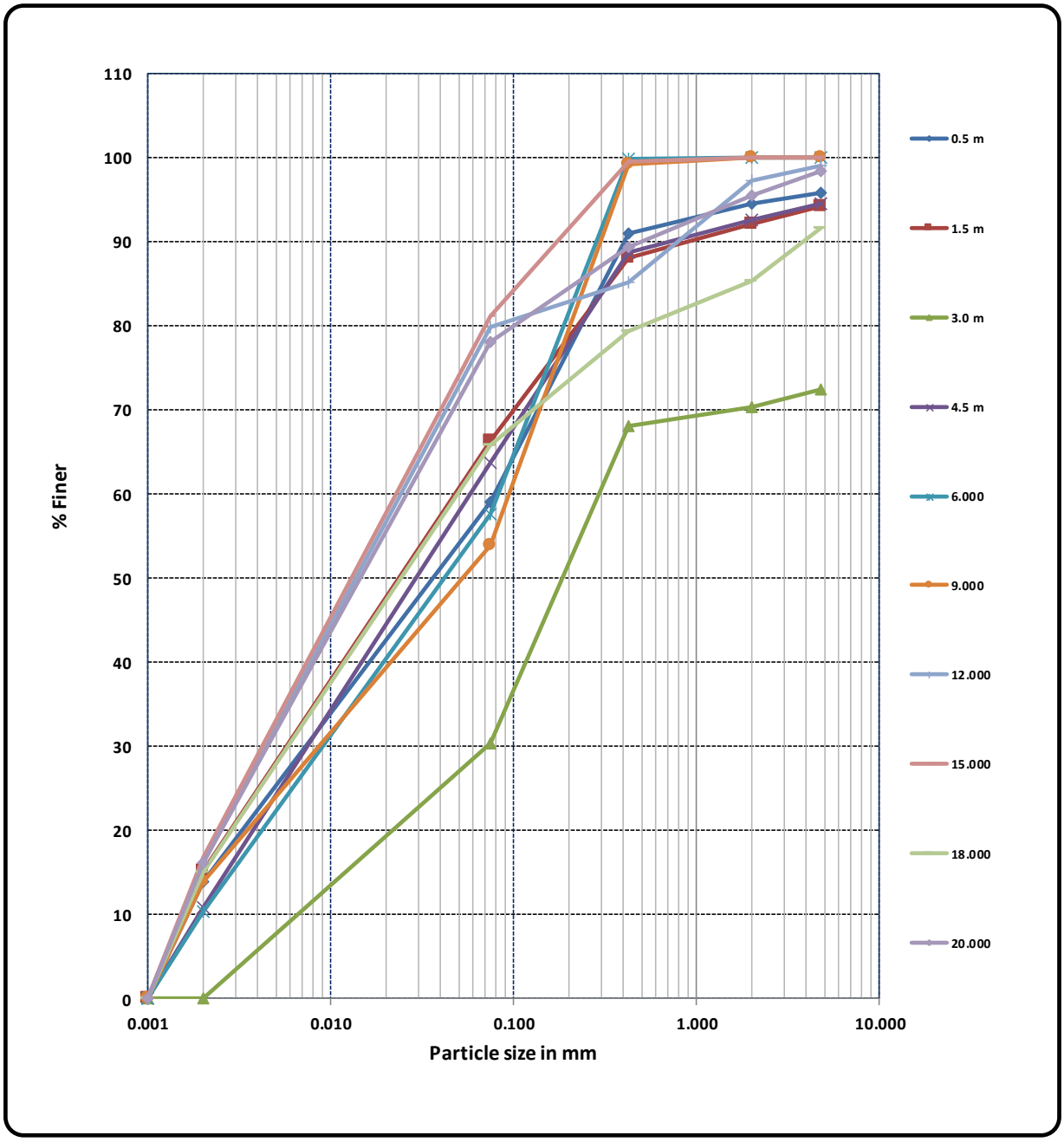
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-29



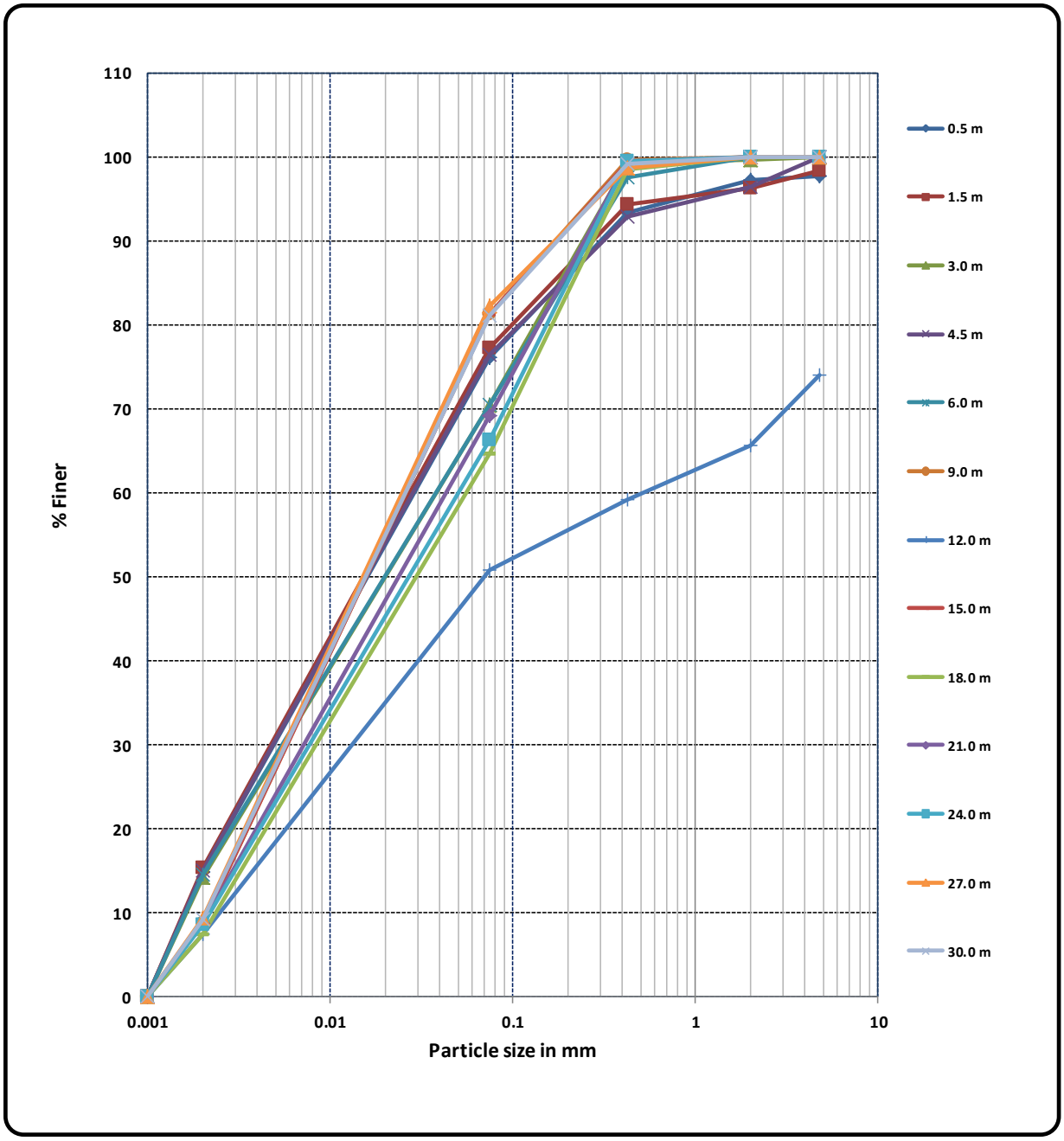
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-30



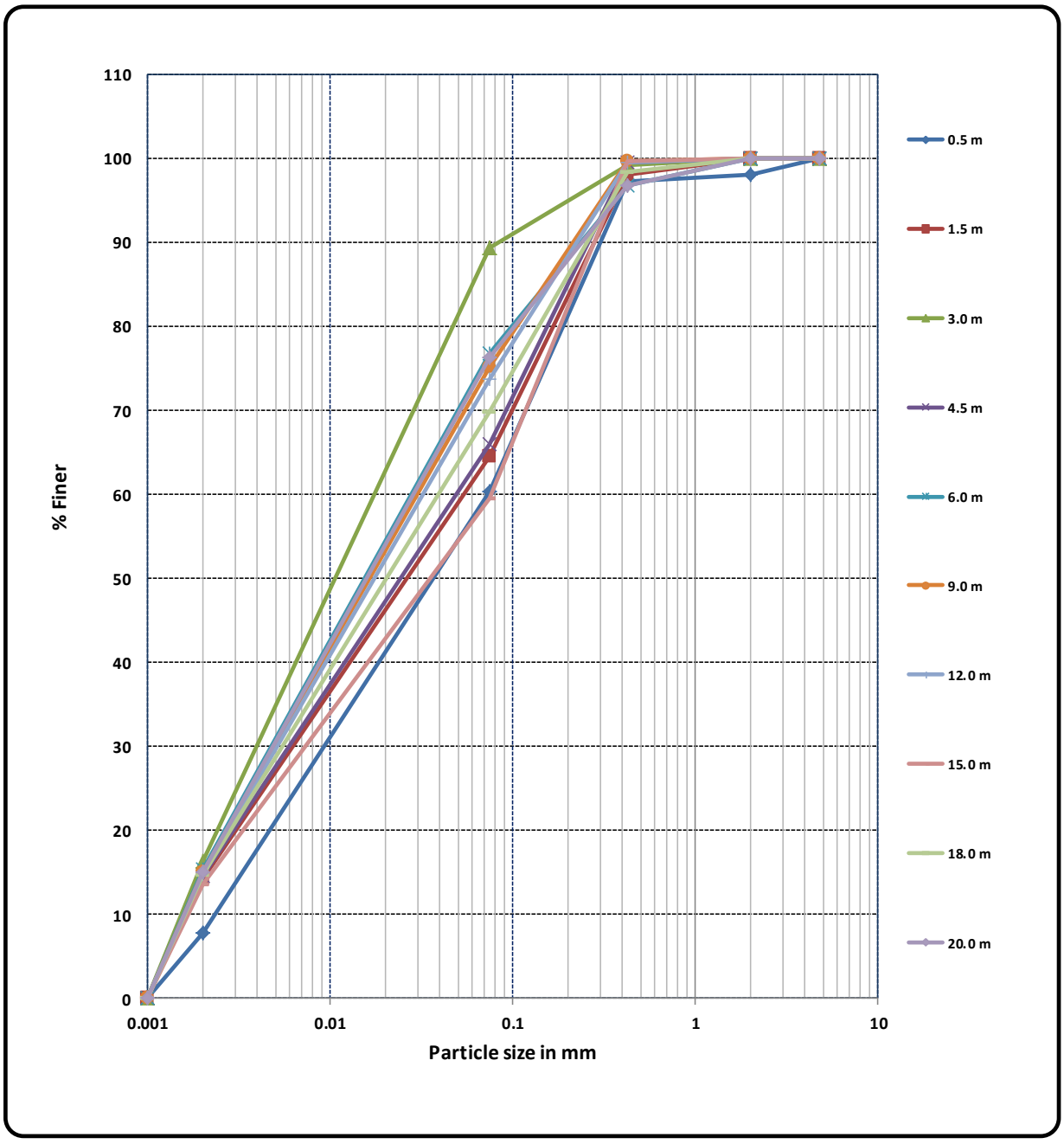
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-31



GRAIN SIZE DISTRIBUTION CURVE OF BH NO-32



GRAIN SIZE DISTRIBUTION CURVE OF BH NO-33



ANNEXURE –I
DESIGN PARAMETER & SPT N VALUE GRAPH

COMPUTATION OF CORRECTED N VALUE

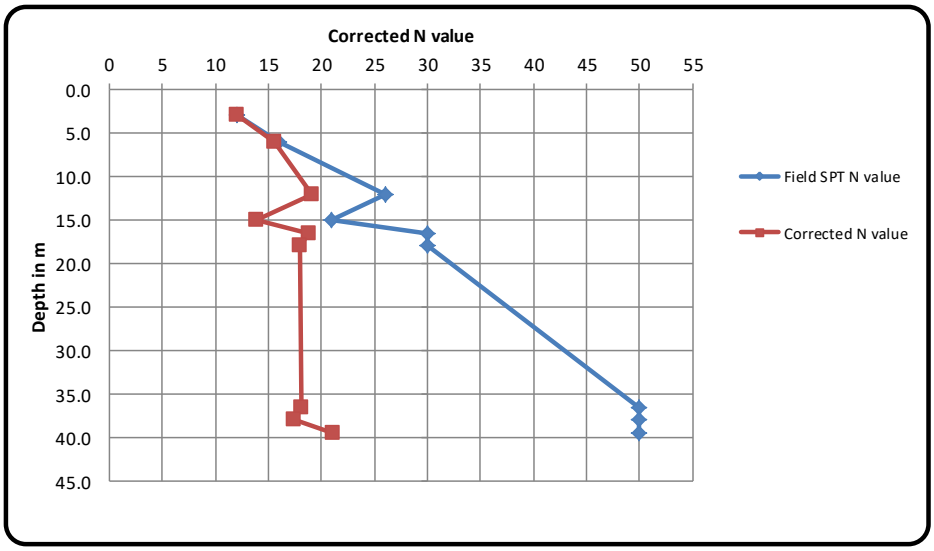
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-17(CH-25785 M)	3.0	38.6 M	ML-CL	12		1.785	0.536	1.00	12.0	12.0
2		6.0		ML-CL	16		1.834	1.100	0.97	15.5	15.5
3		12.0		ML-CL	26		1.853	2.224	0.73	19.1	19.1
4		15.0		ML-CL	21		1.853	2.780	0.66	13.9	13.9
5		16.5		ML-CL	37		1.853	3.057	0.63	18.8	18.8
6		18.0		ML-CL	>50	30	1.853	3.335	0.60	18.0	18.0
7		36.5		SM	>50	50	1.853	6.763	0.36	18.1	18.1
8		38.0		SM	>50	50	1.853	7.041	0.35	17.5	17.5
9		39.5		ML	>50	50	1.000	3.950	0.54	27.1	21.1

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-17



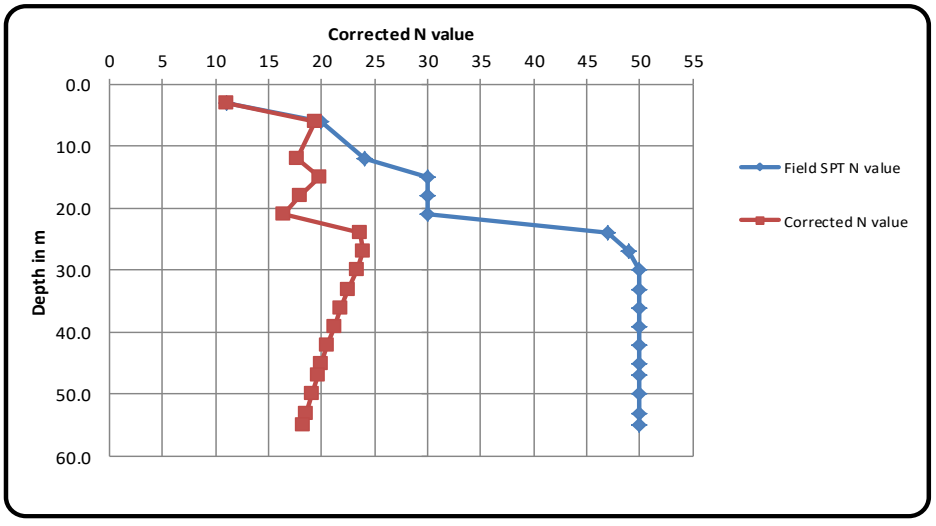
COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-18(CH-25990 M)	3.0	26.2 M	ML	11		1.784	0.535	1.00	11.0	11.0
2		6.0		ML	20		1.828	1.097	0.97	19.4	19.4
3		12.0		ML	24		1.853	2.224	0.73	17.6	17.6
4		15.0		ML-CL	31	30	1.853	2.780	0.66	19.8	19.8
5		18.0		ML-CL	35	30	1.853	3.335	0.60	18.0	18.0
6		21.0		ML-CL	40	30	1.853	3.891	0.55	16.4	16.4
7		24.0		ML	47		1.853	4.447	0.50	23.6	23.6
8		27.0		ML	49		1.000	2.700	0.67	32.8	23.9
9		30.0		ML	57	50	1.000	3.000	0.63	31.7	23.4
10		33.0		ML	64	50	1.000	3.300	0.60	30.1	22.6
11		36.0		ML	69	50	1.000	3.600	0.57	28.7	21.8
12		39.0		ML	77	50	1.000	3.900	0.55	27.3	21.2
13		42.0		ML	84	50	1.000	4.200	0.52	26.1	20.5
14		45.0		ML	>50	50	1.000	4.500	0.50	24.9	20.0
15		47.0		ML	>50	50	1.000	4.700	0.48	24.2	19.6
16		50.0		ML	>50	50	1.000	5.000	0.46	23.2	19.1
17		53.0		ML	>50	50	1.000	5.300	0.44	22.2	18.6
18		55.0		ML	>50	50	1.000	5.500	0.43	21.6	18.3

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-18



COMPUTATION OF CORRECTED N VALUE

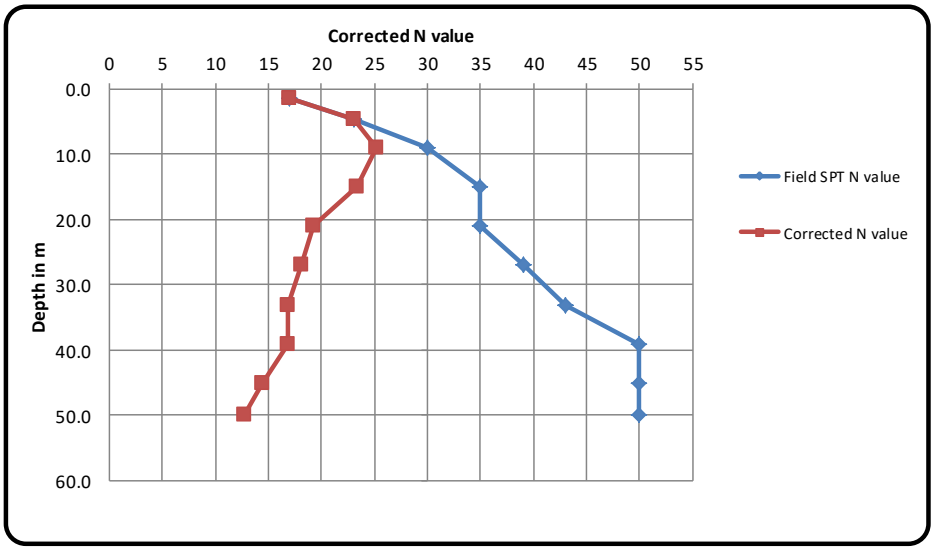
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-19(CH-26210 M)	1.5	NOT FOUND	ML	17		1.761	0.264	1.00	17.0	17.0
2		4.5		ML	23		1.776	0.799	1.00	23.0	23.0
3		9.0		ML	30		1.802	1.622	0.84	25.2	25.2
4		15.0		ML	35		1.819	2.729	0.67	23.3	23.3
5		21.0		ML	35		1.837	3.858	0.55	19.3	19.3
6		27.0		ML	39		1.856	5.011	0.46	18.1	18.1
7		33.0		SM	43		1.871	6.174	0.39	16.9	16.9
8		39.0		SM	52	50	1.871	7.297	0.34	16.9	16.9
9		45.0		SM	65	50	1.871	8.420	0.29	14.5	14.5
10		50.0		SM	80	50	1.871	9.355	0.25	12.7	12.7

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-19



COMPUTATION OF CORRECTED N VALUE

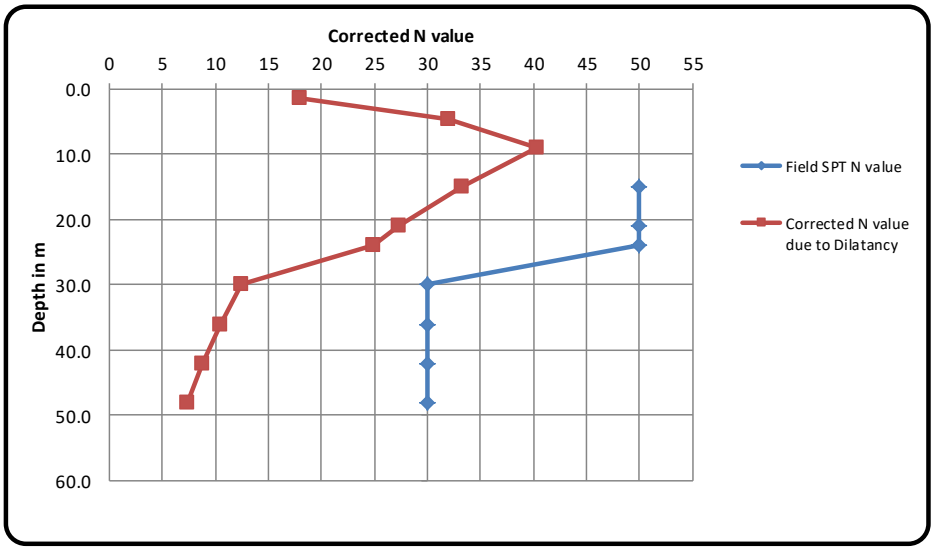
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-20(CH-26387 M)	1.5	NOT FOUND	ML	18		1.761	0.264	1.00	18.0	18.0
2		4.5		ML	32		1.778	0.800	1.00	32.0	32.0
3		9.0		ML	48		1.795	1.616	0.84	40.4	40.4
4		15.0		ML	60	50	1.830	2.745	0.66	33.2	33.2
5		21.0		ML	67	50	1.858	3.902	0.55	27.3	27.3
6		24.0		ML	76	50	1.879	4.510	0.50	24.9	24.9
7		30.0		CL	58	30	1.918	5.754	0.42	12.5	12.5
8		36.0		CL	67	30	1.946	7.006	0.35	10.5	10.5
9		42.0		CL	75	30	1.973	8.287	0.29	8.8	8.8
10		48.0		CL	79	30	1.988	9.542	0.25	7.4	7.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-20



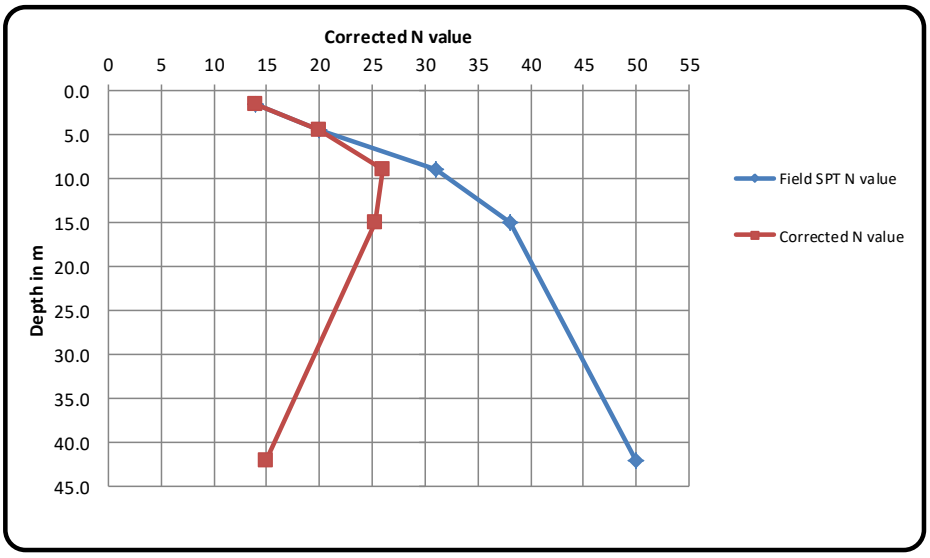
COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-21(CH-26587 M)	1.5	NOT FOUND	ML	14		1.768	0.265	1.00	14.0	14.0
2		4.5		ML	20		1.793	0.807	1.00	20.0	20.0
3		9.0		ML	31		1.821	1.639	0.84	25.9	25.9
4		15.0		ML	38		1.824	2.736	0.67	25.3	25.3
5		42.0		ML	77	50	1.942	8.156	0.30	15.0	15.0

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-21



COMPUTATION OF CORRECTED N VALUE

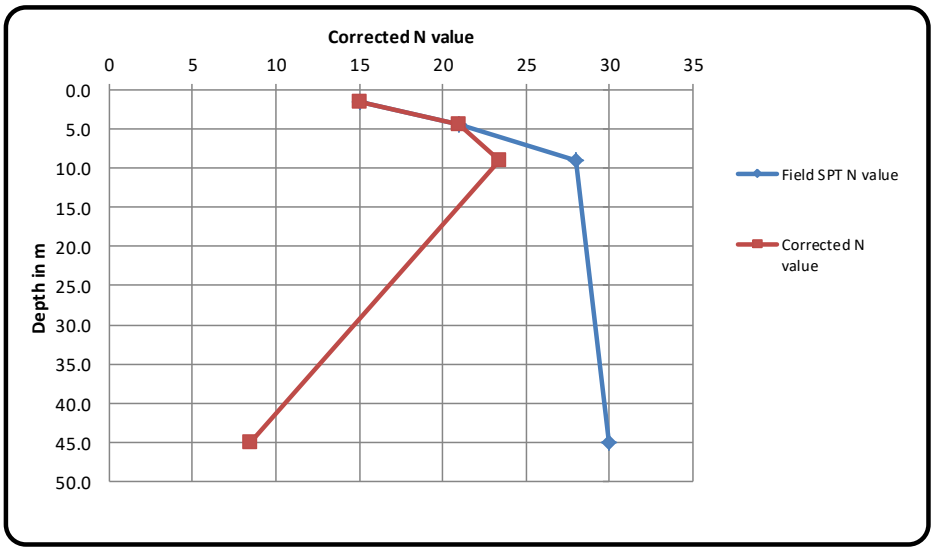
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-22(CH-26787 M)	1.5	NOT FOUND	ML	15		1.752	0.263	1.00	15.0	15.0
2		4.5		ML	21		1.789	0.805	1.00	21.0	21.0
3		9.0		ML	28		1.826	1.643	0.84	23.4	23.4
4		45.0		CL	60	30	1.916	8.622	0.28	8.4	8.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-22



COMPUTATION OF CORRECTED N VALUE

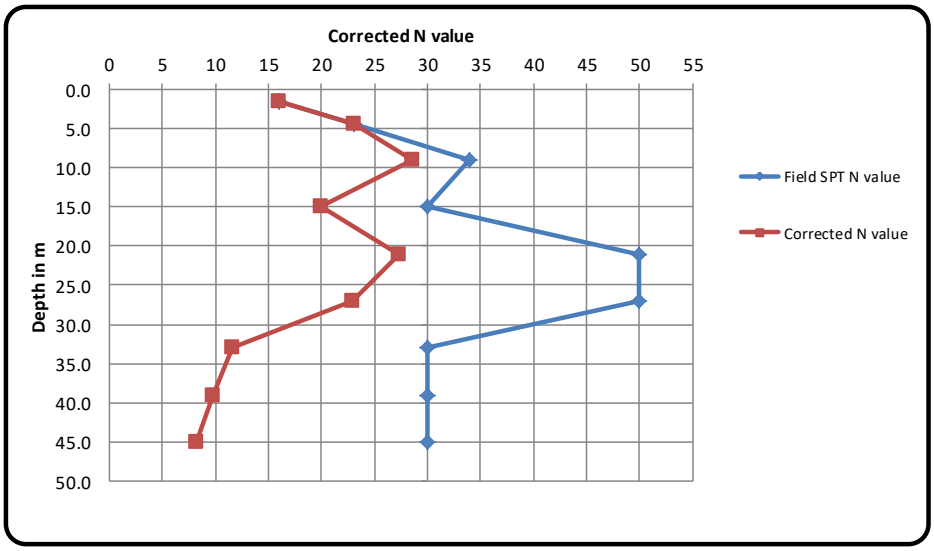
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-23(CH-26980 M)	1.5	NOT FOUND	CL	16		1.761	0.264	1.00	16.0	16.0
2		4.5		CL	23		1.778	0.800	1.00	23.0	23.0
3		9.0		ML	34		1.795	1.616	0.84	28.6	28.6
4		15.0		CL	38	30	1.830	2.745	0.66	19.9	19.9
5		21.0		SM	50		1.858	3.902	0.55	27.3	27.3
6		27.0		SM	63	50	1.879	5.073	0.46	22.9	22.9
7		33.0		CL	73	30	1.918	6.329	0.38	11.5	11.5
8		39.0		CL	77	30	1.946	7.589	0.32	9.7	9.7
9		45.0		CL	85	30	1.973	8.879	0.27	8.1	8.1

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-23



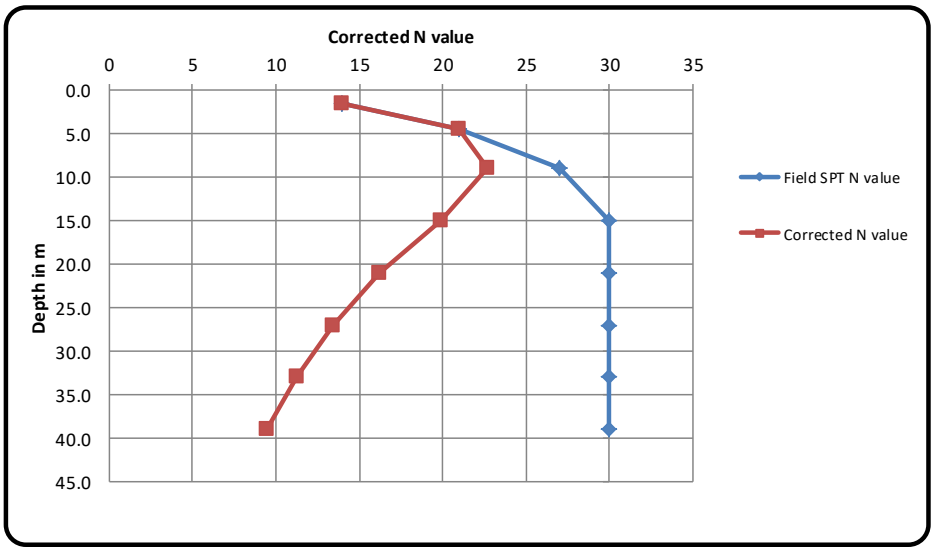
COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-24(CH-27187 M)	1.5	NOT FOUND	CL	14		1.761	0.264	1.00	14.00	14.0
2		4.5		CL	21		1.773	0.798	1.00	21.00	21.0
3		9.0		CL	27		1.804	1.624	0.84	22.67	22.7
4		15.0		CL	33	30	1.831	2.747	0.66	19.92	19.9
5		21.0		CL	43	30	1.887	3.963	0.54	16.24	16.2
6		27.0		CL	58	30	1.946	5.254	0.45	13.41	13.4
7		33.0		CL	72	30	1.975	6.518	0.37	11.25	11.2
8		39.0		CL	89	30	2.005	7.820	0.31	9.42	9.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-24



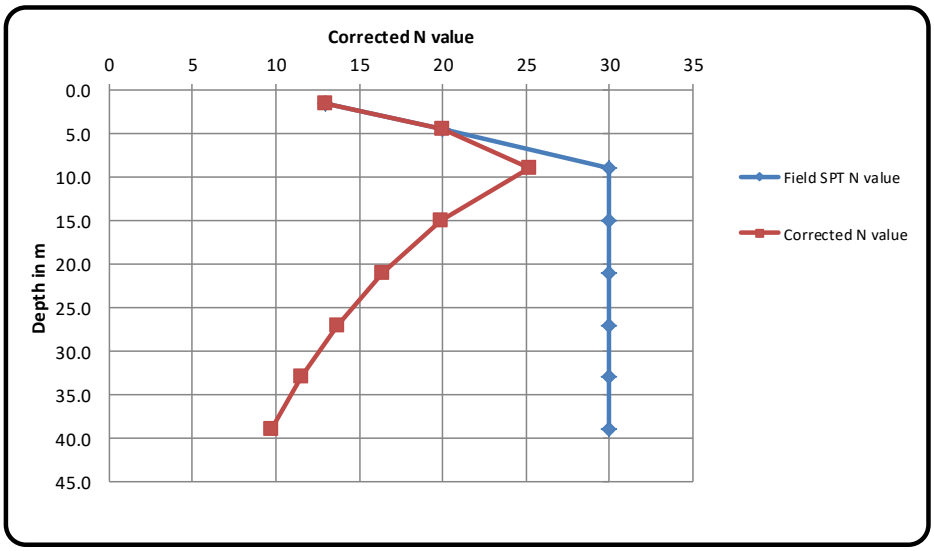
COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-25(CH-27410 M)	1.5	NOT FOUND	CL	13		1.758	0.264	1.00	13.00	13.0
2		4.5		CL	20		1.768	0.796	1.00	20.00	20.0
3		9.0		CL	30		1.797	1.617	0.84	25.23	25.2
4		15.0		CL	31	30	1.831	2.747	0.66	19.92	19.9
5		21.0		CL	33	30	1.862	3.910	0.55	16.37	16.4
6		27.0		CL	48	30	1.892	5.108	0.46	13.69	13.7
7		33.0		CL	68	30	1.921	6.339	0.38	11.53	11.5
8		39.0		CL	81	30	1.944	7.582	0.32	9.73	9.7

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-25



COMPUTATION OF CORRECTED N VALUE

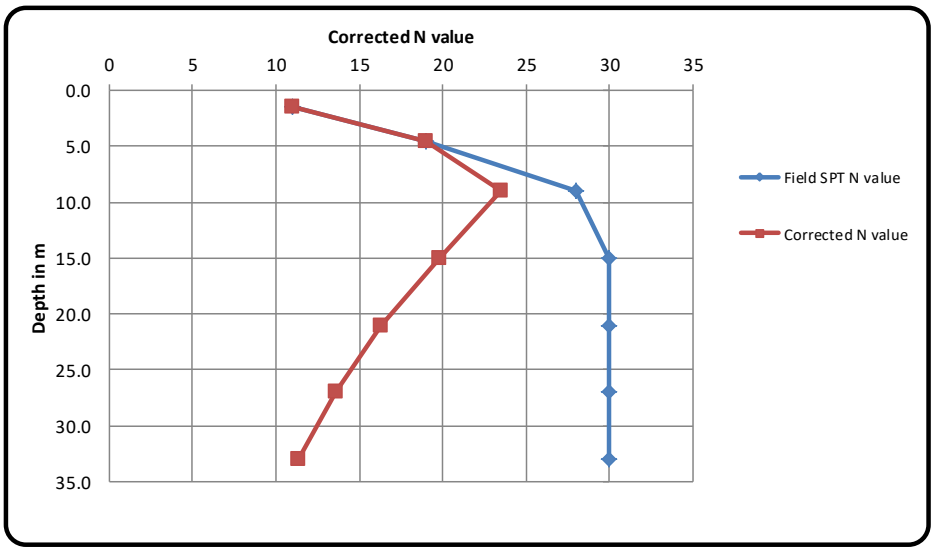
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-26(CH-27550 M)	1.5	NOT FOUND	CL	11		1.763	0.264	1.00	11.00	11.0
2		4.5		CL	19		1.782	0.802	1.00	19.00	19.0
3		9.0		CL	28		1.815	1.634	0.84	23.46	23.5
4		15.0		CL	34	30	1.844	2.766	0.66	19.85	19.8
5		21.0		CL	41	30	1.875	3.938	0.54	16.30	16.3
6		27.0		CL	53	30	1.913	5.165	0.45	13.58	13.6
7		33.0		CL	65	30	1.947	6.425	0.38	11.39	11.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-26



COMPUTATION OF CORRECTED N VALUE

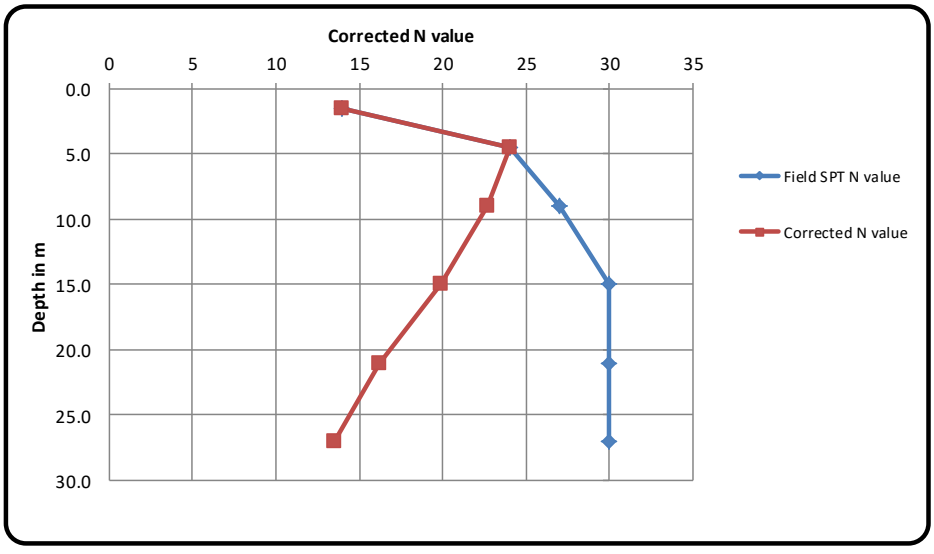
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-27(CH-28050 M)	1.5	NOT FOUND	CL	14		1.758	0.264	1.00	14.00	14.0
2		4.5		CL	24		1.768	0.796	1.00	24.00	24.0
3		9.0		CL	27		1.802	1.622	0.84	22.68	22.7
4		15.0		CL	36	30	1.839	2.759	0.66	19.87	19.9
5		21.0		CL	45	30	1.885	3.959	0.54	16.25	16.3
6		27.0		CL	54	30	1.929	5.208	0.45	13.50	13.5

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-27



COMPUTATION OF CORRECTED N VALUE

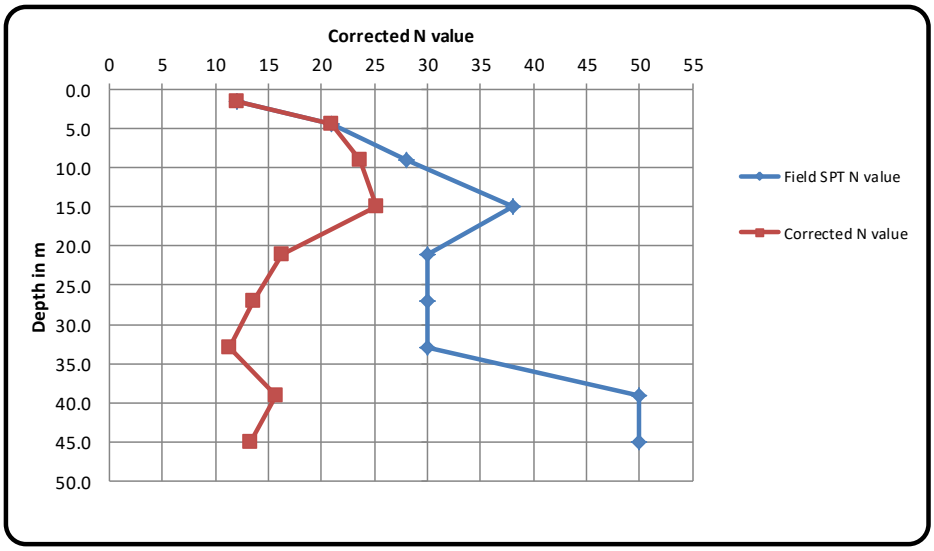
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-28(CH-28350M)	1.5	NOT FOUND	CL	12		1.763	0.264	1.00	12.0	12.0
2		4.5		ML	21		0.772	0.347	1.00	21.0	21.0
3		9.0		ML	28		1.794	1.615	0.84	23.6	23.6
4		15.0		ML	38		1.836	2.754	0.66	25.2	25.2
5		21.0		CL	47	30	1.883	3.954	0.54	16.3	16.3
6		27.0		CL	53	30	1.912	5.162	0.45	13.6	13.6
7		33.0		CL	70	30	1.955	6.452	0.38	11.4	11.4
8		39.0		ML	81	50	1.998	7.792	0.32	15.8	15.8
9		45.0		ML	92	50	2.009	9.041	0.27	13.3	13.3

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-28



COMPUTATION OF CORRECTED N VALUE

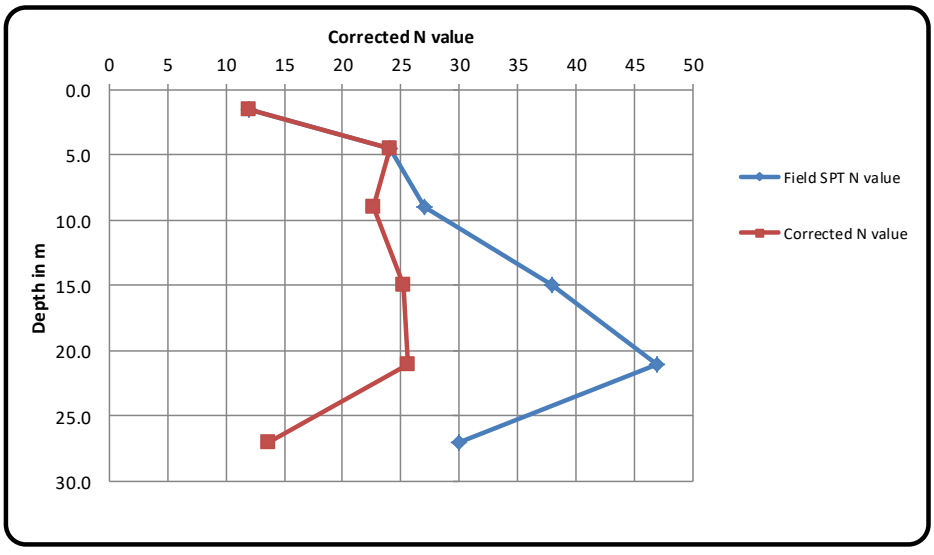
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-29(CH-28550 M)	1.5	NOT FOUND	ML	12		1.761	0.264	1.00	12.0	12.0
2		4.5		ML-CL	24		1.778	0.800	1.00	24.0	24.0
3		9.0		ML-CL	27		1.798	1.618	0.84	22.7	22.7
4		15.0		ML	38		1.829	2.744	0.66	25.2	25.2
5		21.0		ML	47		1.865	3.917	0.55	25.6	25.63
6		27.0		ML-CL	61	30	1.898	5.125	0.46	13.7	13.66

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-29



Geotechnical Investigation Report			
Consultant:			*Client :*
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830	Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

COMPUTATION OF CORRECTED N VALUE

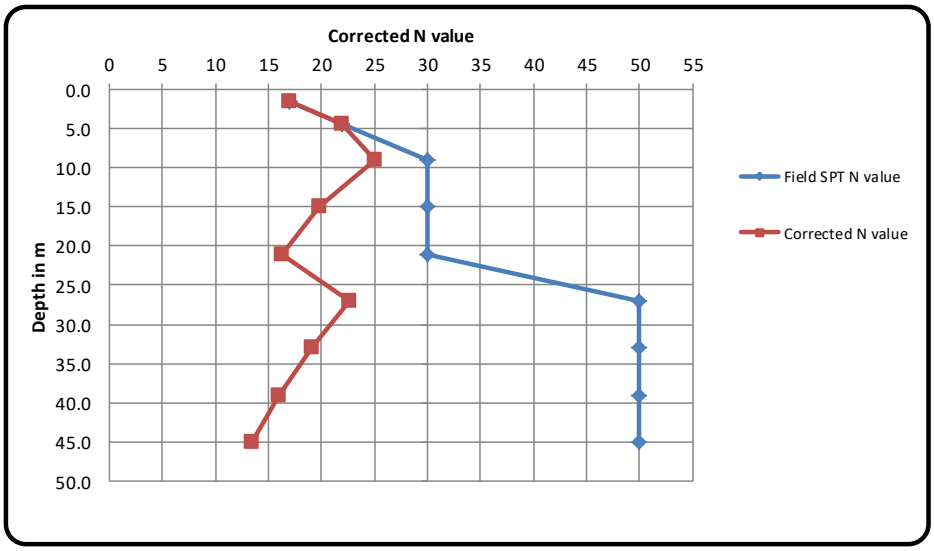
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-30(CH-28750 M)	1.5	NOT FOUND	ML	17		1.768	0.265	1.00	17.0	17.0
2		4.5		ML-CL	22		1.792	0.806	1.00	22.0	22.0
3		9.0		ML-CL	30		1.831	1.648	0.83	25.0	25.0
4		15.0		CL	38	30	1.855	2.783	0.66	19.8	19.8
5		21.0		CL	44	30	1.871	3.929	0.54	16.3	16.3
6		27.0		ML	56	50	1.907	5.149	0.45	22.7	22.7
7		33.0		ML	64	50	1.941	6.405	0.38	19.0	19.0
8		39.0		ML	73	50	1.971	7.687	0.32	16.0	16.0
9		45.0		ML	84	50	1.995	8.978	0.27	13.4	13.4

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-30



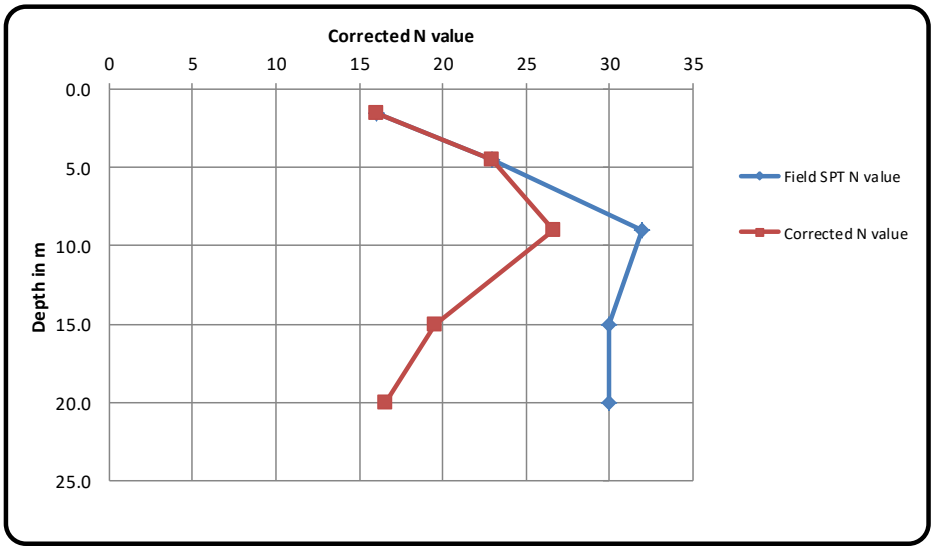
COMPUTATION OF CORRECTED N VALUE

Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-31(CH-29050 M)	1.5	NOT FOUND	CL	16		1.765	0.265	1.00	16.0	16.0
2		4.5		ML	23		1.786	0.804	1.00	23.0	23.0
3		9.0		ML	32		1.845	1.661	0.83	26.6	26.6
4		15.0		ML-CL	40	30	1.904	2.856	0.65	19.5	19.5
5		20.0		ML-CL	51	30	1.926	3.852	0.55	16.5	16.52

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-31



COMPUTATION OF CORRECTED N VALUE

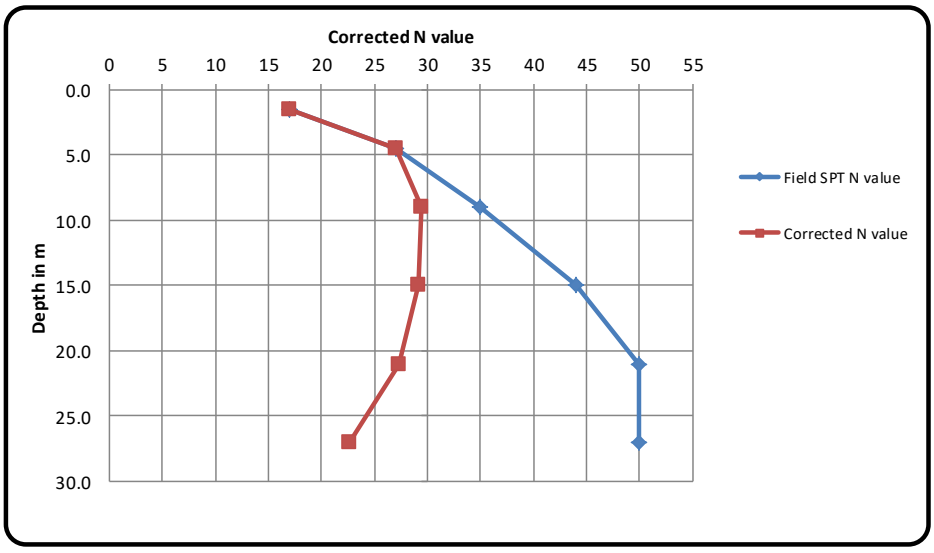
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-32(CH-29550 M)	1.5	NOT FOUND	ML-CL	17		1.754	0.263	1.00	17.0	17.0
2		4.5		ML-CL	27		1.769	0.796	1.00	27.0	27.0
3		9.0		ML	35		1.804	1.624	0.84	29.4	29.4
4		15.0		ML	44		1.835	2.753	0.66	29.2	29.2
5		21.0		ML	54	50	1.864	3.914	0.55	27.3	27.3
6		27.0		ML	63	50	1.909	5.154	0.45	22.7	22.7

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

STANDARD PENETRATION TEST OF BH NO-32



COMPUTATION OF CORRECTED N VALUE

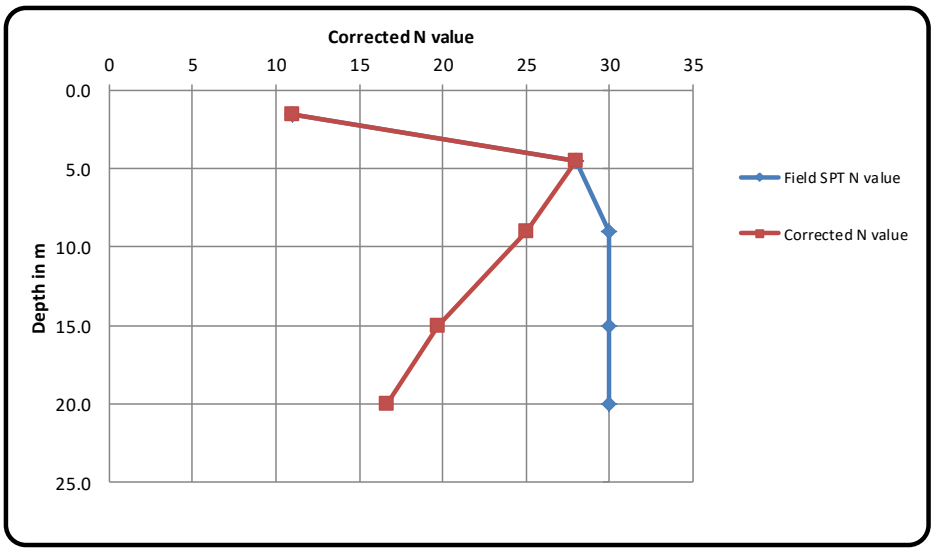
Sl No.	Bridge No.	Depth from G.L in m.	Water table in m	Group of soil	Field SPT N value		Density gm/cm^3	overburden pressure in kg/cm^2	overburden correction factor	Corrected N value due to overburden	Corrected N value due to Dilatancy
1	BH-33(CH-30125 M)	1.5	NOT FOUND	ML-CL	11		1.772	0.266	1.00	11.0	11.0
2		4.5		ML-CL	28		1.793	0.807	1.00	28.0	28.0
3		9.0		ML-CL	39	30	1.828	1.645	0.84	25.1	25.1
4		15.0		ML-CL	50	30	1.874	2.811	0.66	19.7	19.7
5		20.0		ML-CL	63	30	1.901	3.802	0.56	16.7	16.7

Note: Above Strength parameters (C& ϕ) are calculated theoritically from N value.

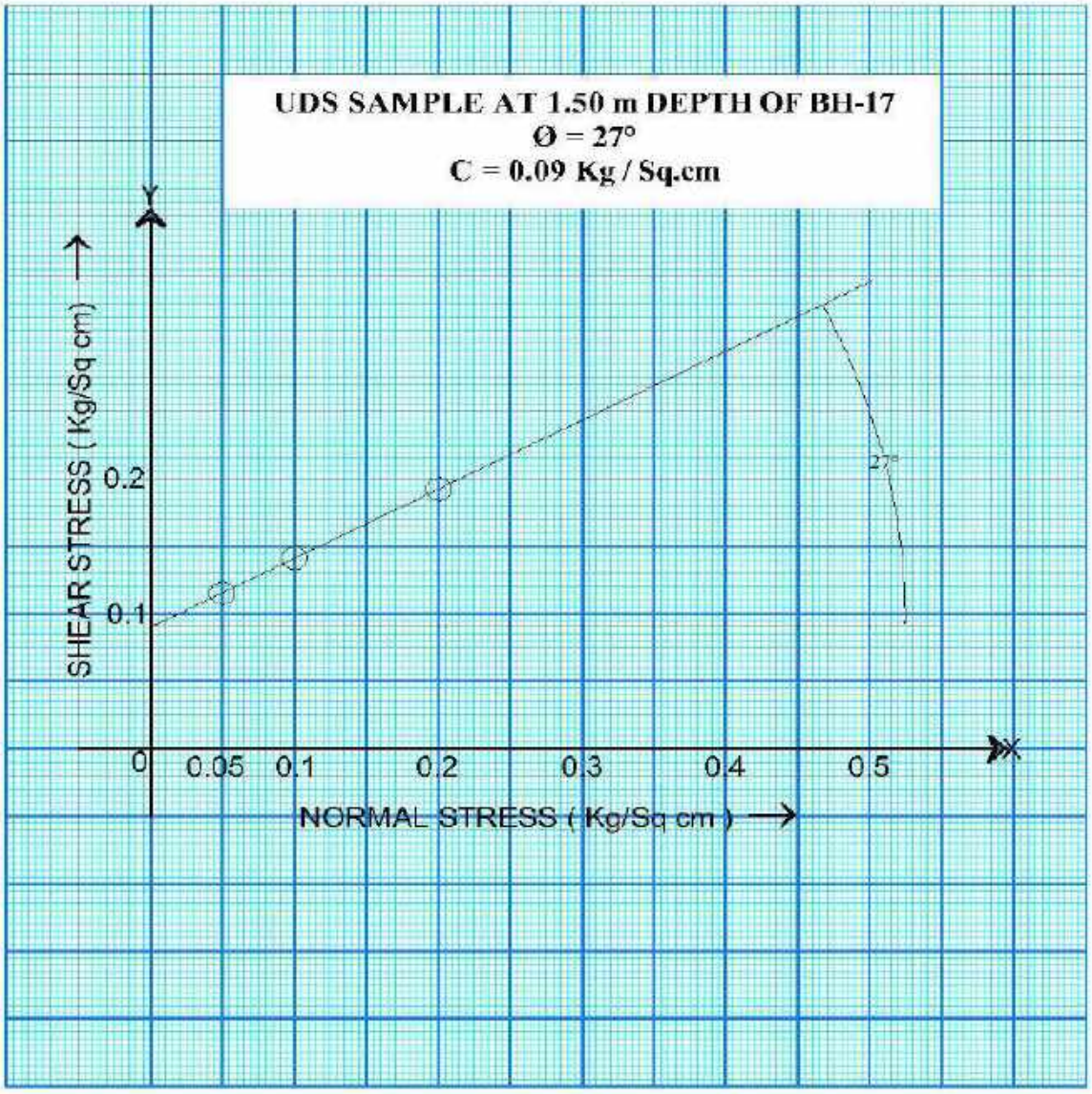
1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

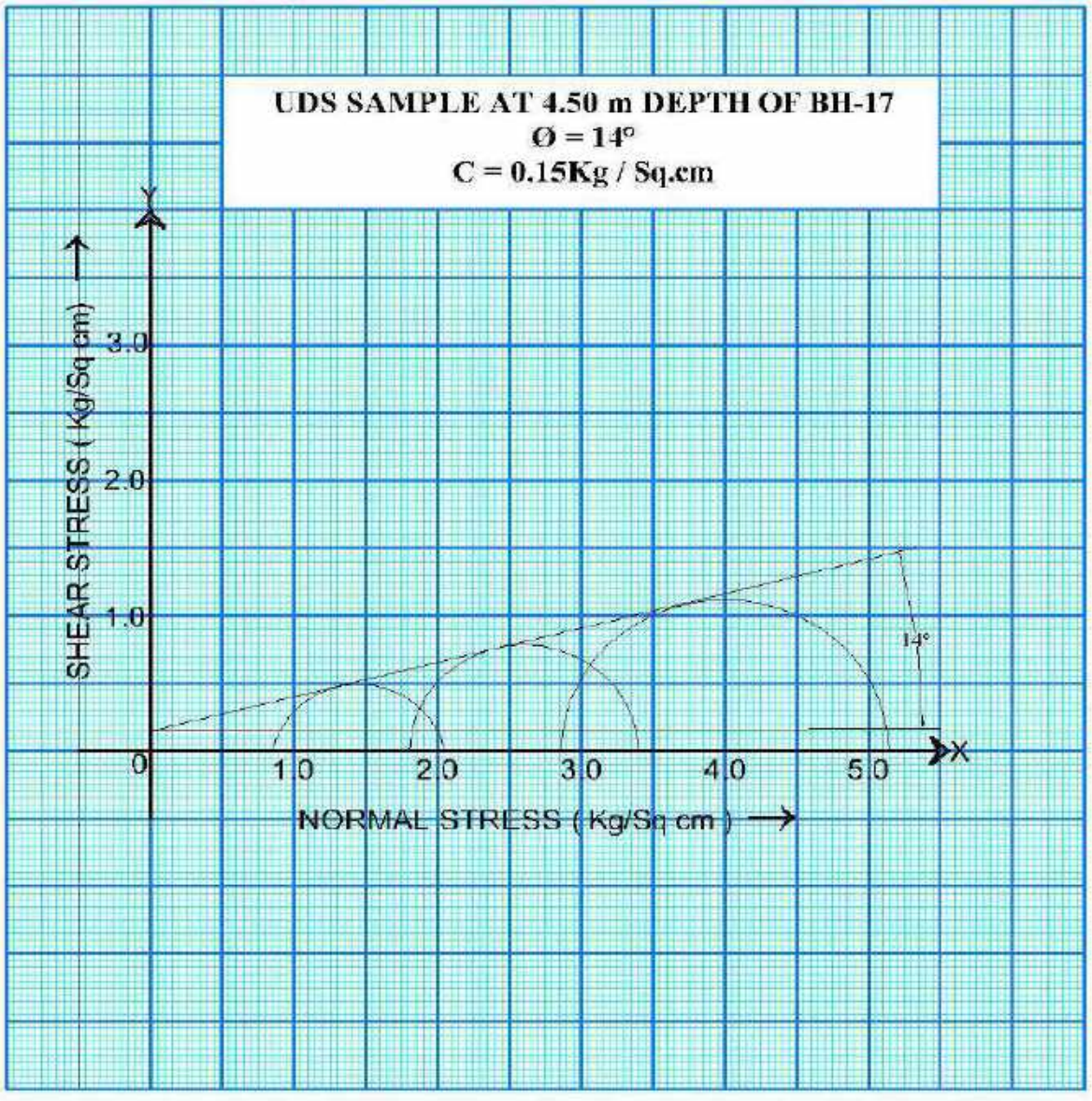
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance (ϕ), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

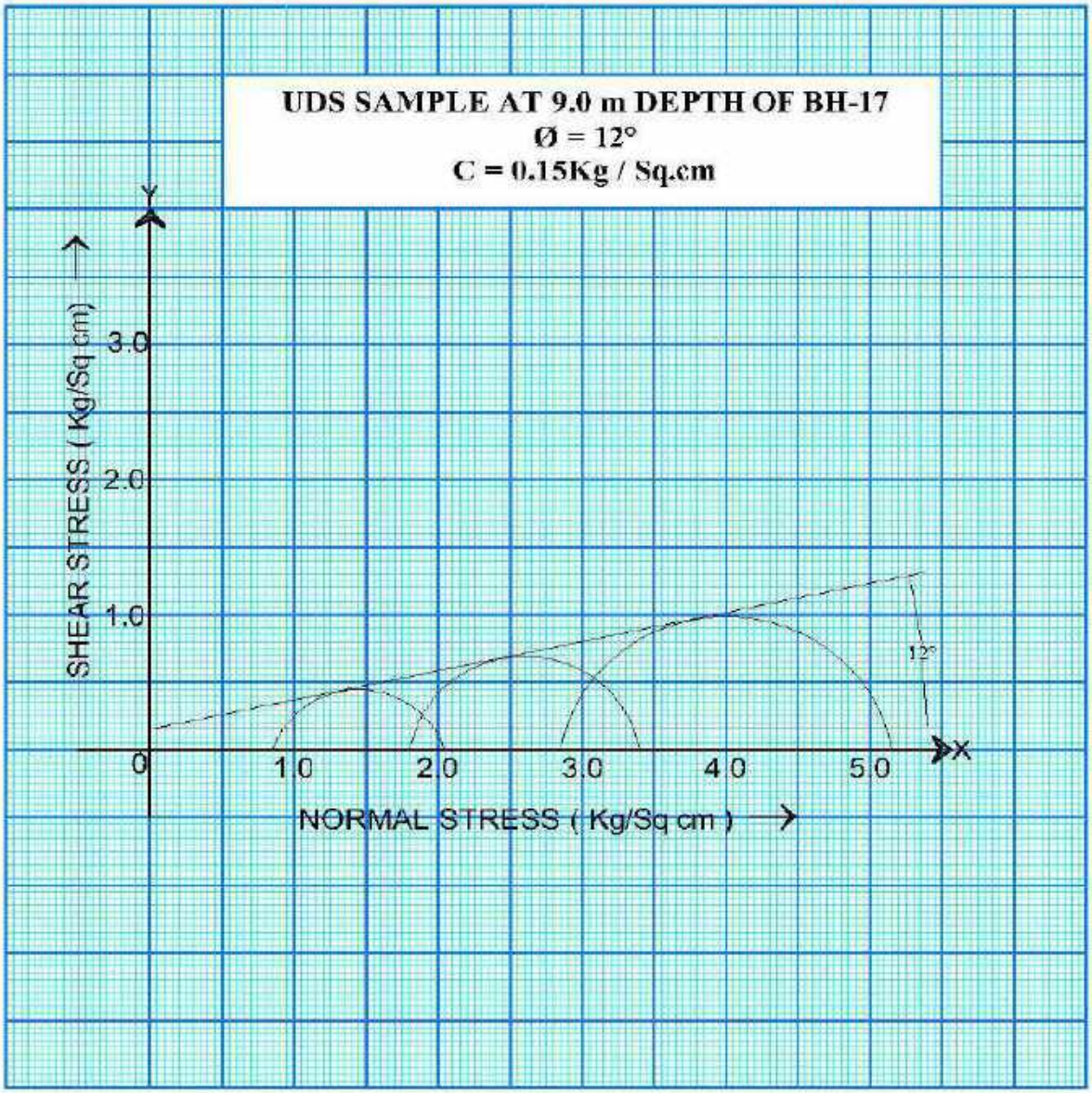
STANDARD PENETRATION TEST OF BH NO-33

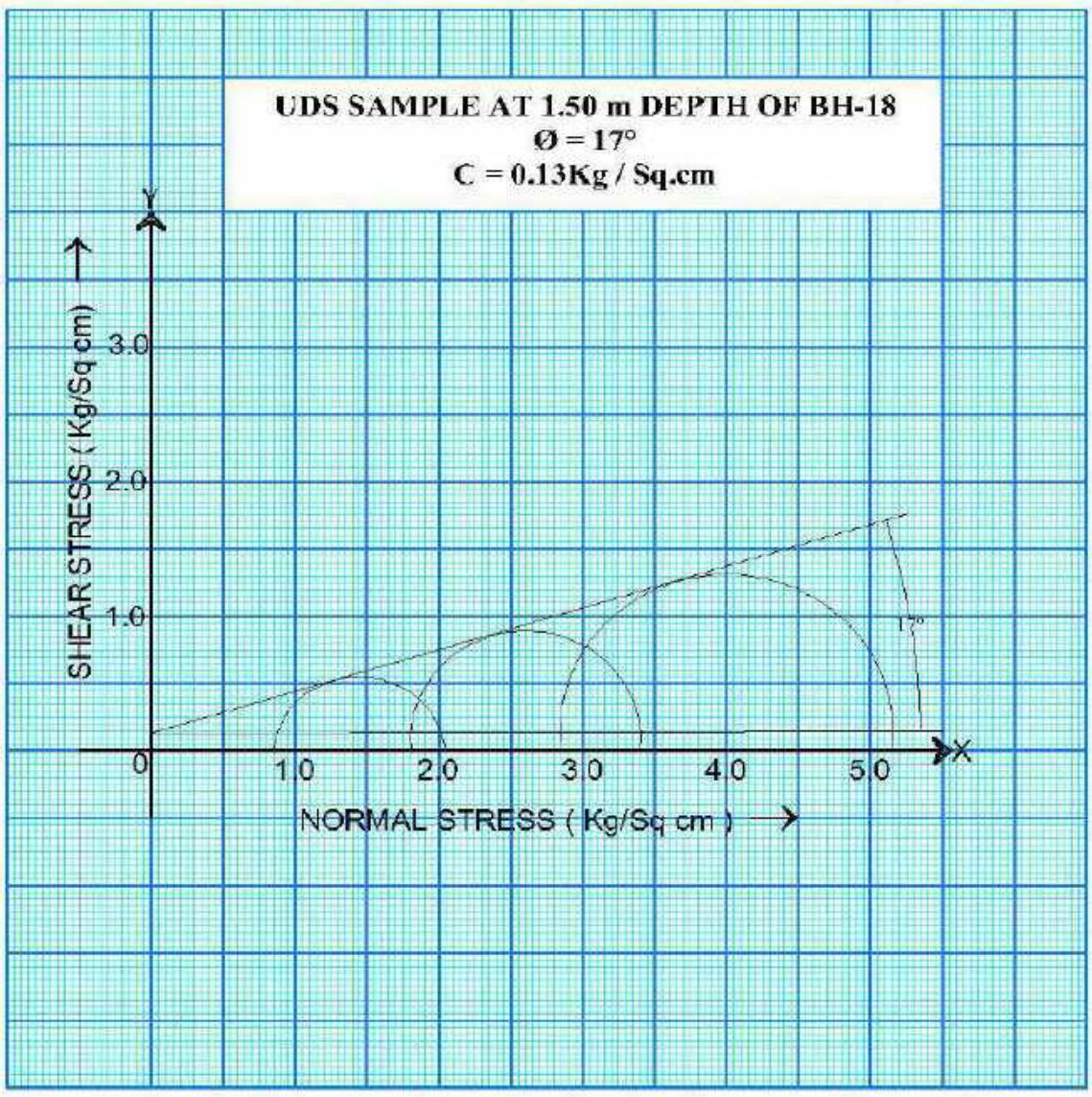


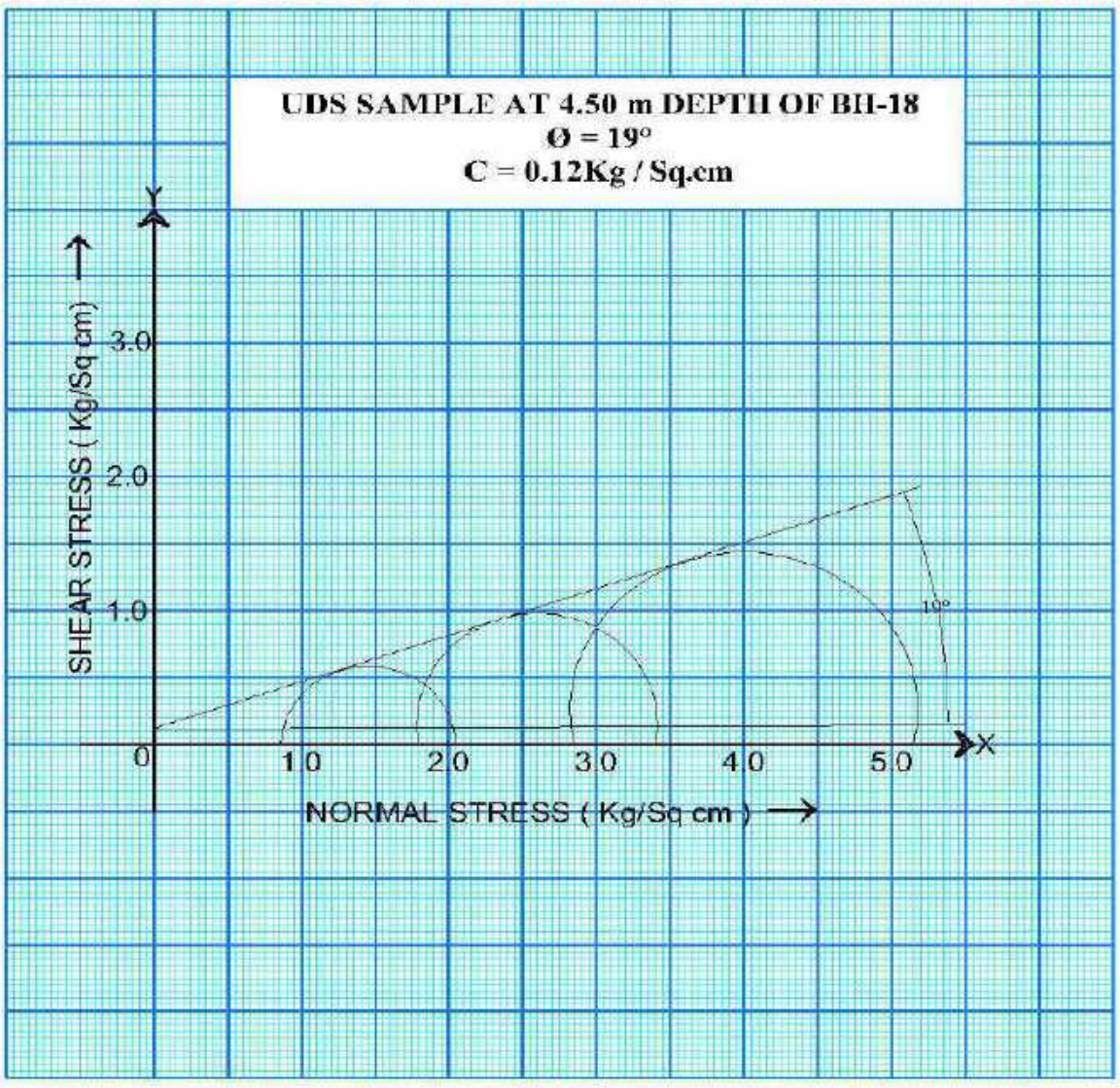
ANNEXURE –J
GRAPHICAL REPRESENTATION OF SHEAR STRENGTH PARAMETER

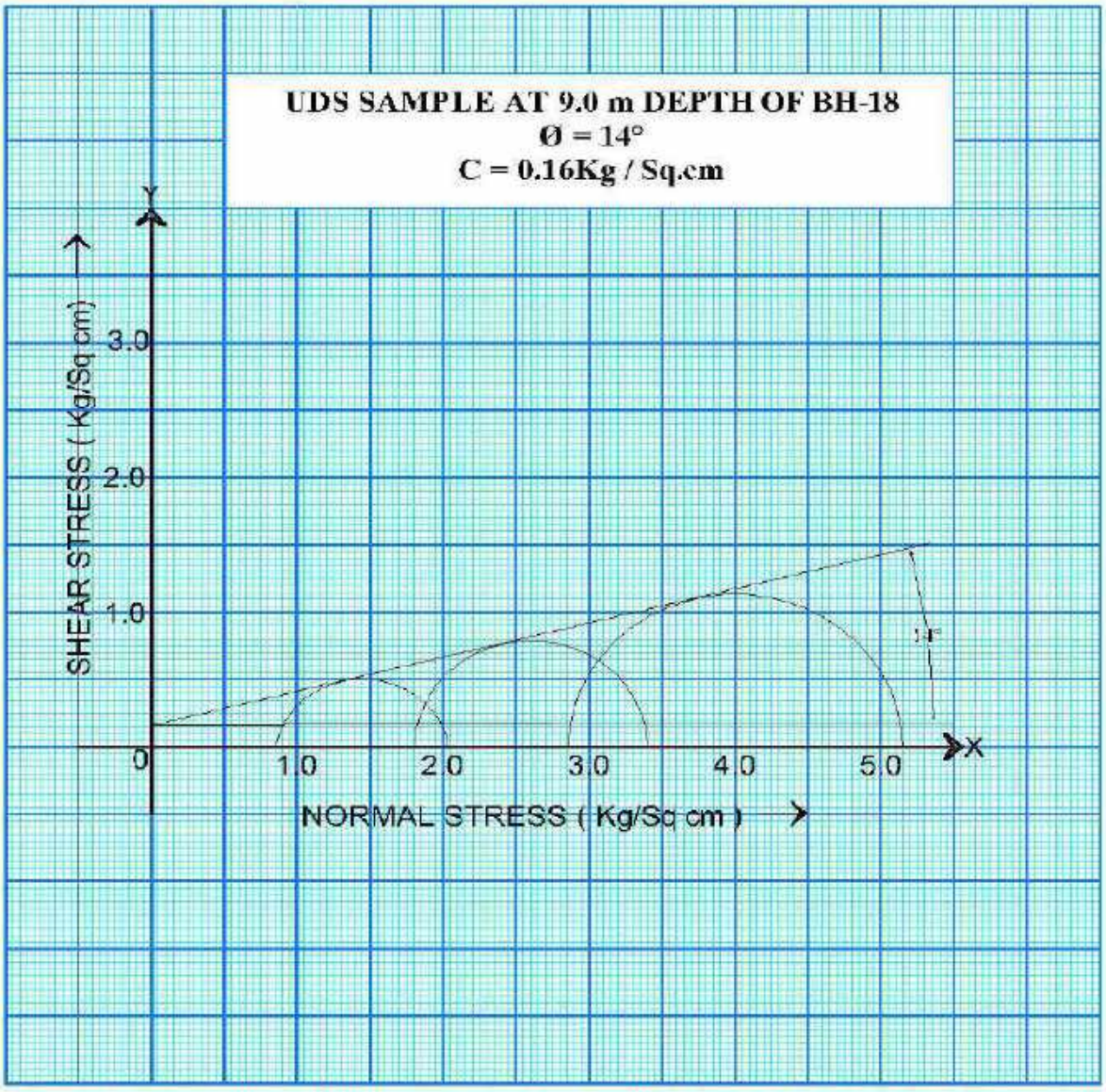

UDS SAMPLE AT 1.50 m DEPTH OF BH-17
Ø = 27°
C = 0.09 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
27°

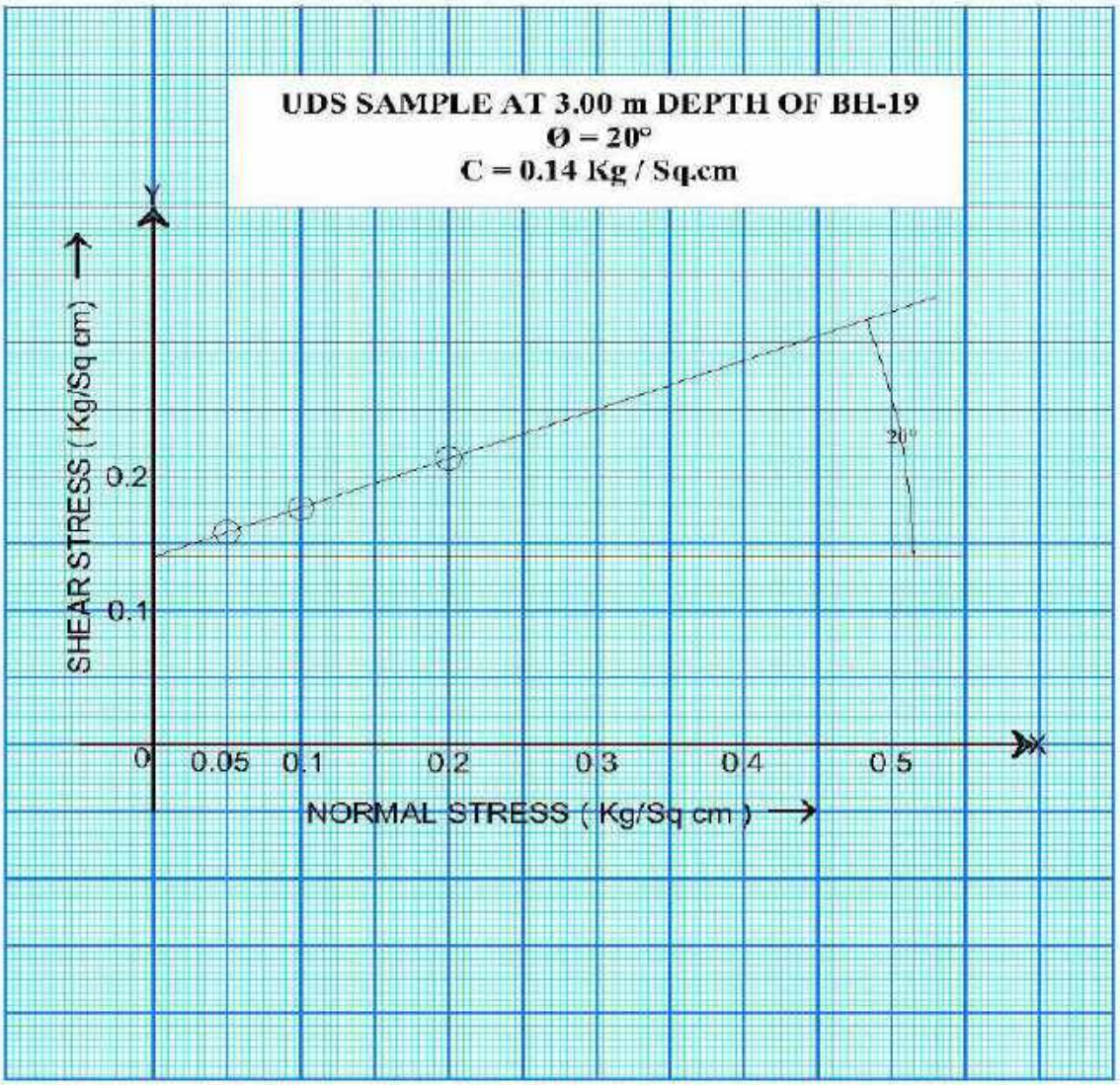

UDS SAMPLE AT 4.50 m DEPTH OF BH-17
Ø = 14°
C = 0.15Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS (Kg/Sq cm)

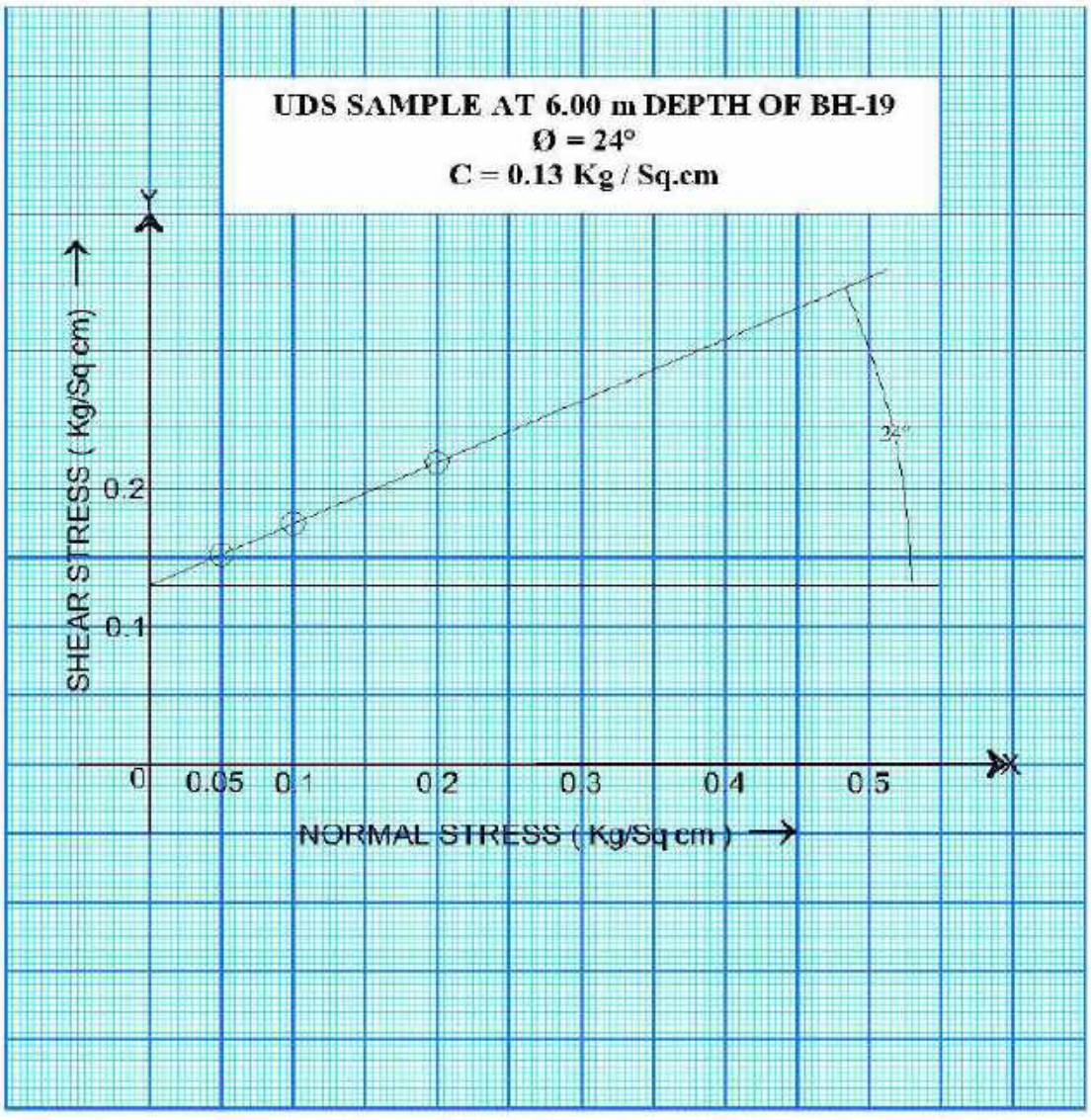

UDS SAMPLE AT 9.0 m DEPTH OF BH-17
Ø = 12°
C = 0.15Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
12°
NORMAL STRESS (Kg/Sq cm)

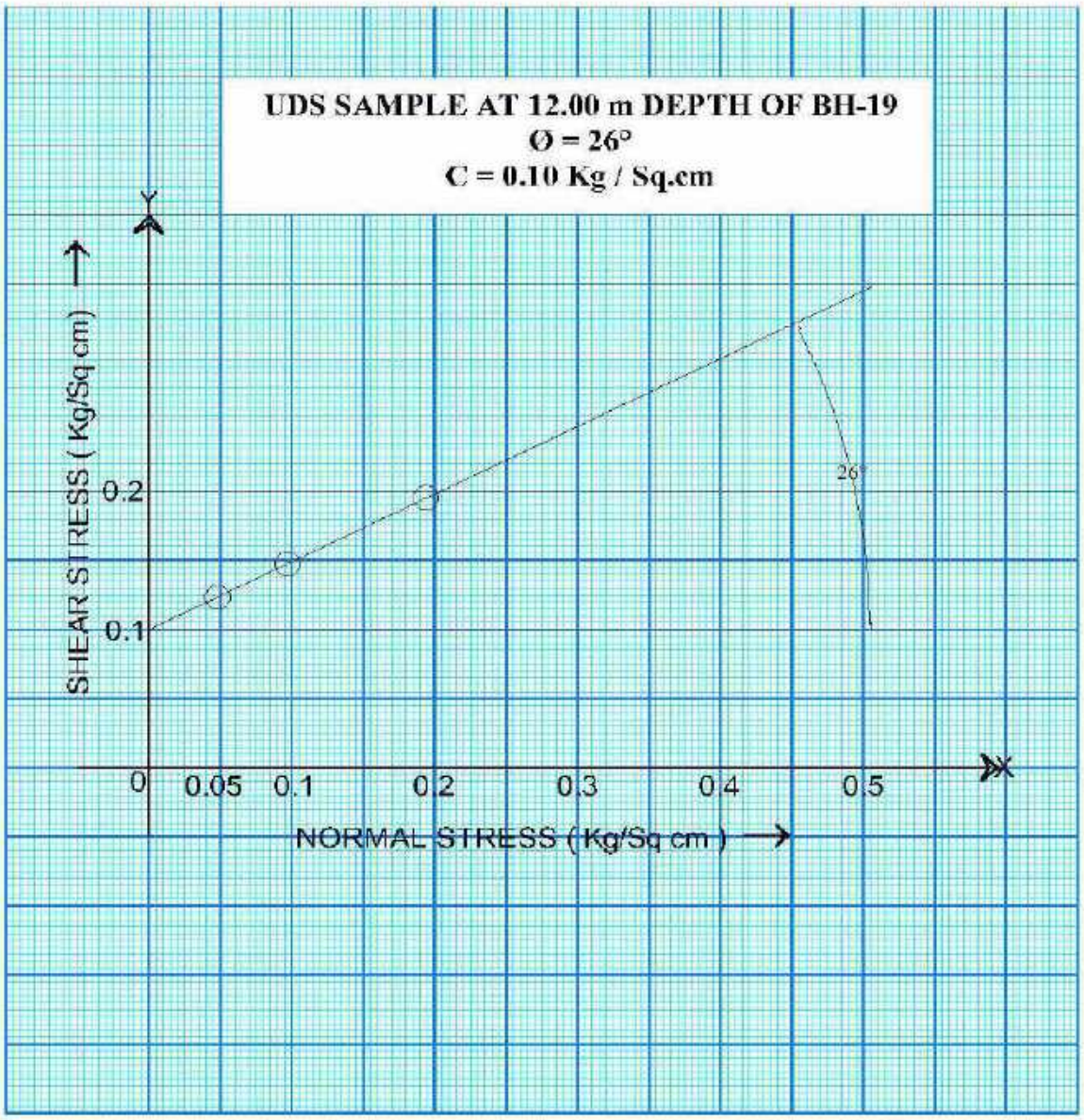

UDS SAMPLE AT 1.50 m DEPTH OF BH-18
Ø = 17°
C = 0.13Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
17°

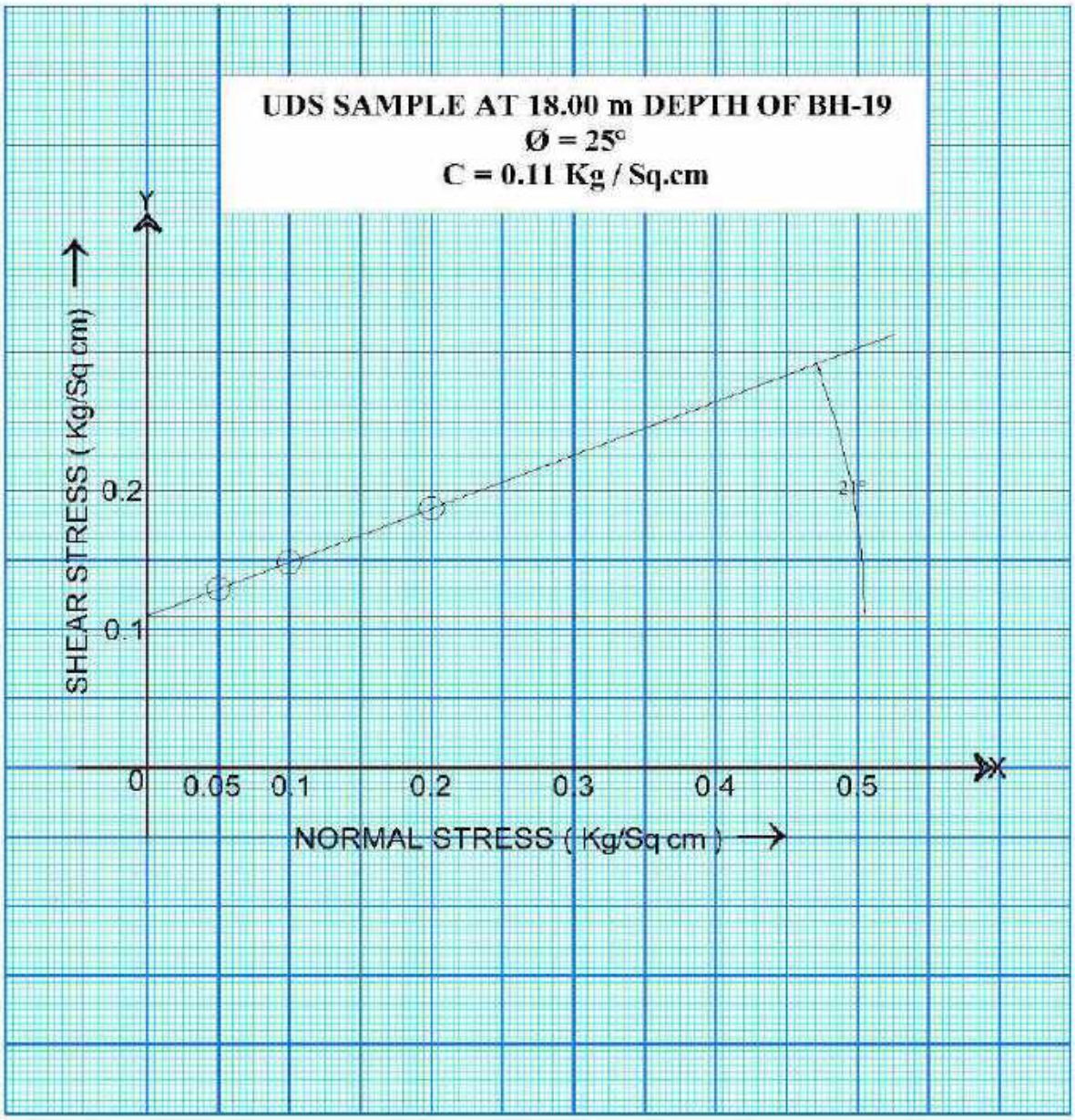

UDS SAMPLE AT 4.50 m DEPTH OF BH-18
Ø = 19°
C = 0.12Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
19°

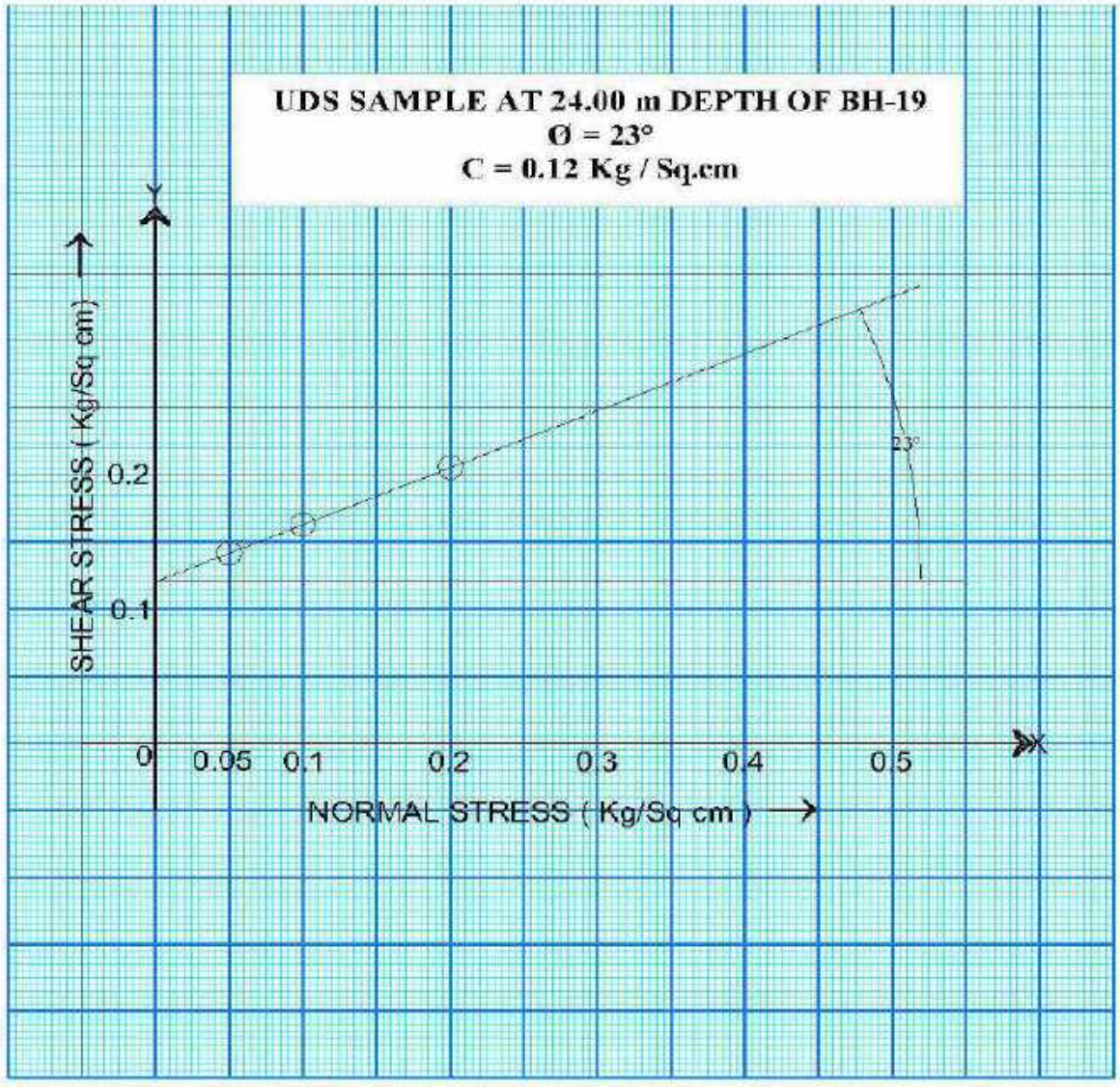

UDS SAMPLE AT 9.0 m DEPTH OF BH-18
Ø = 14°
C = 0.16Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
4.0
5.0
1.0
2.0
3.0

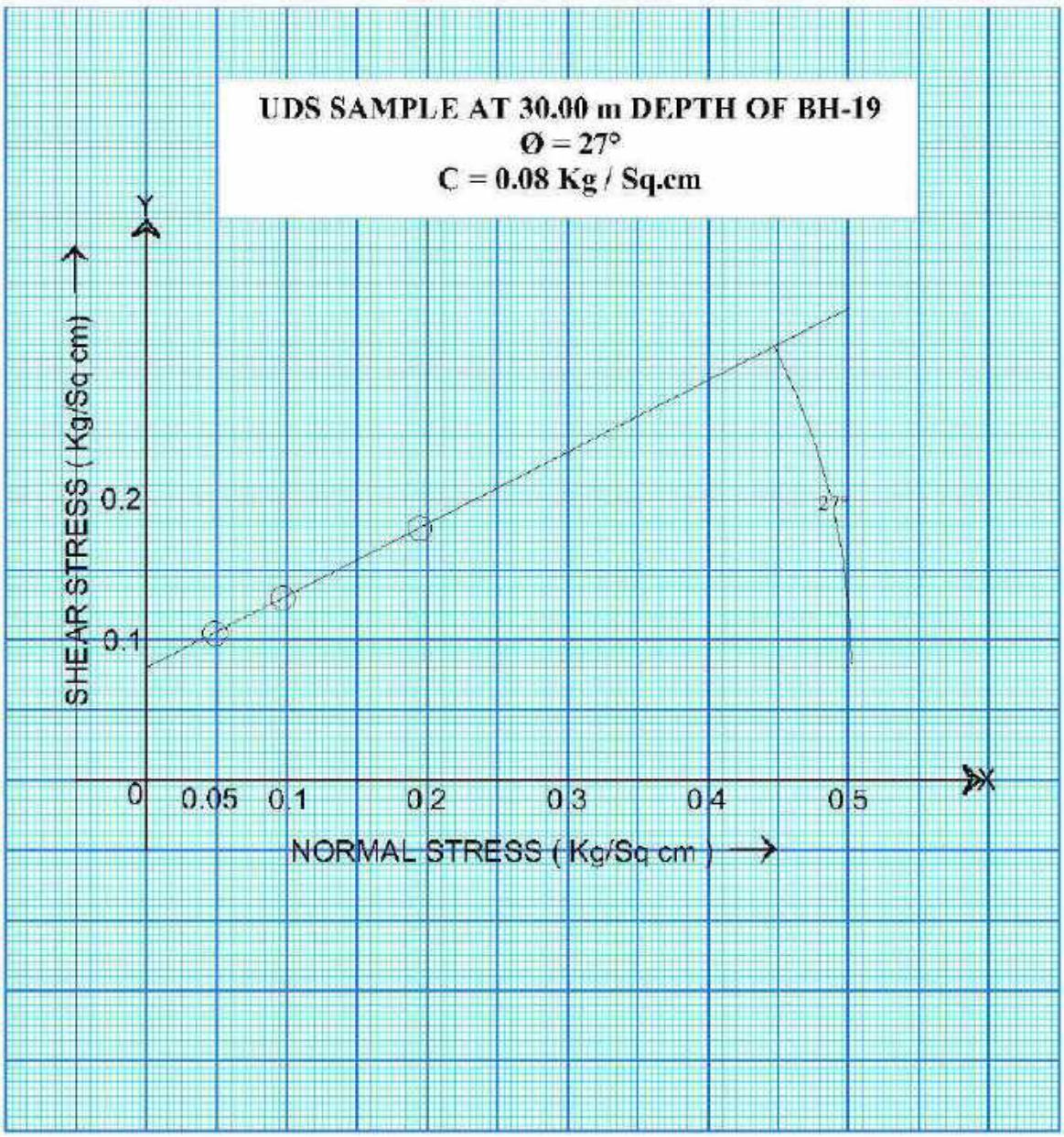

UDS SAMPLE AT 3.00 m DEPTH OF BH-19
Ø = 20°
C = 0.14 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
20°

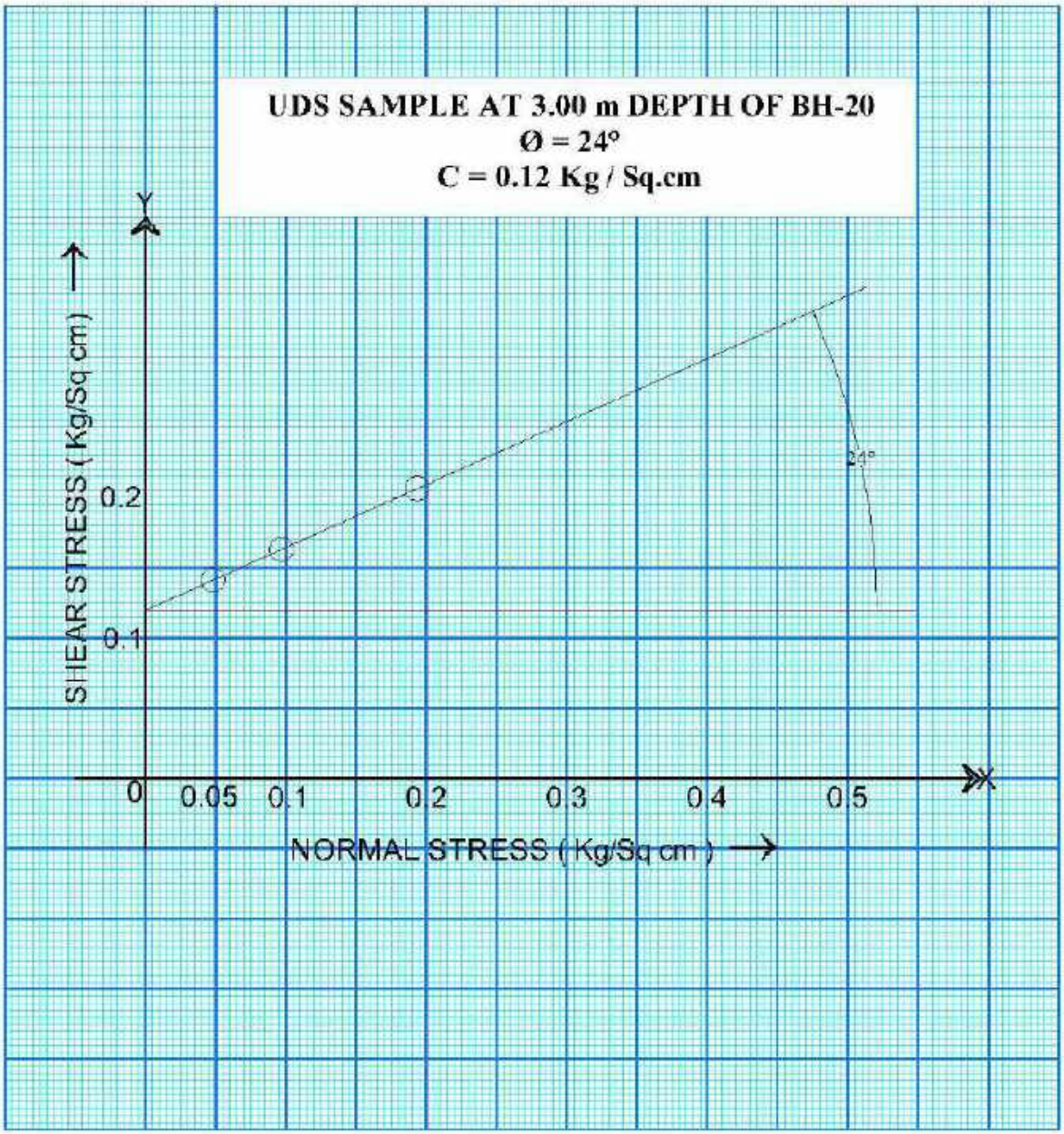

UDS SAMPLE AT 6.00 m DEPTH OF BH-19
Ø = 24°
C = 0.13 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
24°

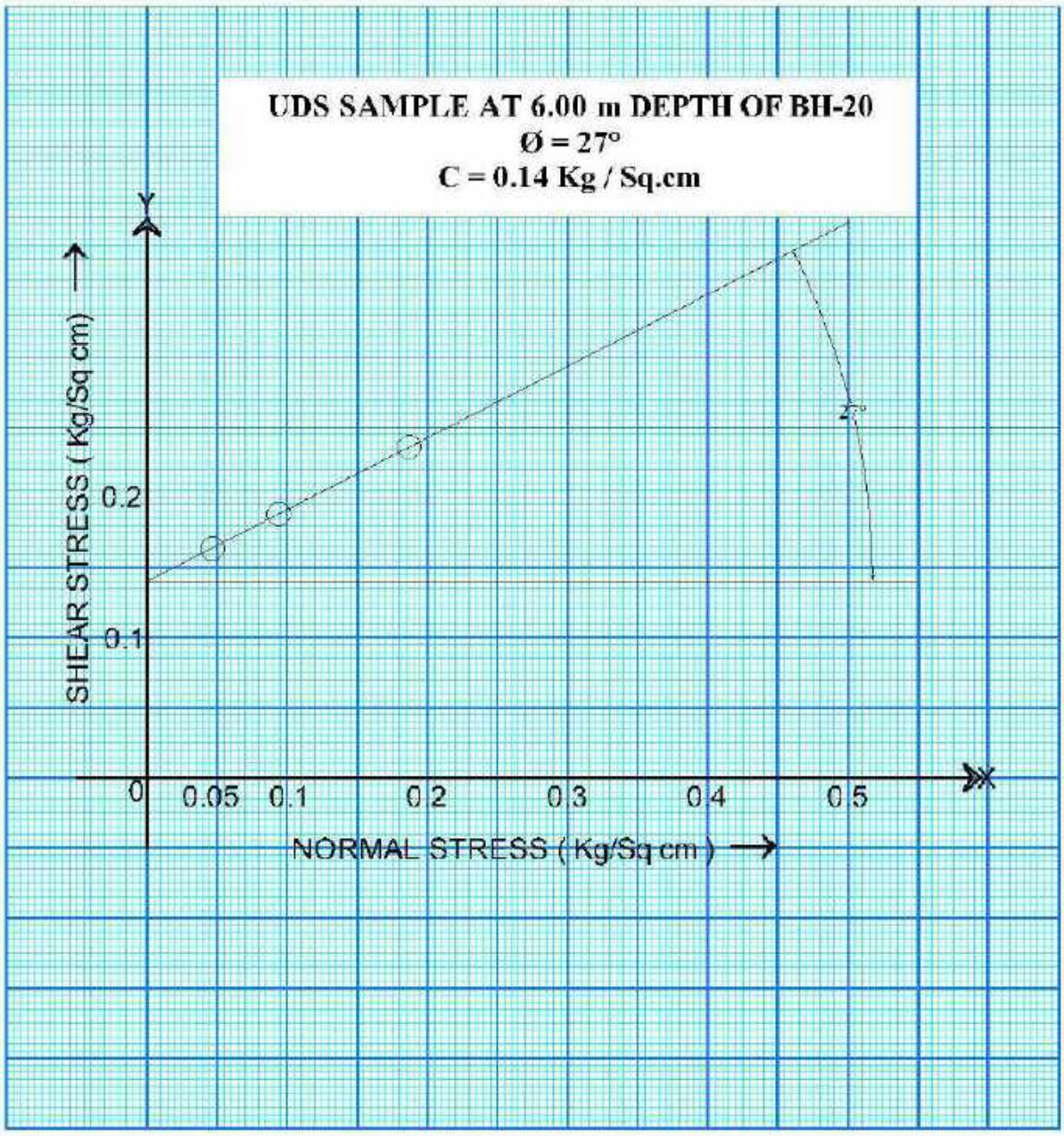

UDS SAMPLE AT 12.00 m DEPTH OF BH-19
Ø = 26°
C = 0.10 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
0.05
0.1
0.2
0.3
0.4
0.5
26°

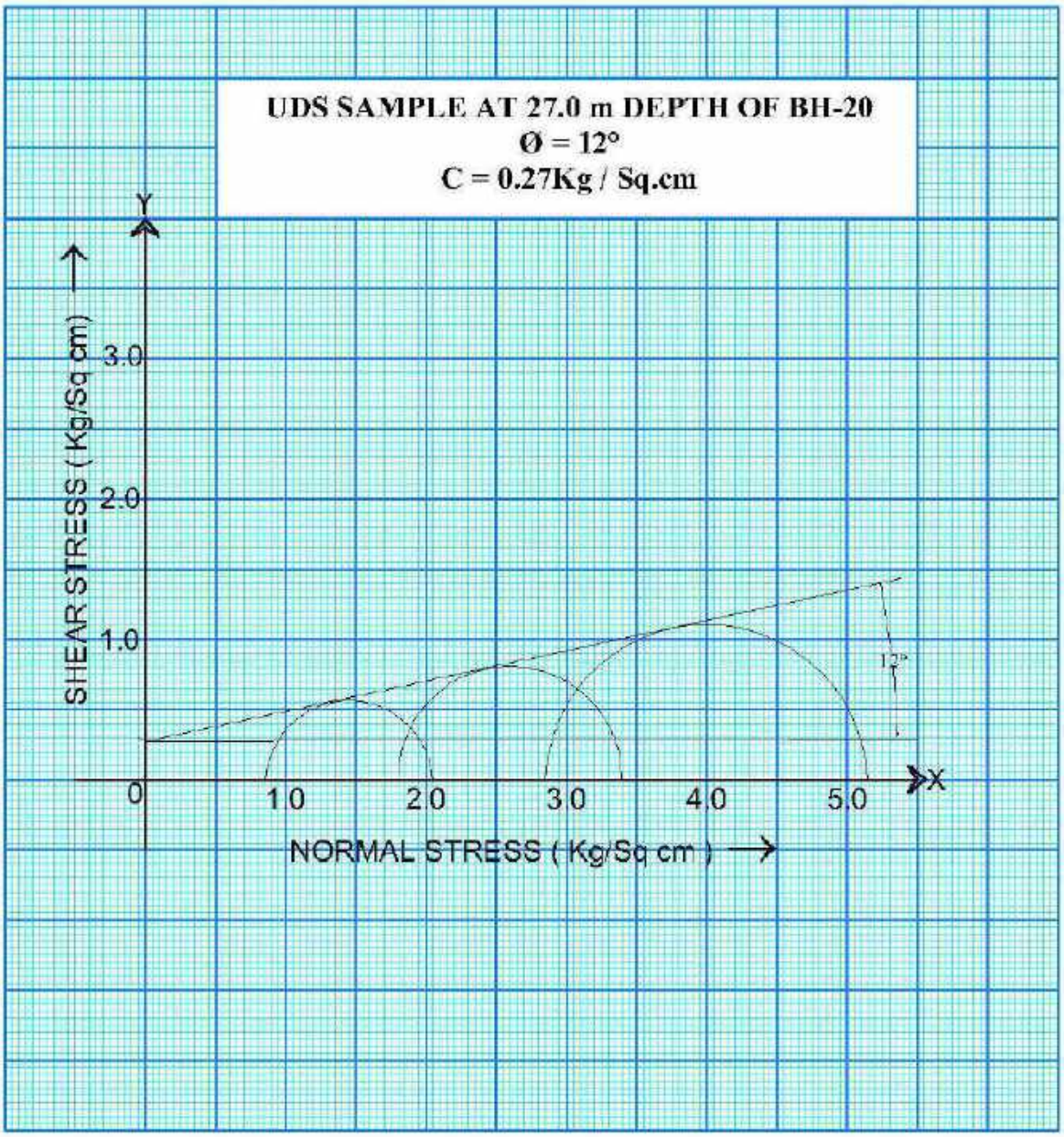

UDS SAMPLE AT 18.00 m DEPTH OF BH-19
Ø = 25°
C = 0.11 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)

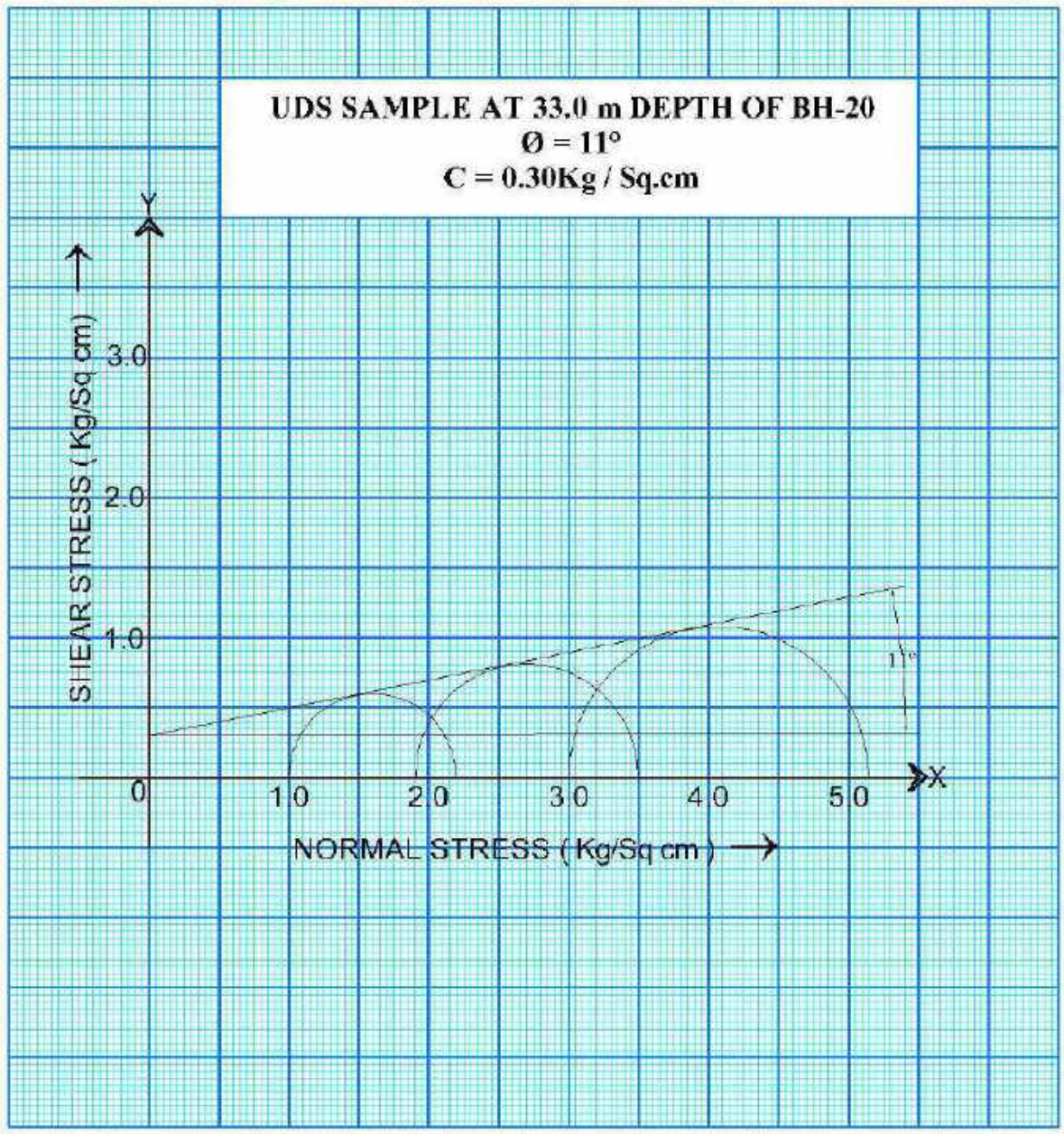

UDS SAMPLE AT 24.00 m DEPTH OF BH-19
Ø = 23°
C = 0.12 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
23°

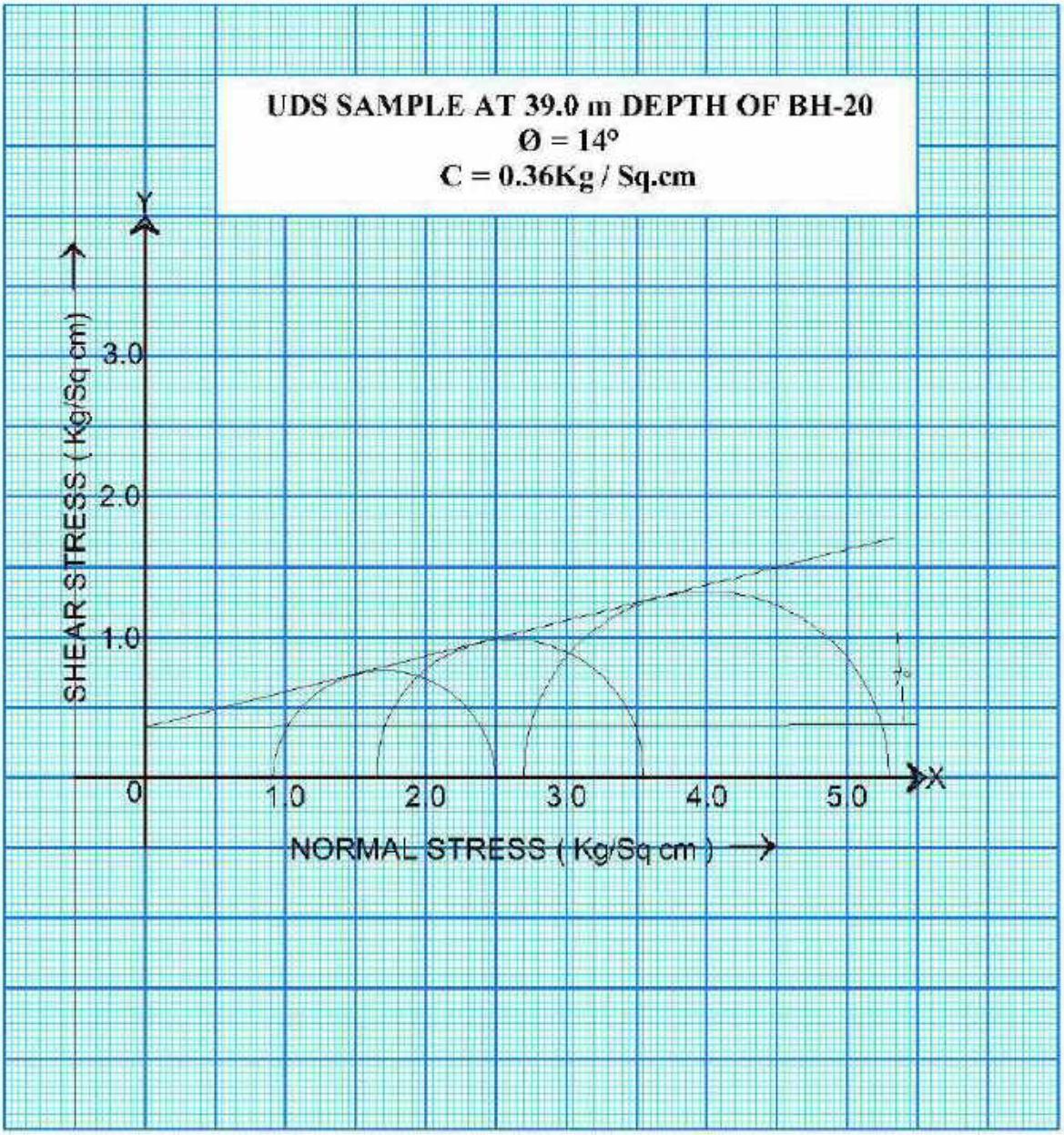

UDS SAMPLE AT 30.00 m DEPTH OF BH-19
Ø = 27°
C = 0.08 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
27°

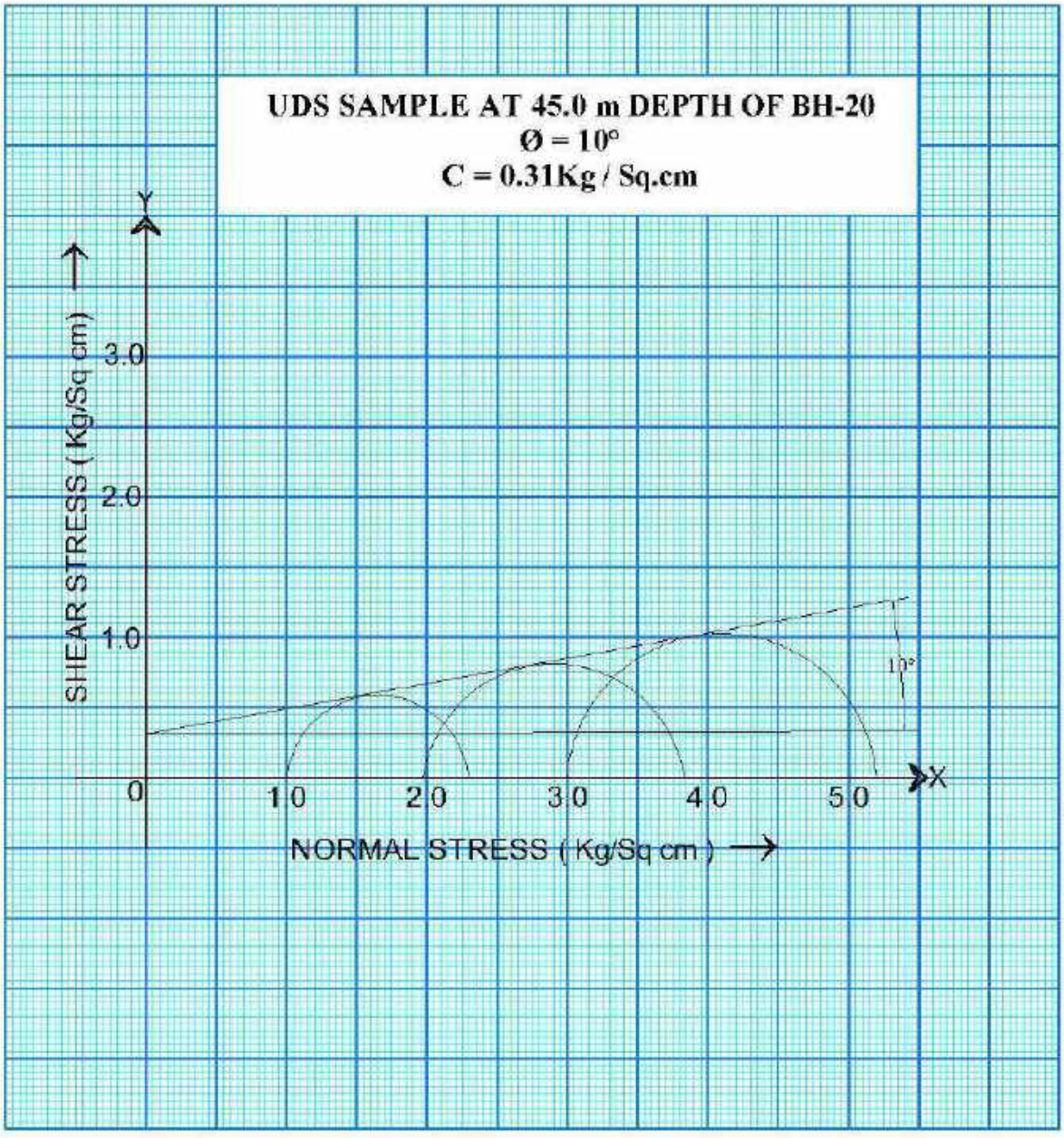

UDS SAMPLE AT 3.00 m DEPTH OF BH-20
Ø = 24°
C = 0.12 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
24°

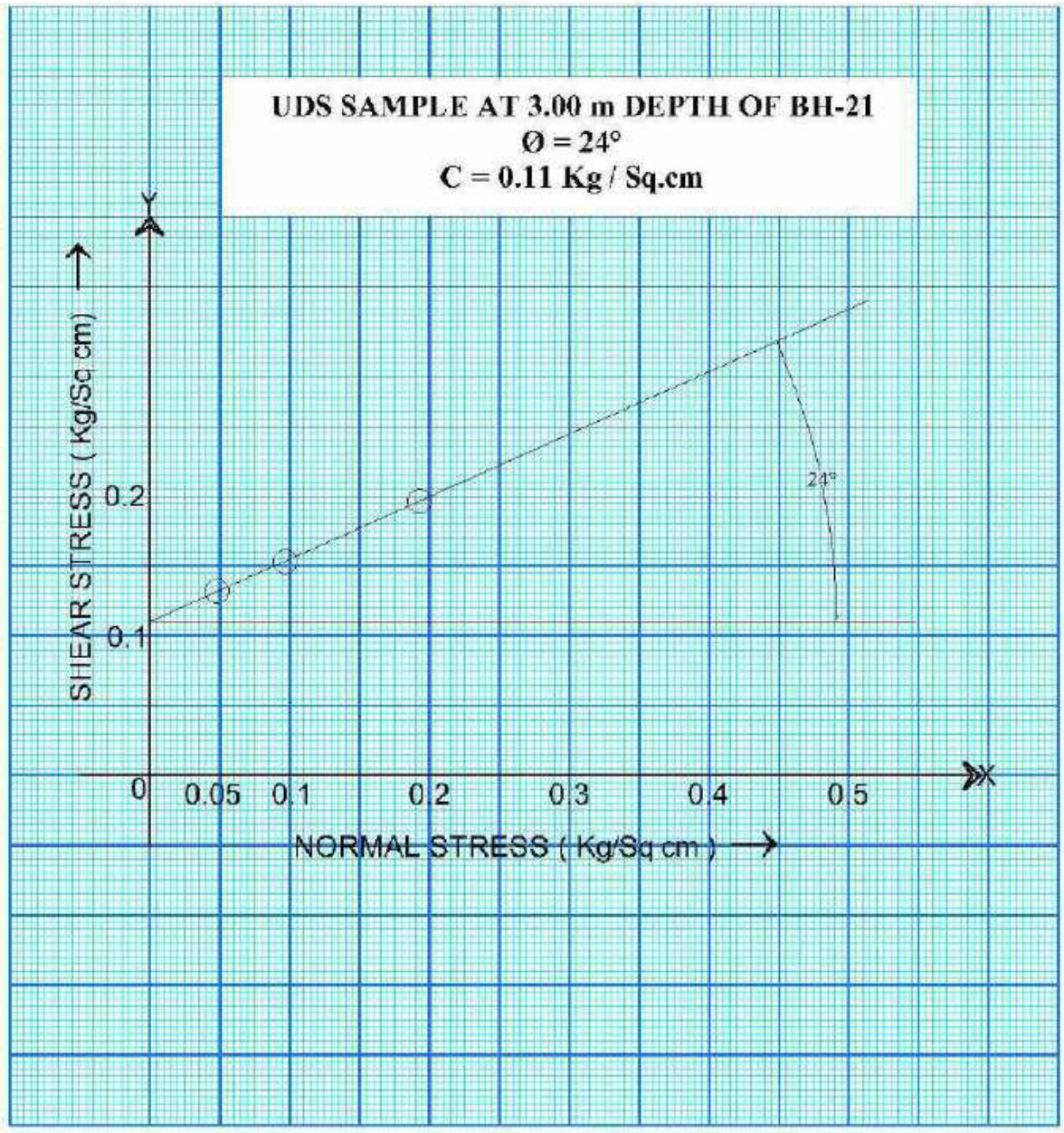

UDS SAMPLE AT 6.00 m DEPTH OF BH-20
Ø = 27°
C = 0.14 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)

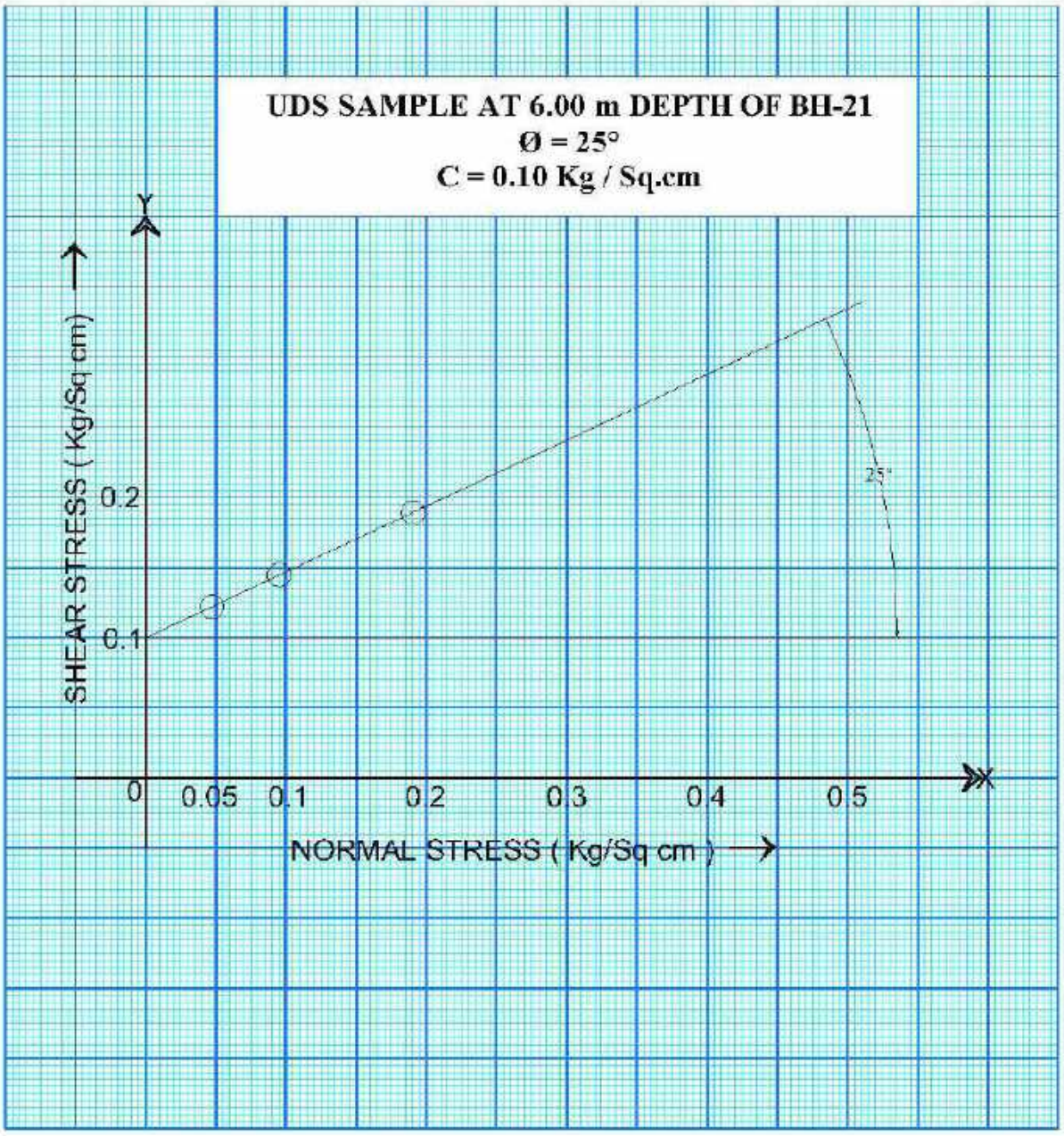

UDS SAMPLE AT 27.0 m DEPTH OF BH-20
Ø = 12°
C = 0.27Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
12°

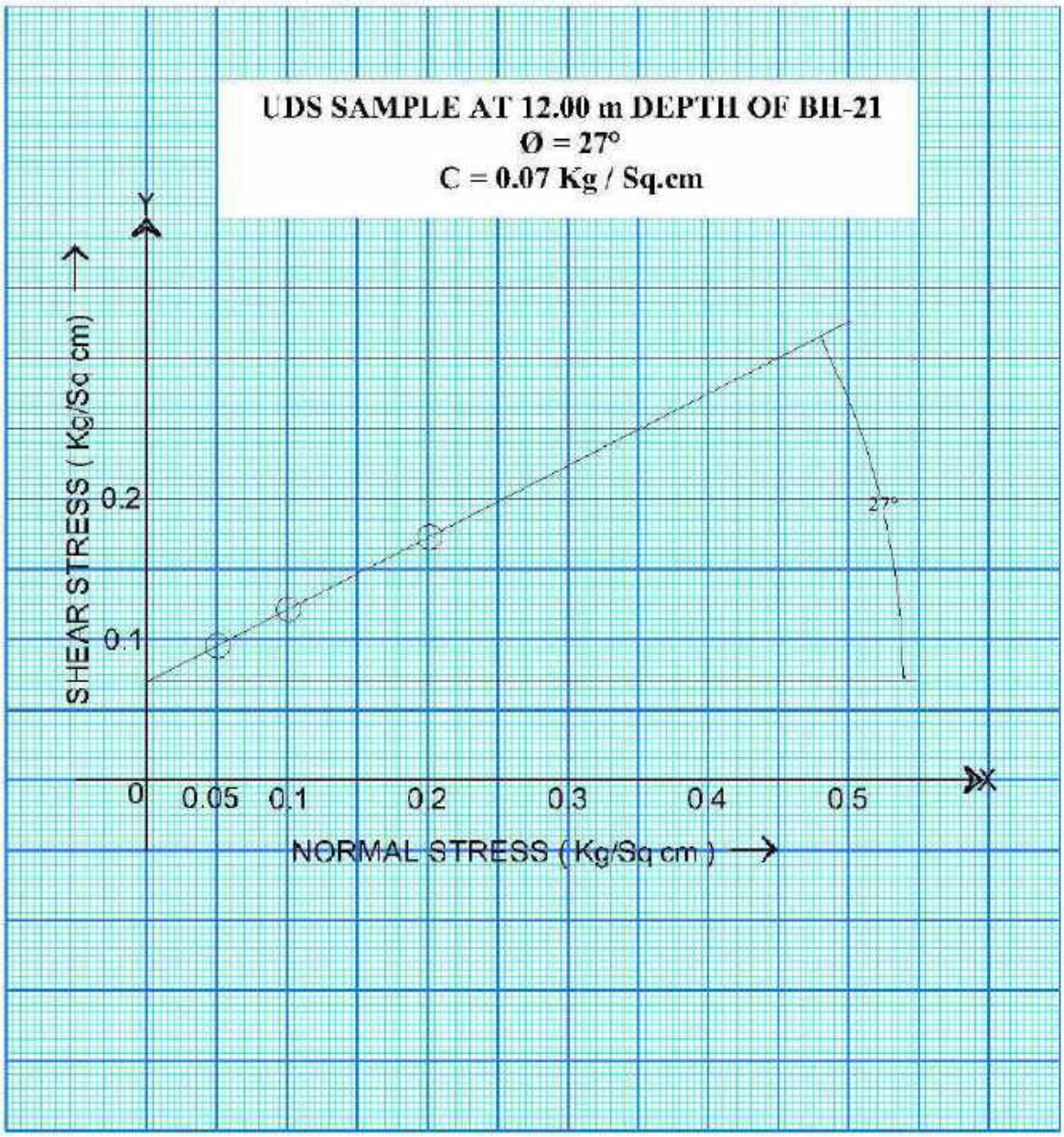

UDS SAMPLE AT 33.0 m DEPTH OF BH-20
Ø = 11°
C = 0.30Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
4.0
5.0
11°

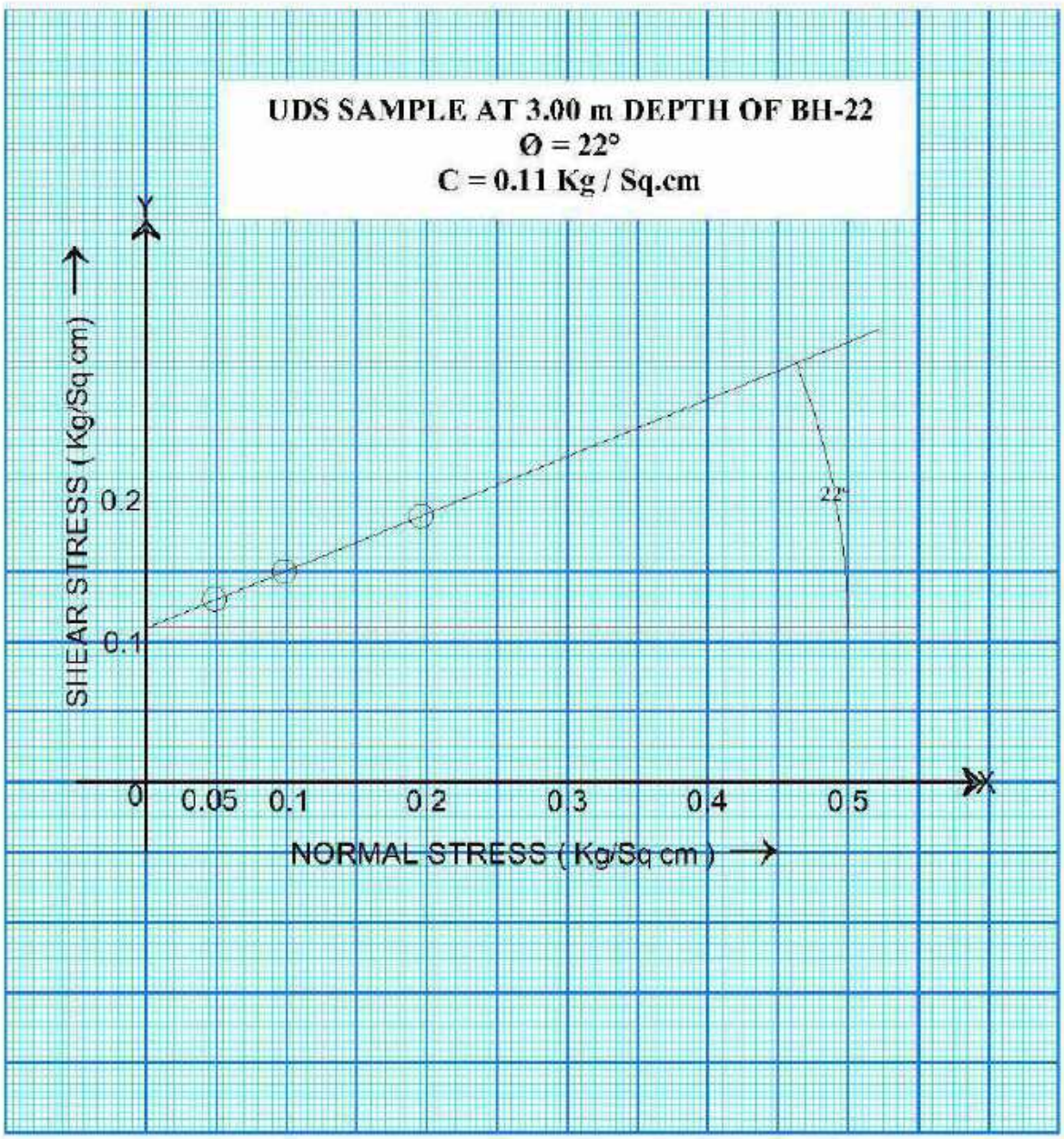

UDS SAMPLE AT 39.0 m DEPTH OF BH-20
Ø = 14°
C = 0.36Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)

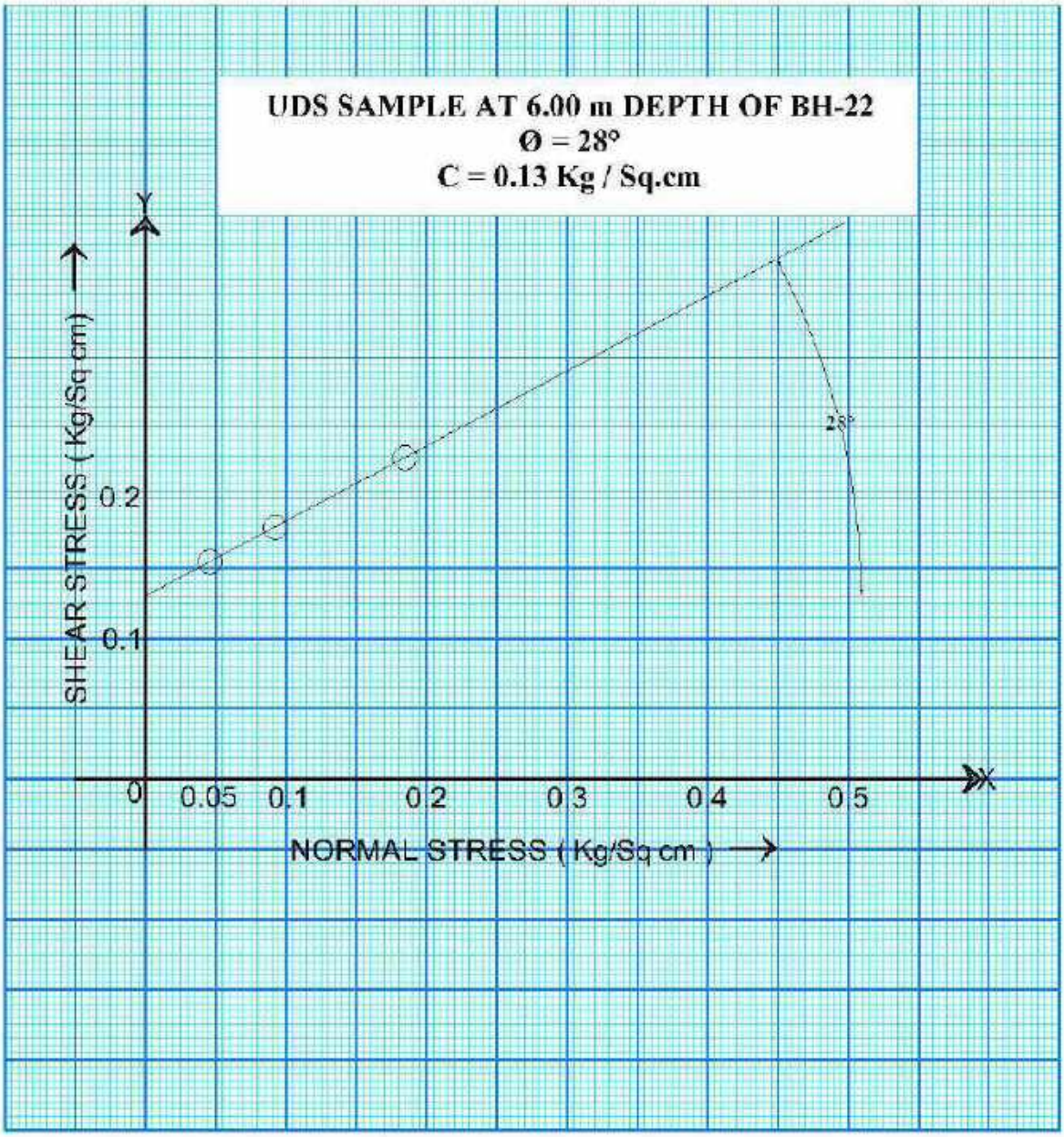

UDS SAMPLE AT 45.0 m DEPTH OF BH-20
Ø = 10°
C = 0.31Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
1 0
2 0
3 0
4 0
5 0
X
Y
10°

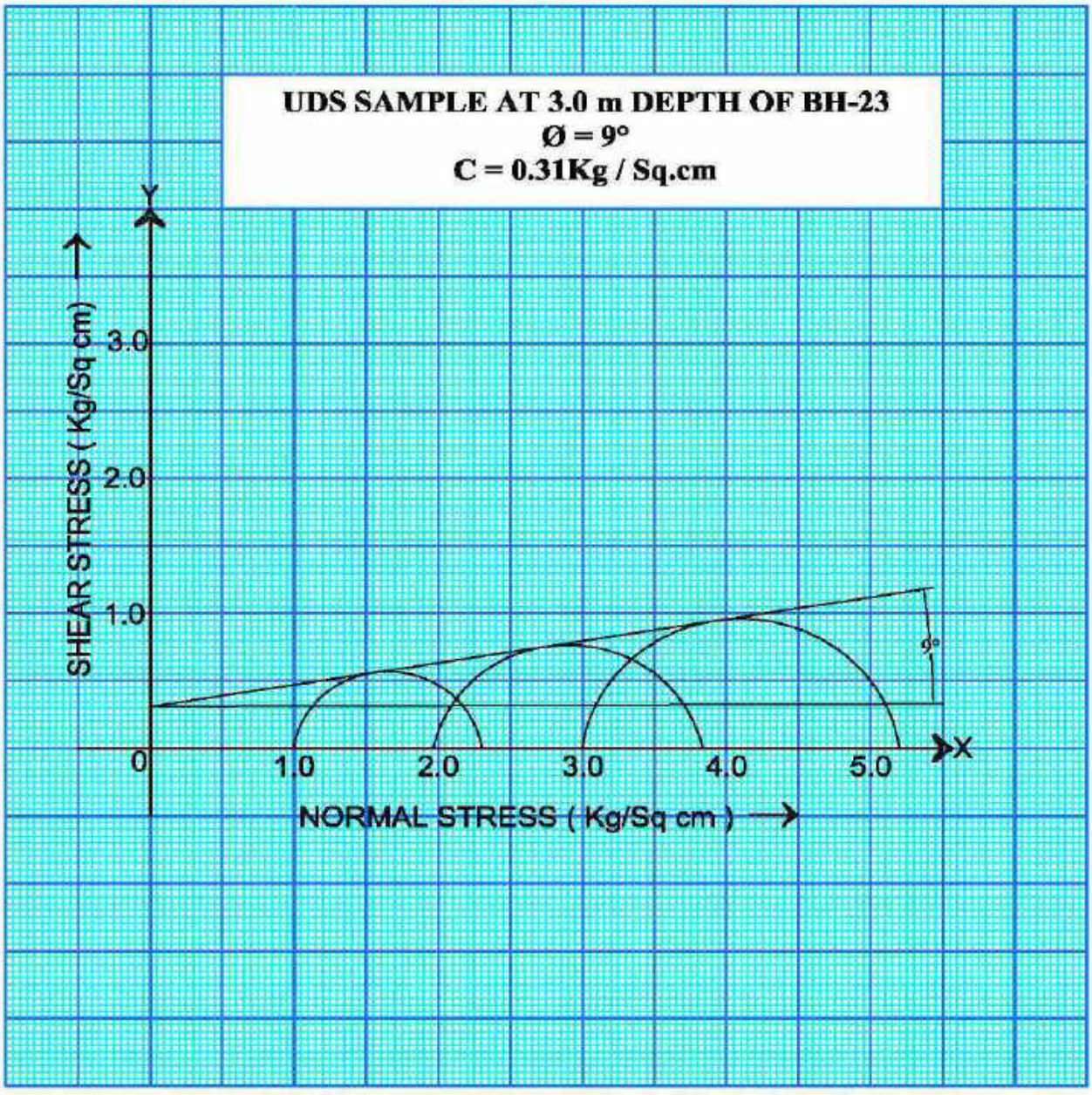

UDS SAMPLE AT 3.00 m DEPTH OF BH-21
Ø = 24°
C = 0.11 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
0.05
0.1
0.2
0.3
0.4
0.5
0.1
0.2
24°

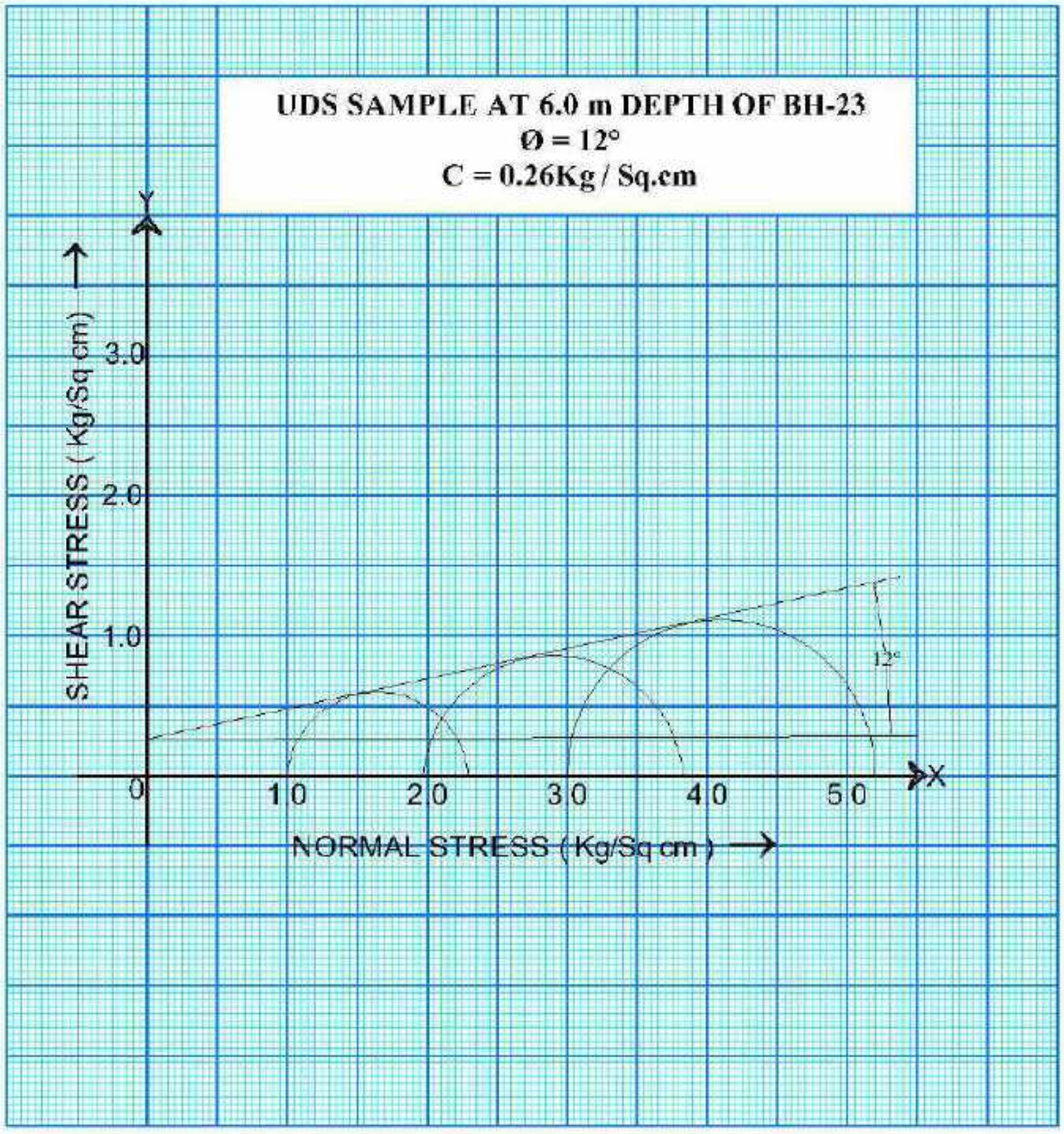

UDS SAMPLE AT 6.00 m DEPTH OF BH-21
Ø = 25°
C = 0.10 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
25°

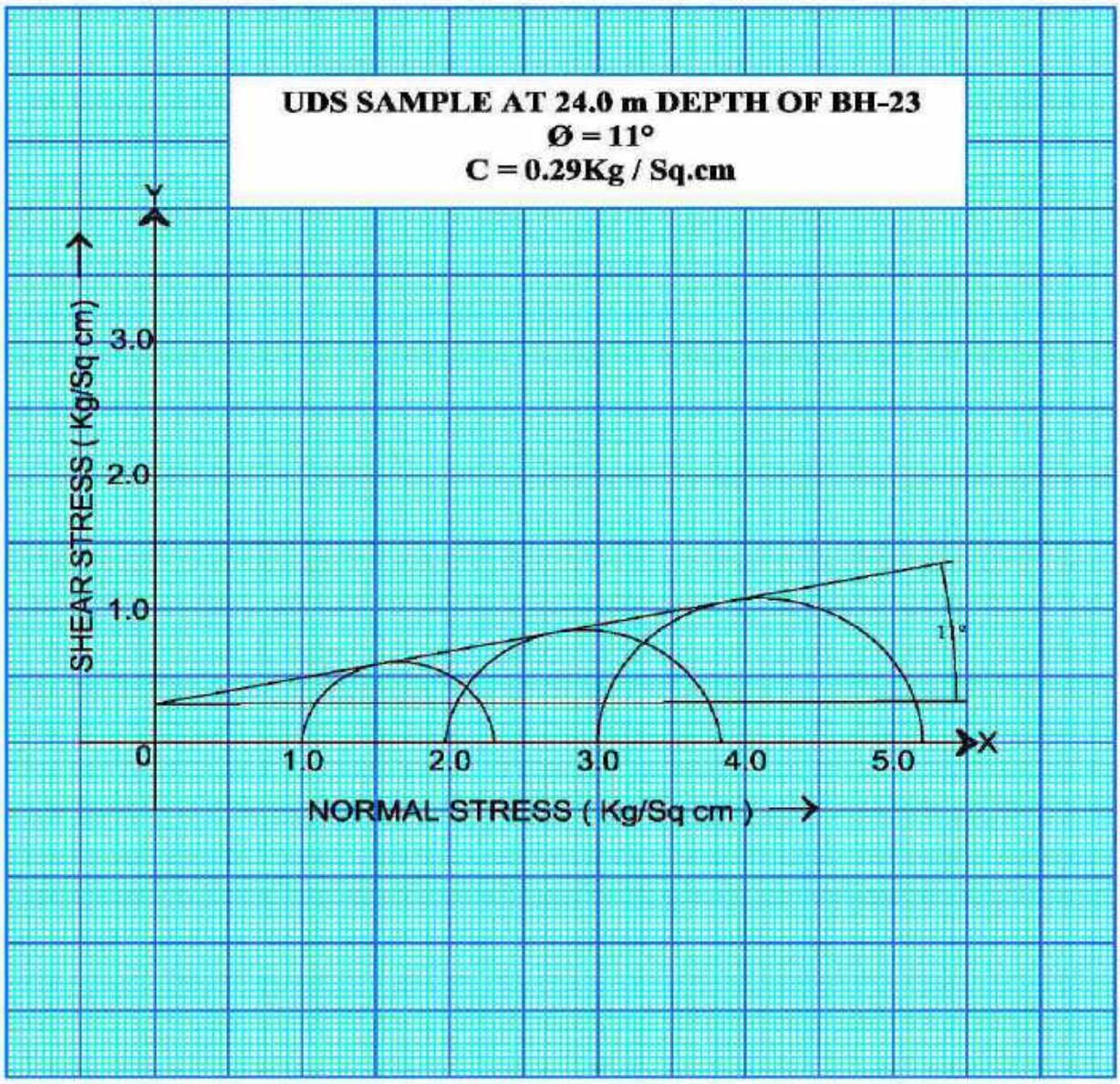

UDS SAMPLE AT 12.00 m DEPTH OF BH-21
Ø = 27°
C = 0.07 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
0.05
0.1
0.2
0.3
0.4
0.5
0.1
0.2
27°

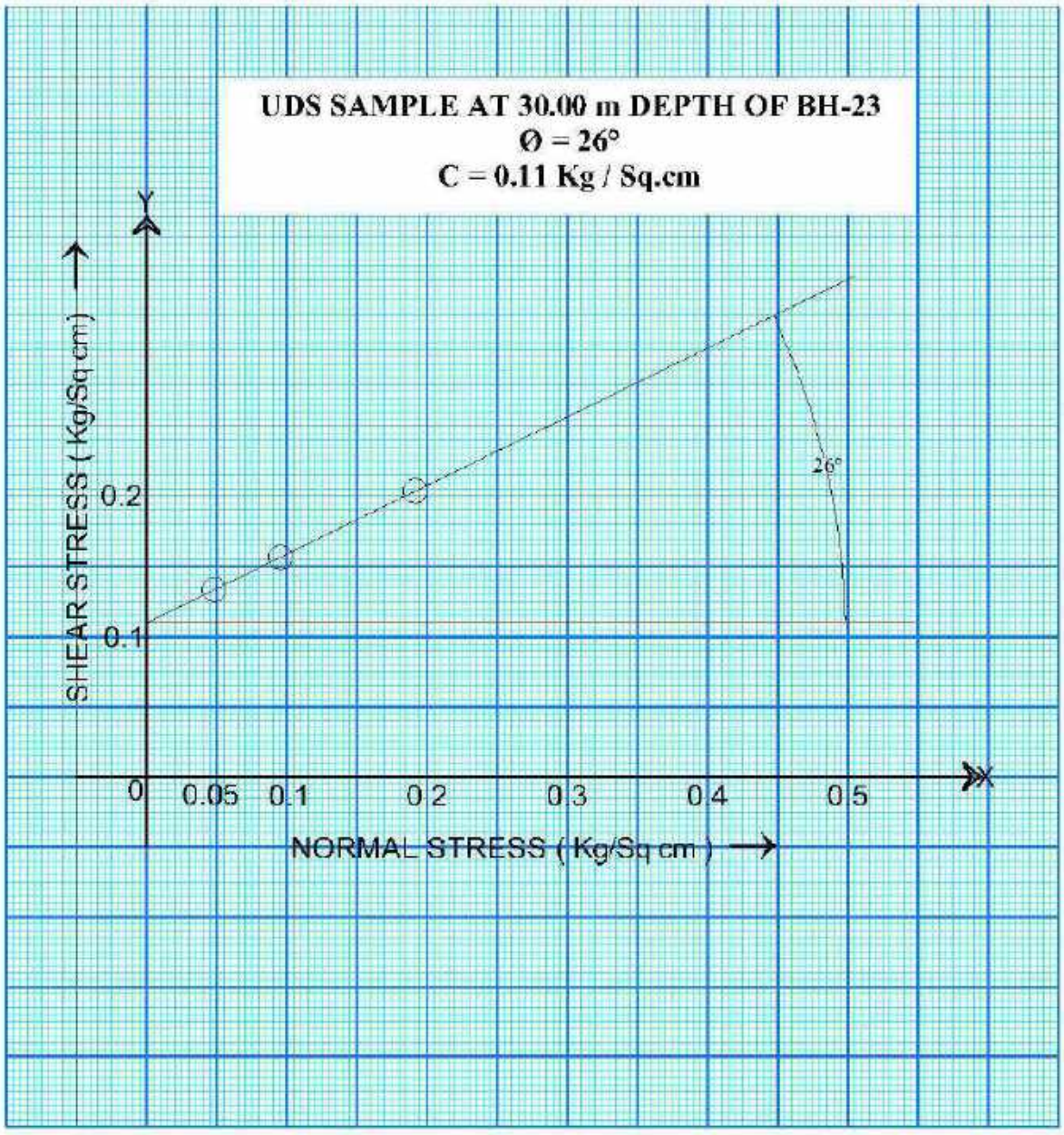

UDS SAMPLE AT 3.00 m DEPTH OF BH-22
Ø = 22°
C = 0.11 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
22°

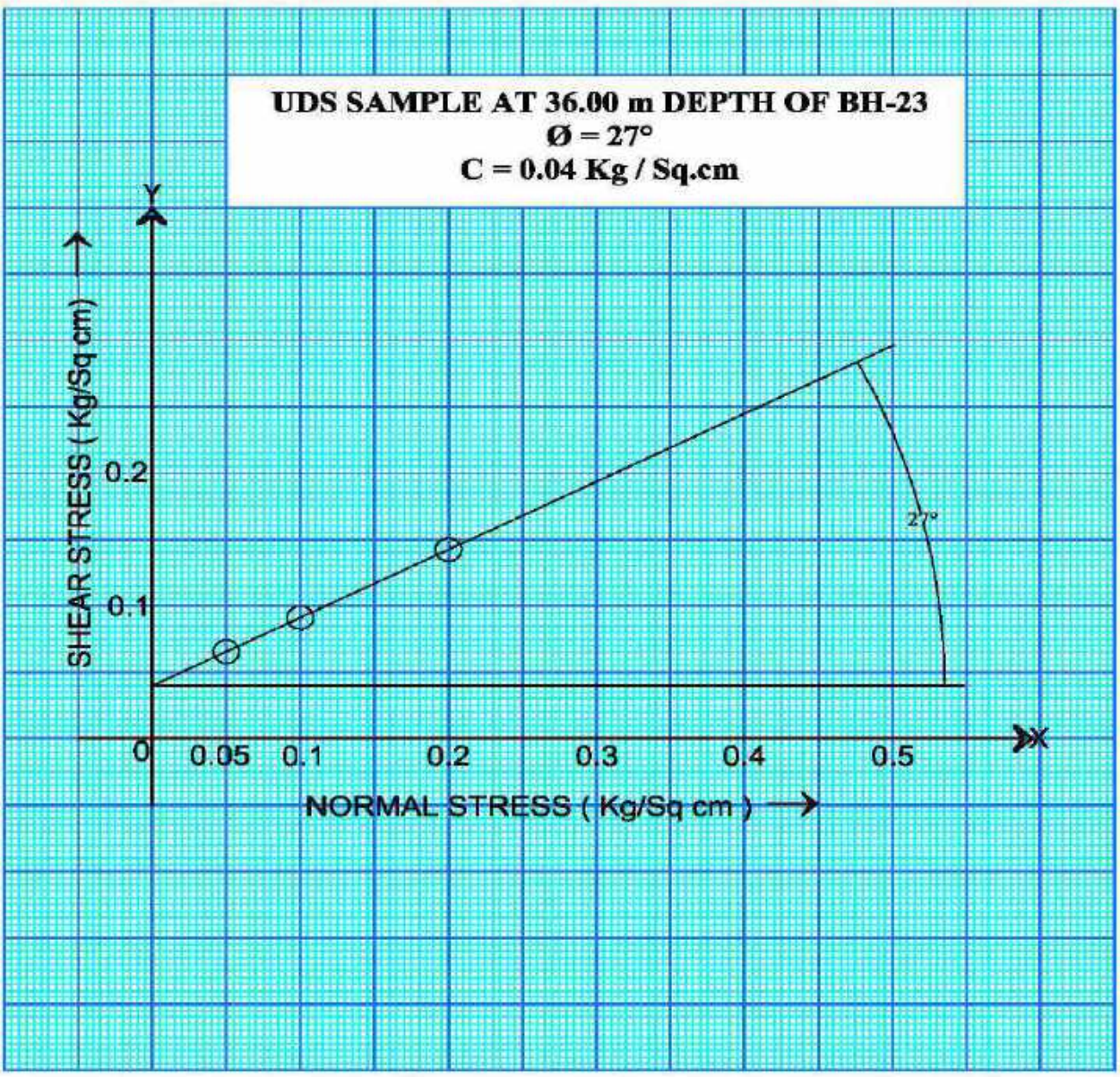

UDS SAMPLE AT 6.00 m DEPTH OF BH-22
Ø = 28°
C = 0.13 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
28°

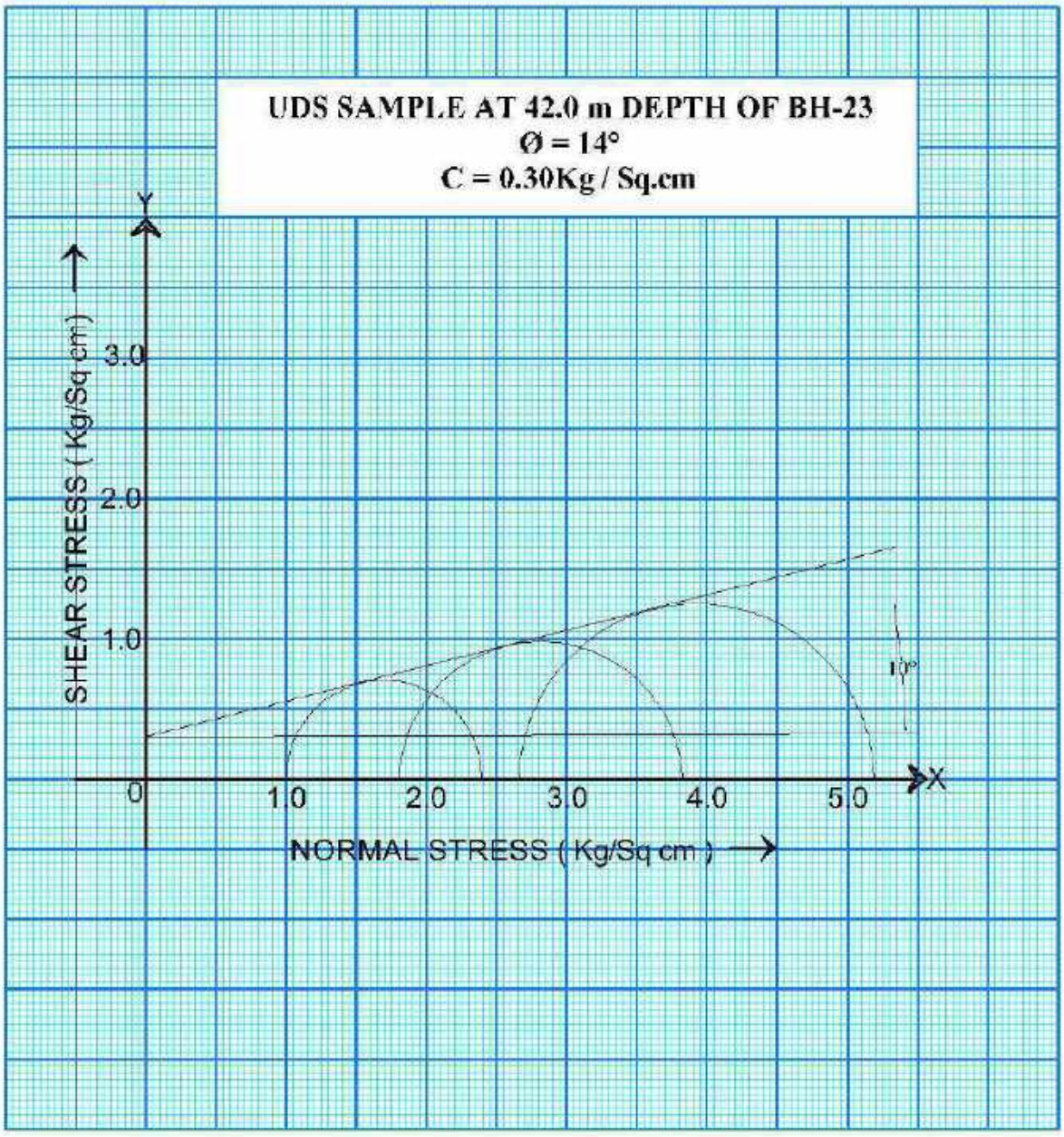

UDS SAMPLE AT 3.0 m DEPTH OF BH-23
Ø = 9°
C = 0.31Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
9°
NORMAL STRESS (Kg/Sq cm)

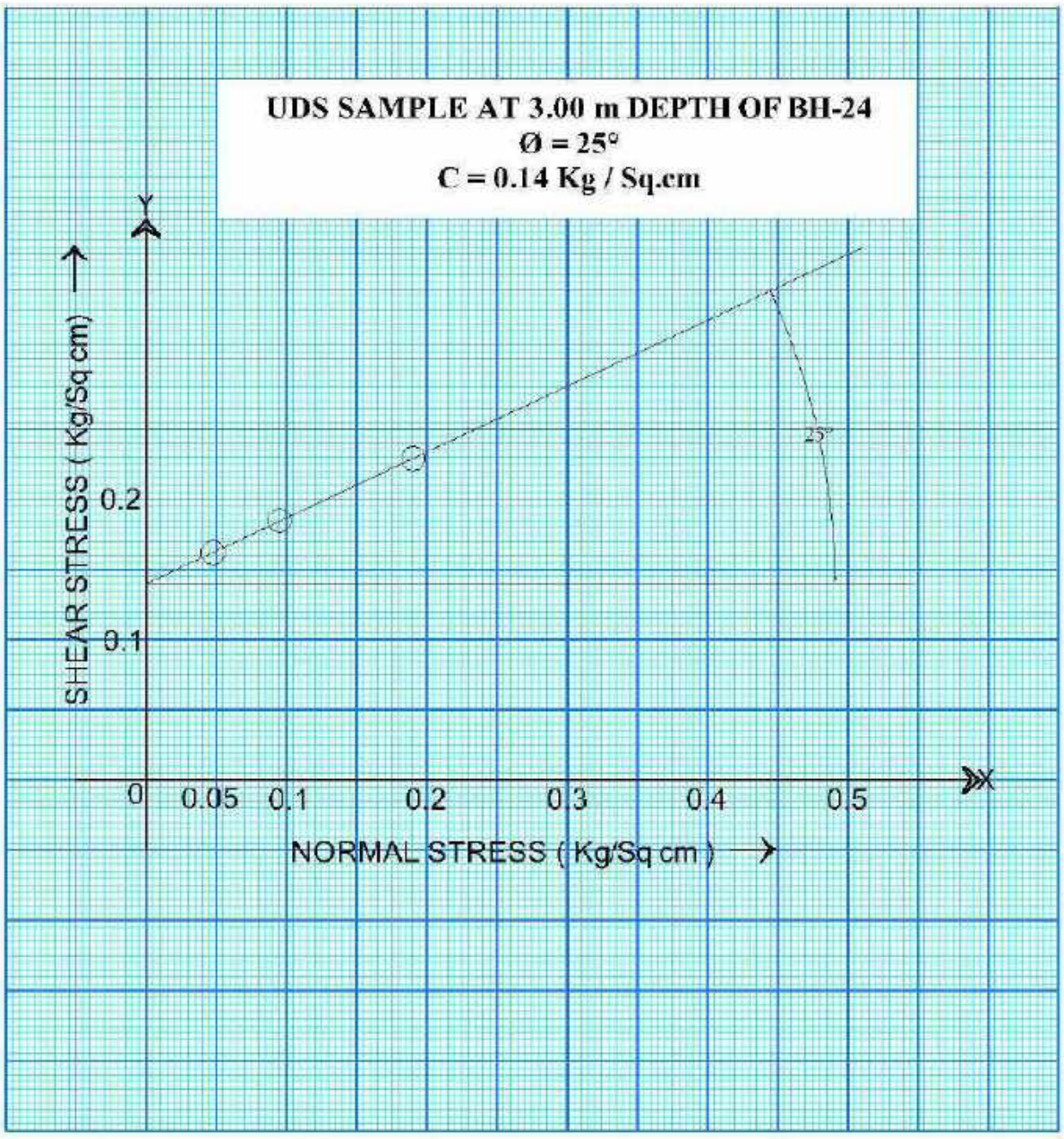

UDS SAMPLE AT 6.0 m DEPTH OF BH-23
Ø = 12°
C = 0.26Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
10
20
30
40
50
X
NORMAL STRESS (Kg/Sq cm)
12°

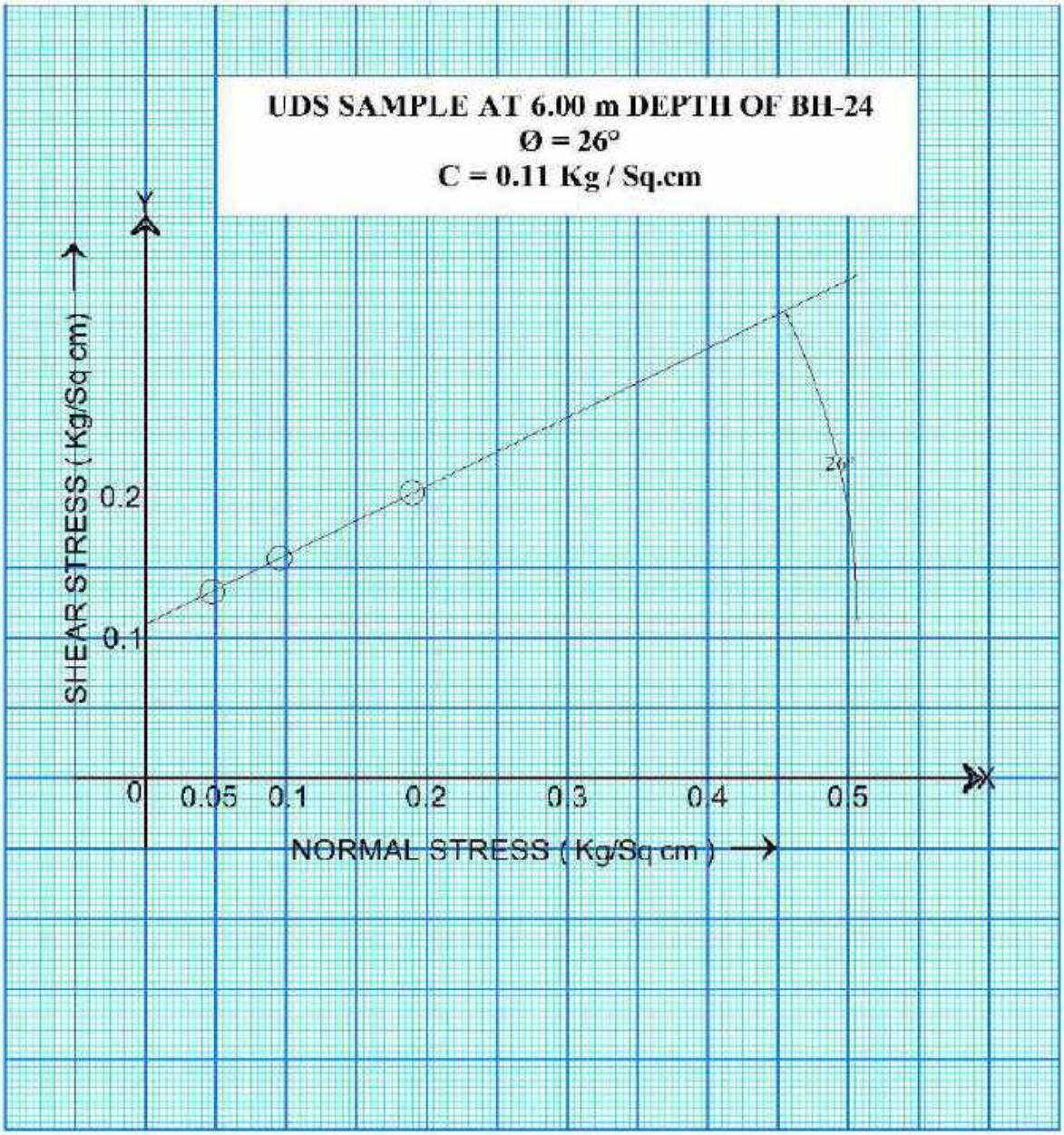

UDS SAMPLE AT 24.0 m DEPTH OF BH-23
Ø = 11°
C = 0.29Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
11°

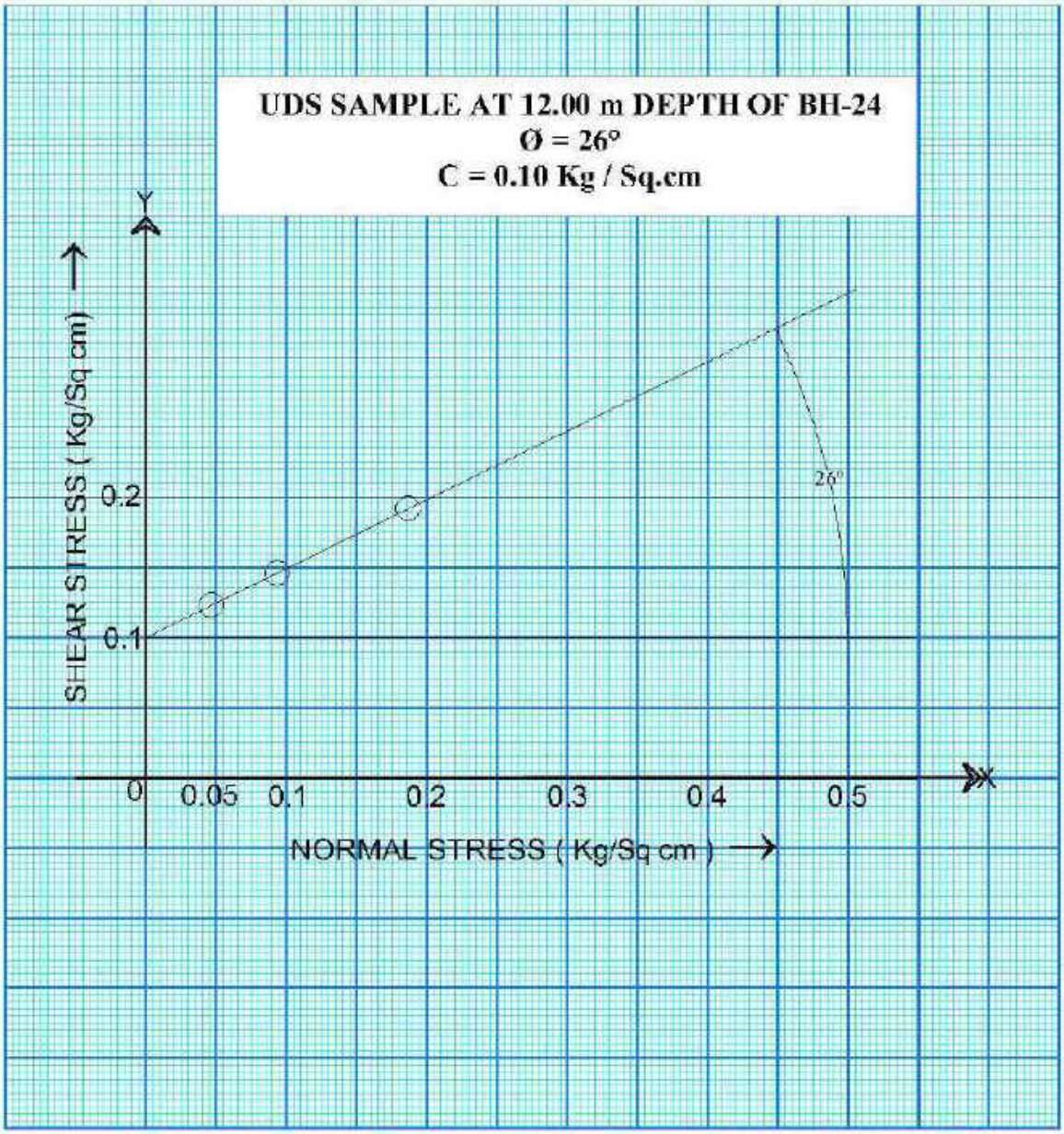

UDS SAMPLE AT 30.00 m DEPTH OF BH-23
Ø = 26°
C = 0.11 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
26°

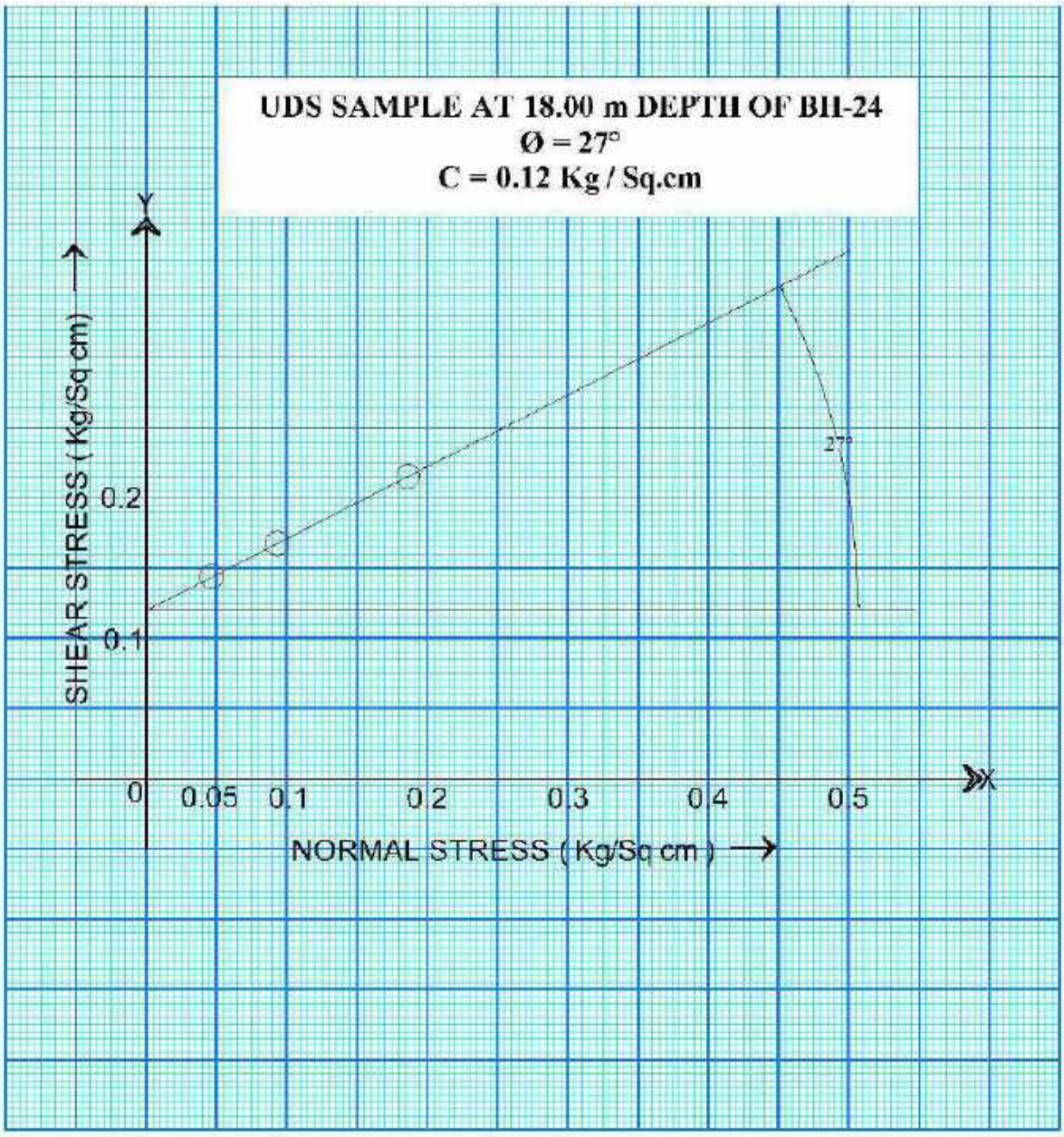

UDS SAMPLE AT 36.00 m DEPTH OF BH-23
Ø = 27°
C = 0.04 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
27°

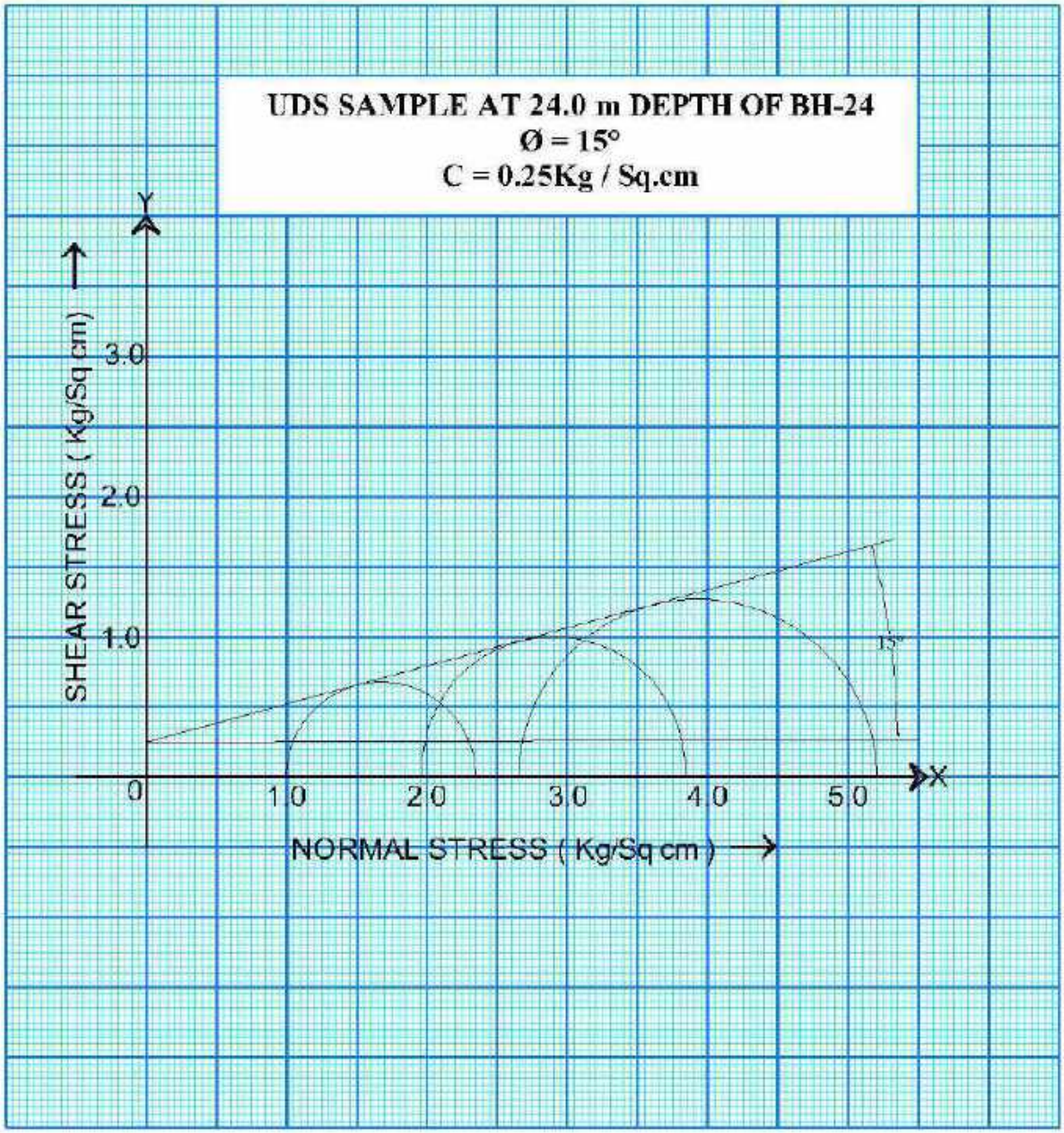

UDS SAMPLE AT 42.0 m DEPTH OF BH-23
Ø = 14°
C = 0.30Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
14°

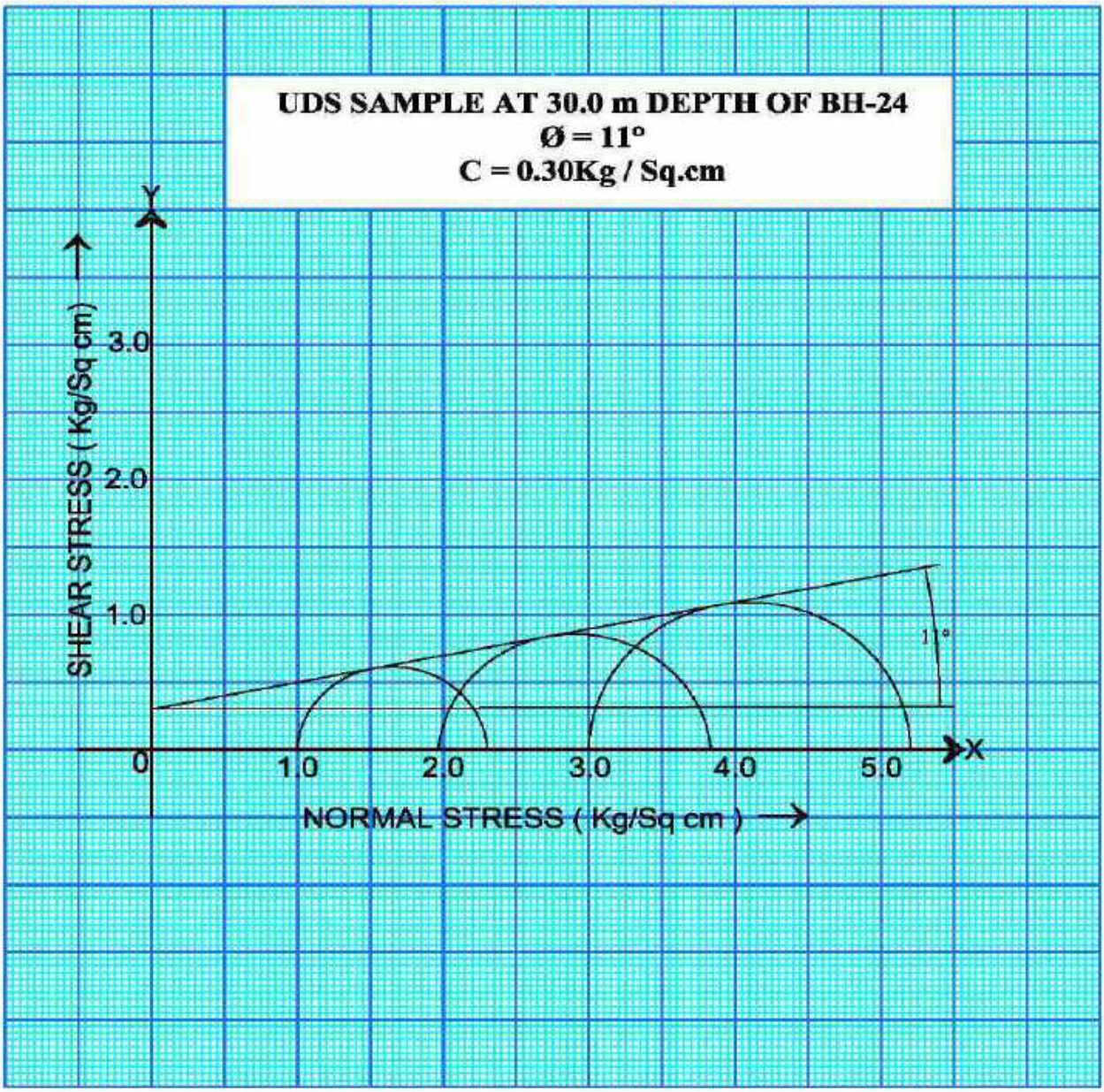

UDS SAMPLE AT 3.00 m DEPTH OF BH-24
Ø = 25°
C = 0.14 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
25°
X
Y

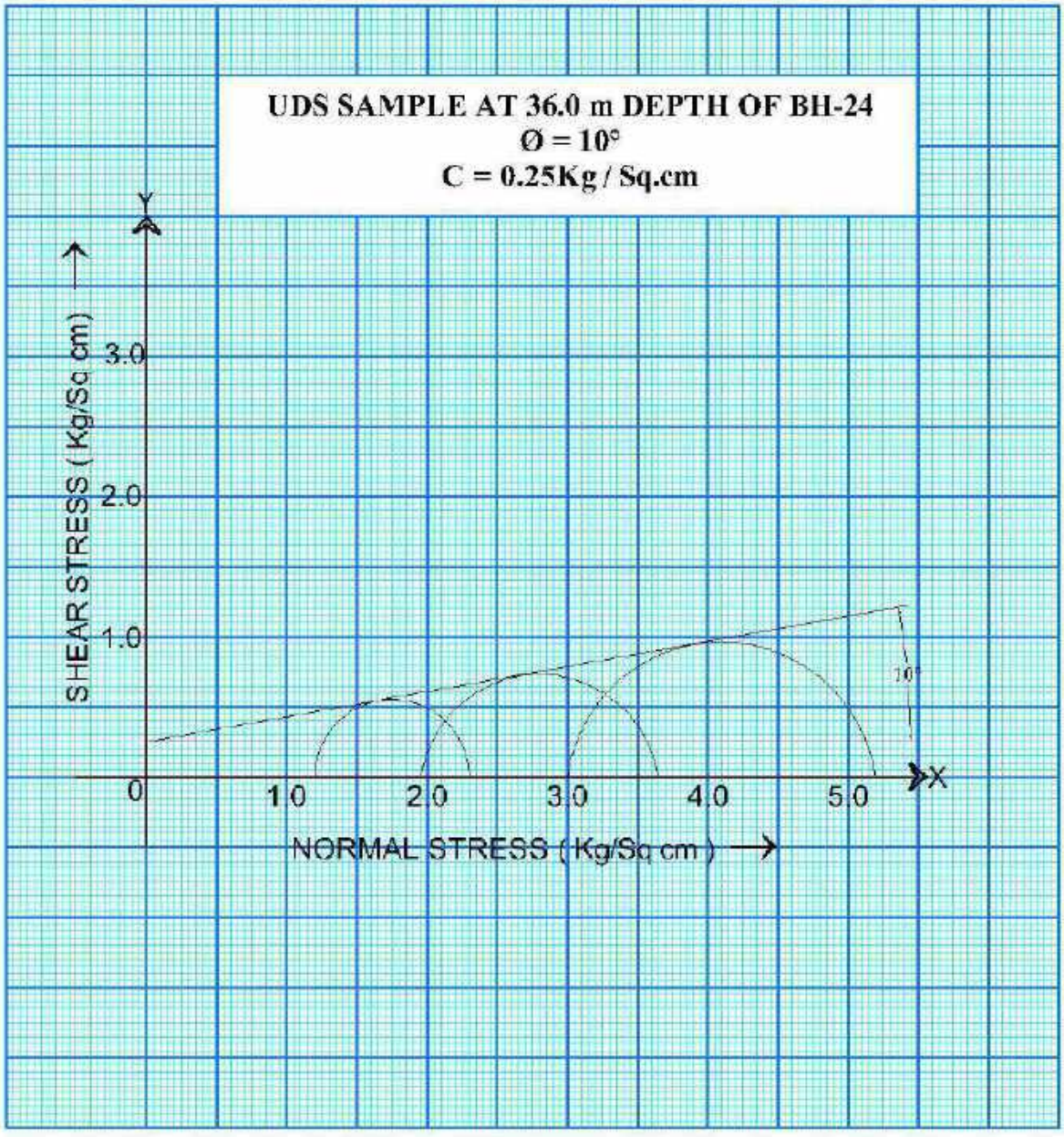

UDS SAMPLE AT 6.00 m DEPTH OF BH-24
Ø = 26°
C = 0.11 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm) →

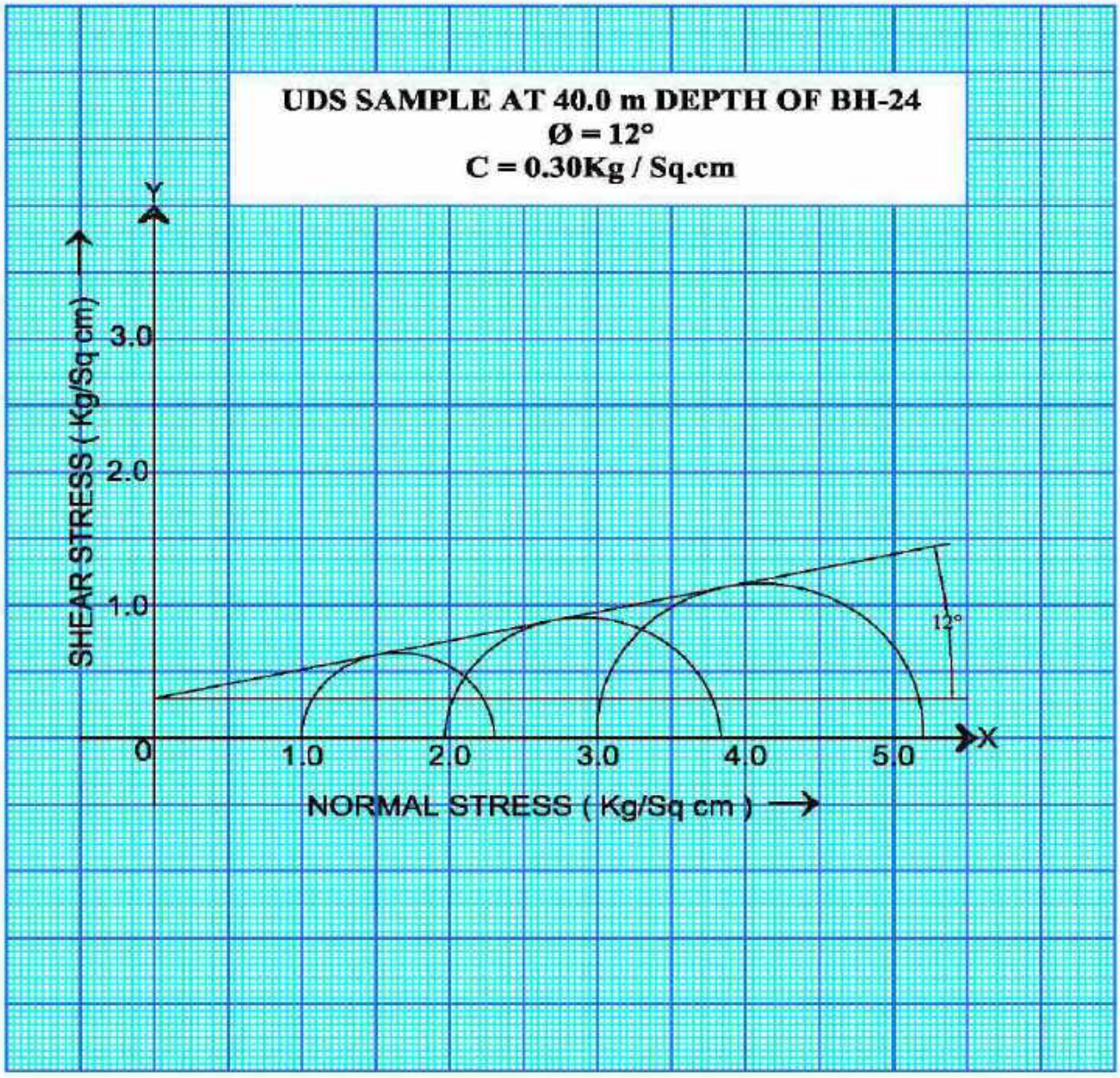

UDS SAMPLE AT 12.00 m DEPTH OF BH-24
Ø = 26°
C = 0.10 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
26°
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)

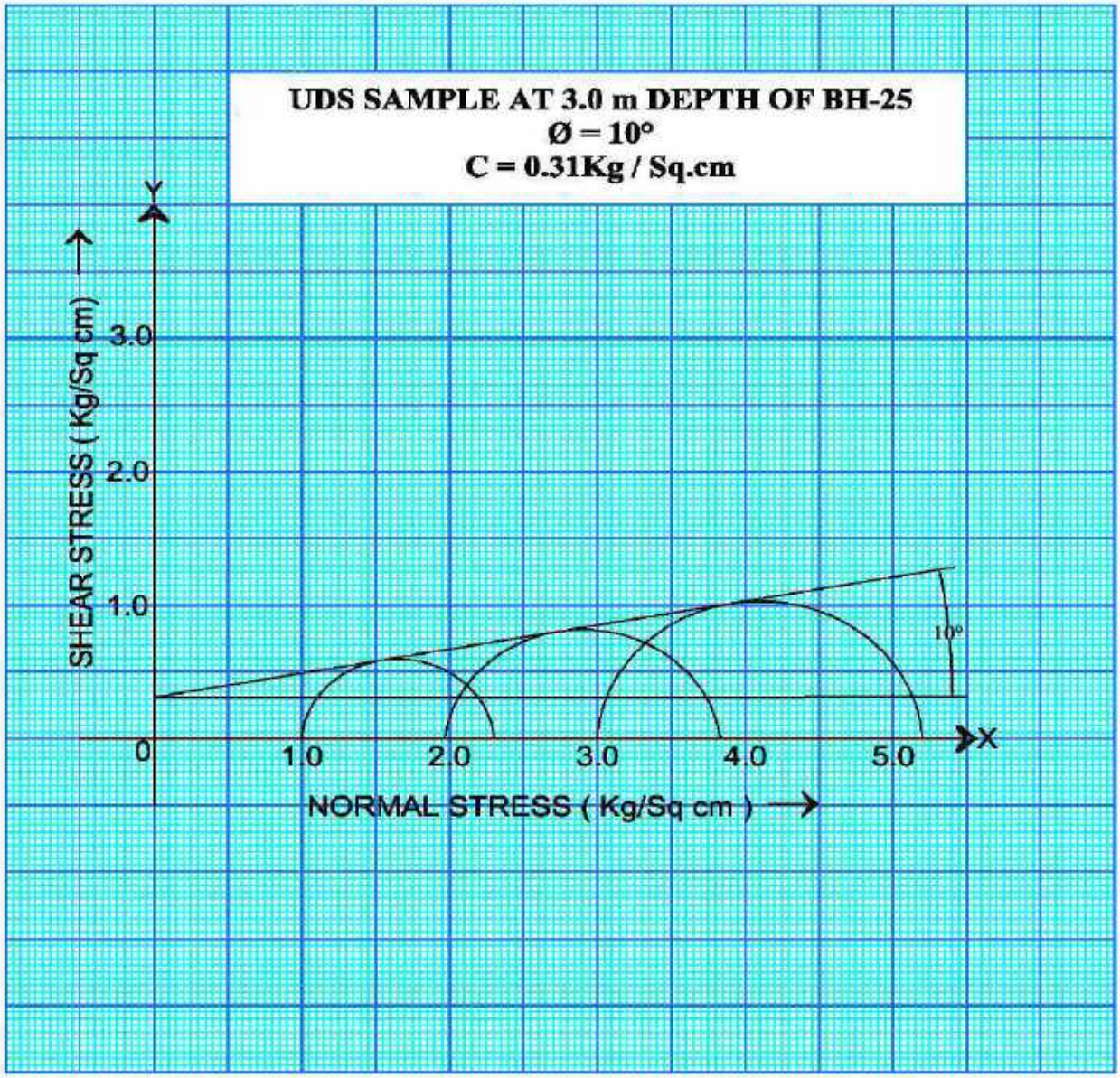

UDS SAMPLE AT 18.00 m DEPTH OF BH-24
Ø = 27°
C = 0.12 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm) →
27°

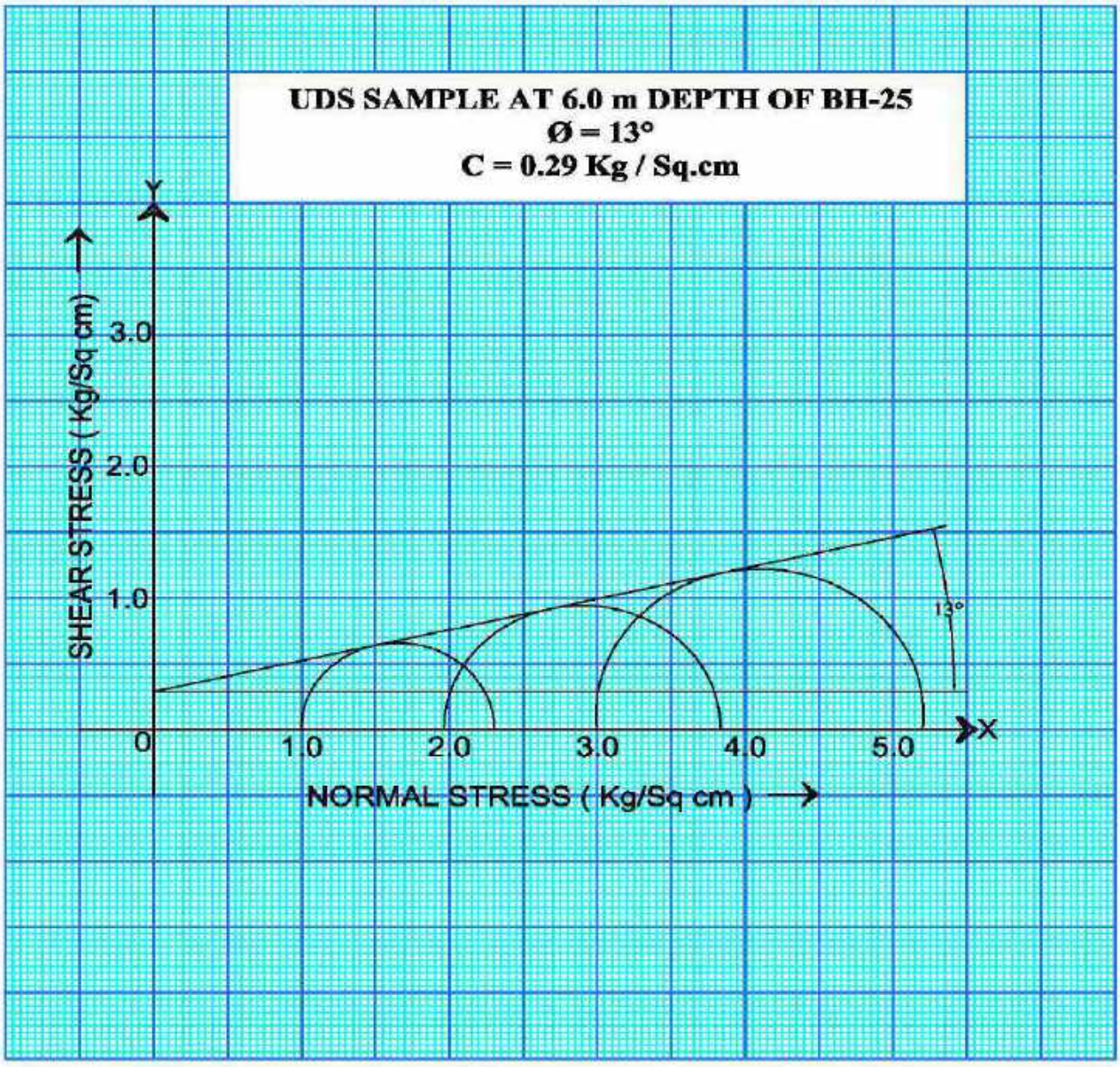

UDS SAMPLE AT 24.0 m DEPTH OF BH-24
Ø = 15°
C = 0.25Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
15°

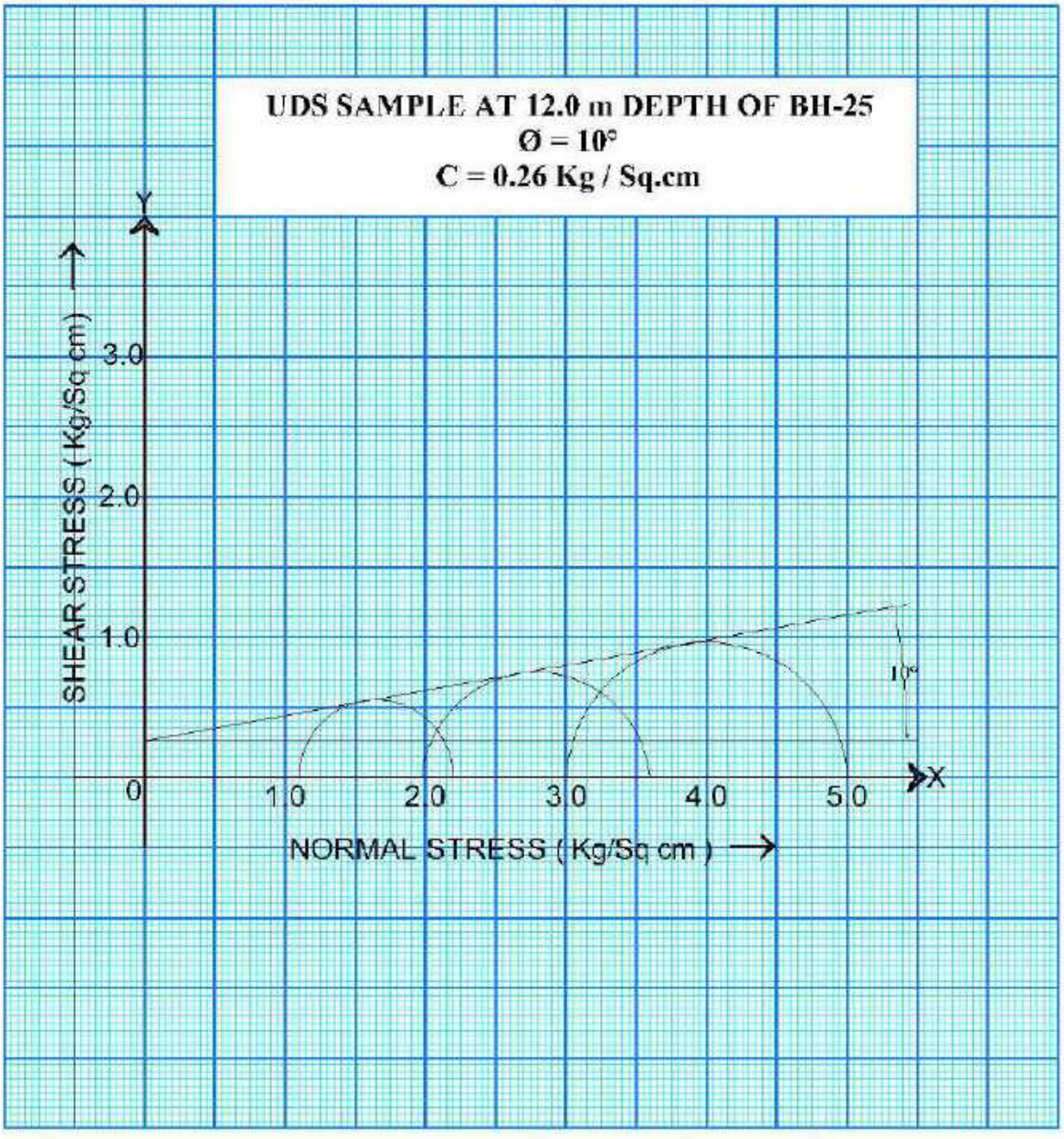

UDS SAMPLE AT 30.0 m DEPTH OF BH-24
Ø = 11°
C = 0.30Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
11°

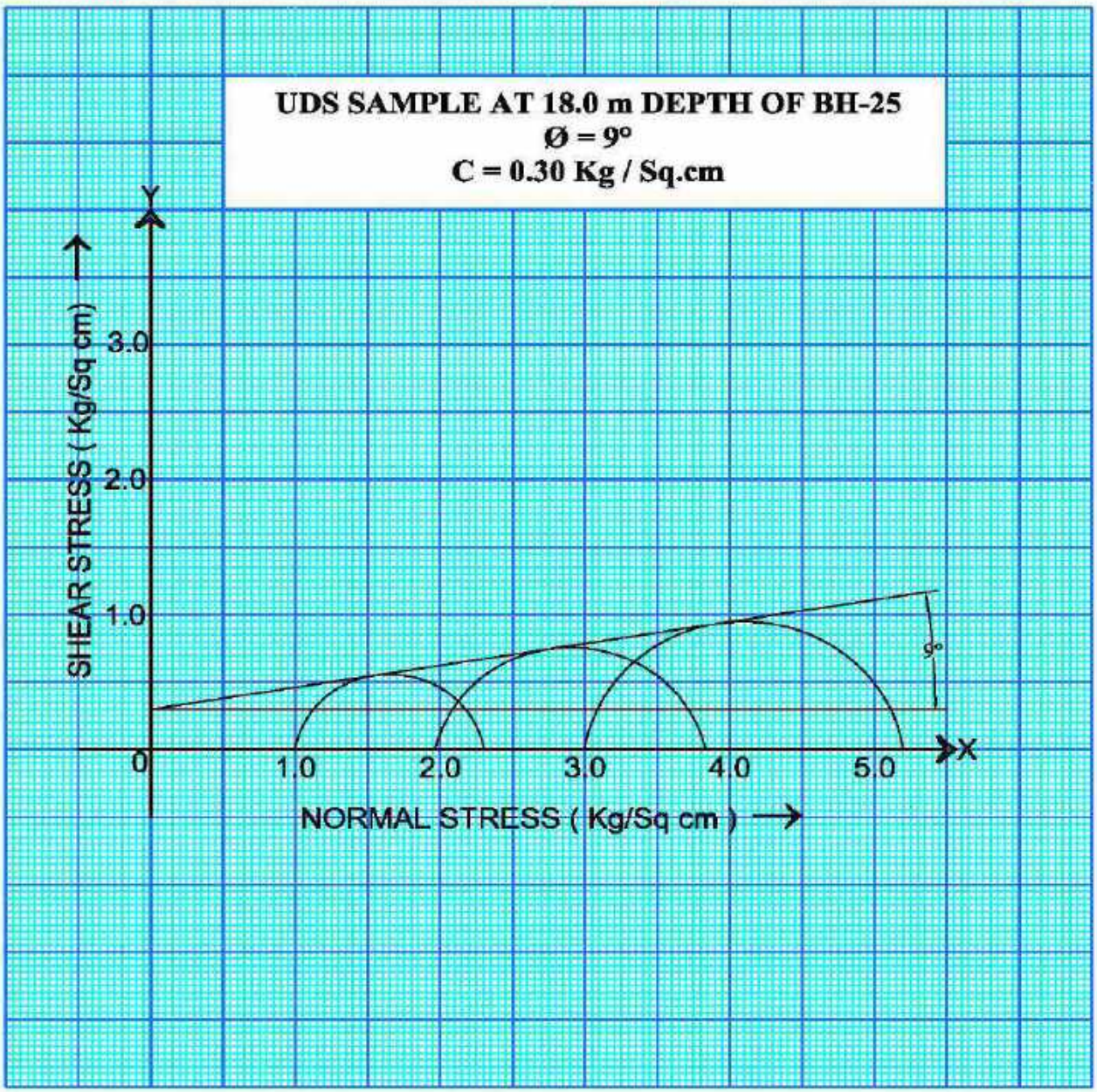

UDS SAMPLE AT 36.0 m DEPTH OF BH-24
Ø = 10°
C = 0.25Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
10°
NORMAL STRESS (Kg/Sq cm)

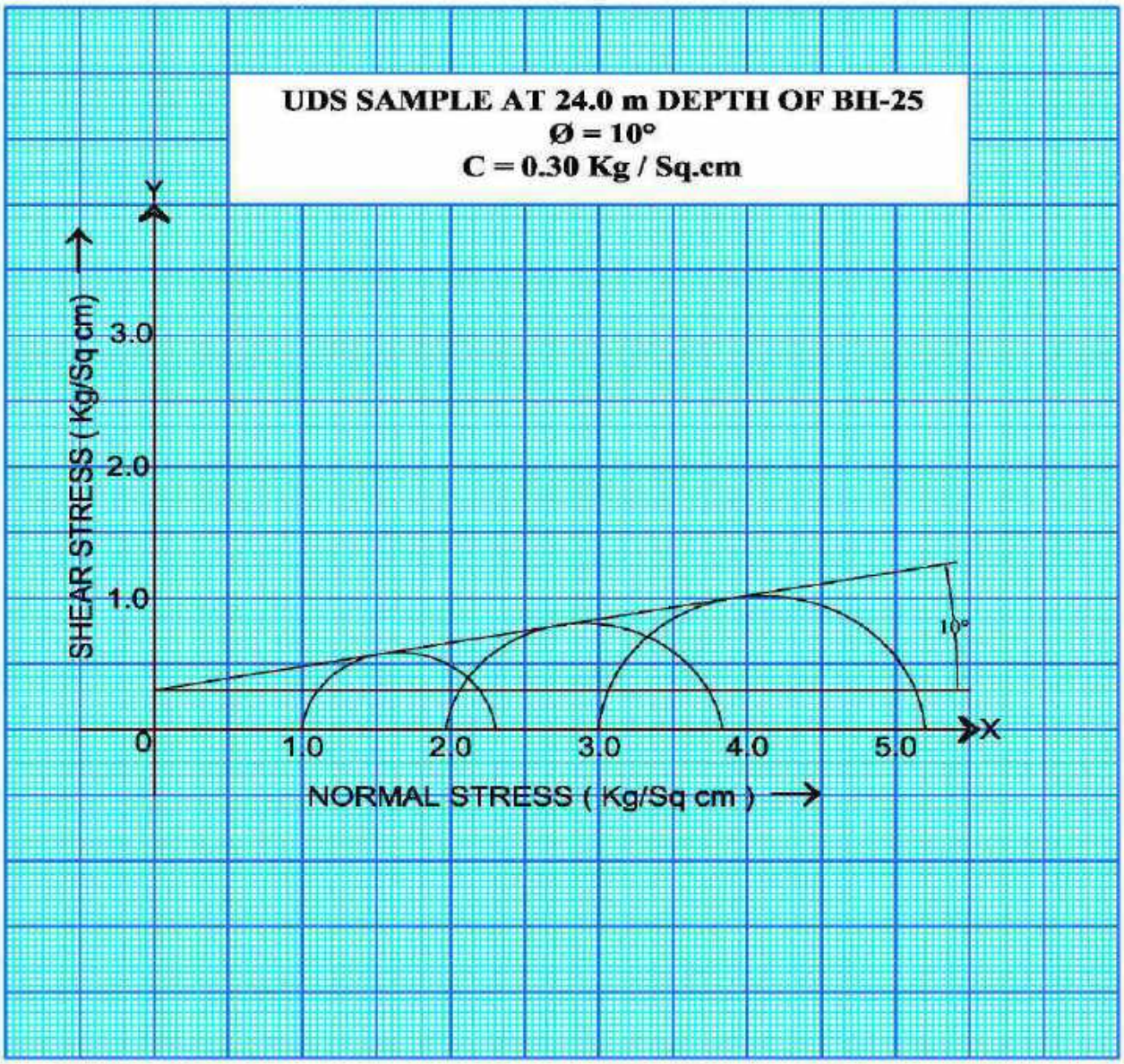

UDS SAMPLE AT 40.0 m DEPTH OF BH-24
Ø = 12°
C = 0.30Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
12°

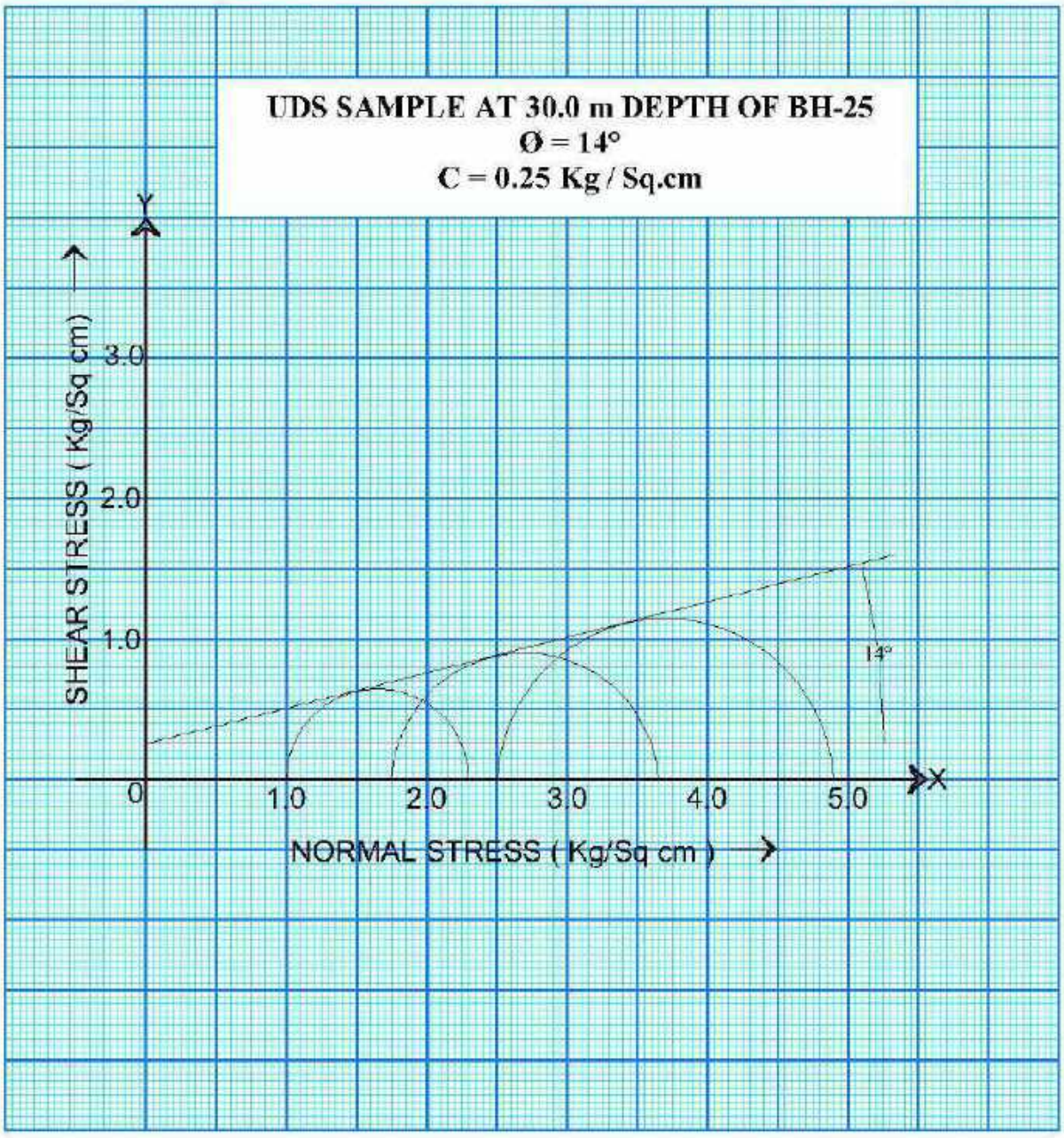

UDS SAMPLE AT 3.0 m DEPTH OF BH-25
Ø = 10°
C = 0.31Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
10°

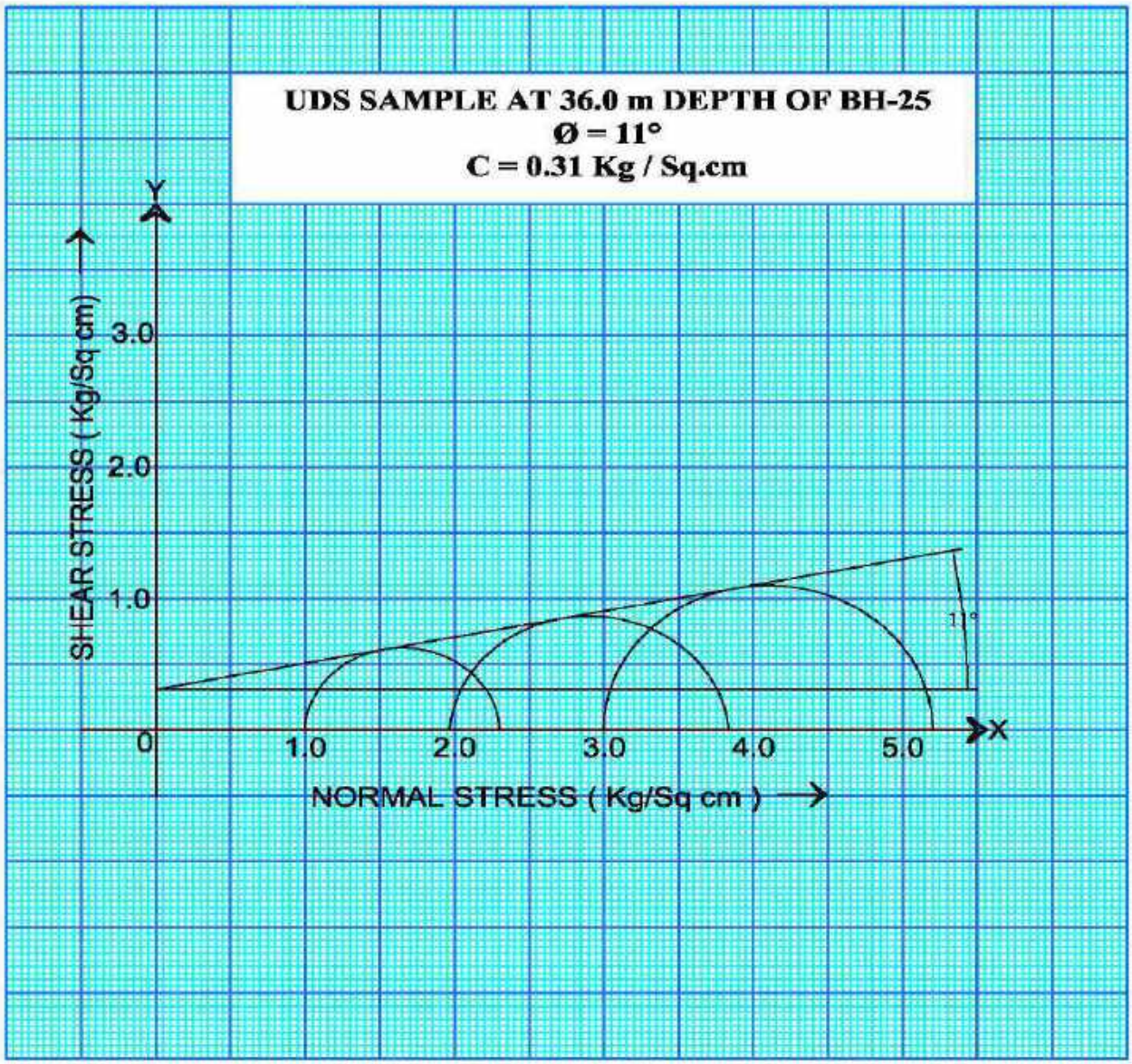

UDS SAMPLE AT 6.0 m DEPTH OF BH-25
Ø = 13°
C = 0.29 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
13°
NORMAL STRESS (Kg/Sq cm)

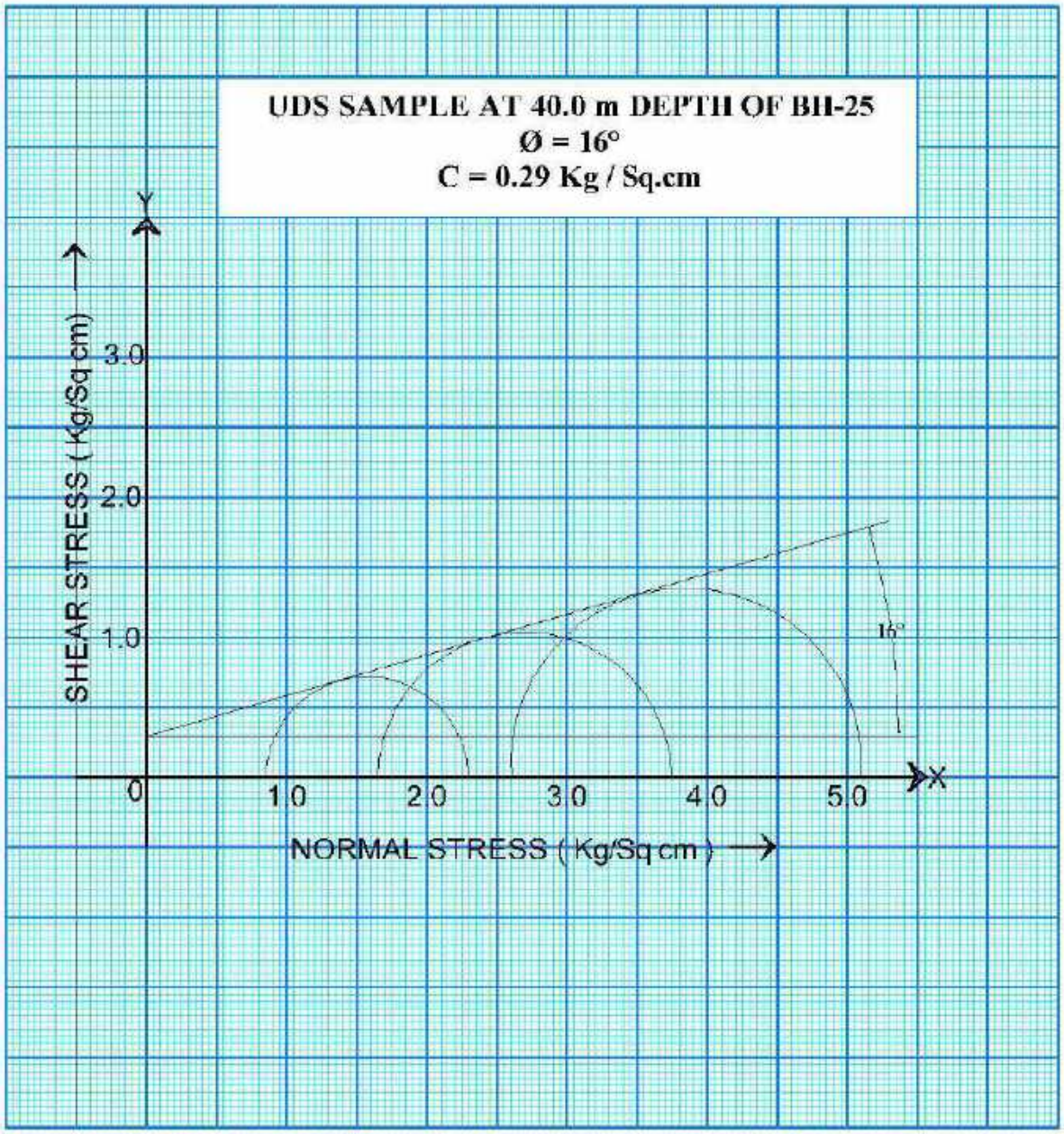

UDS SAMPLE AT 12.0 m DEPTH OF BH-25
Ø = 10°
C = 0.26 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
10
20
30
40
50
NORMAL STRESS (Kg/Sq cm)
X
10°

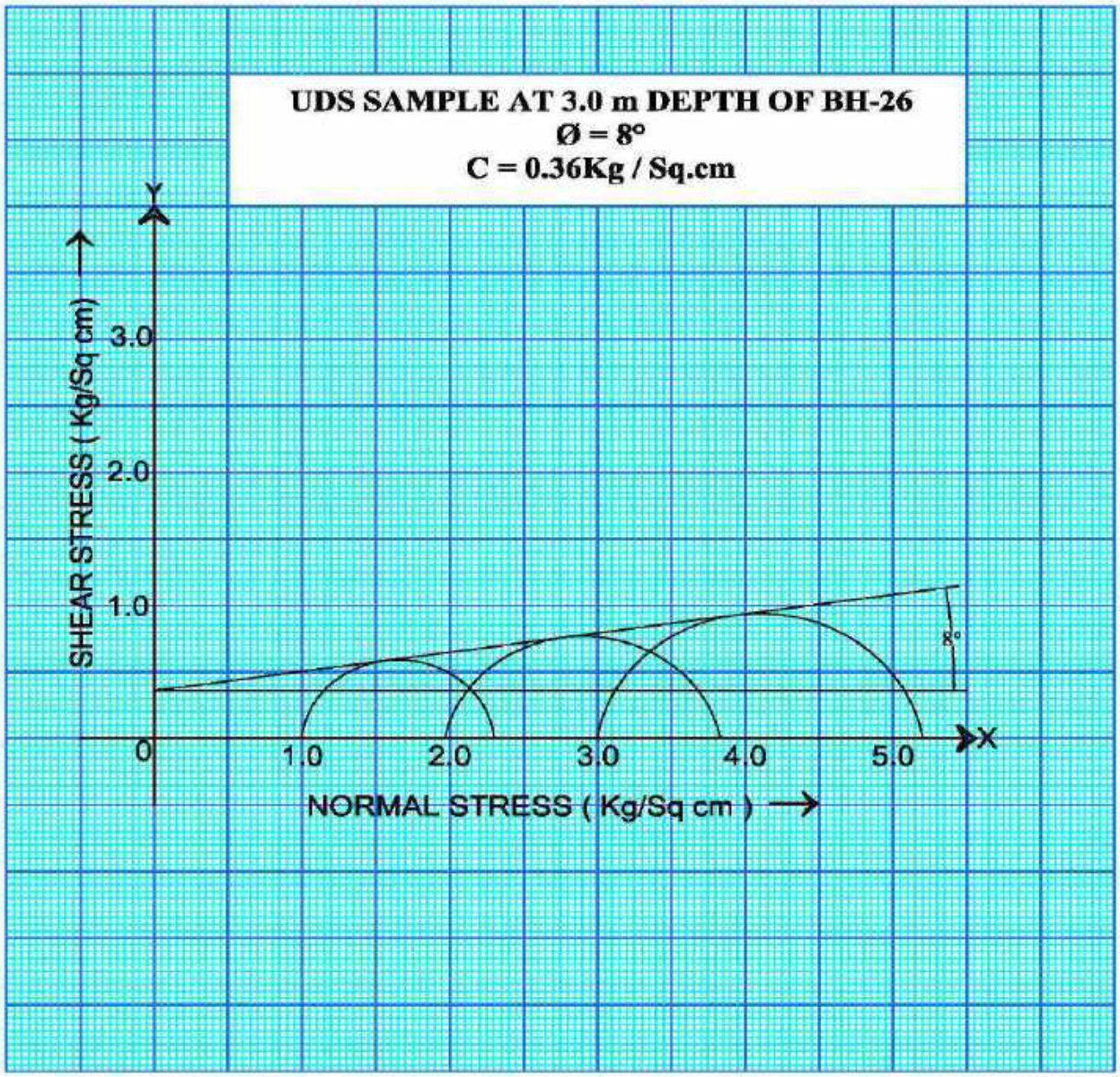

UDS SAMPLE AT 18.0 m DEPTH OF BH-25
Ø = 9°
C = 0.30 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
9°

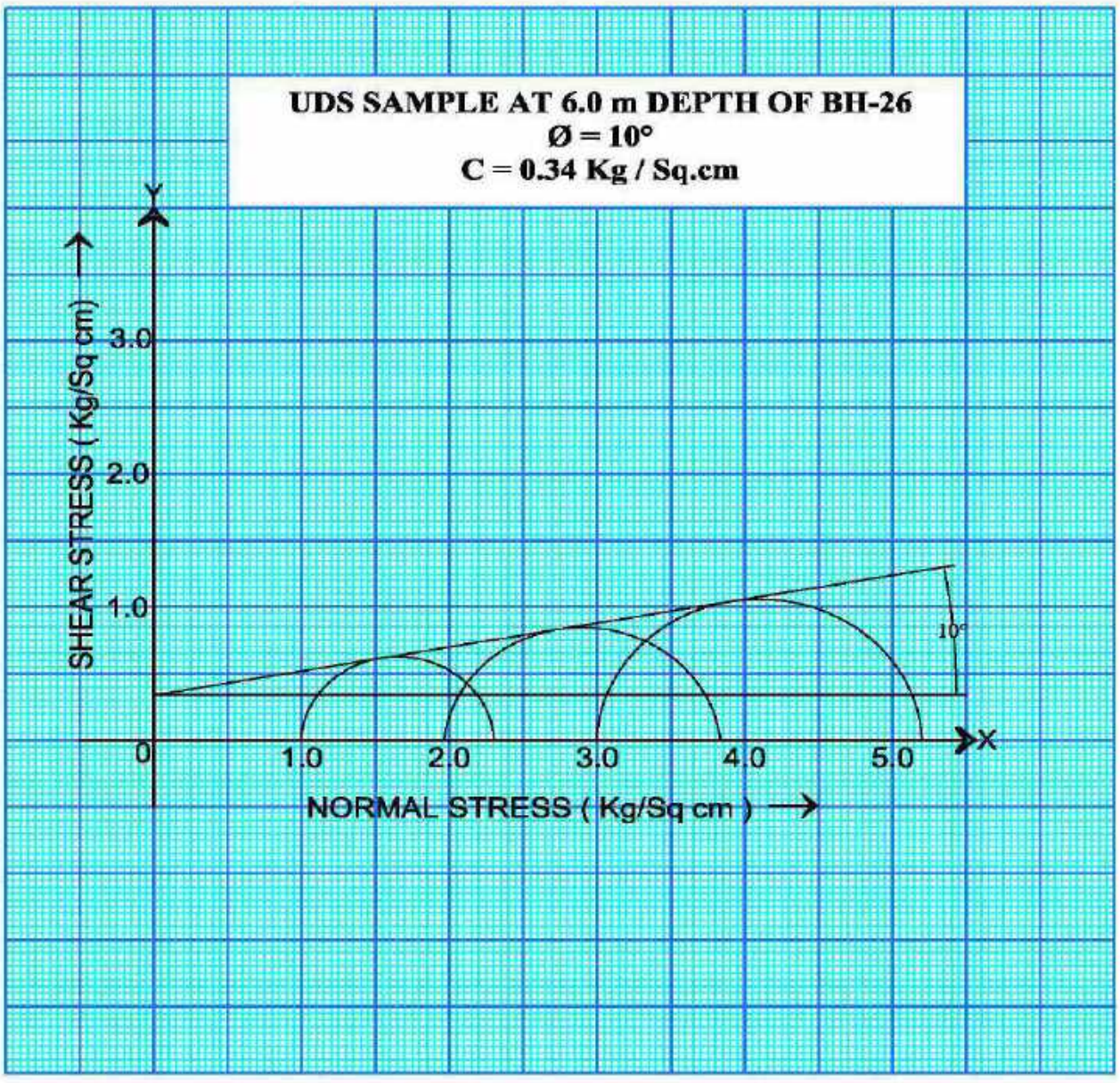

UDS SAMPLE AT 24.0 m DEPTH OF BH-25
Ø = 10°
C = 0.30 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
10°

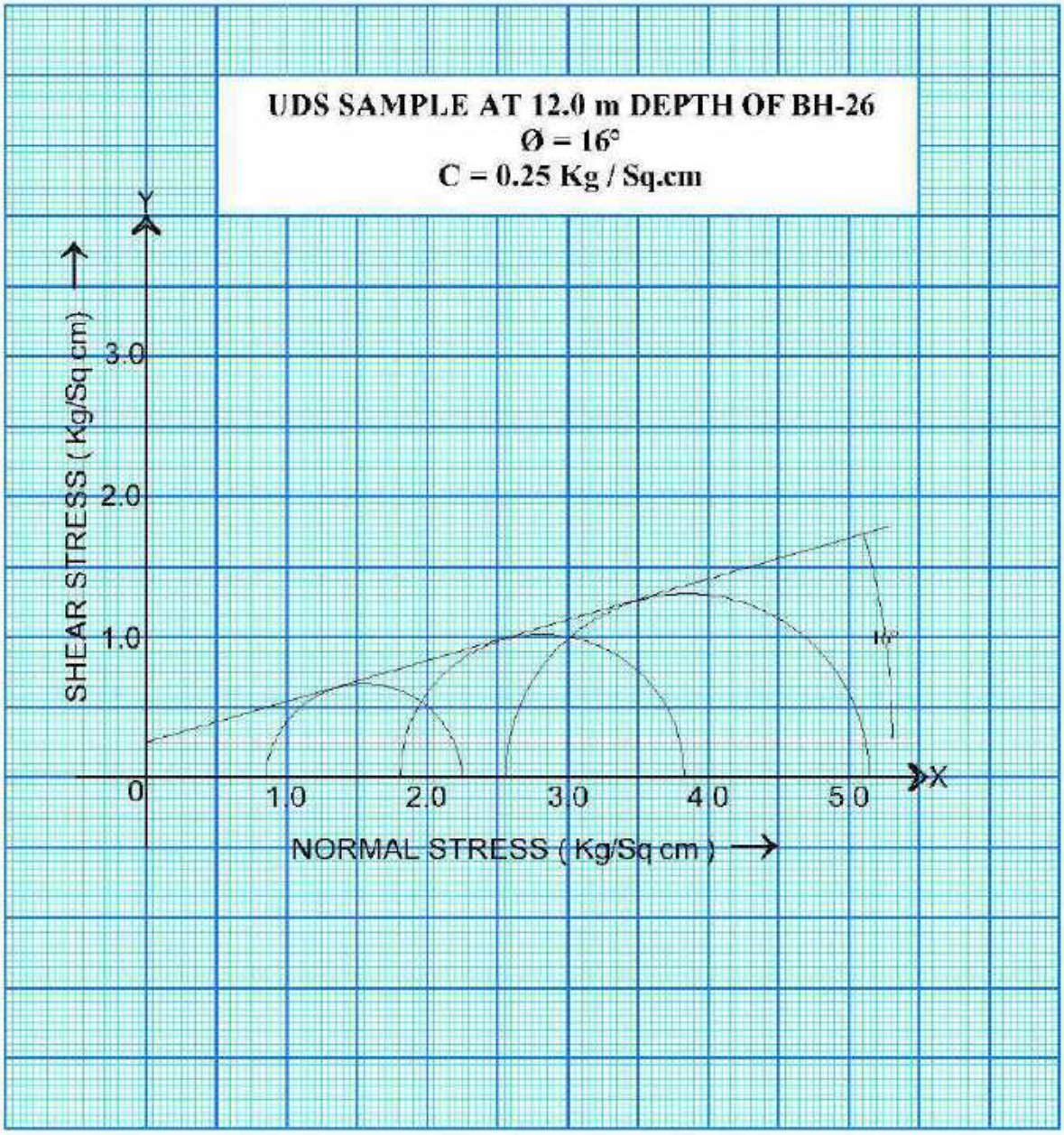

UDS SAMPLE AT 30.0 m DEPTH OF BH-25
Ø = 14°
C = 0.25 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
4.0
5.0
14°

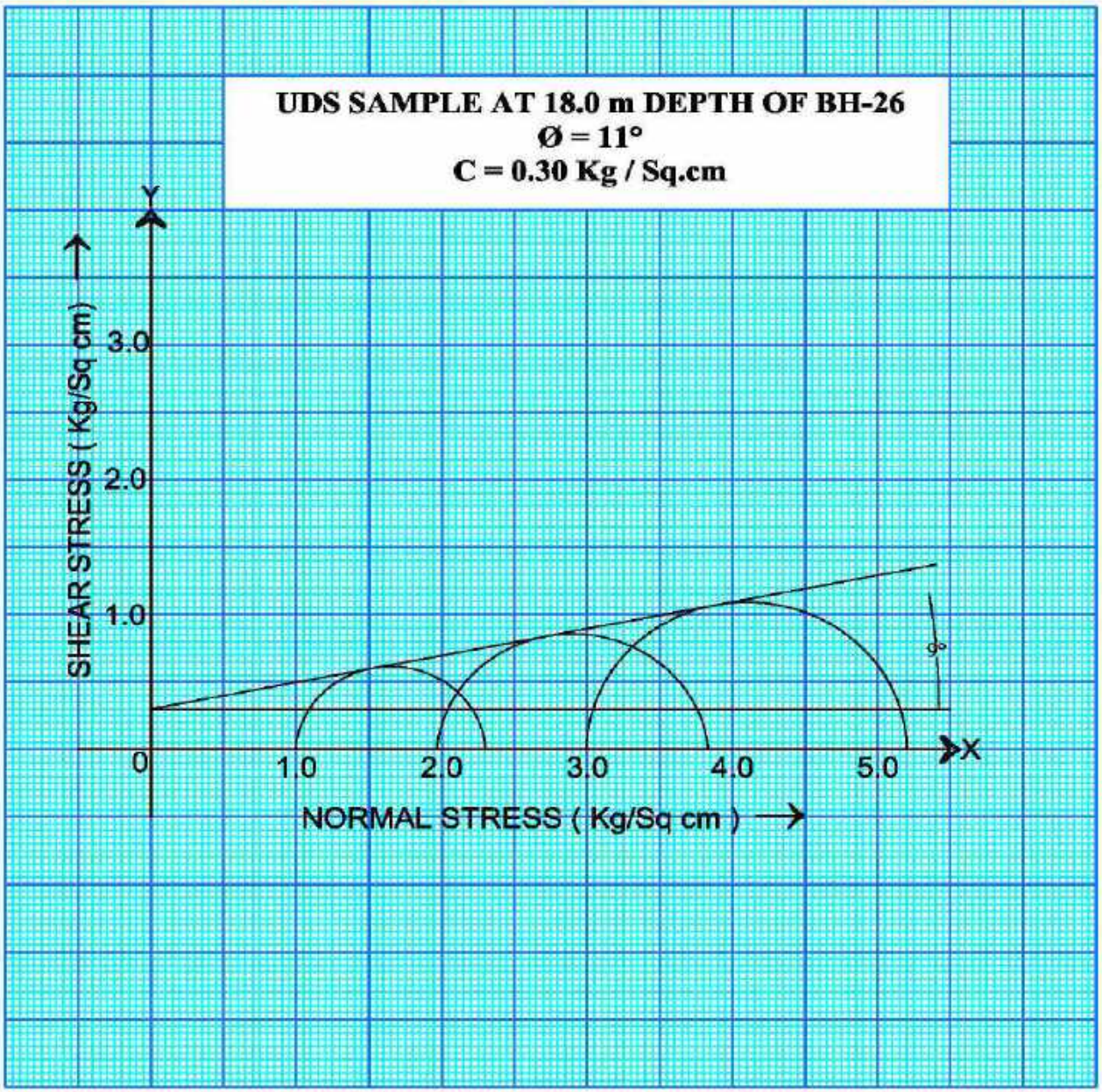

UDS SAMPLE AT 36.0 m DEPTH OF BH-25
Ø = 11°
C = 0.31 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
4.0
5.0
11°

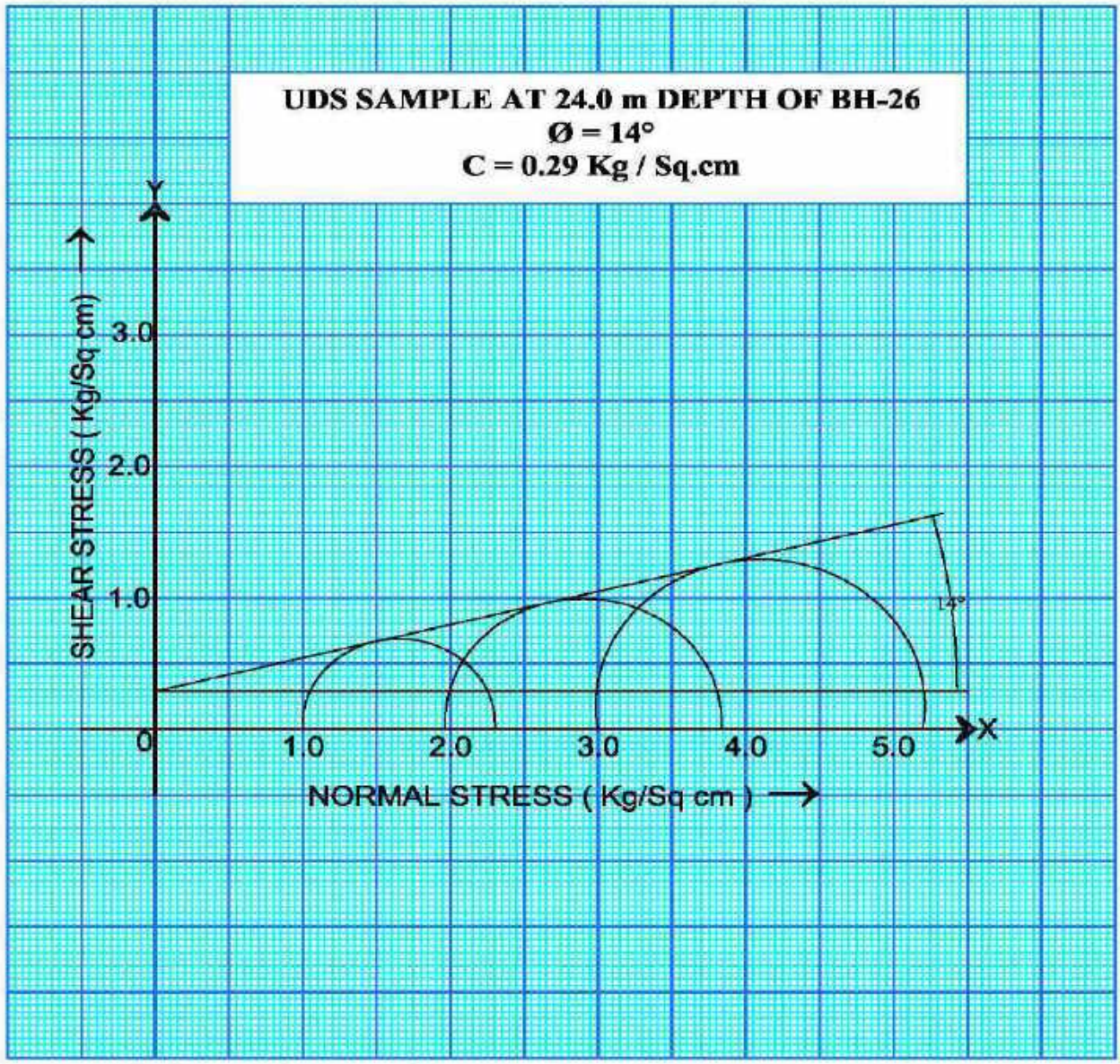

UDS SAMPLE AT 40.0 m DEPTH OF BH-25
Ø = 16°
C = 0.29 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
16°

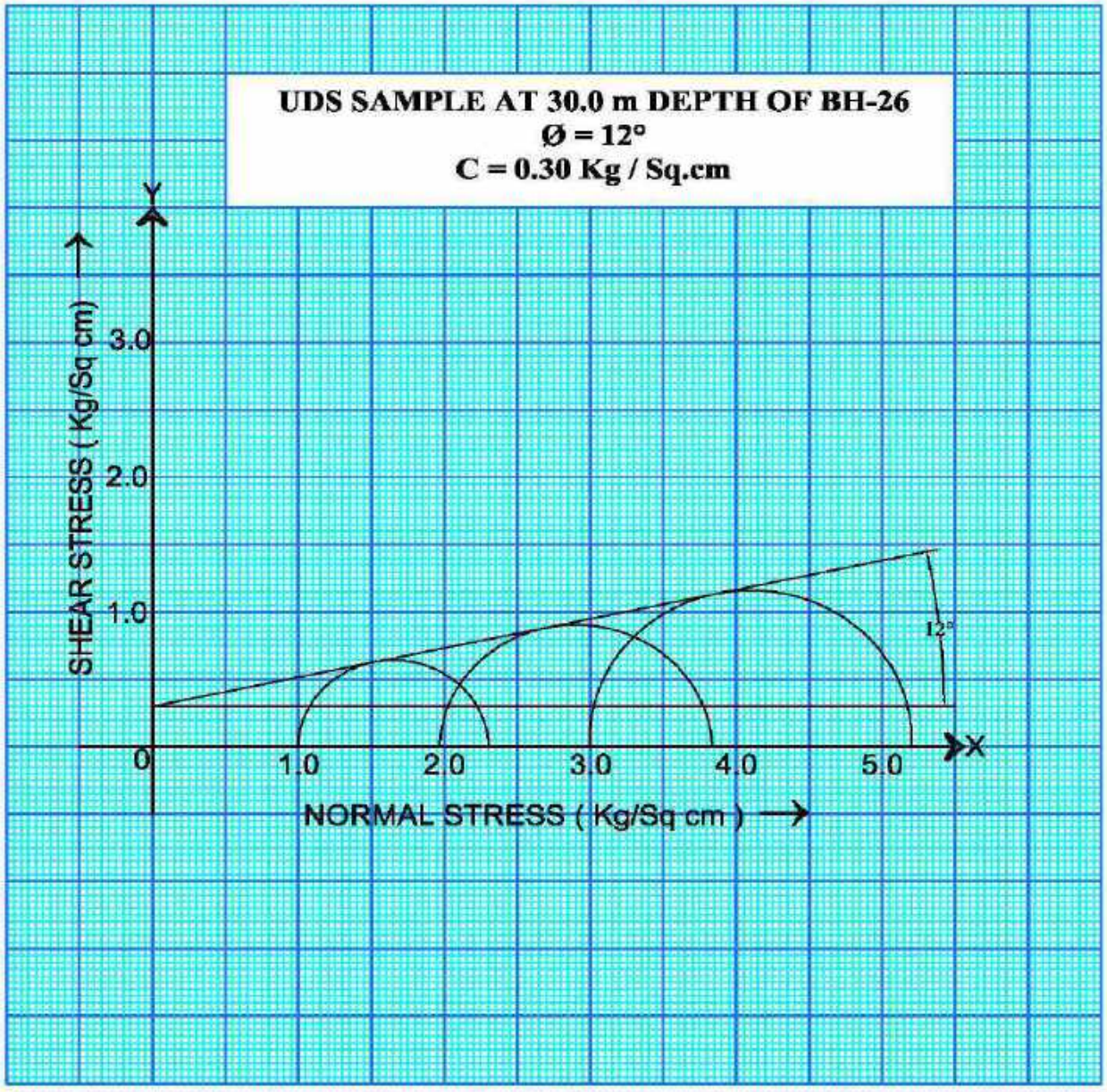

UDS SAMPLE AT 3.0 m DEPTH OF BH-26
Ø = 8°
C = 0.36Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
8°

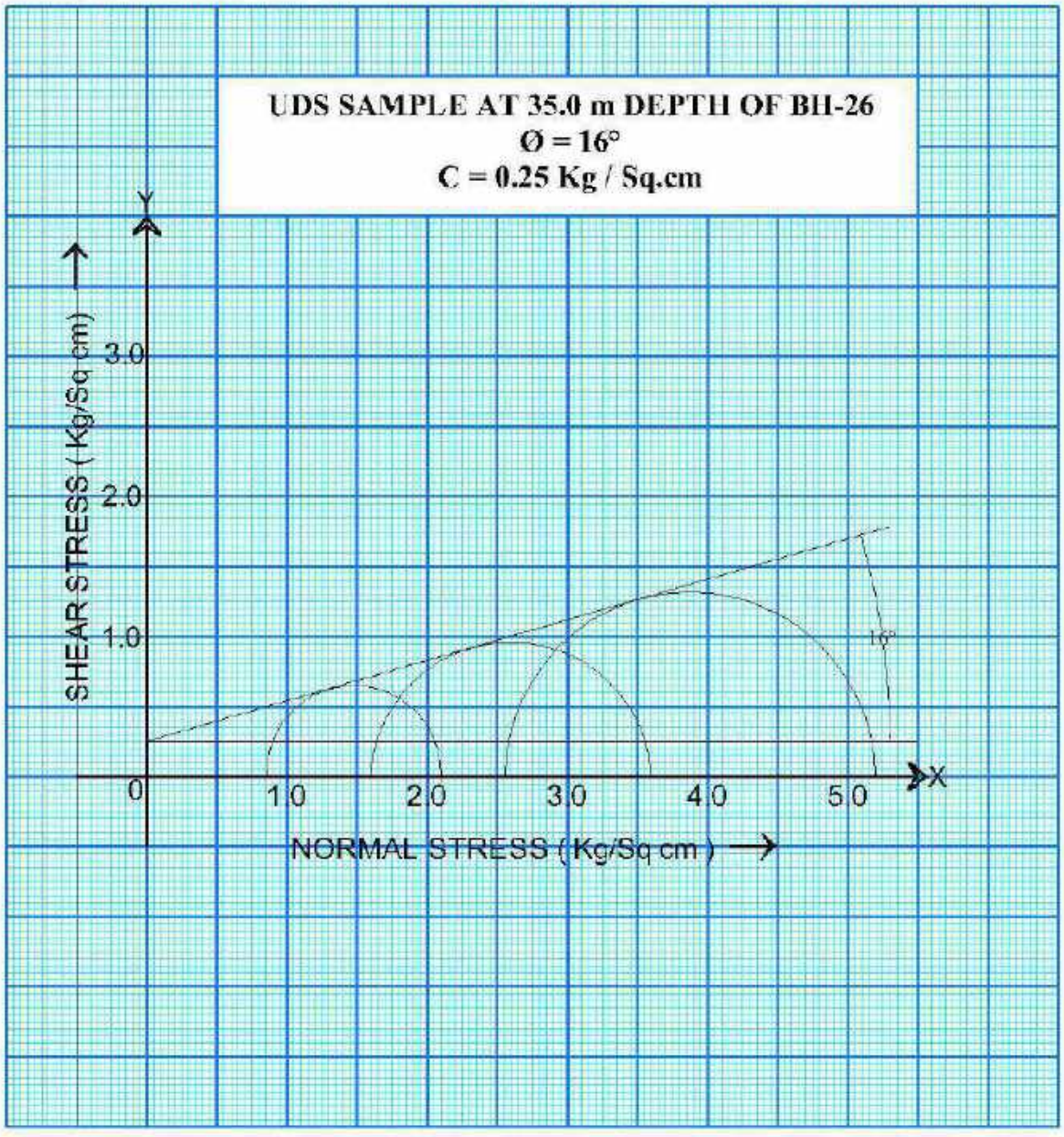

UDS SAMPLE AT 6.0 m DEPTH OF BH-26
Ø = 10°
C = 0.34 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
10°

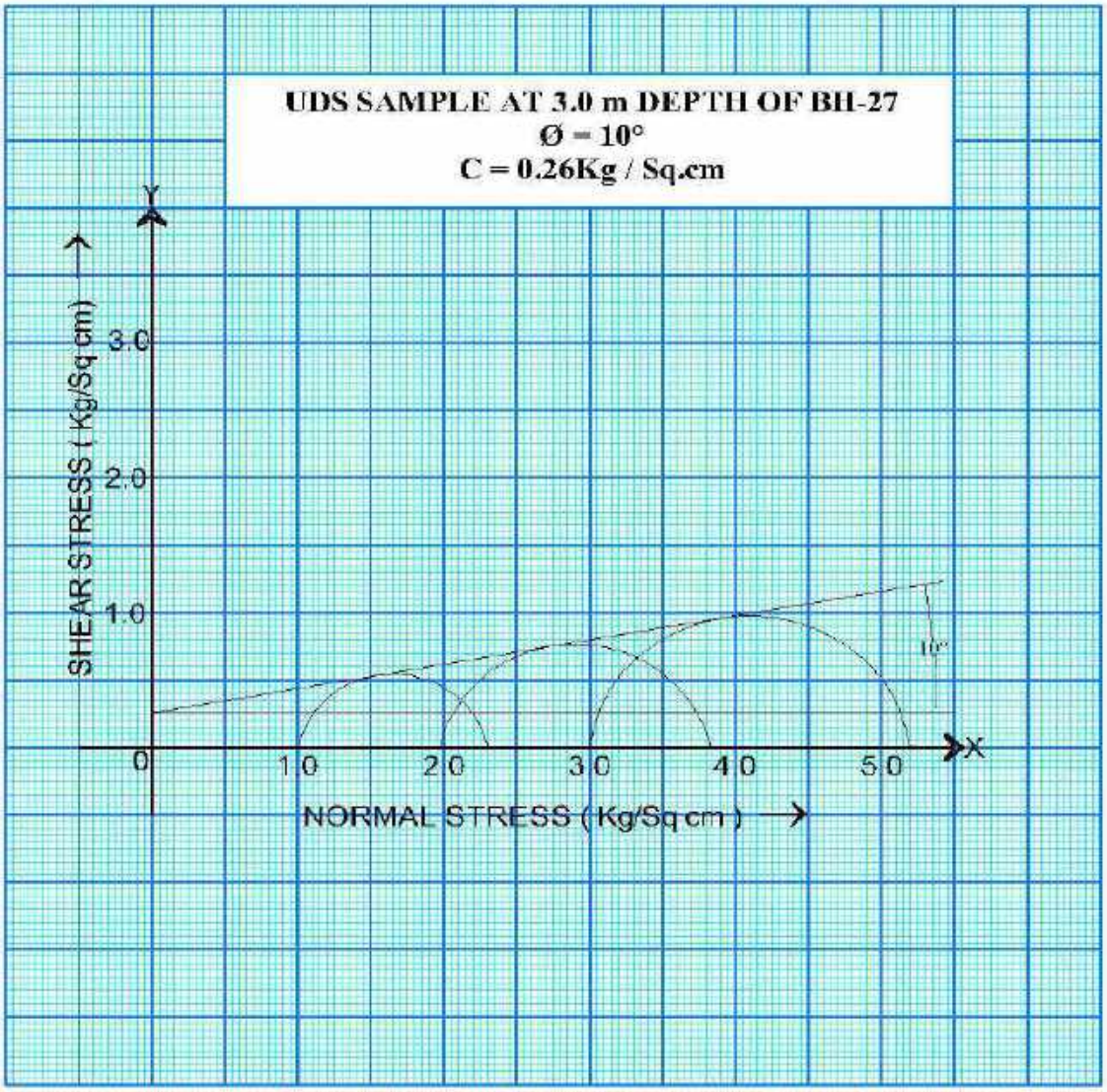

UDS SAMPLE AT 12.0 m DEPTH OF BH-26
Ø = 16°
C = 0.25 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
16°

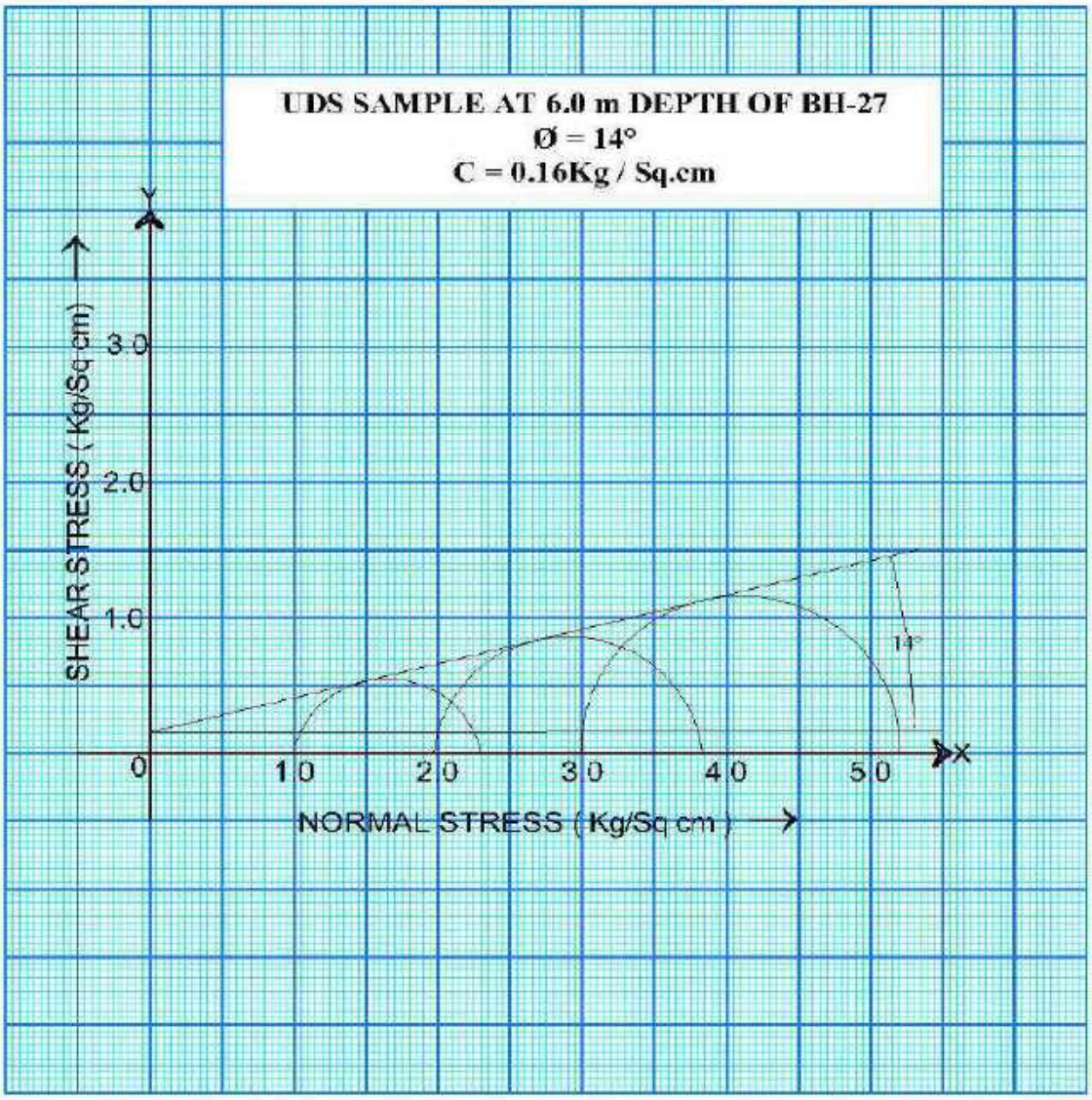

UDS SAMPLE AT 18.0 m DEPTH OF BH-26
Ø = 11°
C = 0.30 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
Ø°

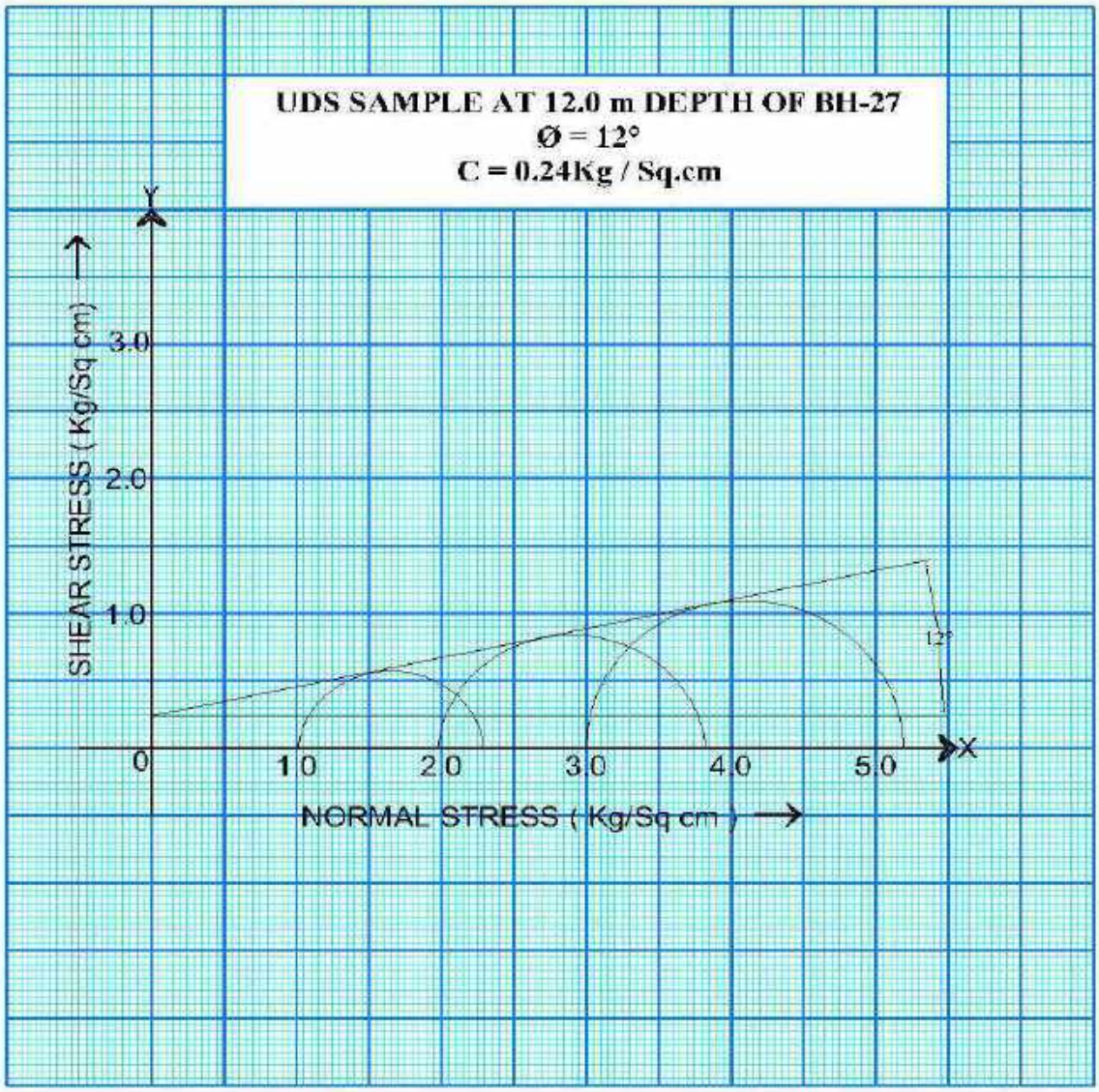

UDS SAMPLE AT 24.0 m DEPTH OF BH-26
Ø = 14°
C = 0.29 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
14°

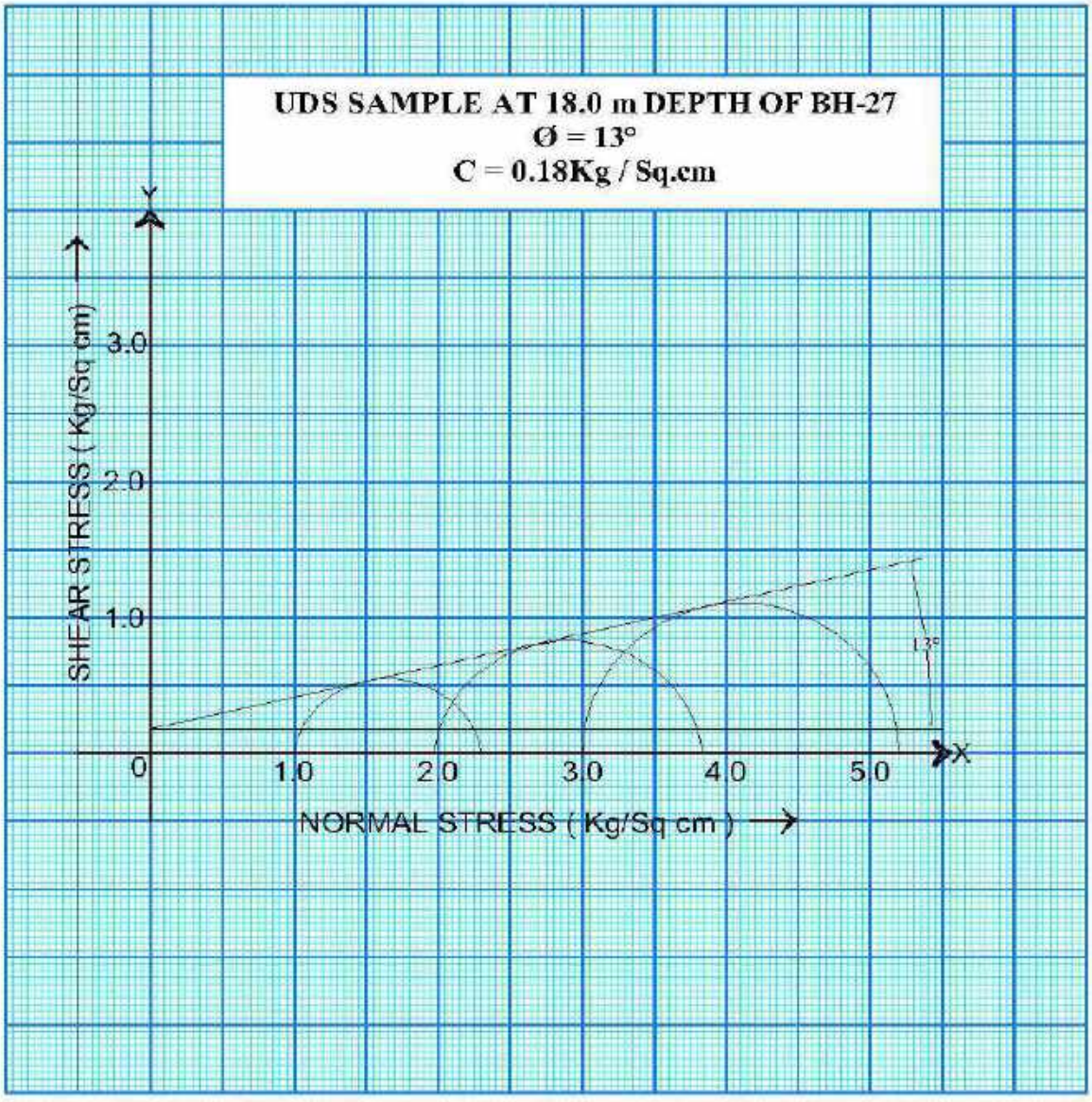

UDS SAMPLE AT 30.0 m DEPTH OF BH-26
Ø = 12°
C = 0.30 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
Y
X
12°
1.0
2.0
3.0
4.0
5.0
NORMAL STRESS (Kg/Sq cm)

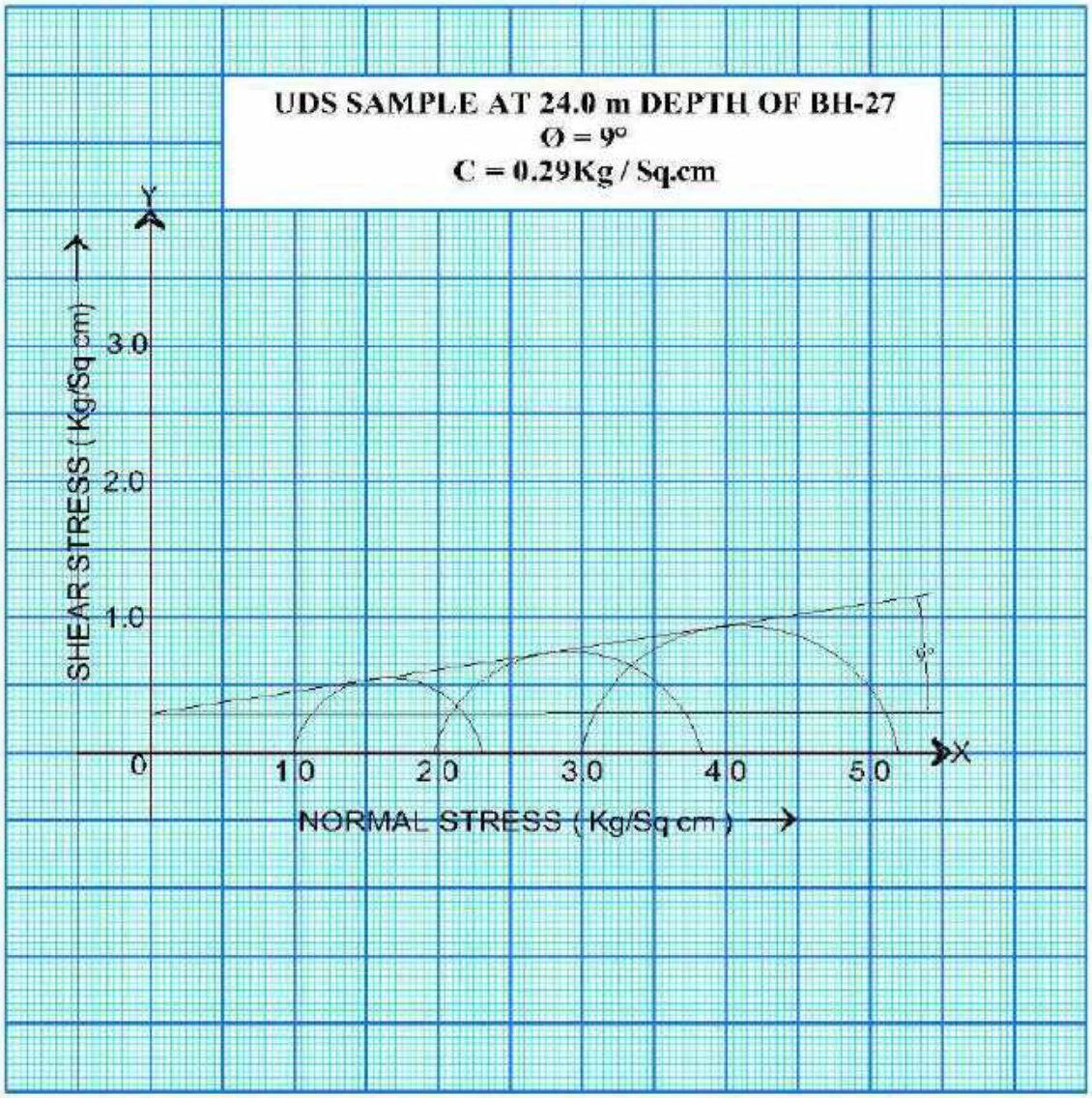

UDS SAMPLE AT 35.0 m DEPTH OF BH-26
Ø = 16°
C = 0.25 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
10
20
30
40
50
X
NORMAL STRESS (Kg/Sq cm)
16°

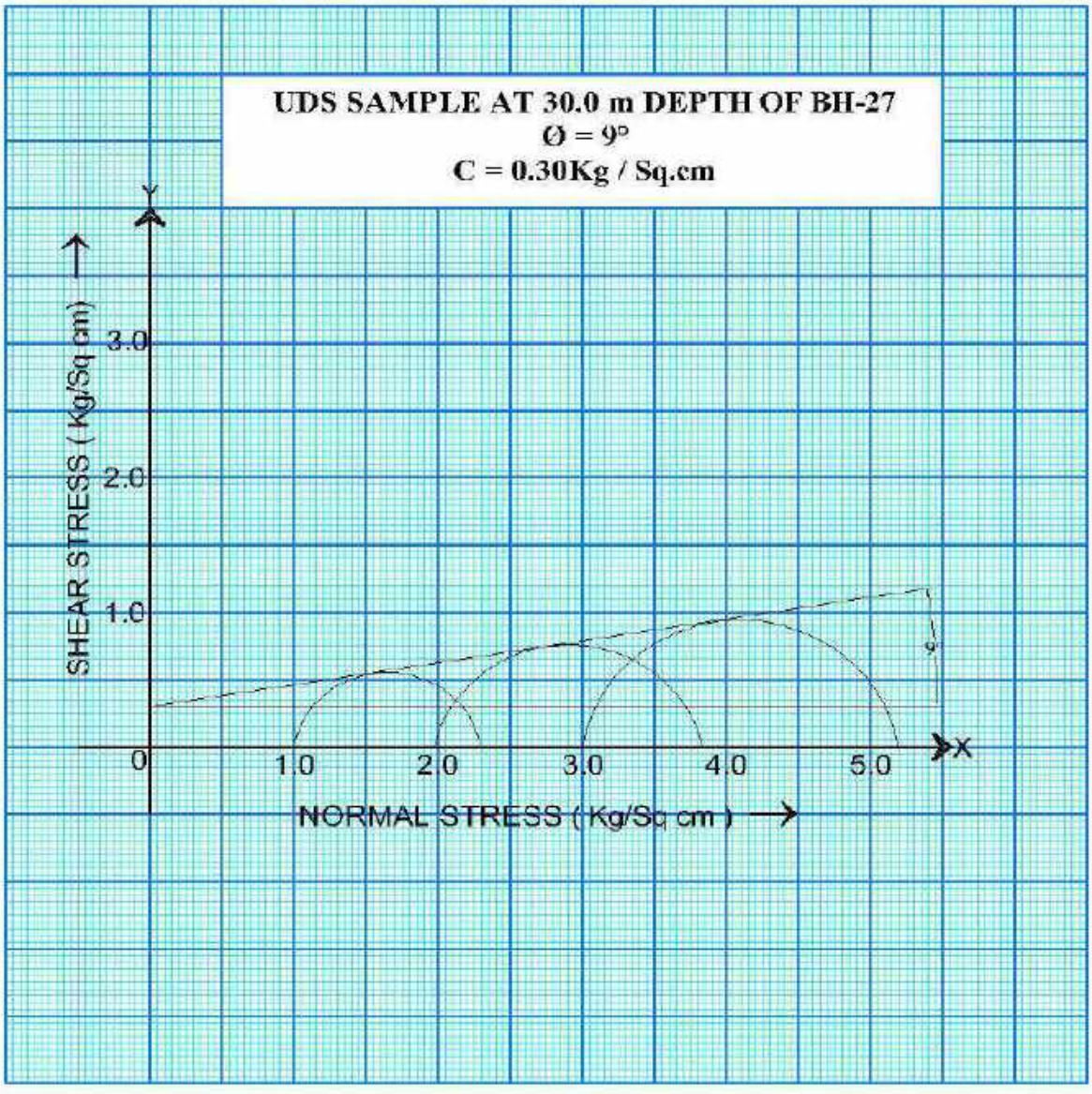

UDS SAMPLE AT 3.0 m DEPTH OF BH-27
Ø = 10°
C = 0.26Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
10°

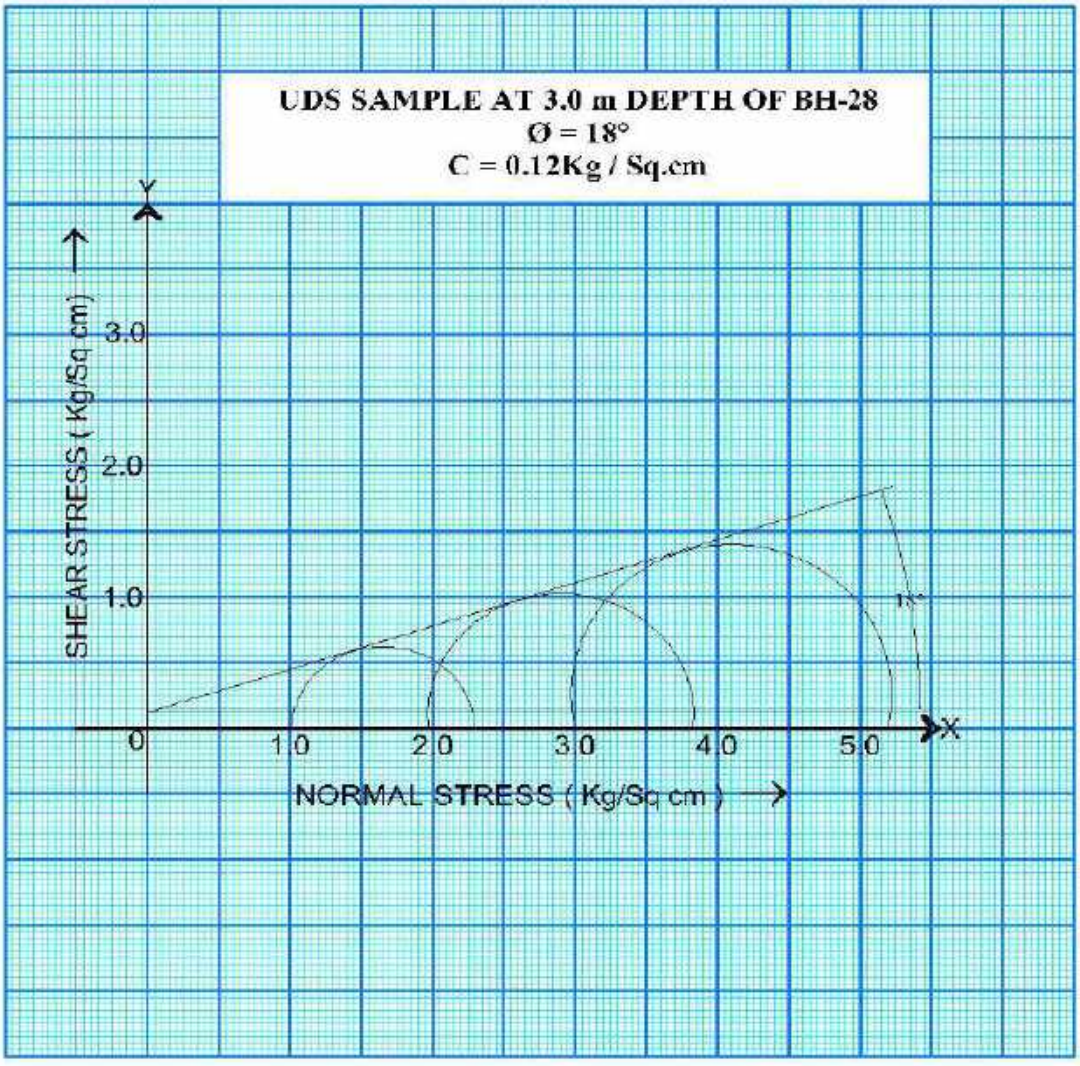

UDS SAMPLE AT 6.0 m DEPTH OF BH-27
Ø = 14°
C = 0.16Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
1.0
2.0
3.0
4.0
5.0
14°

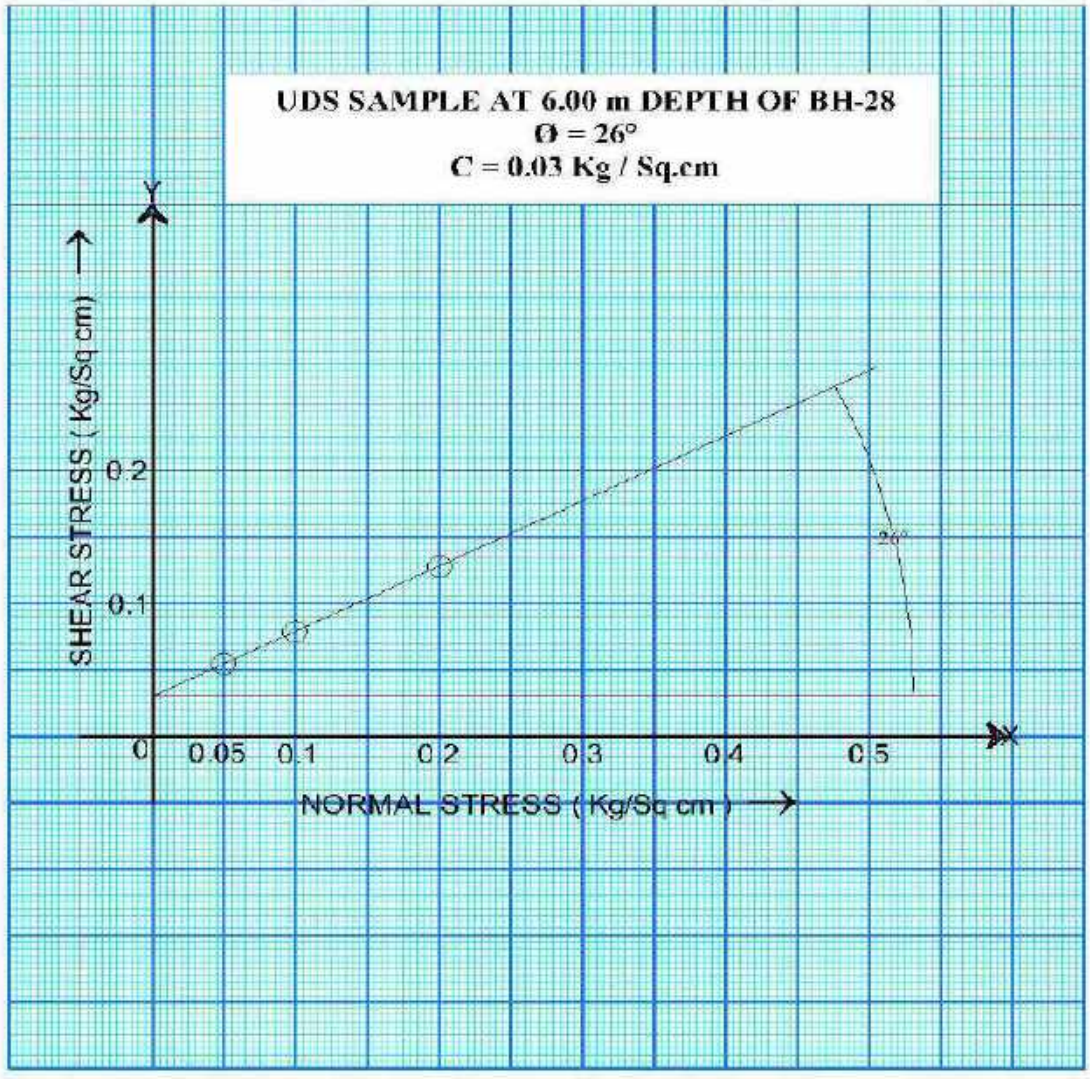

UDS SAMPLE AT 12.0 m DEPTH OF BH-27
Ø = 12°
C = 0.24Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
12°
NORMAL STRESS (Kg/Sq cm)

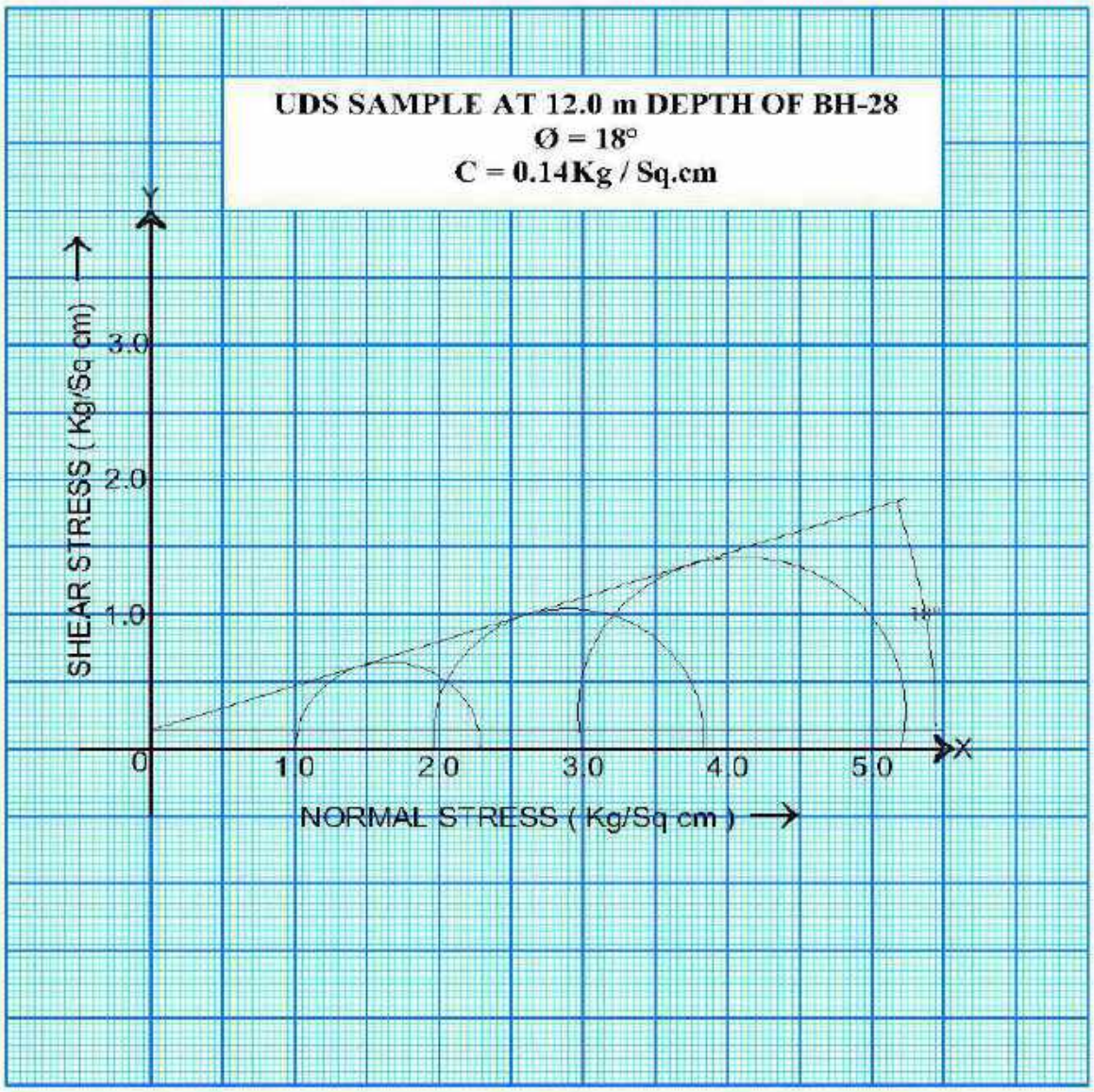

UDS SAMPLE AT 18.0 m DEPTH OF BH-27
Ø = 13°
C = 0.18Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
13°

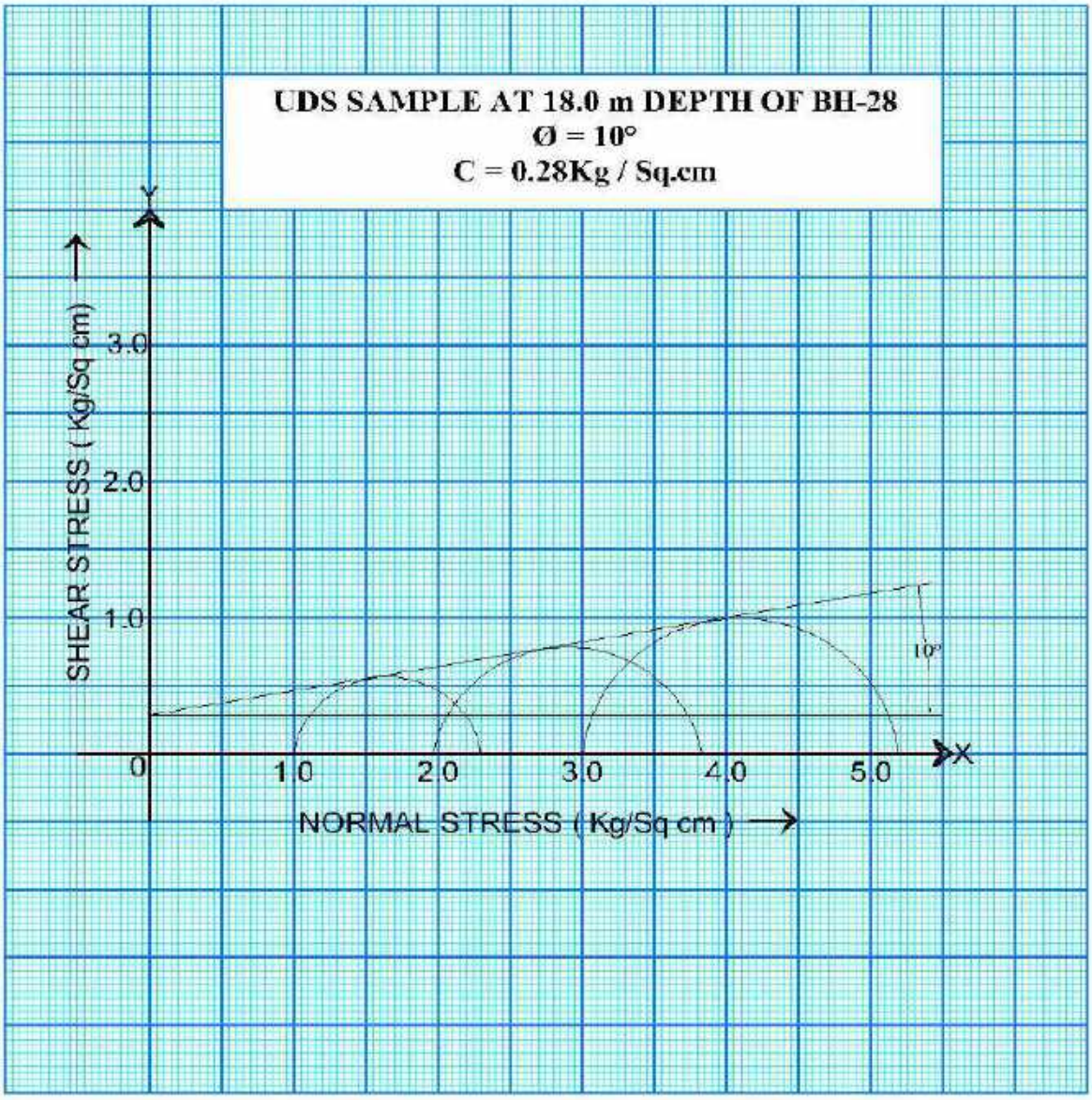

UDS SAMPLE AT 24.0 m DEPTH OF BH-27
Ø = 9°
C = 0.29Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
φ°

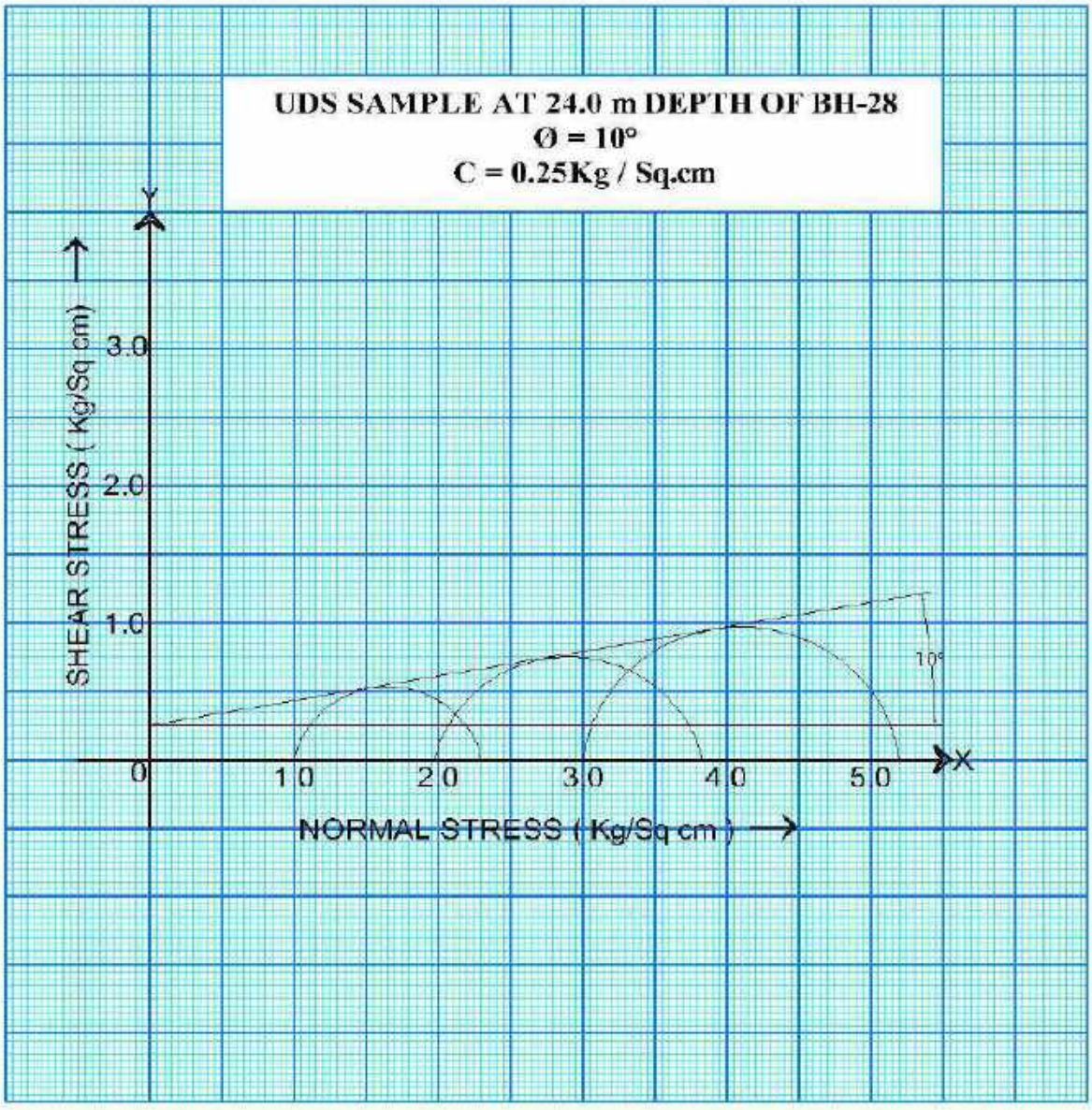

UDS SAMPLE AT 30.0 m DEPTH OF BH-27
Ø = 9°
C = 0.30Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
4.0
5.0
9°

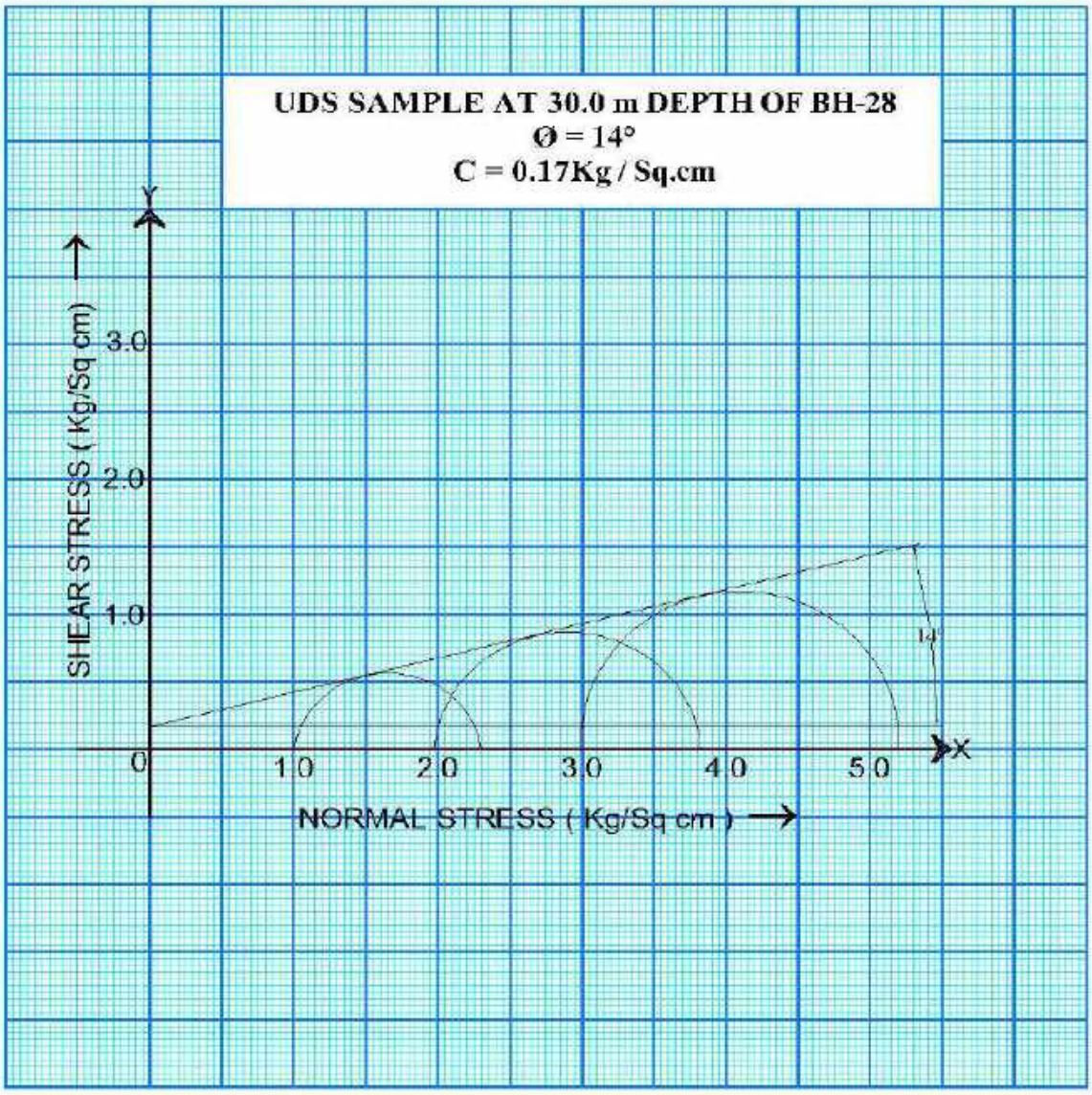

UDS SAMPLE AT 3.0 m DEPTH OF BH-28
Ø = 18°
C = 0.12Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
4.0
5.0

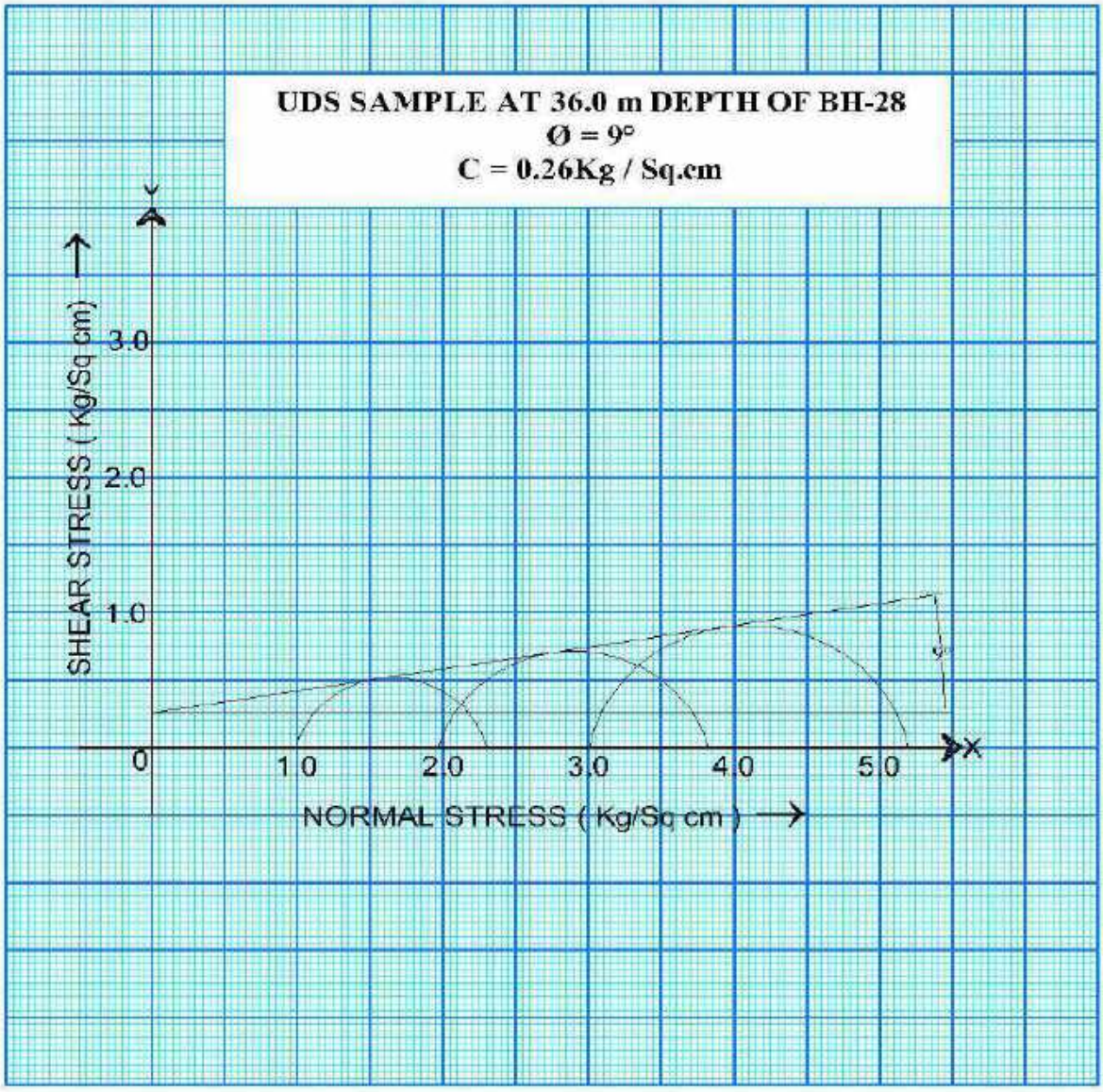

UDS SAMPLE AT 6.00 m DEPTH OF BH-28
Ø = 26°
C = 0.03 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
26°

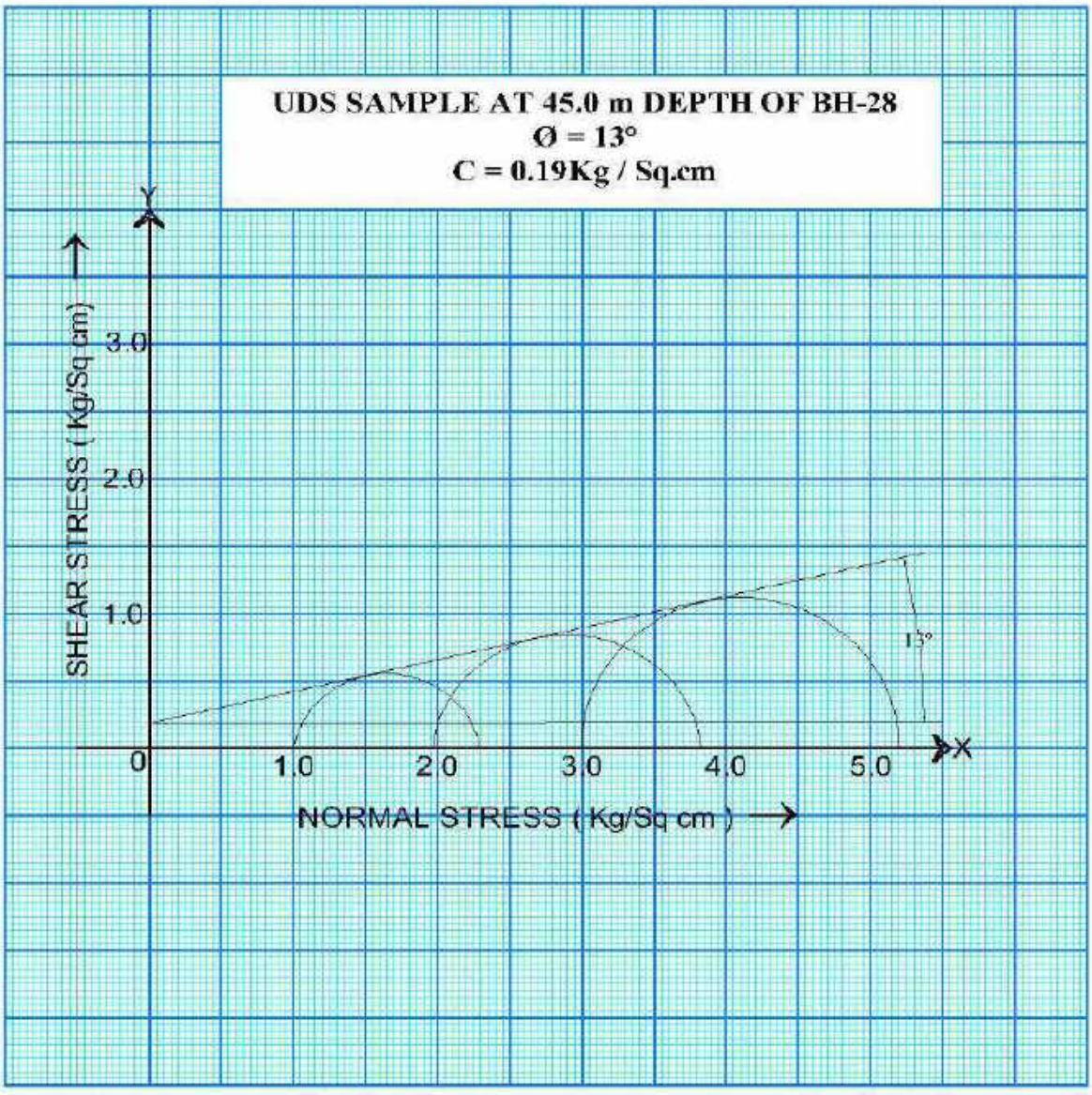

UDS SAMPLE AT 12.0 m DEPTH OF BH-28
Ø = 18°
C = 0.14Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)

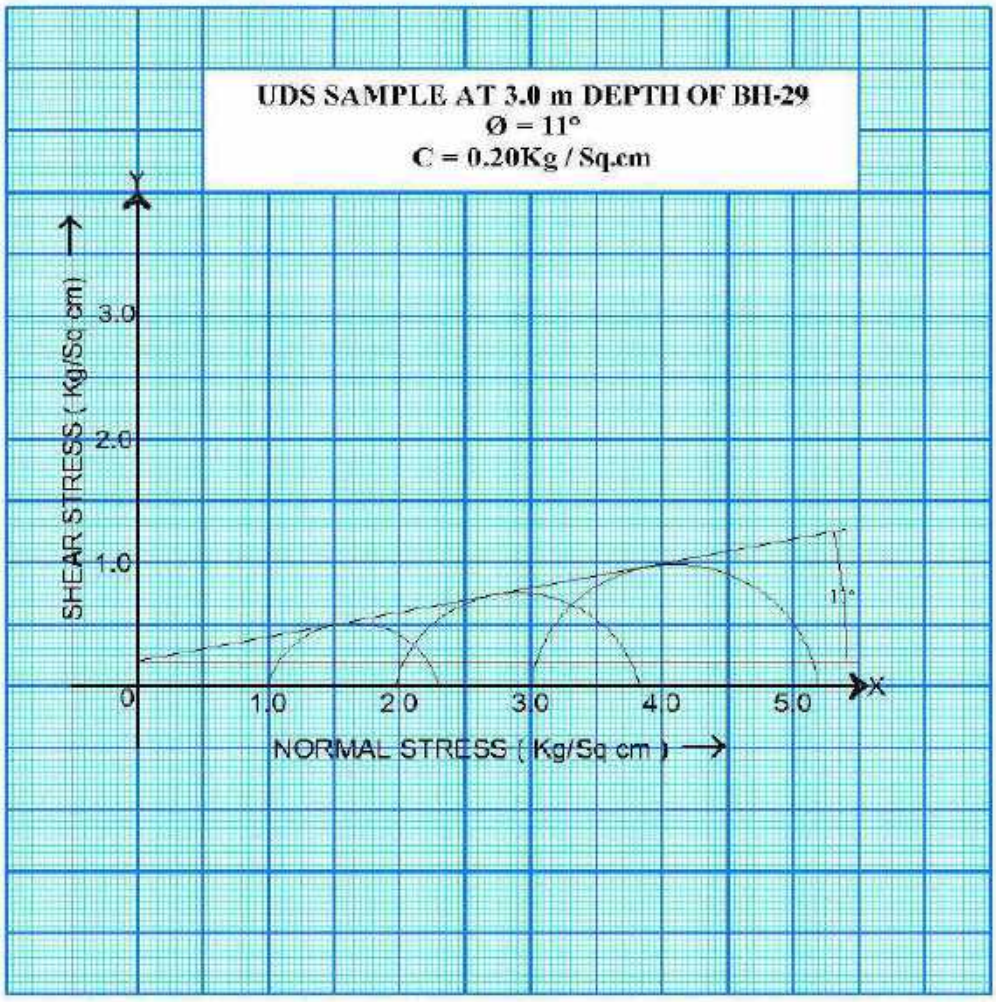

UDS SAMPLE AT 18.0 m DEPTH OF BH-28
Ø = 10°
C = 0.28Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
Y
10°
NORMAL STRESS (Kg/Sq cm)

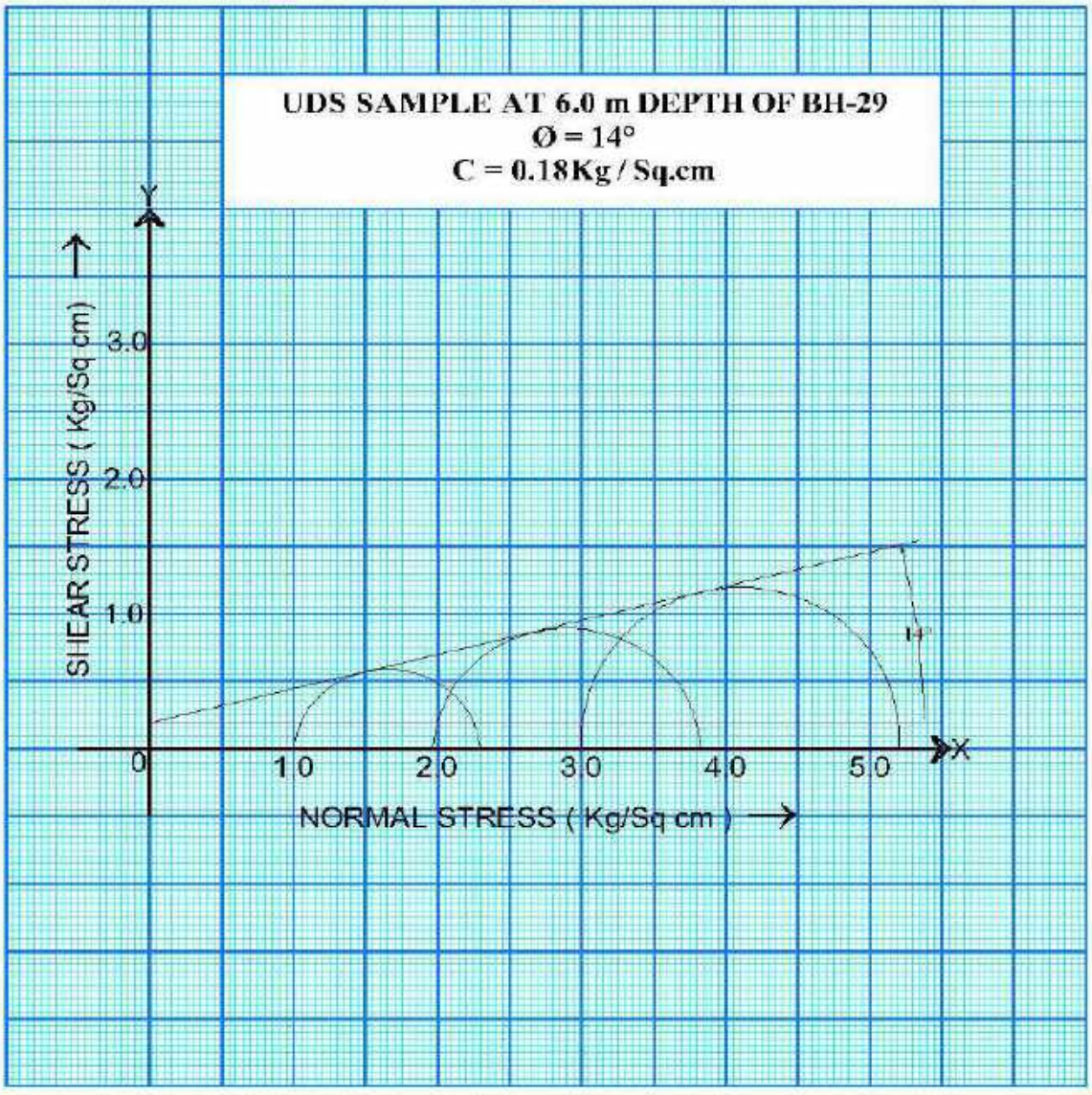

UDS SAMPLE AT 24.0 m DEPTH OF BH-28
Ø = 10°
C = 0.25Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
10°
X
1.0
2.0
3.0
4.0
5.0
NORMAL STRESS (Kg/Sq cm)

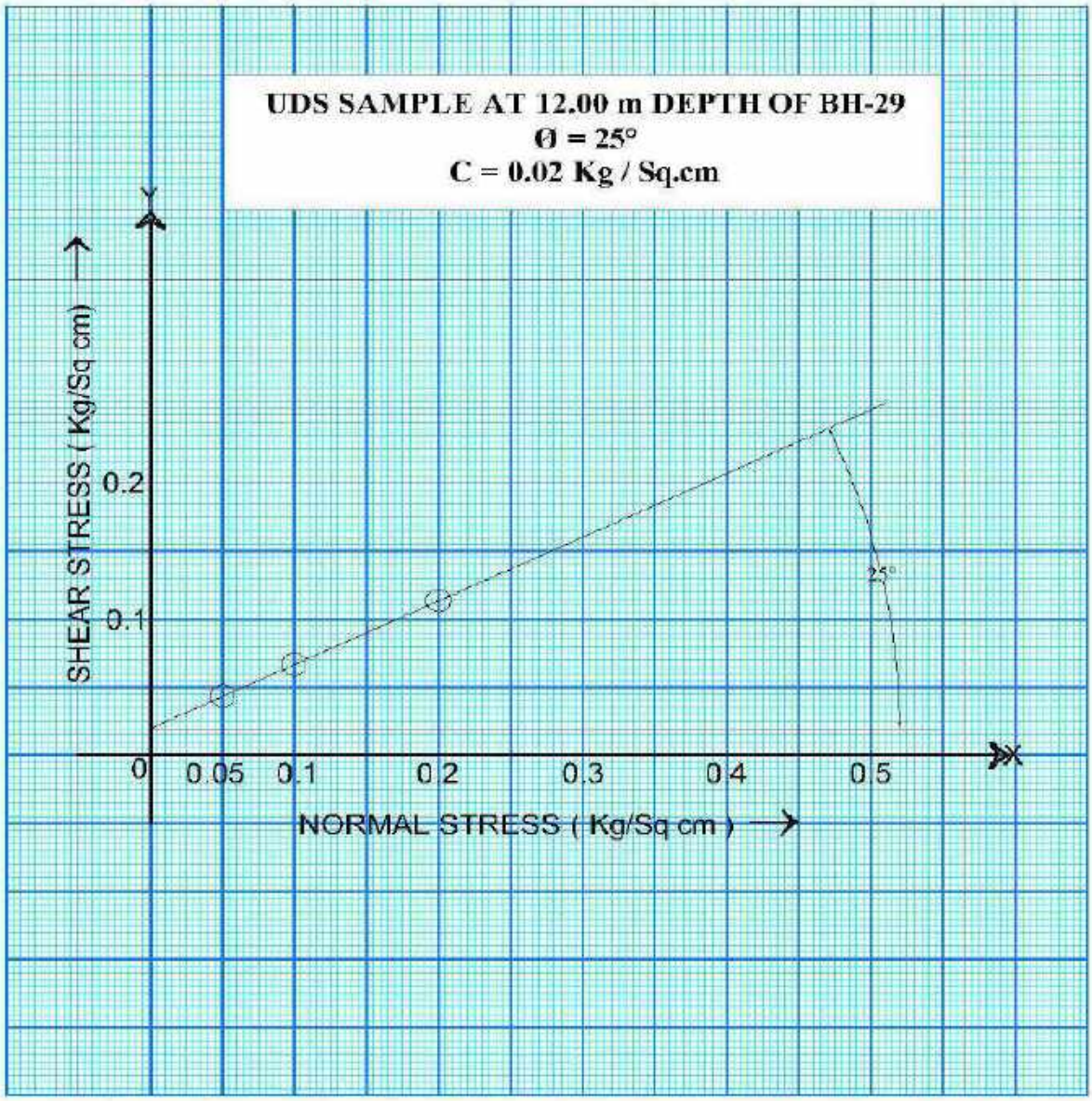

UDS SAMPLE AT 30.0 m DEPTH OF BH-28
Ø = 14°
C = 0.17Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
14°

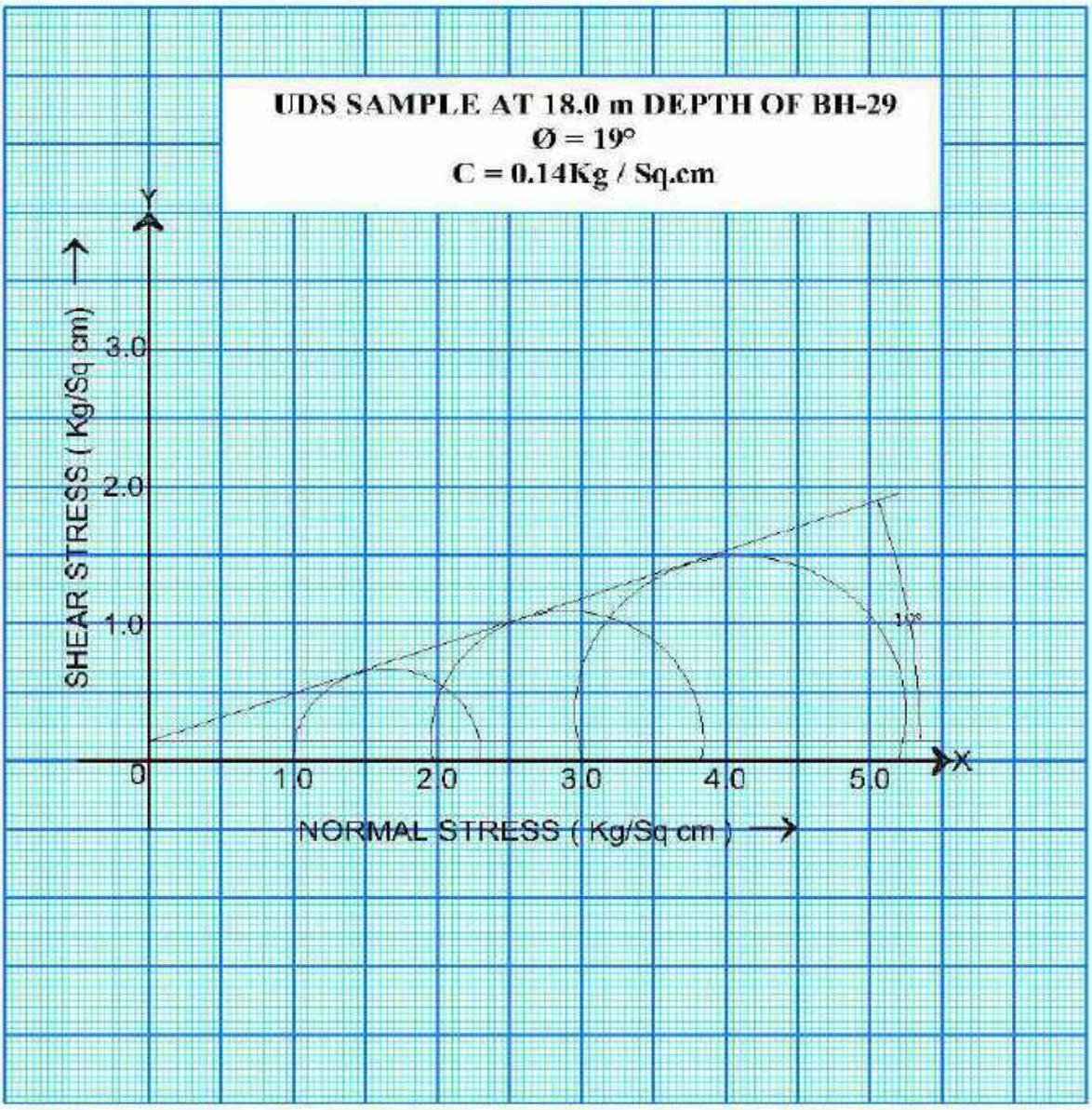

UDS SAMPLE AT 36.0 m DEPTH OF BH-28
Ø = 9°
C = 0.26Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)

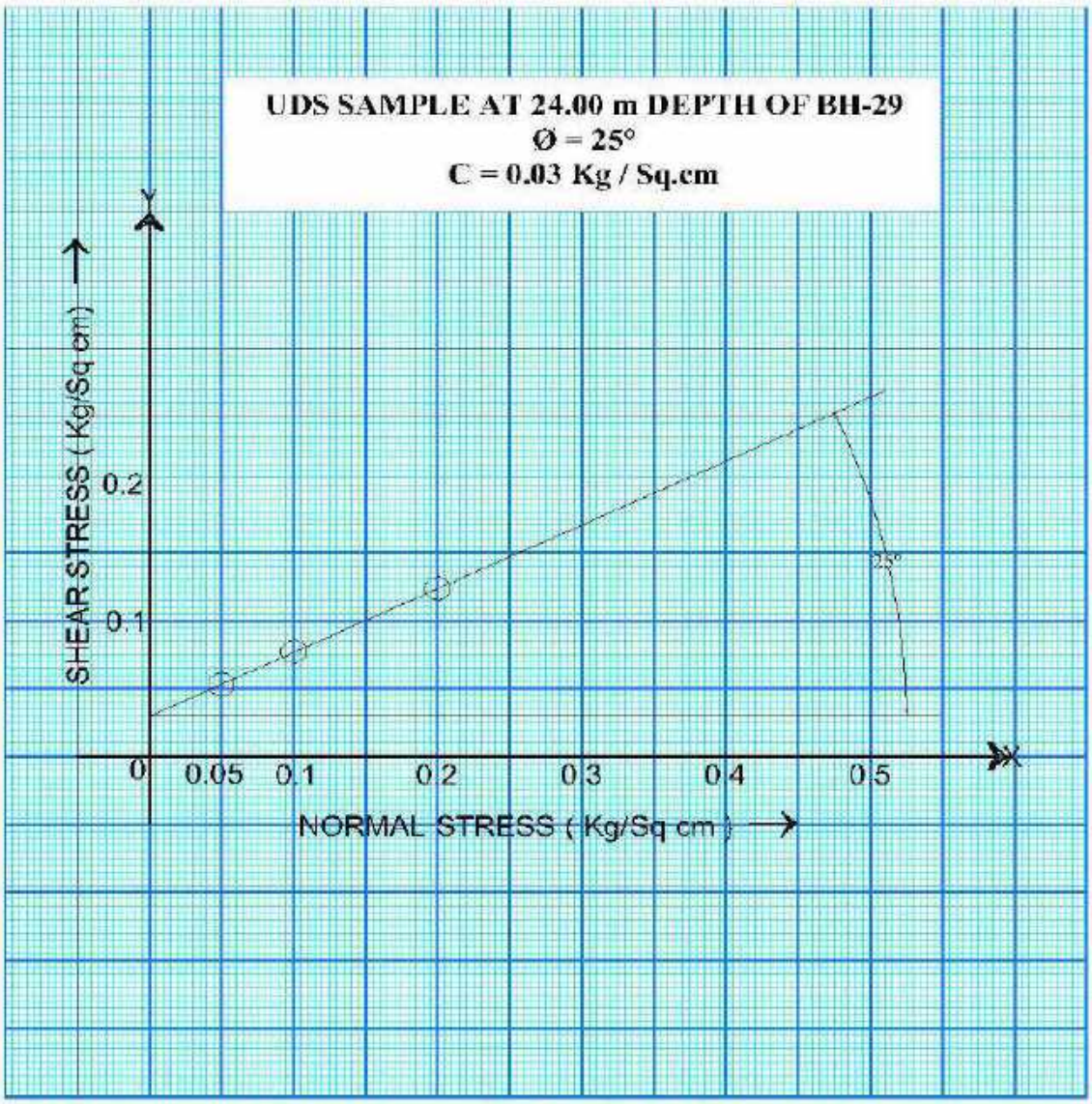

UDS SAMPLE AT 45.0 m DEPTH OF BH-28
Ø = 13°
C = 0.19Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
13°

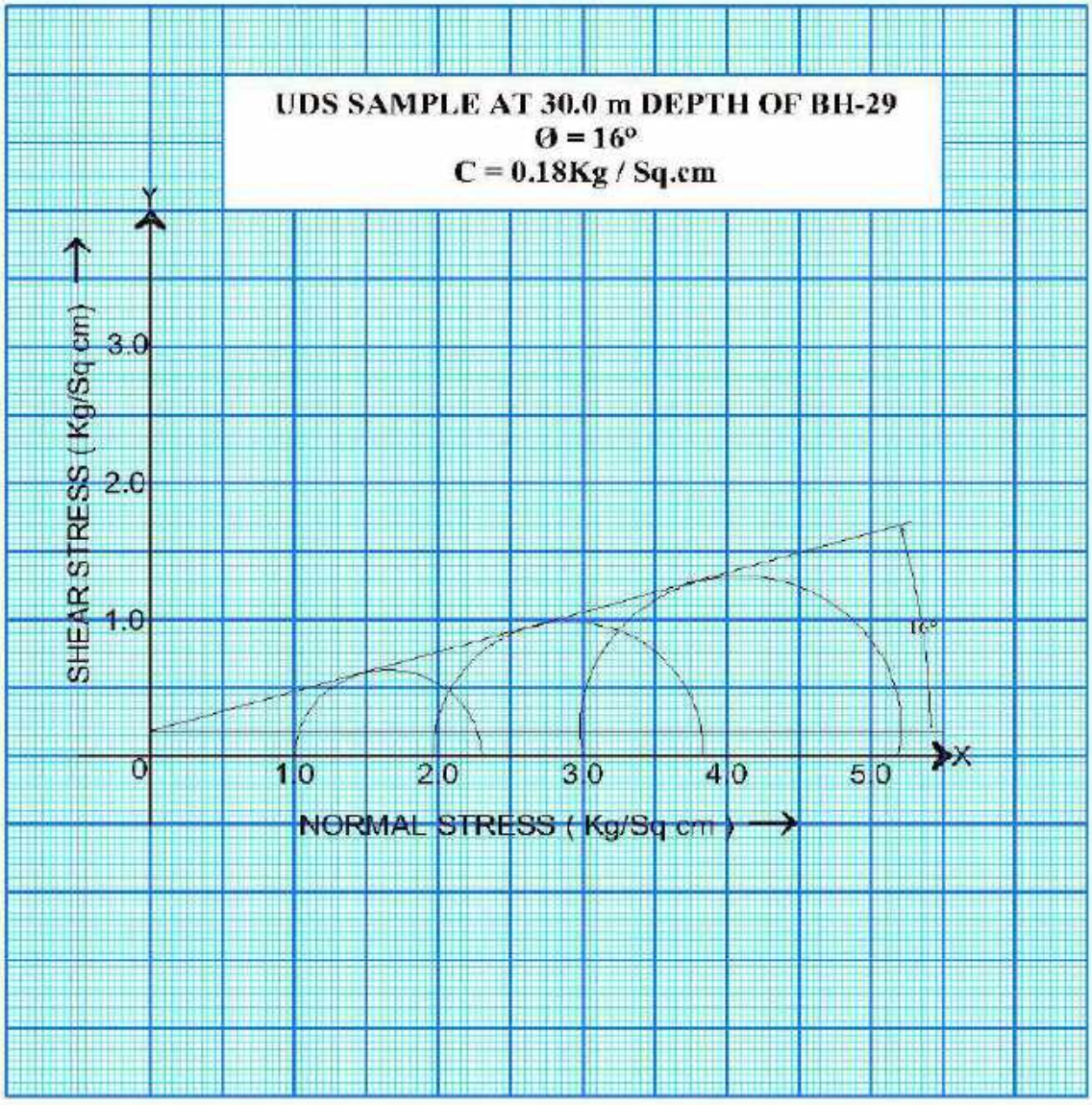

UDS SAMPLE AT 3.0 m DEPTH OF BH-29
Ø = 11°
C = 0.20Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
11°

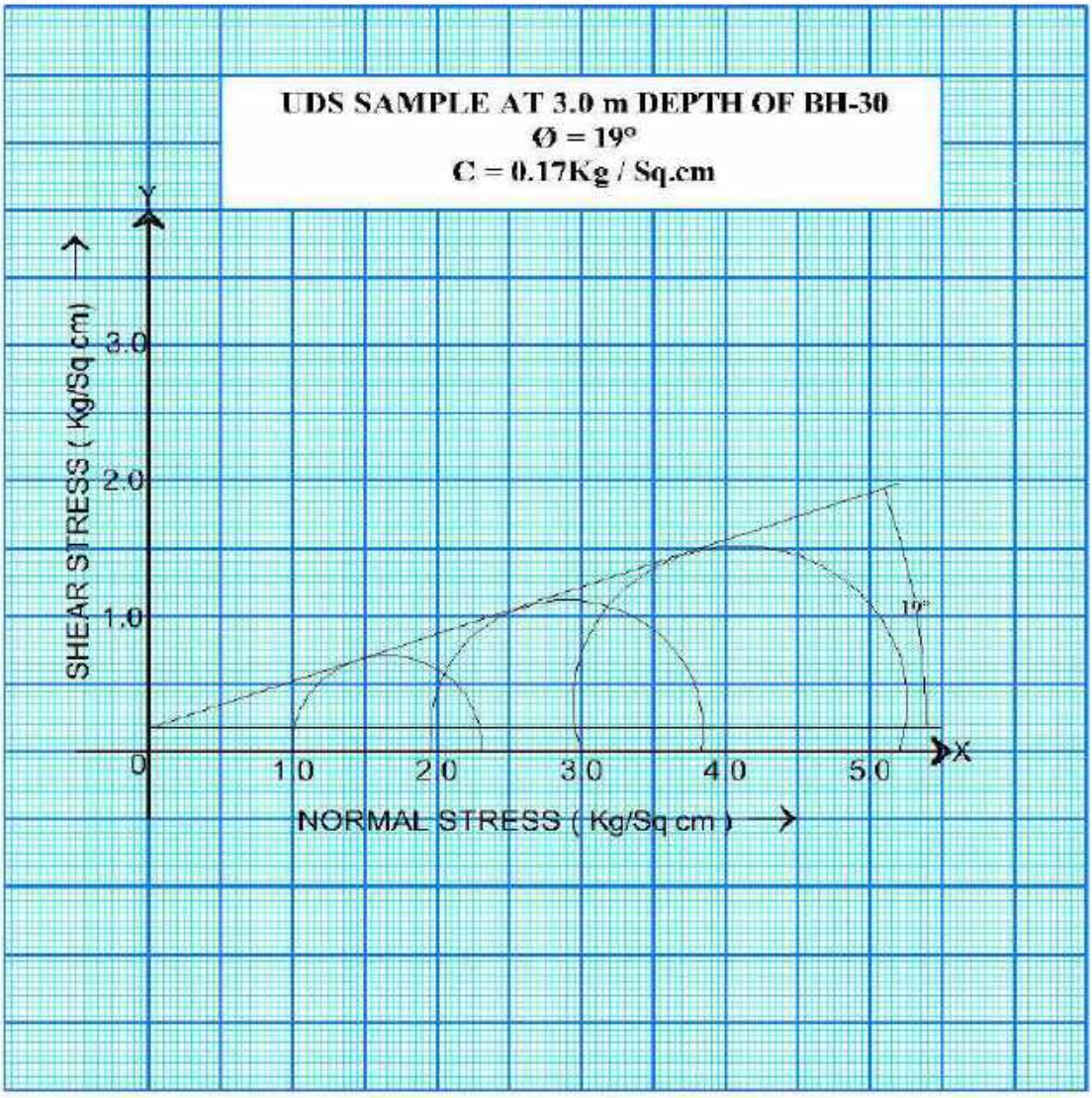

UDS SAMPLE AT 6.0 m DEPTH OF BH-29
Ø = 14°
C = 0.18Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)

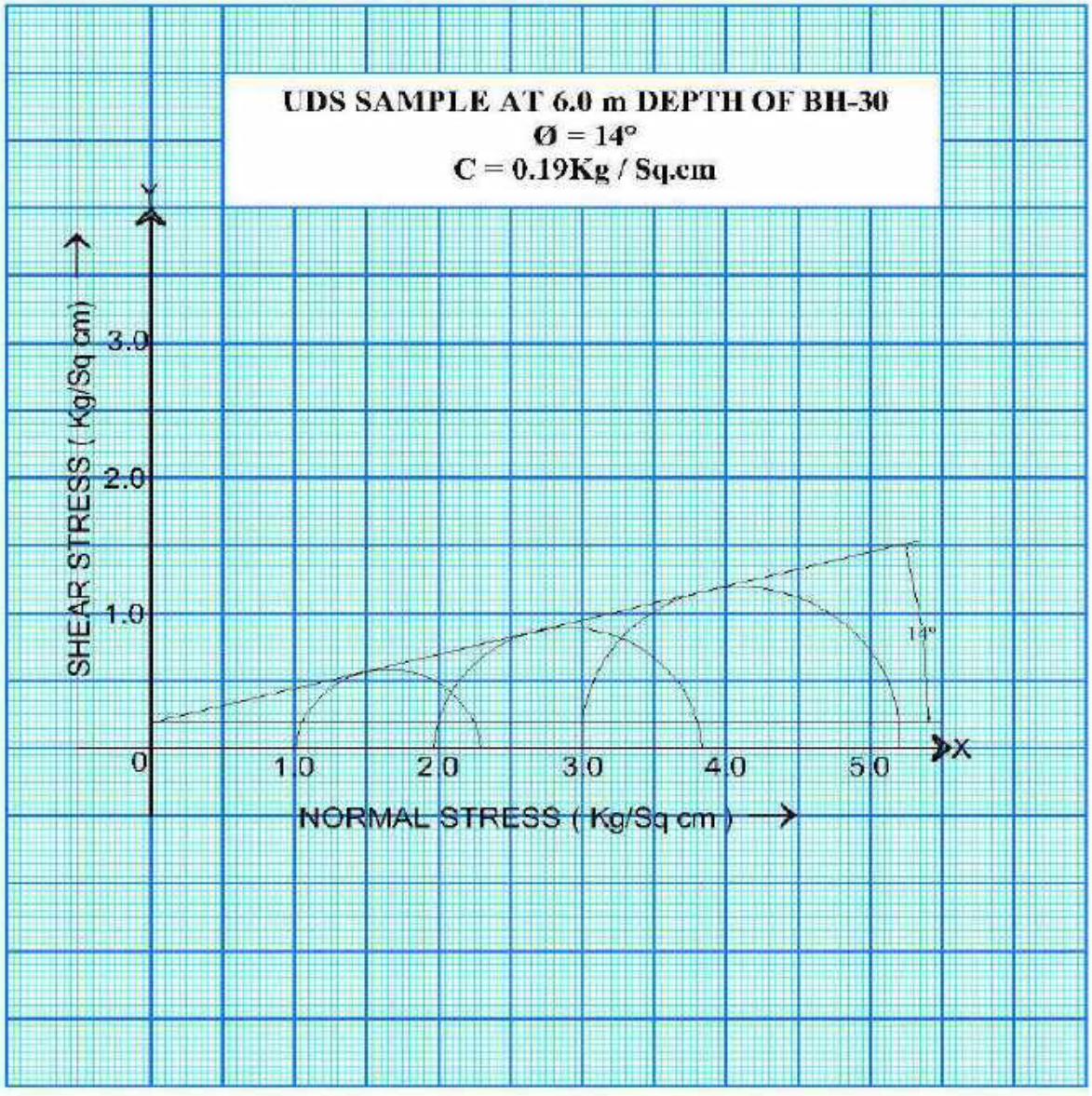

UDS SAMPLE AT 12.00 m DEPTH OF BH-29
Ø = 25°
C = 0.02 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
0.05
0.1
0.2
0.3
0.4
0.5
0.1
0.2
25°

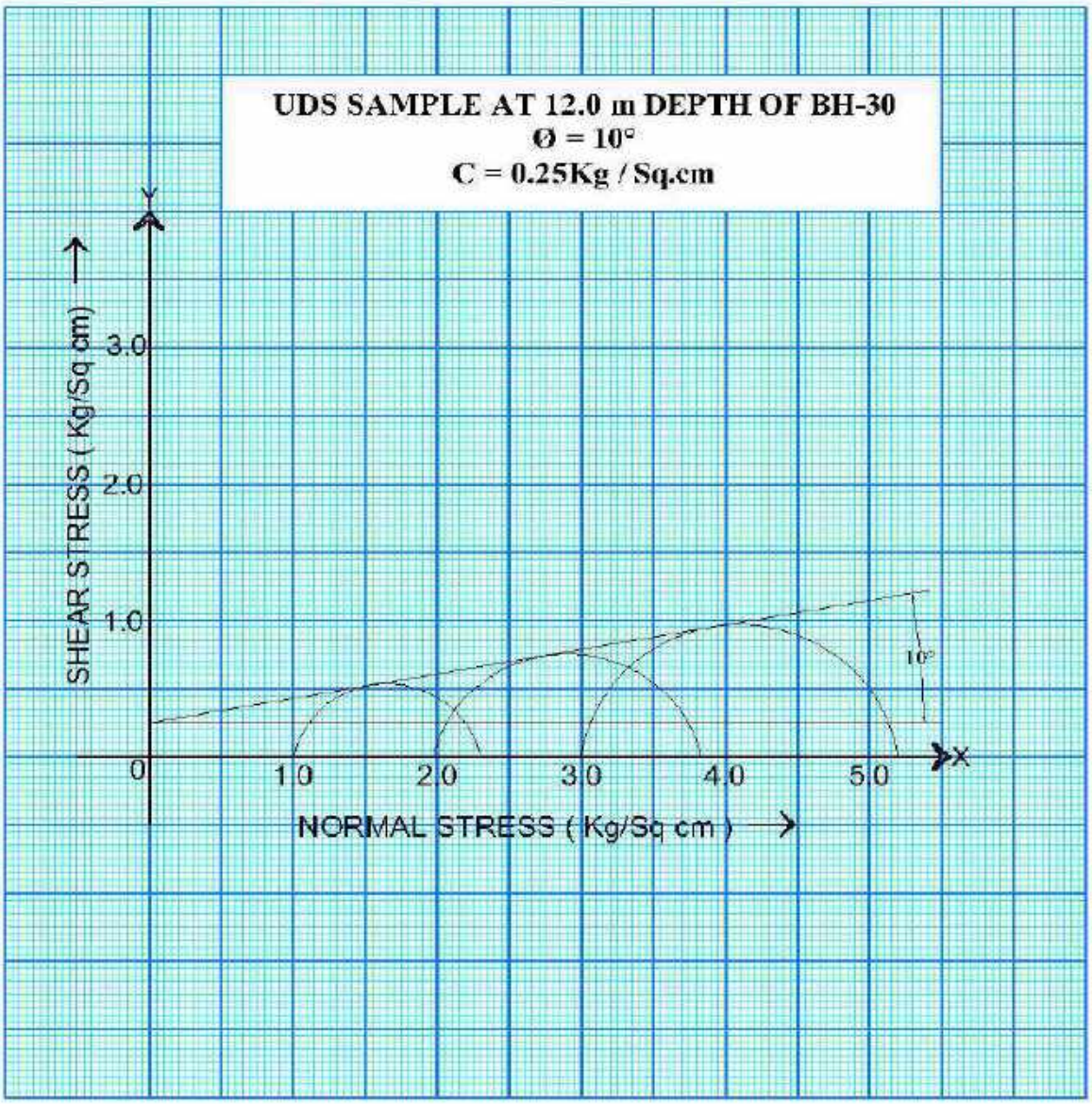

UDS SAMPLE AT 18.0 m DEPTH OF BH-29
Ø = 19°
C = 0.14Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
19°

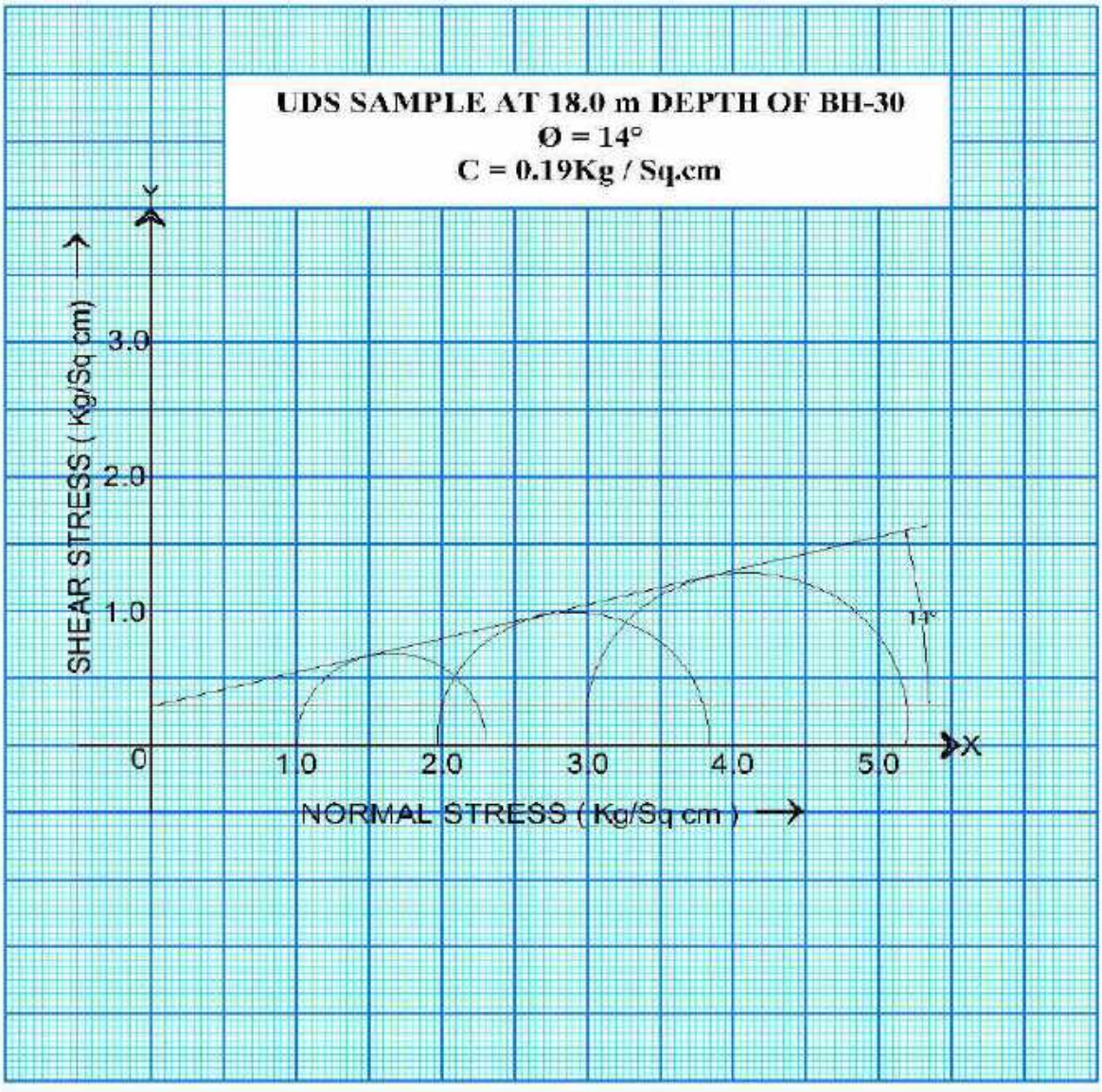

UDS SAMPLE AT 24.00 m DEPTH OF BH-29
Ø = 25°
C = 0.03 Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
25°

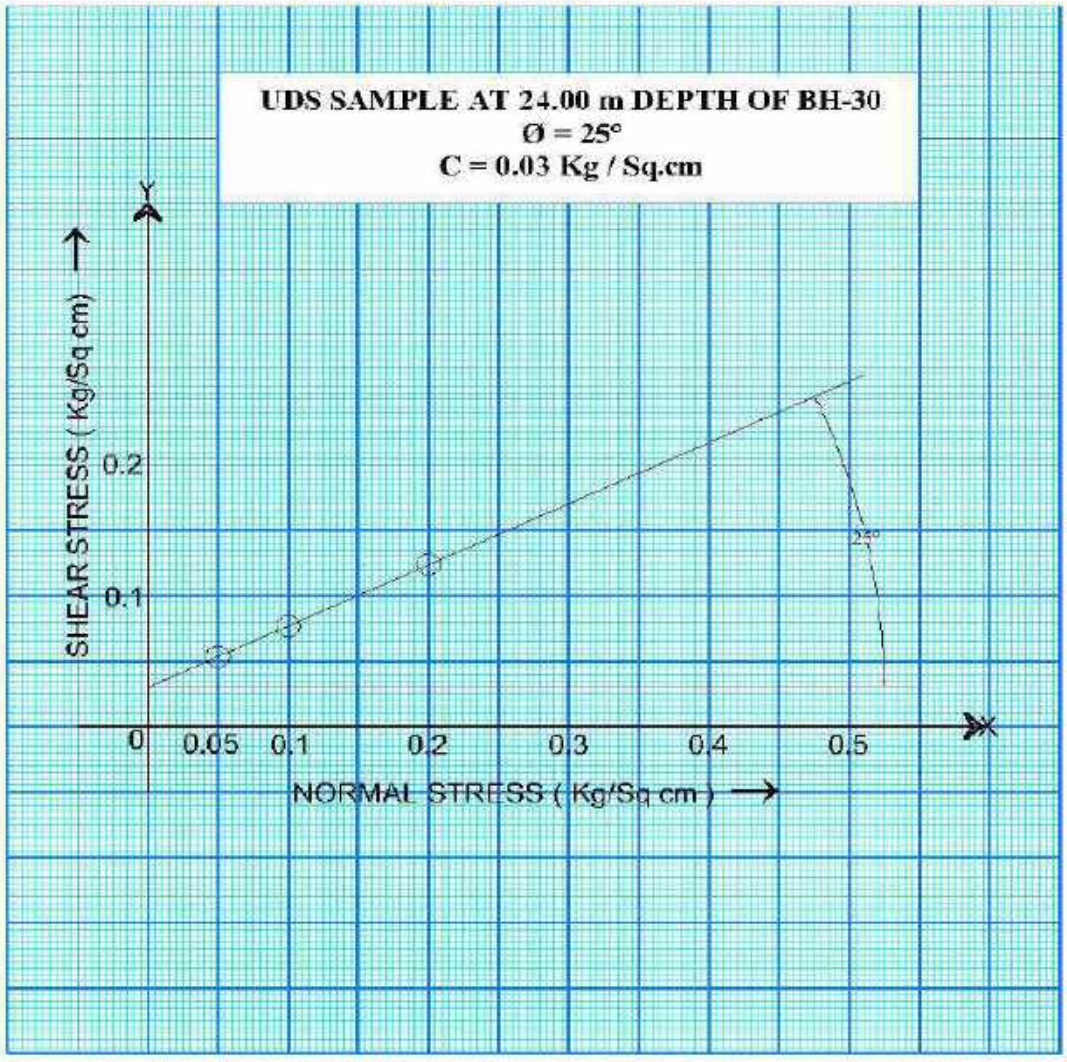

UDS SAMPLE AT 30.0 m DEPTH OF BH-29
Ø = 16°
C = 0.18Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
10
20
30
40
50
X
NORMAL STRESS (Kg/Sq cm)
16°

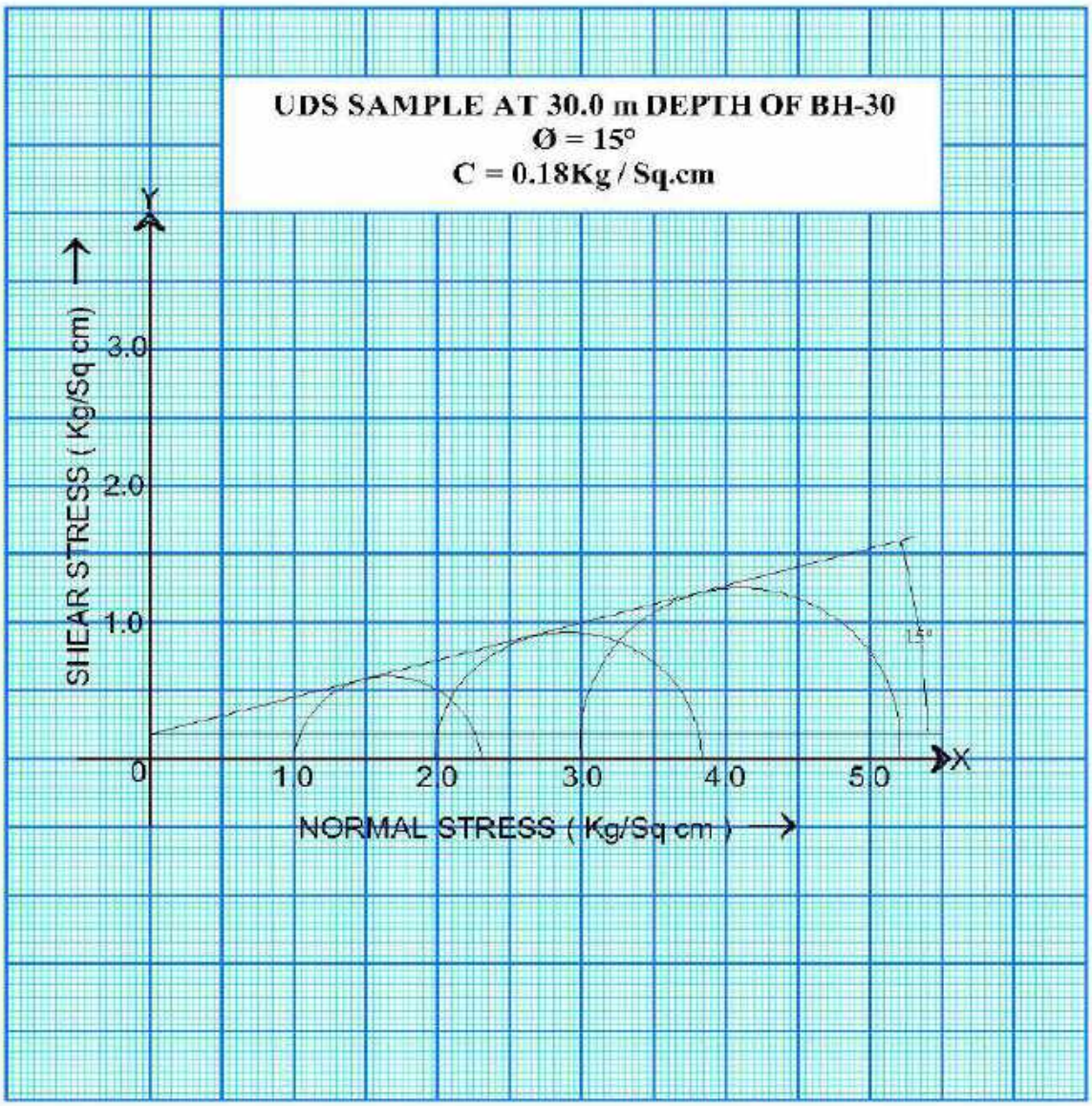

UDS SAMPLE AT 3.0 m DEPTH OF BH-30
Ø = 19°
C = 0.17Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
10
20
30
40
50
X
NORMAL STRESS (Kg/Sq cm)
19°

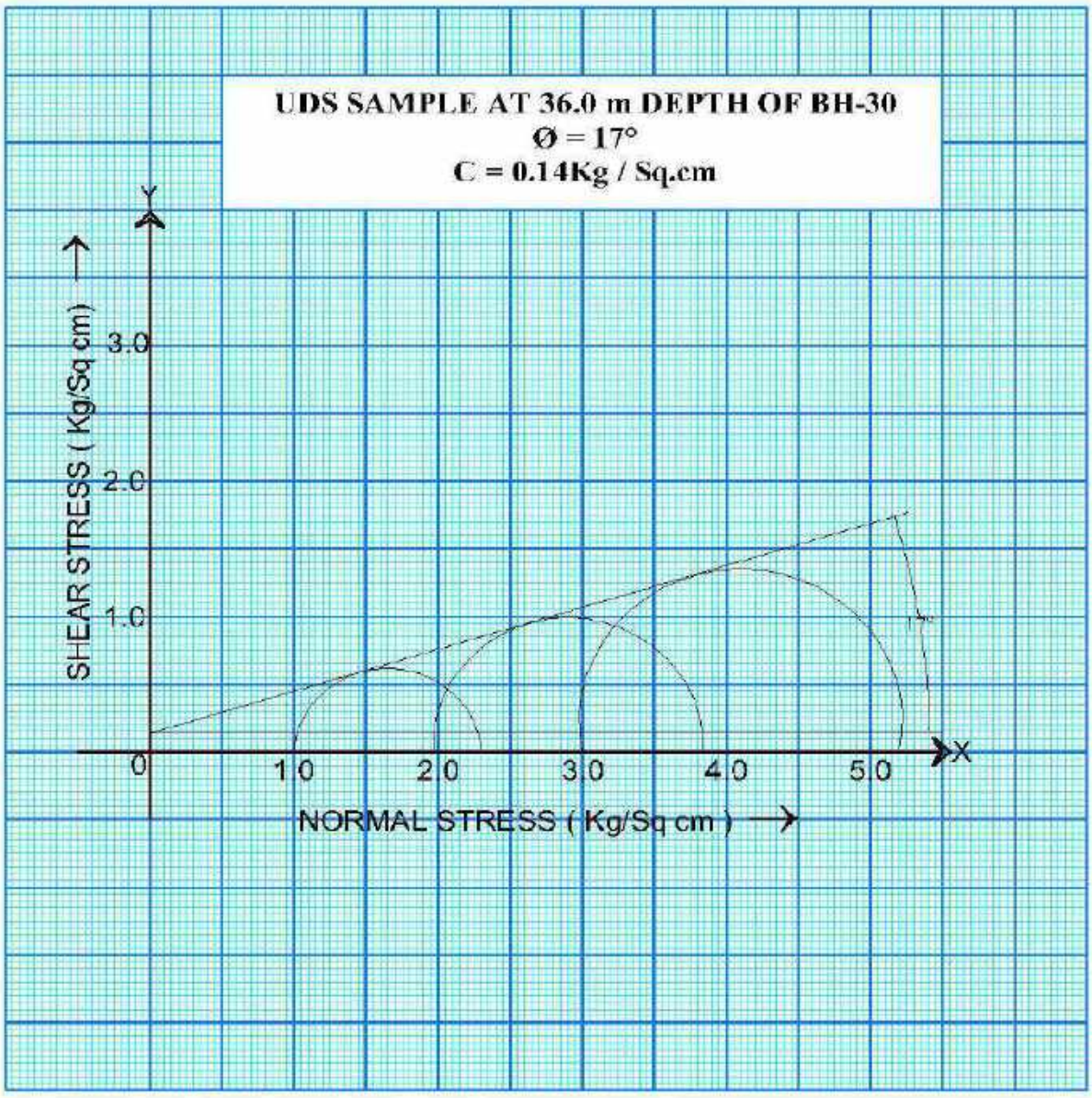

UDS SAMPLE AT 6.0 m DEPTH OF BH-30
Ø = 14°
C = 0.19Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1 0
2 0
3 0
4 0
5 0
X
NORMAL STRESS (Kg/Sq cm)
14°

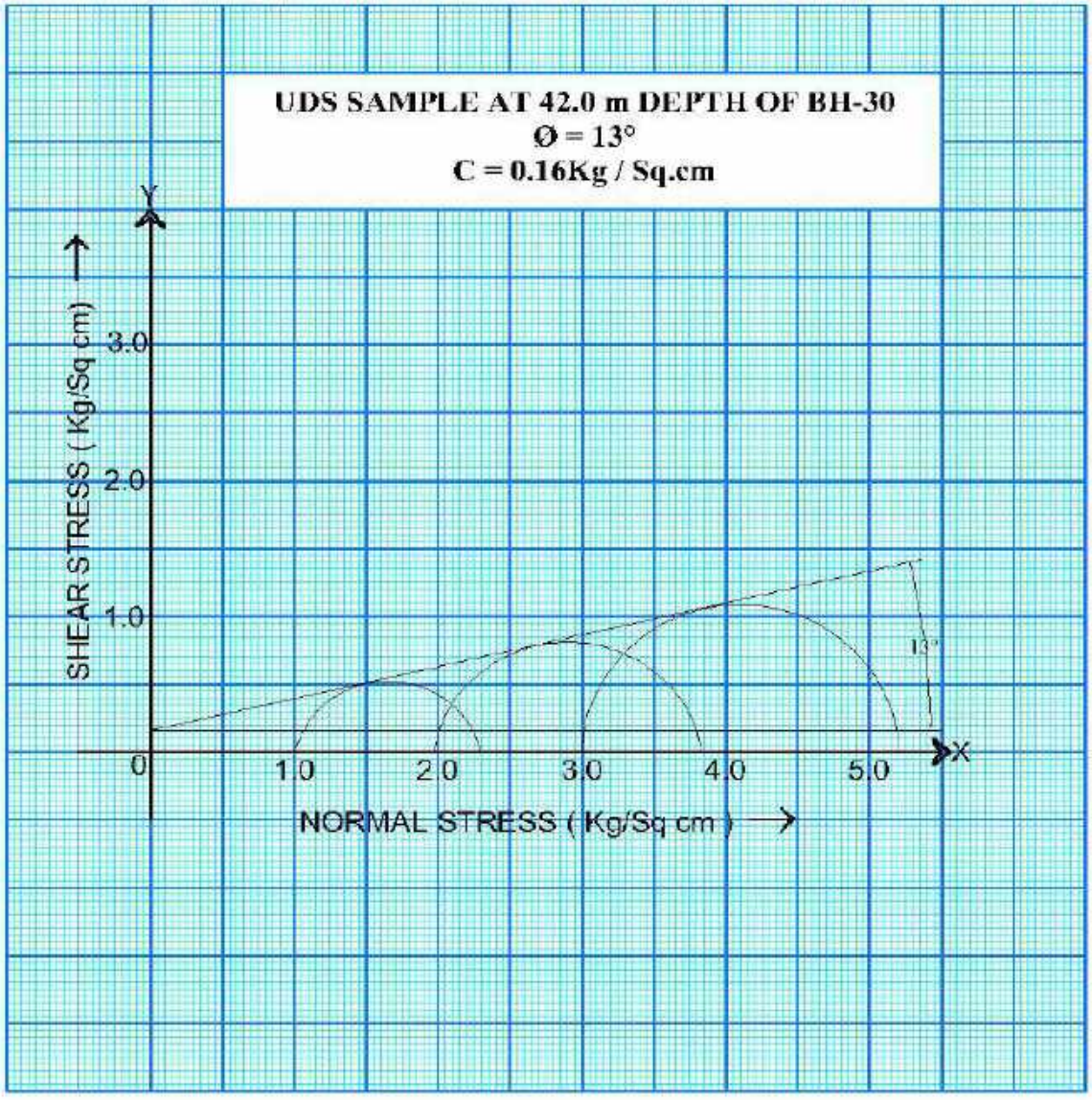

UDS SAMPLE AT 12.0 m DEPTH OF BH-30
Ø = 10°
C = 0.25Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
NORMAL STRESS (Kg/Sq cm)
0
1.0
2.0
3.0
4.0
5.0
10°

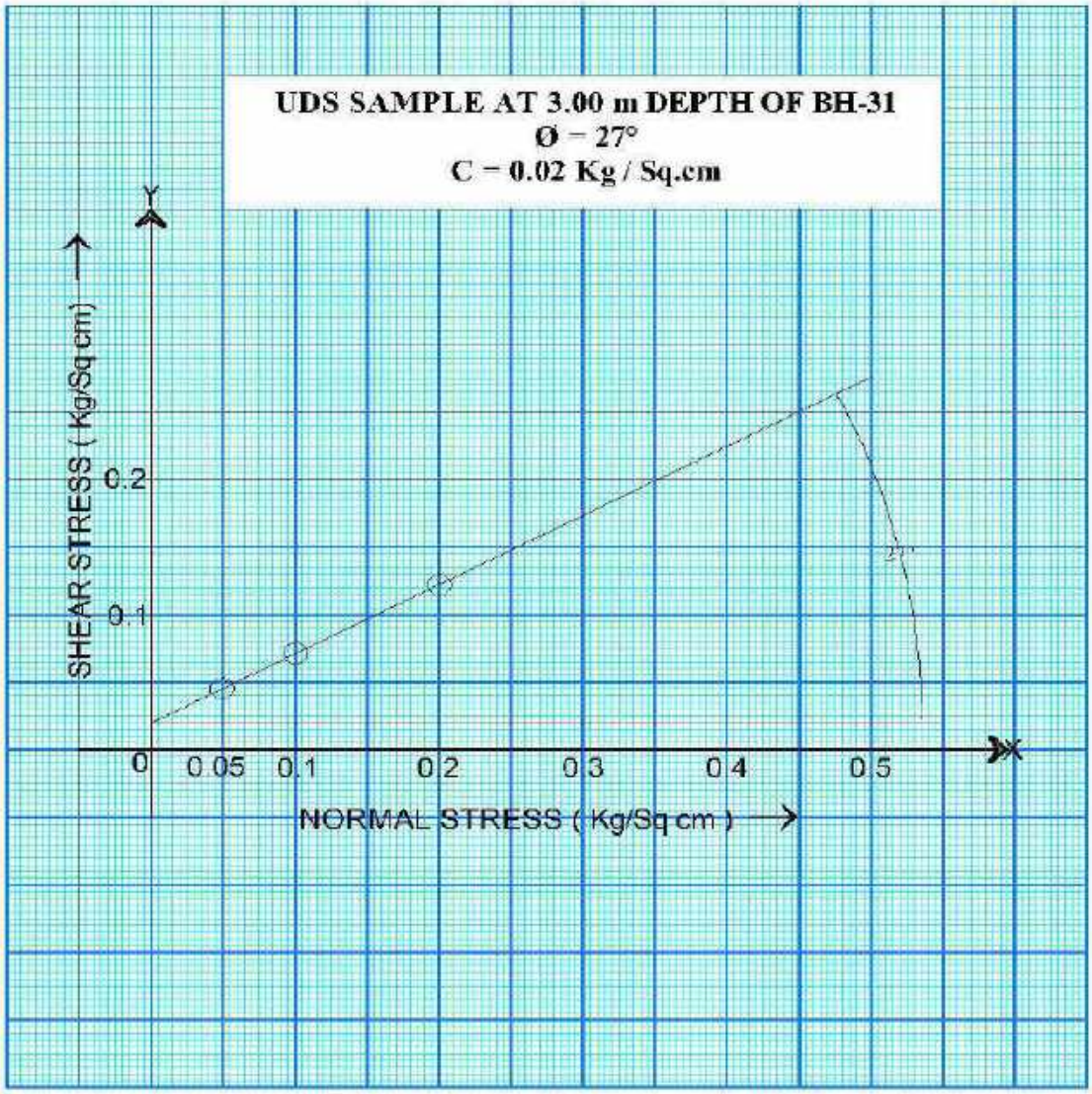

UDS SAMPLE AT 18.0 m DEPTH OF BH-30
Ø = 14°
C = 0.19Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm) →
14°

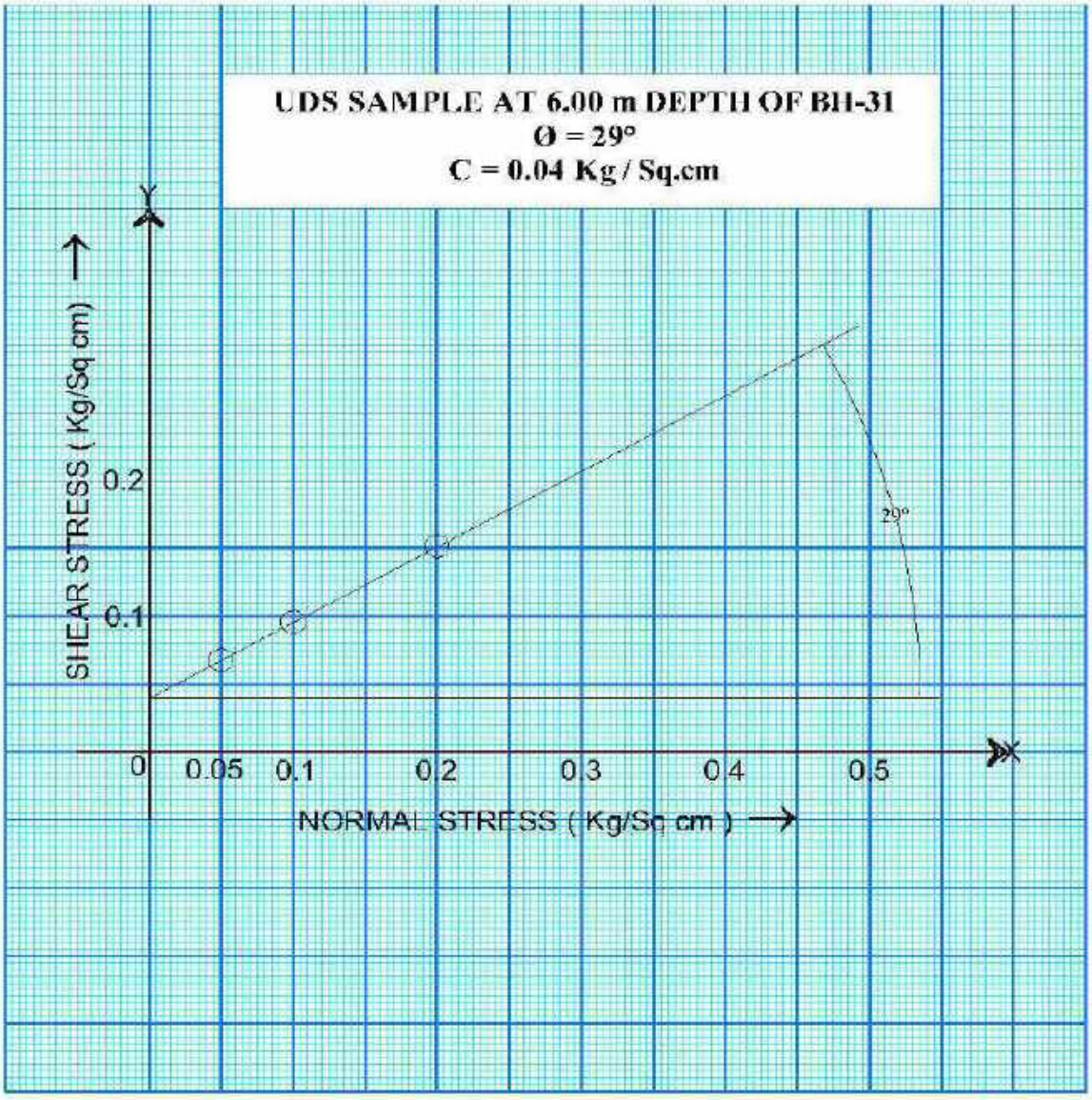

UDS SAMPLE AT 24.00 m DEPTH OF BH-30
Ø = 25°
C = 0.03 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)
25°

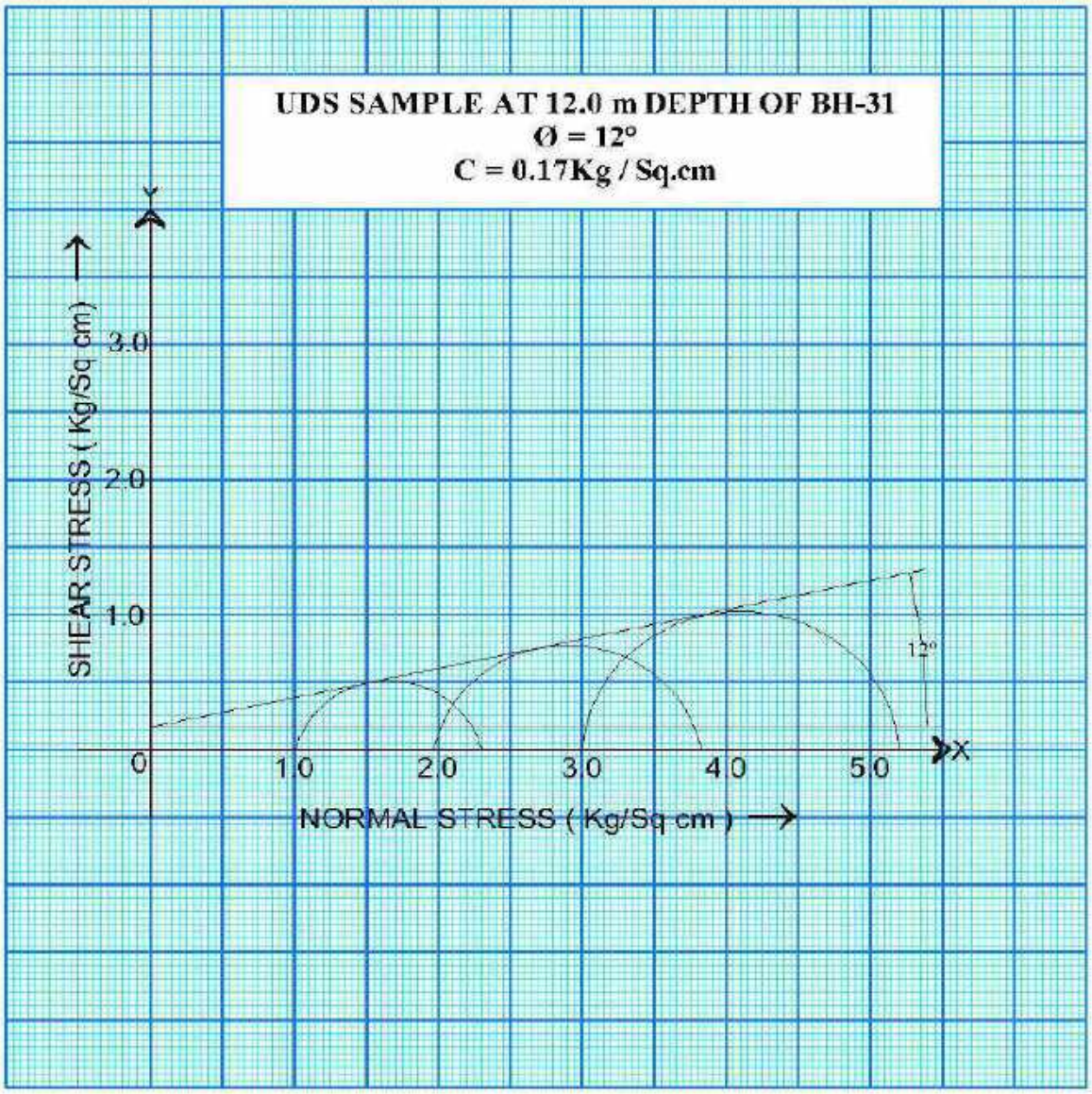

UDS SAMPLE AT 30.0 m DEPTH OF BH-30
Ø = 15°
C = 0.18Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1 0
2 0
3 0
4 0
5 0
X
NORMAL STRESS (Kg/Sq cm)
15°

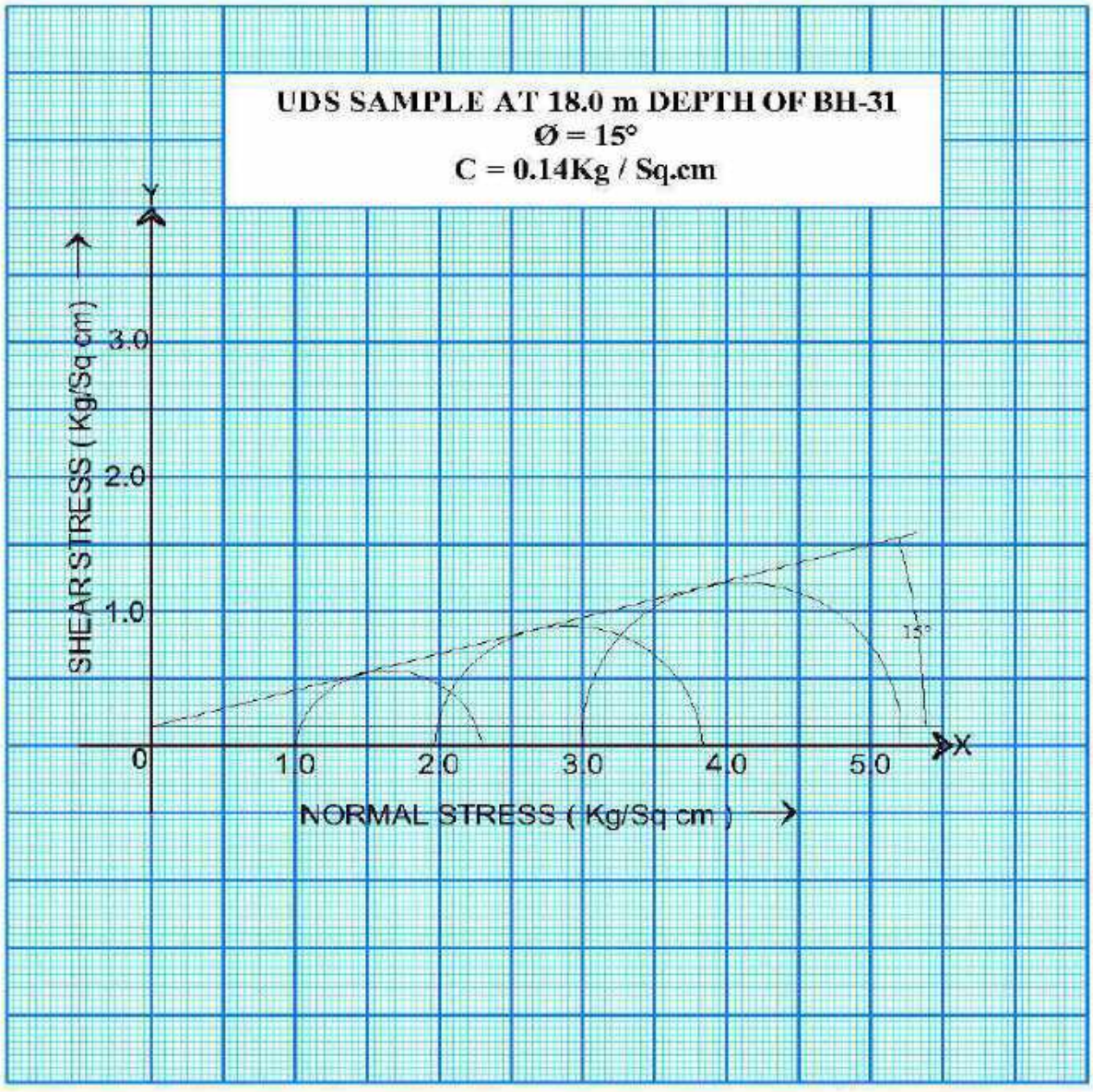

UDS SAMPLE AT 36.0 m DEPTH OF BH-30
Ø = 17°
C = 0.14Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)

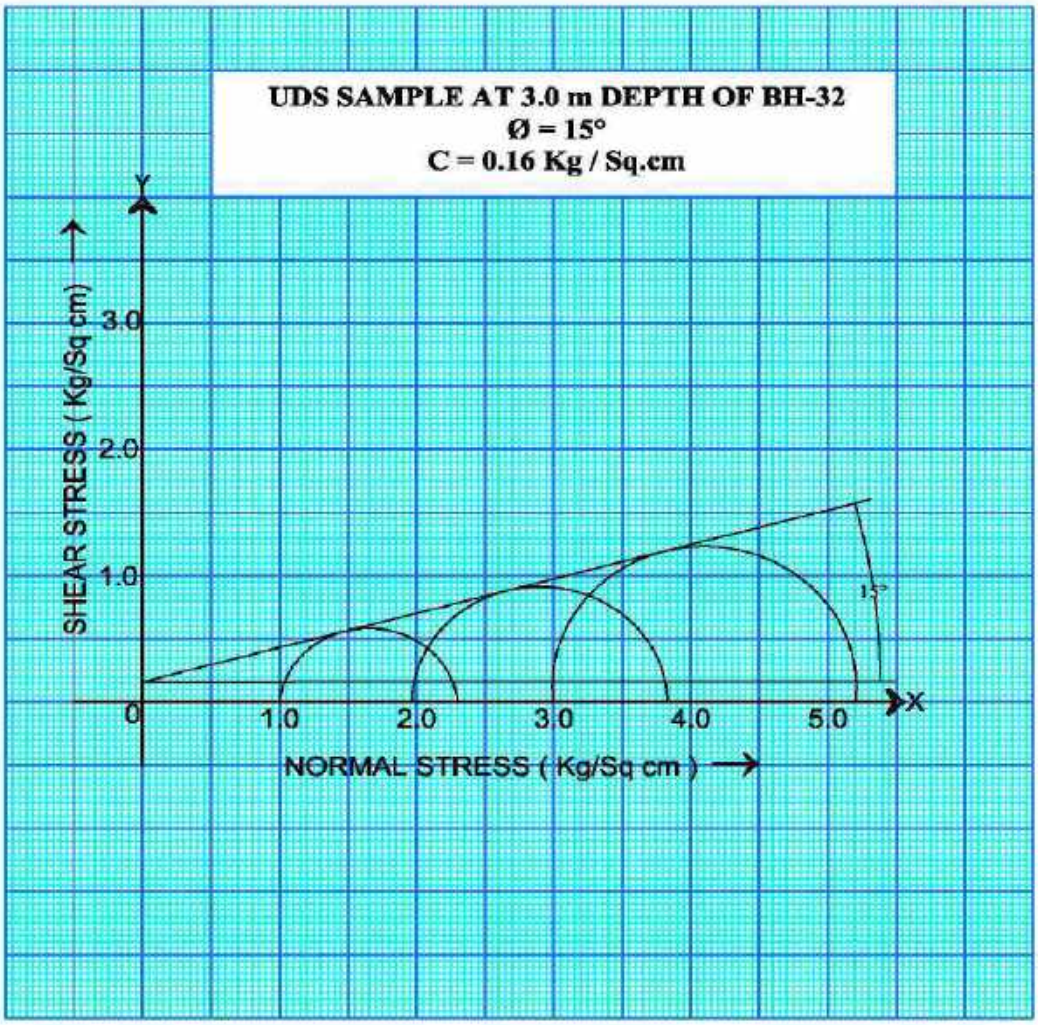

UDS SAMPLE AT 42.0 m DEPTH OF BH-30
Ø = 13°
C = 0.16Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
13°

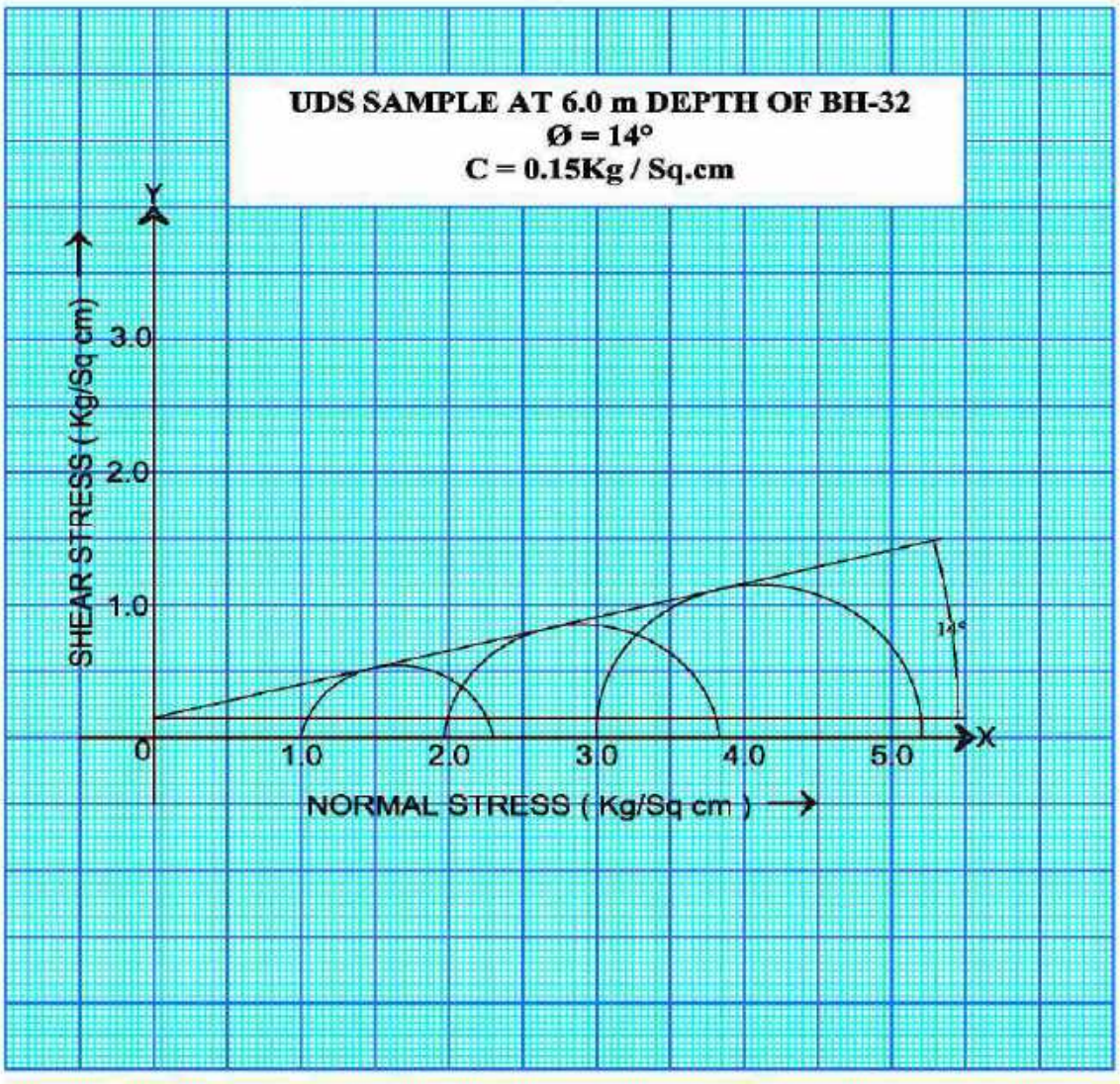

UDS SAMPLE AT 3.00 m DEPTH OF BH-31
Ø = 27°
C = 0.02 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)

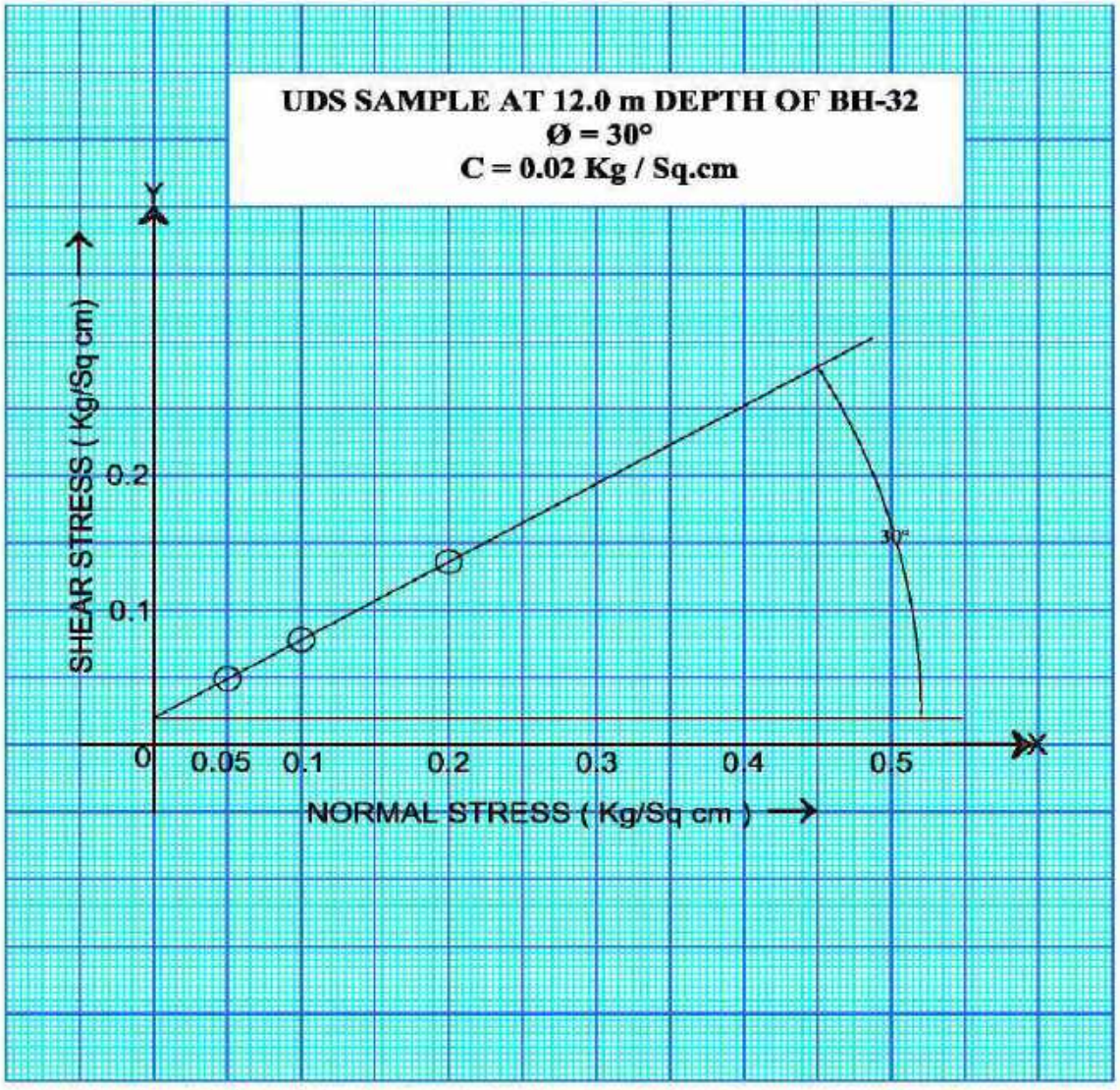

UDS SAMPLE AT 6.00 m DEPTH OF BH-31
Ø = 29°
C = 0.04 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
29°
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)

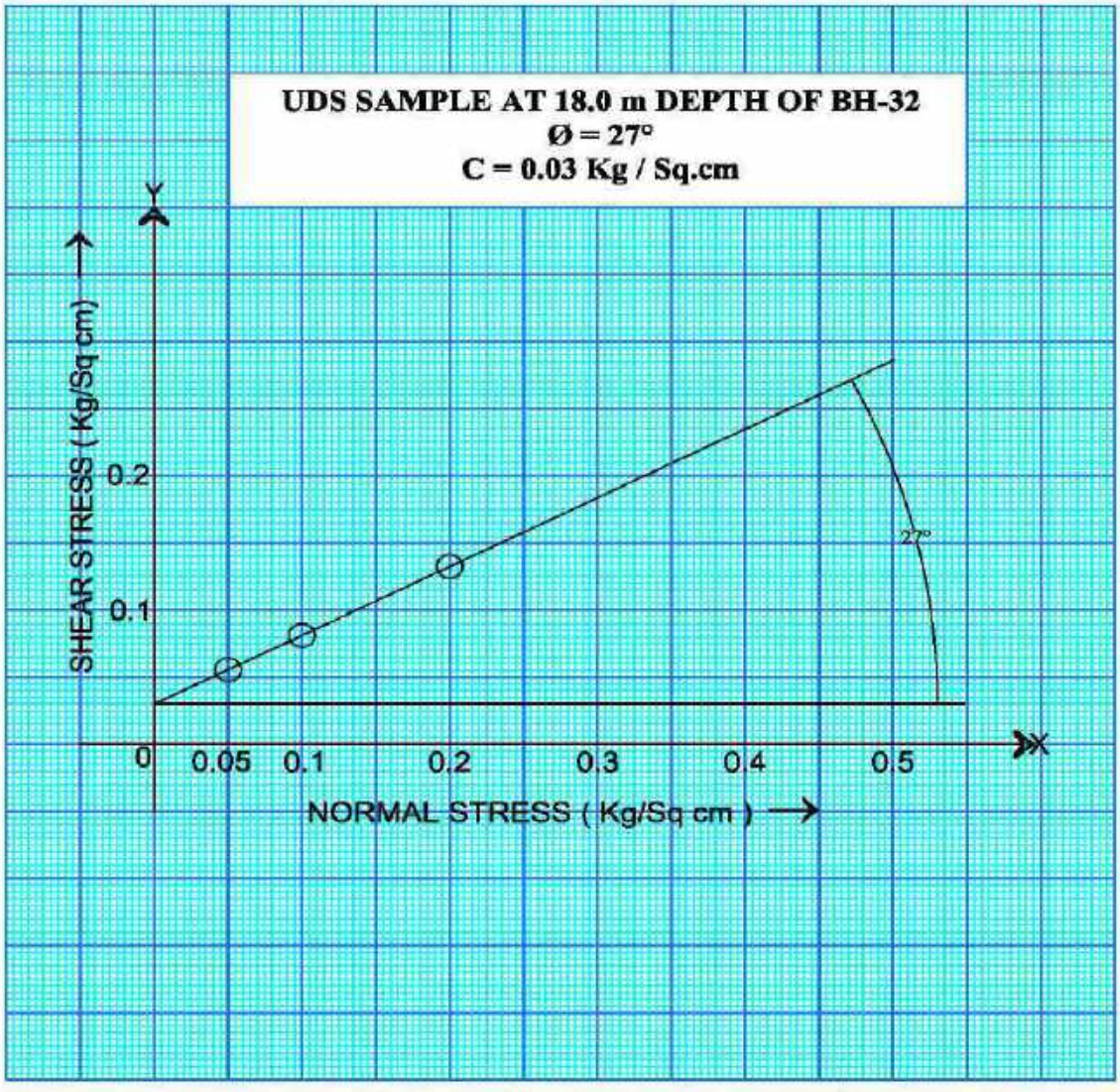

UDS SAMPLE AT 12.0 m DEPTH OF BH-31
Ø = 12°
C = 0.17Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
12°
NORMAL STRESS (Kg/Sq cm)

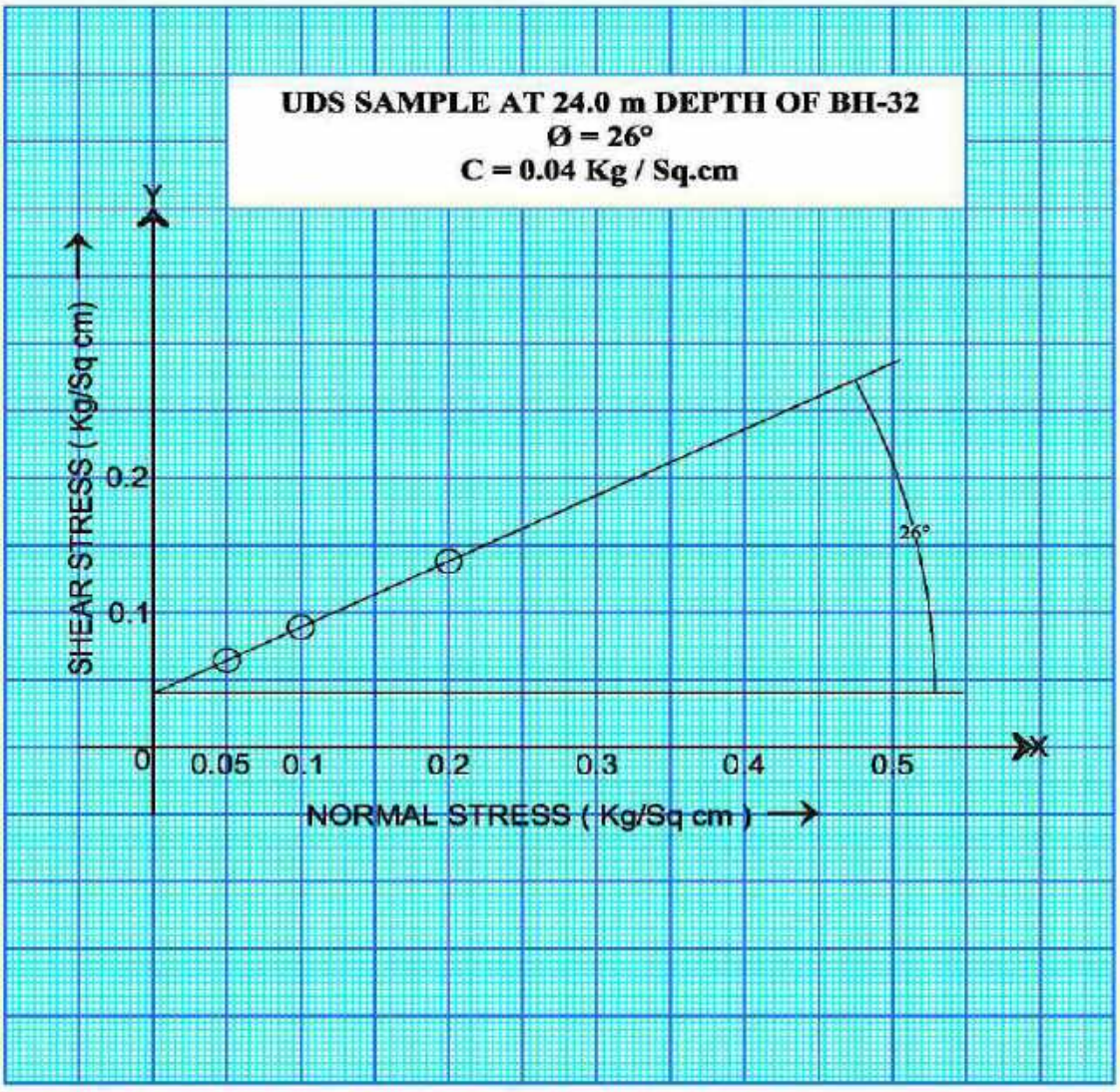

UDS SAMPLE AT 18.0 m DEPTH OF BH-31
Ø = 15°
C = 0.14Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
15°

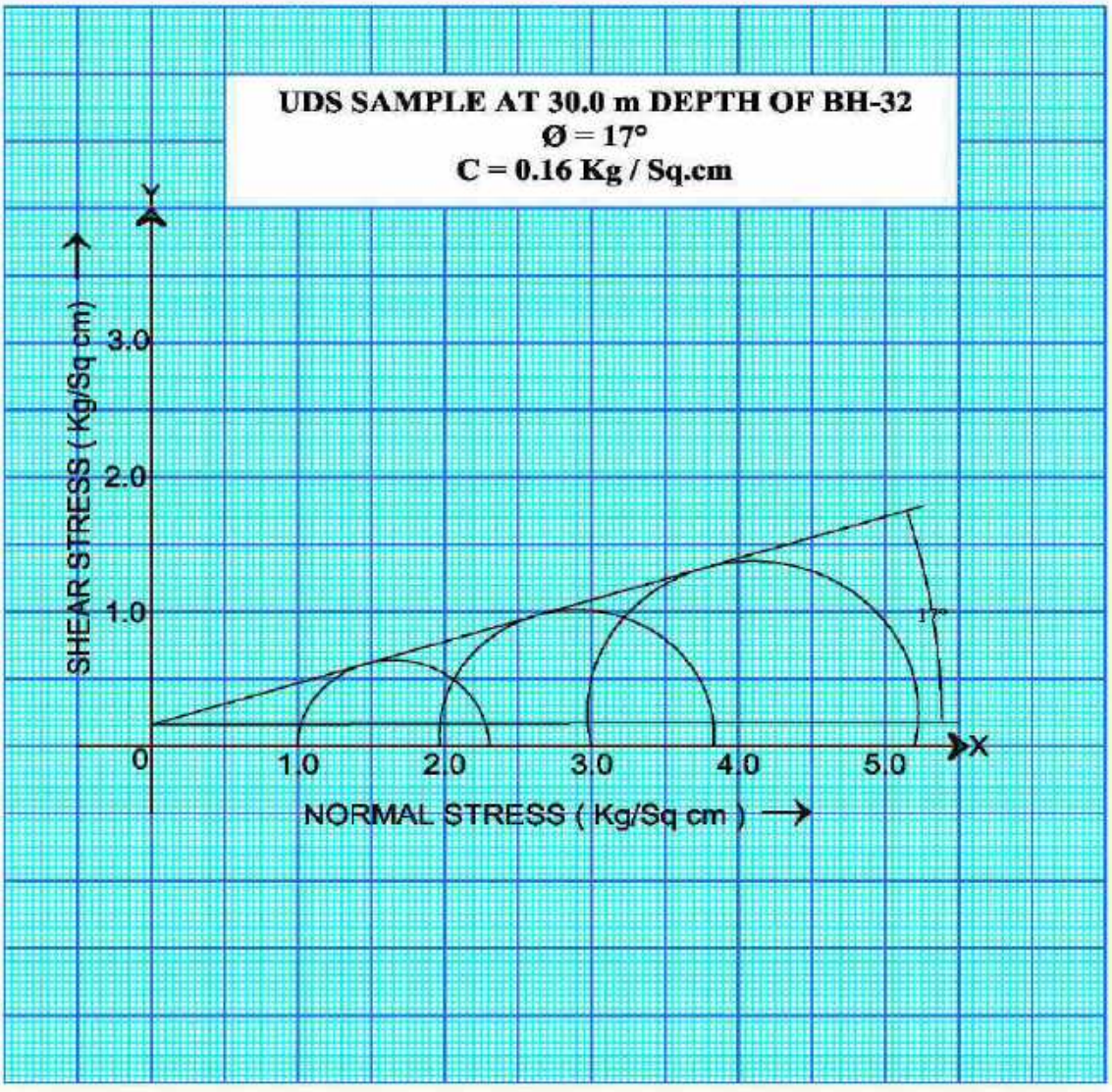

UDS SAMPLE AT 3.0 m DEPTH OF BH-32
Ø = 15°
C = 0.16 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
15°

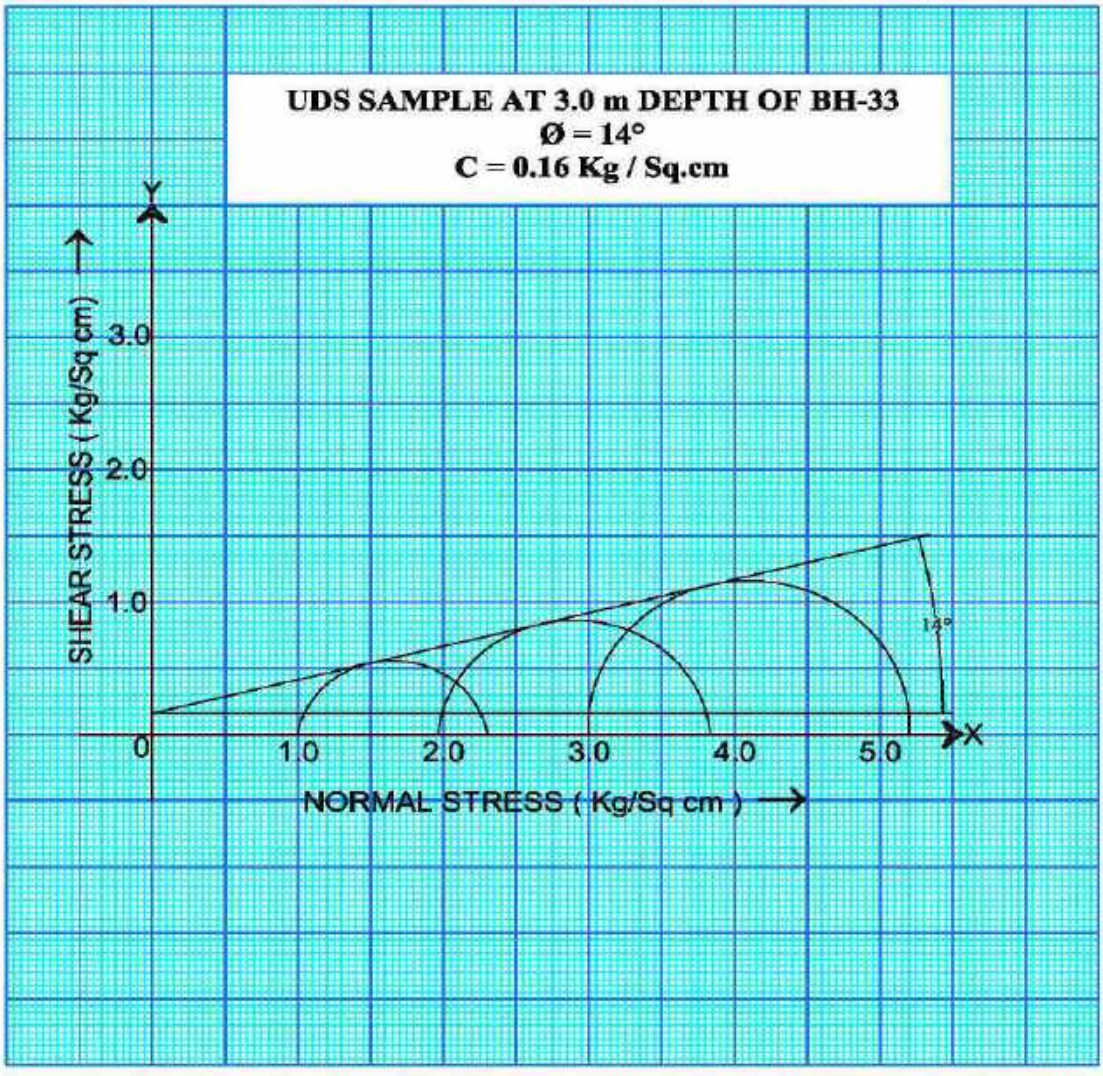

UDS SAMPLE AT 6.0 m DEPTH OF BH-32
Ø = 14°
C = 0.15Kg / Sq.cm
Y
X
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
NORMAL STRESS (Kg/Sq cm)
14°

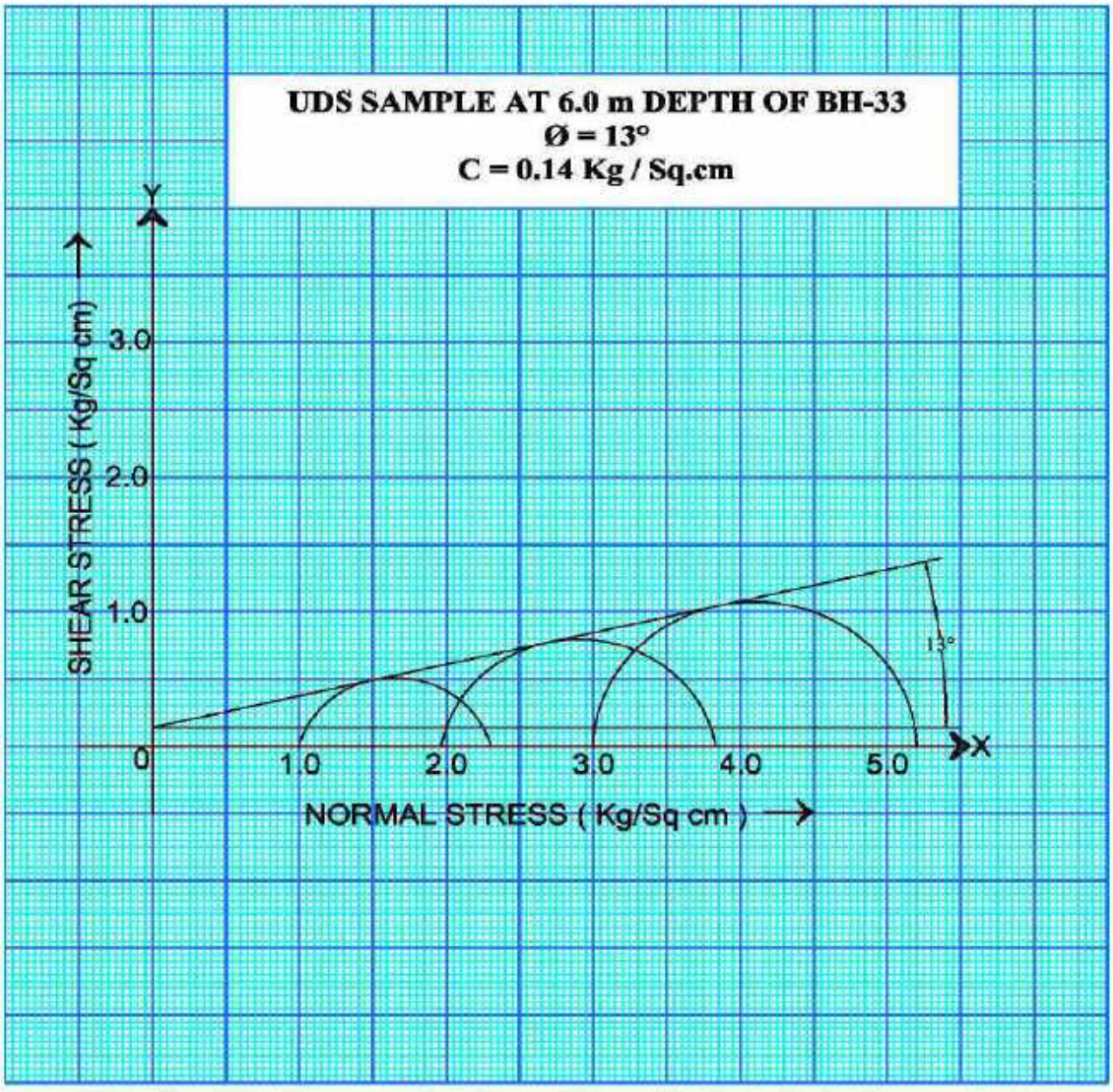

UDS SAMPLE AT 12.0 m DEPTH OF BH-32
Ø = 30°
C = 0.02 Kg / Sq.cm
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS (Kg/Sq cm)
30°

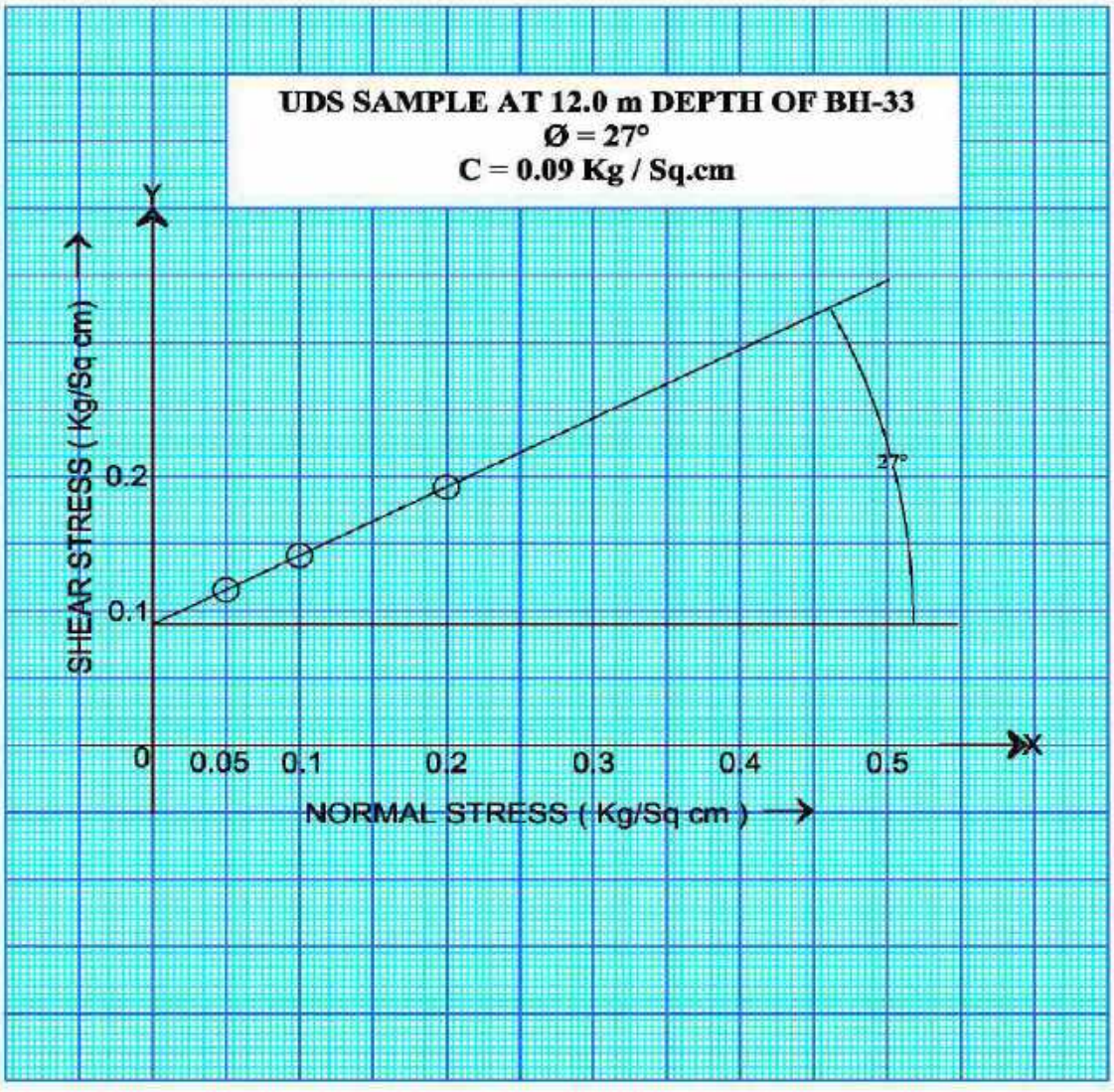

UDS SAMPLE AT 18.0 m DEPTH OF BH-32
Ø = 27°
C = 0.03 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
27°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)

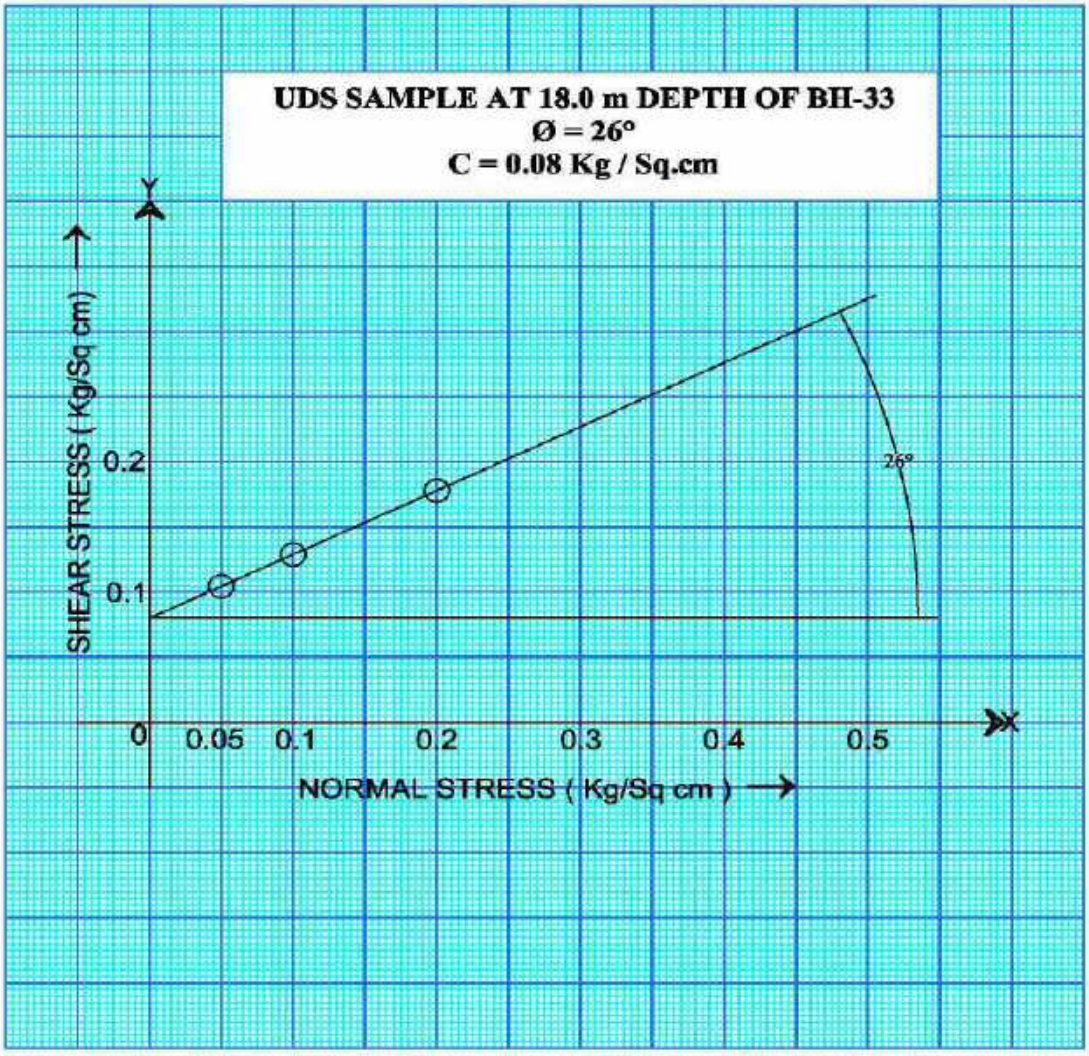

UDS SAMPLE AT 24.0 m DEPTH OF BH-32
Ø = 26°
C = 0.04 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
26°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)


UDS SAMPLE AT 30.0 m DEPTH OF BH-32
Ø = 17°
C = 0.16 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
17°


UDS SAMPLE AT 3.0 m DEPTH OF BH-33
Ø = 14°
C = 0.16 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS (Kg/Sq cm)
14°


UDS SAMPLE AT 6.0 m DEPTH OF BH-33
Ø = 13°
C = 0.14 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
13°
NORMAL STRESS (Kg/Sq cm)


UDS SAMPLE AT 12.0 m DEPTH OF BH-33
Ø = 27°
C = 0.09 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
27°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)


UDS SAMPLE AT 18.0 m DEPTH OF BH-33
Ø = 26°
C = 0.08 Kg / Sq.cm
Y
SHEAR STRESS (Kg/Sq cm)
0.2
0.1
26°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS (Kg/Sq cm)

ANNEXURE K

ON-SITE LOG OF BOREHOLES

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S.M CONSULTANTS

Geological Log of Borehole 13

BORE HOLE NO	: 13	CO-ORDINATES	X: 700692.317	LOCATION	Sohna
CHAINAGE m.	: 25000		Y: 3121852.437	TOTAL DEPTH	60.0 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 276.867 m	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	Not Found
START DATE	: 25-08-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M ConsultantS
		DATE COMPLETED	: 06-09-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS	
276.867	0.00		Clayey Silt(DS), Silty Sand(DS Wash)																				
275.367	1.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	86		8	6		Joints of 0°,5°		18		Nil	>15	NX						12.5	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*	18
273.867	3.00		Slightly Weathered, Moderately Fractured, Highly Jointed, White to Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	82		7	11		Joints of 0°,10°, One Andulating Joint		28.6		Nil	>15							13.63		28.6
272.367	4.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	95		5			Joints of 0°,5°,10°		44.6		Nil	>15							15		44.6
270.867	6.00		Highly Weathered, Highly Fractured, Highly Jointed, Light Grey to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	93	1	6			Highly Fractured, Crushed Zone		21.33		Nil	>15							12.5		21.3
269.367	7.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	85			15		Highly Fractured, Joints of 0°,10°,15°		70		10	>15					Light Brown		12		25.3
267.867	9.00		Highly Weathered, Highly Fractured, Highly Jointed, White to Light Brown,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	91	1	8			Highly Fractured, Crushed Zone		37.33		Nil	>15							12.5		37.3
266.367	10.50			97		3					34		Nil	>15							12.5		34
264.867	12.00		Moderately Weathered, Highly Fractured, Highly Jointed, Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	80		2	7	11	Joints of 0°,10°, 65°, 80°		28		17.3	>15							13.04		28
263.367	13.50		Highly Weathered, Highly Fractured, Highly Jointed, Grey,Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	98	2				Highly Fractured, Joint of 80°		21.33	Diamond Bit	Nil	>15							11.53		21.3
261.867	15.00			100					Highly Fractured, Joints of 0°,10°,80°		34		Nil	>15							12.5		34
260.367	16.50		Slightly Weathered, Highly Fractured, Highly Jointed, Reddish Brown to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	87		8	5		Joints of 0°,5°,10°		32		Nil	>15							14.28		32
258.867	18.00		Slightly Weathered, Highly Fractured, Highly Jointed, Milky White to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	84	1	4	11				32.85		Nil	>15							12.5		32.9
257.367	19.50		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Reddish Brown to Light Brown Staining)	87		3	10		Highly Fractured, Joint of 0°		30		9	>15							12.5		30
255.867	21.00			87		5	8		Joints of 0°,5°,10°		39.33		Nil	>15							14.28		39.3
254.367	22.50			75		9	16		Joints of 0°,10°,65°, Closed Joint of 80°		33.33		Nil	>15							15		33.3
252.867	24.00		Slightly Weathered, Highly Fractured, Highly Jointed, Reddish Brown to Light Brown and Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	82		7	11		Joints of 0°,10°,45°		39.33		Nil	>15							12.5		39.3
251.367	25.50		Slightly Weathered, Highly Fractured, Highly Jointed, Milky White to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	70		4	26		Joints of 0°,10°		28.66		9	>15							14.28		28.7
249.867	27.00			74			14	12			34		18	>15							13.63		34
248.367	28.50			64			8	28			34		24	>15							14.28		34

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S M CONSULTANTS AN ISO 9001 COMPANY BHUBANESHWAR

Geological Log of Borehole 13

BORE HOLE NO	: 13	CO-ORDINATES	X: 700692.317	LOCATION	Sohna
CHAINAGE m.	: 25000		Y: 3121852.437	TOTAL DEPTH	60.0 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 276.867 m	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	Not Found
START DATE	: 25-08-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED:	06-09-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
248.367	28.50																					
246.867	30.00		Slightly Weathered, Highly Fractured, Highly Jointed, Milky White to Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Completely weathered Garnet Pores)	68			15	17	Joints of 0°,10°		40		20	>15						Light Brown	12.5	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
245.367	31.50		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	79		21			Joints of 0°,10°, Closed Joint of 80°		31.33		Nil	>15							14.28	
243.867	33.00			80			20		Joints of 0°,5°,10°		33.33		8.6	>15							12.5	
242.367	34.50			76		5	7	12			24		10.6	>15							11.53	
240.867	36.00		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Minor Phyllite Band Noticed)	87		5	8		Joints of 0°,10°, Closed Joint of 85°		35.33		7.6	>15							13.63	
239.367	37.50			76		7	17		Contact Joint of 85°		32.6		7.6	>15							14.28	
237.867	39.00			94			6		Highly Fractured, Highly Jointed		26.66		Nil	>15							11.53	
236.367	40.50			85		6	9		Joints of 0°,10°, 30°, 80°		32		8.6	>15							13.63	
234.867	42.00			78			6	16	Joints of 0°,10°,Contact Joint of 80°		43.33		9.3	>15							16.66	
233.367	43.50			83		3	14		Joints of 0°,10°, Very Rough Joint of 80°		26	Diamond Bit	7.6	>15							12.5	
231.867	45.00			78			15	7	Joints of 0°,10°		33.33		15.6	>15							14.28	
230.367	46.50			97		3			Highly Fractured, Joints of 10°,20°, 70°, 80°		30		Nil	>15							12.5	
228.867	48.00		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Reddish Brown to Light Brown Staining)	79		3	8	10			22.66		19	>15							14.28	
227.367	49.50			69		2	7	22			34		28.6	15-8							12.5	
225.867	51.00			90		4	6		Highly Fractured, Joints of 0°,10°,15°		27.33		Nil	>15							13.63	
224.367	52.50			92		2	6				26		Nil	>15							14.28	
222.867	54.00			91		4	5				34		Nil	>15							12.5	
221.367	55.50			81		5	14		Joints of 0°,10°, 15°, 20°		34		Nil	>15							12.5	
219.867	57.00			88		3	9		Joints of 10°, 15°, 20°, Very Rough Joint 80°		26.66		8.6	>15							1..63	
218.367	58.50			88				12	Joints of 0°,10°, 15°, 20°		28		8	>15							12.5	
216.867	60.00			84		3		13	Joints of 0°,10°, 15°, 30°		22		13	>15							12.5	

Geotechnical Investigation Report

Consultant:		Client :
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830 / Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S.M. CONSULTANTS AN ISO 9001 COMPANY BHUBANESWAR

Geological Log of Borehole 14

BORE HOLE NO	: 14	CO-ORDINATES	X: 700578.153			LOCATION	Sohna
CHAINAGE m.	: 25195		Y: 3122015.421			TOTAL DEPTH	75m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 294.218			TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	: ---			DEPTH OF WATER TABLE (m)	Not Found
START DATE	: 11-08-2021	ANGLE WITH HORIZONTAL:	0°			DRILLING AGENCY	S.M Consultants
		DATE COMPLETED	: 23-08-2021			NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20	40	60	80	100	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
294.218	0.00																									
292.718	1.50			100					Highly Fractured		30						Nil	>15	NX						16.6	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
291.218	3.00		Moderately Weathered, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	82		5	13		Joints of 0°,5°,10°,65°		48						Nil	>15							15	
289.718	4.50			76		11	13				38						Nil	>15							16.6	
288.218	6.00		Moderately Weathered, Moderately Fractured, Highly Jointed Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite (Small Talc Amygdals Noticed)	54		3	43				66						24	>15							20	
286.718	7.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite	82		11	7		Highly Fractured		45						Nil	>15						Light Brown	16.6	
285.218	9.00		Slightly to Moderately Weatherd, Highly Farctured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite (Very Fine Grained Muscovite Flakes)	88		3	9		Joints of 0°,5°,10°,65°		50						18	>15							11.5	
283.718	10.50		Moderately Weathered, Moderately Fractured, Highly Jointed Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	76		11	13				51						Nil	>15							12.5	
282.218	12.00		Slightly to Moderately Weatherd, Highly Farctured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	60		4	9	27			40						21	>15							13.6	
280.718	13.50		Moderately Weathered, Highly Fractured, Highly Jointed Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	78		4		18			34						15	>15							16.6	
279.218	15.00		Highly Weathered, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	96		4			Highly Fractured		21						Nil	>15							12.5	
277.718	16.50			93		7					29						Nil	>15							12.5	
276.218	18.00			89				11	Joints of 0°,5°,10°,65°		28						9	>15							16.6	
274.718	19.50		Slightly Weathered, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	84			16				34						6	>15							16.6	
273.218	21.00			81		3	16				23						Nil	>15							11.53	
271.718	22.50			78		3	19				28						13	>15							10.71	
270.218	24.00			83			17				23						6	>15							13	
268.718	25.50			92		8					20						Nil	>15							11.5	
267.218	27.00			88		2		10	Joints of 0°,5°,10°		25						9	>15							13.6	
265.718	28.50			90		4	6				28						Nil	>15							12.5	
264.218	30.00			75			5	20			25						18	>15							16.3	
262.718	31.50			75		4	6	15			28						14	>15							16.3	
261.218	33.00		Moderately Weathered, Modertely Fractured, Highly Jointed, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	69			11	20			28						18	>15							19.7	
259.718	34.50			87			5	8			22						6	>15							16.6	
258.218	36.00		Highly Weathered, Highly Fractured, Highly Jointed, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	96		4			Joints of 0°,5°,10°,65°		25						Nil	>15							16.6	
256.718	37.50			79		5	16				29						10	>15							12.5	

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S M CONSULTANTS AN ISO 9001 COMPANY BHUBANESHWAR

Geological Log of Borehole 14

BORE HOLE NO	: 14	CO-ORDINATES	X: 700578.153	LOCATION	Sohna
CHAINAGE m.	: 25195		Y: 3122015.421	TOTAL DEPTH	75m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 294.218	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	Not Found
START DATE	: 11-08-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED:	23-08-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
256.718	37.50																					
255.218	39.00		Highly Weathered, Highly Fractured, Highly Jointed, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	84		9	7		Joints of 0°,5°,10°,65°		28		7	>15							15	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
253.718	40.50			96		4			Highly Fractured		30		Nil	>15							15	
252.218	42.00			87		6	7		Joints of 0°,5°,10°,65°		28		7	>15							12.5	
250.718	43.50			81		8	11				25		Nil	>15							12.5	
249.218	45.00			85			6	9			26		6	>15							13.6	
247.718	46.50			83		6	11				24		Nil	>15							21.12	
246.218	48.00			74		20	6				26		Nil	>15							18.07	
244.718	49.50			84		4		12			27		18	>15							178	
243.218	51.00			90		4	6				22		Nil	>15							15.95	
241.718	52.50			90		3	7				22	Diamond Bit	Nil	>15							15.78	
240.218	54.00			70		2		28			22		Nil	>15							18.75	
238.718	55.50			84		16			Joints of 0°,5°,10°		26		Nil	>15							13.63	
237.218	57.00			91	1	8					26		Nil	>15							18.07	
235.718	58.50		Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	93			7				22		10	>15							20.27	
234.218	60.00			93		2	5				21		Nil	>15							18.75	
232.718	61.50			91			9				22		Nil	>15							15.78	
231.218	63.00			100					Joints of 0°,5°,10°,80°		22		Nil	>15							16.4	
229.718	64.50			86		5	9				25		13	>15							16.3	
228.218	66.00			91		2	7		Highly Fractured		28		11	>15							19.7	
226.718	67.50			95			5				28		Nil	>15							17.6	
225.218	69.00			82		13	5				28		Nil	>15							14.8	
223.718	70.50			91			9				26		8	>15							16.6	
222.218	72.00			82			18		Joints of 0°,5°,10°,65°		27		14	>15							15.15	
220.718	73.50			80		9	11		Joints of 0°,5°,65°		26		14	>15							19.23	
219.218	75.00			100					Highly Fractured		22		Nil	>15							12.50	

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S M CONSULTANTS

Geological Log of Borehole 15

BORE HOLE NO	: 15	CO-ORDINATES	X: 700451.868	LOCATION	Sohna
CHAINAGE Km.	: 25380		Y: 3122157.745	TOTAL DEPTH	70.0 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 295.532	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	61.0 m
START DATE	: 12-08-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED	: 28-08-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20	40	60	80	100	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS	
295.532	0.00																										
294.032	1.50		Moderately Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	91		4	5		Joints of 0°, 5, 10°, 15°		26					Diamond Bit	0	>15	NX					Light Brown	12.5	As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.	26
292.532	3.00			83		9	8				28						7	>15							16.6		28
291.032	4.50			75		6	19				42						7	>15							16.3		42
289.532	6.00			72		15	13				36						0	>15							15.6		36
288.032	7.50			59		22	19				46						0	>15							13.04		46
286.532	9.00			78		9	13				24						7	>15							17.64		24
285.032	10.50			78		8	14				34						14	>15							16.3		34
283.532	12.00			87	1	12					20						0	>15							16.66		20
282.032	13.50			90		10					23						0	>15							18.75		23
280.532	15.00			100							16						0	>15							15		16
279.032	16.50		Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	91		9			Joints of 0°, 5, 10°, 25°		16						0	>15							12.5		16
277.532	18.00			84		5	11		Joints of 0°, 5, 10°, 15°		22						0	>15							12.5		22
276.032	19.50			68	2	8	22				41						17	>15							14.28		41
274.532	21.00			82		12	6				28						0	>15							14.28		28
273.032	22.50			95		5					26						0	>15							16.66		26
271.532	24.00			80			7	13	Joints of 0°, 5, 10°, 35°		36						18	>15							13.63		36
270.032	25.50			97		3					27						0	>15							12.5		27
268.532	27.00			85		9	6				36						0	>15							16.66		36
267.032	28.50			82		9	9				33						8	>15							16.66		33
265.532	30.00			91	2	7					20						0	>15							15.7		20
264.032	31.50			84		16					23						0	>15							16.66		23
262.532	33.00			81	2	4	13				21						0	>15							16.66		21
261.032	34.50			78		2	20				30						7	>15							14.7		30
259.532	36.00			82			18		Joints of 0°, 5, 10°, 45°		32						0	>15							17.04		32
258.032	37.50			84		9	7				31						0	>15							15.6		31

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

Geological Log of Borehole 15

BORE HOLE NO	: 15	CO-ORDINATES X:	700451.868	LOCATION	Sohna
CHAINAGE Km.	: 25380	Y:	3122157.745	TOTAL DEPTH	70.0 m
COLLAR ELEVATION	: ---	GROUND ELEVATION:	295.532	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH :	---	DEPTH OF WATER TABLE (m)	61.0 m
START DATE	: 12-08-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED:	25-08-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
258.032																						
256.532	39.00		Slightly Weathered, Highly Fractured, Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, very Hard, Quartzite	83		10	7		Joints of 0°, 5, 10°, 45°		30	Diamond Bit	6	>15							18.51	As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Highly Jointed. Quartzite is the Prominent Rock
255.032	40.50			94	1	5			Joints of 0°, 5, 10°, 15°		25		0	>15							16.12	
253.532	42.00			63		13	8	16			40		22	>15							15.7	
252.032	43.50			66		11	23				28		8	>15							15	
250.532	45.00			82	1		17				30		6	>15							15.7	
249.032	46.50			85		4	11				26		0	>15							15	
247.532	48.00			69		4	27		Joints of 0°, 5, 10°, 55°		38		27	>15							15.7	
246.032	49.50			85		5	10		Joints of 0°, 5, 10°, 15°		29		10	>15							16.6	
244.532	51.00			90			10				22		0	>15							17.6	
243.032	52.50			76		3	21				26		15	>15							14.8	
241.532	54.00			88				12			20		10	>15							15.9	
240.032	55.50			83			17		Joints of 0°, 5, 10°, 35°		26		0	>15							15.7	
238.532	57.00			100					Joints of 0°, 5, 10°, 90°		20		0	>15							15.7	
237.032	58.50			87		6	7		Highly Fractured		25		0	>15							16.6	
235.532	60.00			92		8					34		0	>15						Greyish Brown	16.3	
234.032	61.50			76			24		Joints of 0°, 5, 10°, 15°		28		24	>15							14.2	
232.532	63.00			92			8				20		8	>15							15.7	
231.032	64.50			84			16				32		16	>15							14.2	
229.532	66.00			79		7	14		Joints of 0°, 5, 10°, 30° 75°		31		14	>15						Light Brown	12.5	
228.032	67.50			83			7	10			27		9	>15							14.28	
226.532	69.00			73		4	23				28		8	>15							12.5	
225.532	70.00			67		6	27				57		10	>15							12.5	

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
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BHUBANESWAR

Geological Log of Borehole 15(A)

BORE HOLE NO	: 15A (Ditch)	CO-ORDINATES	X: 700374.567	LOCATION	Sohna
CHAINAGE m.	: 25488		Y: 3122232.681	TOTAL DEPTH	50m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 276.442 m	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	10m
START DATE	: 15-09-2021	ANGLE WITH HORIZONTAL:	0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED	: 01-10-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20	40	60	80	100	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
276.442	0.00																									
274.942	1.50		Moderately Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Very Fine Grained Pyrite Crystals)	90	1	4	5		Joints of 0°, 5°,10°,15°								0	>15							15	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
273.442	3.00			78	4	3		15				39					10	>15							14	
271.942	4.50			79			21					32					21	>15							15	
270.442	6.00			88		12						35					0	>15							13	
268.942	7.50			72			28		Joints of 0°, 5°,10°,15°, 30°								28	15-8							18	
267.442	9.00			90	3	7											0	>15							14	
265.942	10.50			70	3	4	23										30	15-8							15	
264.442	12.00			78			22					35					22	>15						Light Brown	14	
262.942	13.50			82	1	3	14		Joints of 0°, 5°,15°, 45°			32				Diamond Bit	8	>15							15	
261.442	15.00			65	2			33				47					32	15-8							15	
259.942	16.50			89		2	9		Joints of 0°, 5°,15°, 80°			28					8	>15							18	
258.442	18.00			90	1	2	7					41					7	>15							16	
256.942	19.50		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Very Fine Grained Pyrite Crystals)	81	2		17		Joints of 0°, 5°,10°, 15°			36					16	>15							15	
255.442	21.00			76		4		20				45					20	>15							15	
253.942	22.50			80		5	15					30					15	>15							15	
252.442	24.00			88	1	5	6		Joints of 0°, 5°,10°, 35°			36					0	>15							14	
250.942	25.50			99	1				Joints of 0°, 5°,10°, 15°			27					0	>15						Grey	15	
249.442	27.00			83		2	15					40					15	>15							16	
247.942	28.50			77			23					32					23	>15							14	
246.442	30.00			87		13						34					0	>15							16	
244.942	31.50			78			22					34					22	>15							15	
243.442	33.00			83			17					30					15	>15						Light Brown	14	
241.942	34.50			90		2	8		Joints of 0°, 5°,10°, 70°			30					8	>15							13	
240.442	36.00			94		6						36					0	>15							15	
238.942	37.50			97		3			Joints of 0°, 5°,10°, 15°			37					23	>15							15	

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
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AN ISO 9001 COMPANY
BHUBANESHWAR

Geological Log of Borehole 15(A)

BORE HOLE NO	: 15A (Ditch)	CO-ORDINATES	X:	700374.567	LOCATION	Sohna
CHAINAGE Km.	: 25488		Y:	3122232.68	TOTAL DEPTH	50.0 m
COLLAR ELEVATION	: ---	GROUND ELEVATION:		276.442	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	AZIMUTH	:	---	DEPTH OF WATER TABLE (m)	10.0 m
START DATE	: 15-09-2021	ANGLE WITH HORIZONTAL:		0°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED:		01-10-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20	40	60	80	100	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
238.942																										
237.442	39.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Very Fine Grained Pyrite Crystals)	89	1	10			Joints of 0°, 5°,10°, 15°			40				Diamond Bit	7	>15						Light Brown	15	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
235.942	40.50			90			10					50					10	>15							13	
234.442	42.00			90		10						34					0	>15							14	
232.942	43.50			84		2	14					32					8	>15							13	
231.442	45.00			81		6	13					35					0	>15							16	
229.942	46.50			98	2							30					0	>15							13	
228.442	48.00			92	1		7		Joints of 0°, 5°,10°, 70°			36					7	>15							15	
226.942	49.50			86	2	4	8					40					8	>15							15	
226.442	50.00			98			2		Joints of 0°, 5°,10°, 15°			40					0	>15							15	

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S M CONSULTANTS AN ISO 9001 COMPANY BHUBANESWAR

Geological Log of Borehole 16

BORE HOLE NO	: 16	CO-ORDINATES	X: 700297.426	LOCATION	Sohna
CHAINAGE Km.	: 25586		Y: 3122294.327	TOTAL DEPTH	62.0 m
COLLAR ELEVATION	: ---	---	GROUND ELEVATION : 287.324	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: ---	---	AZIMUTH : ---	DEPTH OF WATER TABLE (m)	50.0 m
START DATE	: 26-08-2021		ANGLE WITH HORIZONTAL: 0°	DRILLING AGENCY	S.M Consultants
			DATE COMPLETED : 10-09-2021	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition	Log	% of Core-Recovery	Type of BT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
287.324	0.00																					
285.824	1.50		Moderately Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite (DS and DS Wash Collected)	93		2	5		Highly Fractured		16		0	>15	NX						12.5	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominent Rock here with some tracts and bands of Phyllite and Schist.*
284.324	3.00			93			7				25		0	>15							14.8	
282.824	4.50		Moderately Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	90		4	6				32		0	>15							13.63	
281.324	6.00			88		5	7				32		0	>15							13.63	
279.824	7.50			97		3					30		0	>15							12.5	
278.324	9.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	84			16				31		10	>15							14.28	
276.824	10.50			83	1	3	13				30		0	>15						Light Brown	12.5	
275.324	12.00			78		6	16		Joints of 0°,10°,15°,20°		34		0	>15							16.6	
273.824	13.50			74		4	9	13			31	Diamond Bit	15.33	>15							12.5	
272.324	15.00		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	74			11	15			27		10.3	>15							13.04	
270.824	16.50			80				20	Closed Joint of 80°		36		19	>15							13.63	
269.324	18.00			85				15			28		15.3	>15							15	
267.824	19.50			56	1		10	33	Joints of 0°,10°,15°,20°		46		36.3	15-8							12.5	
266.324	21.00			71			19	10			48		0	>15							11.53	
264.824	22.50			72				28			44		14	>15							12.5	
263.324	24.00			74			26		Joints of 0°,10°,15°,45°		43		11	>15						Light Brown	13.63	
261.824	25.50			65			6	29			42		28	15-8							13.04	
260.324	27.00			78			22		Joints of 0°,10°,15°,20°		34		15	>15							13.63	
258.824	28.50			53				47			53		47	15-8							15	
257.324	30.00			76			24		Joints of 0°,10°,15°, 70°		31		8	>15							11.5	
255.824	31.50			79				21			39		34	15-8							15	
254.324	33.00			83			17				30		14	>15							12.5	
252.824	34.50			71		2		27	Joints of 0°,10°,15°		36		25	>15							16.6	
251.324	36.00			78				22			30		22	>15							13.6	
249.824	37.50			65			5	30			37		22	>15							15	

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**
		Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
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BHUBANESHWAR

Geological Log of Borehole 16

BORE HOLE NO	: 16	CO-ORDINATES	X:	700297.426	LOCATION		Sohna
CHAINAGE Km.	: 25586		Y:	3122294.327	TOTAL DEPTH		62.0 m
COLLAR ELEVATION	: ---	GROUND ELEVATION:		287.324	TYPE OF CORE BARREL		Double Tube
RAIL LEVEL	: ---	AZIMUTH	:	---	DEPTH OF WATER TABLE (m)		50.0 m
START DATE	: 26-08-2021	ANGLE WITH HORIZONTAL:		0°	DRILLING AGENCY		S.M Consultants
		DATE COMPLETED:		10-09-2021	NAME OF GEOLOGIST		Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20	40	60	80	100	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
249.824																										
	39.00		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	85			15		Joints of 0°,10°,15°		30						8	>15						Light Brown	12.5	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
248.324	40.50			69		3	5	23			34						20	>15							10.71	
246.824	42.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	86			14		Highly Fractured		36						0	>15							12.5	
245.324	43.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	64			18	18	Joints of 0°,10°,15°, 75°		42						16.6	>15							13.63	
243.824	45.00			55				45	Joints of 0°,10°,15°		44						44	15-8							11.53	
242.324	46.50		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	85			15		Highly Fractured		37						0	>15							14.28	
240.824	48.00			46				54			53						51.3	8-5							12.5	
239.324	49.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	62	1		26	11	Joints of 0°,10°,15°		45					Diamond Bit	15.3	>15							11.53	
237.824	51.00			68		4		28			38						26.6	15-8						Light Brown	12.5	
236.324	52.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Weathered Medium Grained Garnet Grains, Contact of Phyllite Band Noticed)	60		3		37	Open Joint 80° (Phyllite Band Contact)		40						29.3	15-8						Light Brown	10.71	
234.824	54.00			72			16	12			43						16.3	>15							10.71	
233.324	55.50			60			17	23			43						21	>15							12.5	
231.824	57.00			76			24				31						8	>15							13.63	
230.324	58.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	80				20	Joints of 0°,10°,15°		30						17.6	>15							13.63	
228.824	60.00			75				25			25						20	>15						Light Brown	12.5	
227.324	61.50			70			10	20			32						24.3	>15							11.53	
225.824	62.00			83			17		Closed Joint of 70°		66						8.6	>15							14.28	
224.324																										

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S M CONSULTANTS

Geological Log of Borehole 17

BORE HOLE NO	: 17	CO-ORDINATES	X: 700117.355	LOCATION	Sohna
CHAINAGE Km.	: 25785		Y: 3122388.462	TOTAL DEPTH	62.0 m
COLLAR ELEVATION	: ---	--- GROUND ELEVATION	: 282.461	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: 232.394	--- AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	38.6 m
START DATE	: 22-12-2021	ANGLE WITH HORIZONTAL:	90°	DRILLING AGENCY	S.M Consultants
		DATE COMPLETED	: 27-01-2022	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20 40 60 80 100	Standard Penetration Test N Value	Depth of Penetration in cm	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss Nil	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
282.461	0.00																							
280.961	1.50		Brown colour, very fine to fine grained, clayey silt deposit						very fine to fine grained, clayey silt deposit		0				NA	NA	NX						30.61	*As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominnent Rock here with some tracts and bands of Phyllite and Schist.*
279.461	3.00										0	12	45		NA	NA							33.3	
277.961	4.50		Brown colour, very fine to fine grained, clayey silt deposit						very fine to fine grained, clayey silt deposit		0				NA	NA							27.27	
276.461	6.00										0	16	45		NA	NA							27.27	
274.961	9.00										30				NA	NA					Brown		30	
273.461	12.00		Brown colour, very fine to fine grained, clayey silt with gravels..						very fine to fine grained, clayey silt with gravels..		0	26	45		NA	NA							31.57	
271.961	15.00										0	21	45		NA	NA							30	
270.461	16.50										0	37	45		NA	NA							21.42	
268.961	18.00		Brown colour, very fine to fine grained, sub angular to sub rounded pebbels with clayey silt.						It shows very fine to fine grained, sub angular to sub rounded pebbels clayey silt.		0	>50	23	Diamond Bit	NA	NA							21.12	
267.461	19.50		Highly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Hard Quartzite.	<10	23	35			Joints of 0°,45°		17				0	>15							12	
265.961	20.50			<10	20	31			Closed Joint of 10°		22				0	>15							6.89	
264.461	22.00			<10				174			25				11.6	>15							10	
262.961	23.00			<10		70			It shows highly fractured weathered rock		32				0	15-8							11.11	
261.461	24.50			<10			175				33				0	>15							10.71	
259.961	25.00		Moderately Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite.			35	125		Joints of 0°,10°,15°		48				25	15 to 8							5.5	
258.461	26.00			<10		42		376	Joints of 0°, 15°,80°		59				32.6	15 to 8							7.4	
256.961	27.50			<10		66	175	190	Joints of 0°,10°,15°,20°		44				12.66	15 to 8							12.5	
255.461	28.00					70	214				68				25.8	15 to 8							6.6	
253.961	29.50		Highly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Hard Quartzite.	<10		130			It shows highly fractured weathered rock		58				7.6	15 to 8							11.53	
252.461	30.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	<10		49	93		Joints of 0°,10°,15°, 70°		70				0	>15							7.14	
250.961	31.00			<10		30	191	153			47				17.13	>15							7.4	
249.461	32.50			<10		60	80		It shows highly angular fractured and jointed, weak strength		54				0	>15							11.53	
247.961	33.50		Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	<10		50	395				54				15.53	>15							11.11	
246.461	35.00		Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite.(crushed zone)	<10	17	75	90				34.66				0	15 to 8							11.53	
244.961	36.50		Light Brown colour, Coarse grained, Sand. (SPT Rebounded)						Coarse grained, Sand. (SPT Rebounded)		0	>50	3		NA	NA					Brown		21.42	

Geotechnical Investigation Report			
Consultant:			*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

Geological Log of Borehole 17

BORE HOLE NO	: 17	CO-ORDINATES	X: 700117.355	LOCATION	Sohna
CHAINAGE Km.	: 25785		Y: 3122388.462	TOTAL DEPTH	62.0 m
COLLAR ELEVATION	: ---	---	GROUND ELEVATION : 282.461	TYPE OF CORE BARREL	Double Tube
RAIL LEVEL	: 232.394	---	AZIMUTH : ---	DEPTH OF WATER TABLE (m)	38.6 m
START DATE	: 22-12-2021		ANGLE WITH HORIZONTAL: 90°	DRILLING AGENCY	S.M Consultants
			DATE COMPLETED : 27-01-2022	NAME OF GEOLOGIST	Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces <10mm	10-25mm	25-75mm	75-150mm	>150mm	Structural condition Description	Log	% of Core-Recovery 20	40	60	80	100	Standard Penetration N Value	Depth of Penetration in cm	Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss NI	Partial	Complete	Colour of Returned Water	Rate of Penetration (mm/min)	REMARK / OBSERVATIONS
244.961																												
											0					>50	2		NA	NA							23	As per the Surface as well as Subsurface data such as the lithology of the area, it can be stated that the Stratigraphy of the area is of North Delhi fold Belt which is related to the Aravalli Sucsession. The Strata is Highly Fractured and Higly Jointed. Quartzite is the Prominent Rock here with some tracts and bands of Phyllite and Schist.
243.461	38.00		Light Brown colour, Coarse grained, Sand. (SPT Rebounded)						Coarse grained, Sand. (SPT Rebounded)																Brown		
											0					>50	2		NA	NA							14.28	
241.961	39.50																											
				<10		60		165	Highly Fractured		32								11	15 to 8							10.71	
240.461	41.00																											
				<10			110	180	Joints of 0°,10°,15°		41.33								19.33	15 to 8							12.5	
238.961	42.50																											
				<10			150	473	Joints of 0°		54								41.53	15 to 8							11.11	
237.461	44.00																											
				<10		107	257		Highly Fractured, Joints of 0°		30								16.66	15 to 8							12	
235.961	45.50																											
			Moderatey to Slightly Weathered, Moderately to Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	<10			180				37.33								0	15 to 8							11.53	
234.461	47.00																											
				<10		56	316				41.33								21.06	15 to 8							10.86	
232.961	48.50																											
				<10		279			Highly Fractured, Joints of 0°,10°,15°		30							Diamond Bit	0	15 to 8							10.34	
231.461	50.00																											
				<10	25	383					36.66								0	15 to 8							12	
229.961	51.50																											
				<10		71	323	180			34.66								12	15 to 8							11.53	
228.461	53.00																											
				<10		135	192		Highly Fractured, Joints of 0°		33.33								6.8	15 to 8							11.11	
226.961	54.50																											
				<10			181				28								6.73	15 to 8							15	
225.461	56.00																											
			Highly Weathered, Light Brown, Moderately Fractured, Loose material, Red, very fine to Fine Grained, weak silt stone with clay material (Crushed zone)	<10		50		160	very fine to Fine Grained, weak silt stone with clay material		38								8	15 to 8							12.96	
223.961	58.00																											
				<10		70					38.33								0	15 to 8							13	
222.461	59.50																											
			Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite	<10		30	235	180	Joints of 0°,10°,15°		40.6								27.66	15 to 8							12	
220.961	61.00																											
				<10		48	345	190			70								12.66	15 to 8							9.5	
220.461	62.00																											

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830** / **Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-18

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-18	CO-ORDINATES	X : 699961.797			LOCATION	: Patuka	
CHAINAGE (m.)	: 25990		Y : 3122515.204			TOTAL DEPTH	: 55m	
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 280.253			TYPE OF CORE BARREL	: Double Tube	
RAIL LEVEL	: ---	AZIMUTH	: ---			DEPTH OF WATER TABLE (m)	: 26.20m	
START DATE	: 02-02-2022	ANGLE WITH HORIZONTAL	: 90°			DRILLING AGENCY	: S.M. Consultants	
ENDING DATE	: 07-02-2022					NAME OF GEOLOGIST	: Gaurav Chunekar	

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
280.253																								
279.753	0.50		Brown colour, fine grained,medium to dense compacted, silty clay with none to low plasticity														---	---						**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 280.253 m. The stratigraphy of area is prominently of Silty clay which comes under Alluvial Type of Category. Silty clay and with gravels is majorly tracked in the borehole.
278.753	1.50																---	---						
277.253	3.00													11	45		---	---						
275.753	4.50																---	---						
274.253	6.00													20	45		---	---						
271.253	9.00																---	---						
268.253	12.00													24	45		---	---						
265.253	15.00													31	45		---	---						
262.253	18.00													35	45		---	---						
259.253	21.00													40	45		---	---						
256.253	24.00													47	45	Nx	---	---			Partial		BROWN	
253.253	27.00		Brown colour, fine grained, dense to very densed compacted, Silty clay with gravels.											49	45		---	---						
250.253	30.00													57	45		---	---						
247.253	33.00													64	45		---	---						
244.253	36.00													69	45		---	---						
241.253	39.00													77	45		---	---						
238.253	42.00													84	45		---	---						
235.253	45.00													>50	41		---	---						
233.253	47.00													>50	36									
230.253	50.00													>50	29		---	---						
227.253	53.00													>50	22									
225.253	55.00													>50	17		---	---						

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-19

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-19	CO-ORDINATES	X : 699776.449			LOCATION	: Patuka
CHAINAGE (m.)	: 26210		Y : 3122635.179			TOTAL DEPTH	: 50m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 278.116			TYPE OF CORE BARREL	: Double Tube
RAIL LEVEL	: ---	AZIMUTH	: ---			DEPTH OF WATER TABLE (m)	: Not found
START DATE	: 25-07-2021	ANGLE WITH HORIZONTAL	: ---			DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 26-07-2021					NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
278.116																								
277.616	0.50		Brown colour, fine grained,medium to dense compacted,clayey silt with none to low plasticity														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 278.116 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
276.616	1.50													17	45		---	---						
275.116	3.00																---	---						
273.616	4.50													23	45		---	---						
272.116	6.00																---	---						
269.116	9.00													30	45		---	---						
266.116	12.00																---	---						
263.116	15.00													35	45		---	---						
260.116	18.00																---	---						
257.116	21.00													35	45		---	---						
254.116	24.00																---	---						
251.116	27.00													39	45		---	---						
248.116	30.00																---	---						
245.116	33.00													43	45		---	---						
242.116	36.00		Brown colour, fine grained, dense to very densed compacted,Silty sand														---	---						
239.116	39.00													52	45		---	---						
236.116	42.00																---	---						
233.116	45.00													65	45		---	---						
230.116	48.00																							
228.116	50.00													80	45		---	---						

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-20

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-20	CO-ORDINATES	X : 699630.8892			LOCATION	: Patuka	
CHAINAGE (m.)	: 26387		Y : 3122738.2273			TOTAL DEPTH	: 48.00 m	
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 276.795 m			TYPE OF CORE BARREL	:	
RAIL LEVEL	: ---	AZIMUTH	:			DEPTH OF WATER TABLE (m)	: Absent	
START DATE	: 16-02-2021	ANGLE WITH HORIZONTAL	:			DRILLING AGENCY	: S.M. Consultants	
ENDING DATE	: 25-03-2021					NAME OF GEOLOGIST	: Gaurav Chunekar	

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
276.795																								
276.295	0.50																---	---						**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 276.795 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
275.295	1.50													18	45		---	---						
273.795	3.00		Brown Colour, Fine Grained, medium to Dense Compacted , Clayey Silt with None to Low Plasticity														---	---						
272.295	4.50													32	45		---	---						
270.795	6.00																---	---						
267.795	9.00													48	45		---	---						
264.795	12.00		Brown Colour, Fine Grained, Dense Compacted, Silty Sand														---	---						
261.795	15.00													60	45		---	---						
258.795	18.00		Brown Colour, Fine Grained, Very Dense Compacted, Clayey Silt with None to Low Plasticity														---	---						
255.795	21.00													67	45		---	---						
252.795	24.00													76	45		---	---						
249.795	27.00																---	---						
246.795	30.00													58	45		---	---						
243.795	33.00																---	---						
240.795	36.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											67	45		---	---						
237.795	39.00																---	---						
234.795	42.00													75	45		---	---						
231.795	45.00																---	---						
228.795	48.00													79	45		---	---						

Absent

Partial

BROWN

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-21

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: 21	CO-ORDINATES	X : 699457.333			LOCATION	: Patuka	
CHAINAGE (m.)	: 26587		Y : 3122837.409			TOTAL DEPTH	: 45	
COLLAR ELEVATION	:	GROUND ELEVATION	: 274.993 m			TYPE OF CORE BARREL	:	
RAIL LEVEL	:	AZIMUTH	:			DEPTH OF WATER TABLE (m)	: Absent	
START DATE	: 19-02-2021	ANGLE WITH HORIZONTAL	:			DRILLING AGENCY	: S.M. Consultants	
ENDING DATE	: 28-03-2021					NAME OF GEOLOGIST	: Gaurav Chunekar	

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
274.993																								
274.493	0.50		Brown Colour, Very Fine Grained, Medium to dense Compacted, Clayey Silt with none to Low Plasticity														---	---						**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 274.993 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole. Fragmented and bouldered rock strata of Sandstone and Quartzite has also been noticed from 18.0m to 36.0m. However sandstone was more prominent in both of them.
273.493	1.50													14	45		---	---						
271.993	3.00																---	---						
270.493	4.50													20	45		---	---						
268.993	6.00																---	---						
265.993	9.00													31	45		---	---						
262.993	12.00																---	---						
259.993	15.00													38	45		---	---						
256.993	18.00		Fragmented Rock Strata of Yeollwish Brown, Fine Grained, Hard to Medium Hard, Sandstone						6								4.50	---						
253.993	21.00		Fragmented Rock Strata of Yeollwish Brown, Medium to Coarse Grained, Hard Sandstone						3.5								Nil	---		Absent	Partial		BROWN	
250.993	24.00		Fragmented Rock Strata of Yeollwish Brown, Fine Grained, Medium Hard, Sandstone						4								Nil	---						
247.993	27.00		Fragmented Rock Strata of Yeollwish Brown, Very Fine to Fine Grained, Medium Hard, Sandstone						6								Nil	---						
244.993	30.00		Fragmented Rock Strata of Very Fine to Fine Grained, Hard to Medium Hard, Sandstone and Qaurtzite						9								Nil	---						
241.993	33.00		Fragmented Rock Strata of Yeollwish Brown, Medium to Coarse Grained, Hard Sandstone						6								Nil	---						
238.993	36.00		Fragmented Rock Strata of Yeollwish Brown, Medium to Coarse Grained, Hard Sandstone						4.6								Nil	---						
235.993	39.00		Brown Coour, Very Fine Grained,Very dense Compacted, Clayey Silt with none to Low Plasticity														---	---						
232.993	42.00													75	45		---	---						
229.993	45.00																---	---						

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-22

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-22	CO-ORDINATES	X : 699273.757	LOCATION	: Patuka
CHAINAGE (m.)	: 26787		Y : 3122916.536	TOTAL DEPTH	: 45.00 m
COLLAR ELEVATION	:	GROUND ELEVATION	: 274.321 m	TYPE OF CORE BARREL	:
RAIL LEVEL	:	AZIMUTH	:	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 08-04-2021	ANGLE WITH HORIZONTAL	:	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 11-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
274.321																								
273.821	0.50		Brown Colour, Very Fine Grained, Silt and Clay with Low Compressibility														---	---						**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 274.321 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole. Fragmented and bouldered rock strata of Sandstone and Quartzite has also been noticed from 18 m. to 39 m. However sandstone was more prominent in both of them.
272.821	1.50		Brown Colour, Fine Grained, Medium Compacted, Clayey Silt with none to Low Plasticity											15	45		---	---						
271.321	3.00																---	---						
269.821	4.50													21	45		---	---						
268.321	6.00																---	---						
265.321	9.00													28	45		---	---						
262.321	12.00		Gravels and Pebbles of Quartzite and Sanstone														---	---						
259.321	15.00																---	---						
256.321	18.00		Fragmented Rock Strata of Yeollwish Brown, Medium to Coarse Grained, Hard Sandstone						3.0								Nil	---		Absent	Partial		BROWN	
253.321	21.00								2.3								Nil	---						
250.321	24.00		Fragmented Rock Strata of Yeollwish Brown, Fine Grained, Hard Sandstone						3.0								Nil	---						
247.321	27.00								2.0								Nil	---						
244.321	30.00								3.0								Nil	---						
241.321	33.00								2.3								Nil	---						
238.321	36.00								4.0								Nil							
235.321	39.00								4.0								Nil							
232.321	42.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with Low Compressibility																					
229.321	45.00													91	45									

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-23

S M CONSULTANTS AN ISO 9001 COMPANY BHUBANESHWAR

BORE HOLE NO	: Bh 23	CO-ORDINATES	X : 699087.908			LOCATION	: Patuka	
CHAINAGE (m.)	: 26980		Y : 3122972.138			TOTAL DEPTH	: 45 m	
COLLAR ELEVATION	:	GROUND ELEVATION	: 274.850 M			TYPE OF CORE BARREL	:	
RAIL LEVEL	:	AZIMUTH	:			DEPTH OF WATER TABLE (m)	: Absent	
START DATE	: 04-04-2021	ANGLE WITH HORIZONTAL	:			DRILLING AGENCY	: S.M. Consultants	
ENDING DATE	: 06-04-2021					NAME OF GEOLOGIST	: Gaurav Chunekar	

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
274.850																								
274.350	0.50		Brown Colour, Very Fine Grained, stiff to very stiff Consitency, Silt and Clay with Low Compressibilty														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 274.850 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
273.350	1.50													16	45		---	---					
271.850	3.00																---	---					
270.350	4.50													23	45		---	---					
268.850	6.00																---	---					
265.850	9.00		Brown Colour, Fine grained, Dense Compacted, Clayey Silt with None to Low Plasticity											34	45		---	---					
262.850	12.00		Brown Colour, Very Fine Grained, Hard Consitency, Silt and Clay with Low Compressibilty														---	---					
259.850	15.00													38	45		---	---					
256.850	18.00																---	---					
253.850	21.00		Brown Colour, Fine grained, Dense Compacted, Silty Sand											50	45		---	---					
250.850	24.00		Brown Colour, Very Fine Grained, Silt and Clay with low Compressibility														---	---					
247.850	27.00		Brown Colour, Fine grained, Very Dense Compacted, Silty Sand											63	45		---	---					
244.850	30.00		Brown Colour, Fine Grained, Clayey Silt with None to Low Plasticity														---	---					
241.850	33.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low											73	45		---	---					
238.850	36.00		Brown Colour, Fine grained, Silty Sand														---	---					
235.850	39.00		Brown Colour, Very Fine Grained, Hard Consistencey, Silt and Clay with low Compressibility											77	45		---	---					
232.850	42.00																---	---					
229.850	45.00													85	45		---	---					

Geotechnical Investigation Report			
Consultant:			*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-24

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-24	CO-ORDINATES	X : 698885.647			LOCATION	: Patuka	
CHAINAGE (m.)	: 27187		Y : 3123009.681			TOTAL DEPTH	: 40.00 m	
COLLAR ELEVATION	:	GROUND ELEVATION	: 274.075 M			TYPE OF CORE BARREL	:	
RAIL LEVEL	:	AZIMUTH	:			DEPTH OF WATER TABLE (m)	: Absent	
START DATE	: 04-04-2021	ANGLE WITH HORIZONTAL	:			DRILLING AGENCY	: S.M. Consultants	
ENDING DATE	: 08-04-2021					NAME OF GEOLOGIST	: Gaurav Chunekar	

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
274.075																								
273.575	0.50		Brown Colour, Fine Grained, Medium to dense Compacted, Clayey Silt with None to Low Plasticity														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 274.075 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
272.575	1.50													14	45		---	---					
271.075	3.00																---	---					
269.575	4.50													21	45		---	---					
268.075	6.00																---	---					
265.075	9.00													27	45		---	---					
262.075	12.00																---	---					
259.075	15.00													33	45		---	---					
256.075	18.00																	---					
253.075	21.00													43	45		---	---					
250.075	24.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility														---	---					
247.075	27.00													58	45		---	---					
244.075	30.00																---	---					
241.075	33.00													72	45		---	---					
238.075	36.00																---	---					
235.075	39.00													89	45		---	---					
232.075	40.00																---	---					

Geotechnical Investigation Report			
Consultant:			*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-25

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-25	CO-ORDINATES	X : 698666.173	LOCATION	: Patuka
CHAINAGE (m.)	: 27410		Y : 3123023.037	TOTAL DEPTH	: 40.00 m
COLLAR ELEVATION	:	GROUND ELEVATION	: 273.565 m	TYPE OF CORE BARREL	:
RAIL LEVEL	:	AZIMUTH	:	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 12-04-2021	ANGLE WITH HORIZONTAL	:	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 14-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
273.565																								
273.065	0.50		Brown Colour, Very Fine Grained, stiff to Hard Consistency, Silt and Clay with low Compressibility														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 273.565 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
272.065	1.50													13	45		---	---					
270.565	3.00																---	---					
269.065	4.50													20	45		---	---					
267.565	6.00																---	---					
264.565	9.00													30	45		---	---					
261.565	12.00																---	---					
258.565	15.00													31	45		---	---					
255.565	18.00																	---					
252.565	21.00													33	45		---	---					
249.565	24.00																---	---					
246.565	27.00													48	45		---	---					
243.565	30.00																---	---					
240.565	33.00													68	45		---	---					
237.565	36.00																---	---					
234.565	39.00													81	45		---	---					
231.565	40.00																---	---					

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-26

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-26	CO-ORDINATES	X : 698526.193	LOCATION	: Patuka
CHAINAGE (m.)	: 26880		Y : 3123024.419	TOTAL DEPTH	: 35.00 m
COLLAR ELEVATION	:	GROUND ELEVATION	: 273.112 M	TYPE OF CORE BARREL	:
RAIL LEVEL	:	AZIMUTH	:	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 12-04-2021	ANGLE WITH HORIZONTAL	:	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 14-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
273.112																								
272.612	0.50		Brown Colour, Very Fine Grained,stiff to Hard Consistency, Silt and Clay with low Compressibility														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 273.565 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
271.612	1.50													11	45		---	---					
270.112	3.00																---	---					
268.612	4.50													19	45		---	---					
267.112	6.00																---	---					
264.112	9.00													28	45		---	---					
261.112	12.00																---	---					
258.112	15.00													34	45		---	---					
255.112	18.00																	---					
252.112	21.00													41	45		---	---					
249.112	24.00																---	---					
246.112	27.00													53	45		---	---					
243.112	30.00																---	---					
240.112	33.00													65	45		---	---					
237.112	35.00																---	---					

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-27

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH 27	CO-ORDINATES	X : 698026.203	LOCATION	: Patuka
CHAINAGE (m.)	: 28050		Y : 3123029.181	TOTAL DEPTH	: 30.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 272.210	TYPE OF CORE BARREL	: ---
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 14-04-2021	ANGLE WITH HORIZONTAL	: 90°	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 16-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
272.210																								
271.710	0.50		Brown Colour, Fine grained, Low Dense to Medium Densed Compactness, Silty Sand														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 272.210. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Sandy Clay is majorly tracked in the borehole.
270.710	1.50													14	45		---	---						
269.210	3.00																---	---						
267.710	4.50													24	45		---	---						
266.210	6.00																---	---						
263.210	9.00													27	45		---	---						
260.210	12.00																---	---						
257.210	15.00		Brown Colour, Very Fine to Fine Grained, Hard Consitency, Sand and Clay with Low Compressibilty											36	45		---	---						
254.210	18.00																---	---						
251.210	21.00													45	45		---	---						
248.210	24.00																---	---						
245.210	27.00		Brown Colour, Very Fine to Fine Grained, Hard Consitency, Sand and Clay with Low Compressibilty											54	45		---	---						
242.210	30.00																---	---						

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-28

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-28	CO-ORDINATES	X : 697726.217	LOCATION	: Patuka
CHAINAGE (m.)	: 27680		Y : 3123032.039	TOTAL DEPTH	: 45.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 272.799	TYPE OF CORE BARREL	: ---
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 04-04-2021	ANGLE WITH HORIZONTAL	: 90°	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 08-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
272.799																								
272.299	0.50		Brown Colour, Fine grained, Low Dense to Medium Densed Compactness, Silty Sand														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 272.799 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
271.299	1.50													12	45		---	---						
269.799	3.00																---	---						
268.299	4.50													21	45		---	---						
266.799	6.00																---	---						
263.799	9.00													28	45		---	---						
260.799	12.00																---	---						
257.799	15.00													38	45		---	---						
254.799	18.00																	---						
251.799	21.00		Brown Colour, Fine Grained, Hard Consitency, Sand and Clay with Low Compressibilty.											47	45		---	---						
248.799	24.00																---	---						
245.799	27.00													53	45		---	---						
242.799	30.00																---	---						
239.799	33.00		Brown Colour, Fine Grained, Hard Consitency, Sand and Clay with Low Compressibilty.											70	45		---	---						
236.799	36.00																---	---						
233.799	39.00													81	45		---	---						
230.799	42.00																---	---						
227.799	45.00													92	45		---	---						

Geotechnical Investigation Report			
Consultant:			*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**	**Haryana Rail Infrastructure Development Corporation Ltd**

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-29

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-29	CO-ORDINATES	X : 697526.227	LOCATION	: Patuka
CHAINAGE (m.)	: 28550		Y : 3123034.057	TOTAL DEPTH	: 30.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 269.964 m	TYPE OF CORE BARREL	: ---
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 17-04-2021	ANGLE WITH HORIZONTAL	: 90°	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 18-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
269.964																								
269.464	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 269.964 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
268.464	1.50													12	45		---	---					
266.964	3.00																---	---					
265.464	4.50													24	45		---	---					
263.964	6.00																---	---					
260.964	9.00													27	45		---	---					
257.964	12.00																---	---					
254.964	15.00													38	45		---	---					
251.964	18.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility															---					
248.964	21.00													47	45		---	---					
245.964	24.00																---	---					
242.964	27.00													61	45		---	---					
239.964	30.00																---	---					

Geotechnical Investigation Report		
Consultant:		*Client :*
S.M. CONSULTANTS BHUBANESWAR	**Job No:- 830**	**Report No:- SMC/2050**
		Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-30

S M CONSULTANTS AN ISO 9001 COMPANY BHUBANESHWAR

BORE HOLE NO	: BH-30	CO-ORDINATES	X : 697326.462	LOCATION	: Patuka
CHAINAGE (m.)	: 28750		Y : 3123043.286	TOTAL DEPTH	: 45.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 270.808 m	TYPE OF CORE BARREL	: ---
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 17-04-2021	ANGLE WITH HORIZONTAL	: 90°	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 19-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
270.808																								
270.308	0.50																---	---						**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 270.808 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
269.308	1.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.											17	45		---	---						
267.808	3.00																---	---						
266.308	4.50													22	45		---	---						
264.808	6.00																---	---						
261.808	9.00													30	45		---	---						
258.808	12.00																---	---						
255.808	15.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											38	45		---	---						
252.808	18.00																	---						
249.808	21.00													44	45		---	---		Absent	Partial		BROWN	
246.808	24.00																---	---						
243.808	27.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.											56	45		---	---						
240.808	30.00																---	---						
237.808	33.00													64	45		---	---						
234.808	36.00																---	---						
231.808	39.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											73	45		---	---						
228.808	42.00																---	---						
225.808	45.00													84	45		---	---						

Geotechnical Investigation Report			
Consultant:			*Client :*
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830	Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-31

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-31	CO-ORDINATES	X : 697028.617	LOCATION	: Patuka
CHAINAGE (m.)	: 29050		Y : 3123078.475	TOTAL DEPTH	: 20.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 267.159 m	TYPE OF CORE BARREL	: ---
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 19-04-2021	ANGLE WITH HORIZONTAL	: 90°	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 19-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
267.159																								
266.659	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 267.159 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
265.659	1.50													16	45		---	---						
264.159	3.00																---	---						
262.659	4.50													23	45		---	---						
261.159	6.00																---	---						
258.159	9.00													32	45		---	---						
255.159	12.00																---	---						
252.159	15.00													40	45		---	---						
249.159	18.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility															---						
247.159	20.00													51	45		---	---						

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-32

S M CONSULTANTS AN ISO 9001 COMPANY BHUBANESHWAR

BORE HOLE NO	: BH-32	CO-ORDINATES	X : 696542.399			LOCATION	: Patuka	
CHAINAGE (m.)	: 29550		Y : 3123193.287			TOTAL DEPTH	: 30.00 m	
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 266.684 m			TYPE OF CORE BARREL	: ---	
RAIL LEVEL	: ---	AZIMUTH	: ---			DEPTH OF WATER TABLE (m)	: Absent	
START DATE	: 19-04-2021	ANGLE WITH HORIZONTAL	: 90°			DRILLING AGENCY	: S.M. Consultants	
ENDING DATE	: 20-04-2021					NAME OF GEOLOGIST	: Gaurav Chunekar	

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
266.684																								
266.184	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---		Absent	Partial		BROWN	**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 266.684 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
265.184	1.50													17	45		---	---					
263.684	3.00																---	---					
262.184	4.50													27	45		---	---					
260.684	6.00																---	---					
257.684	9.00													35	45		---	---					
254.684	12.00																---	---					
251.684	15.00													44	45		---	---					
248.684	18.00																---	---					
246.684	21.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											54	45		---	---					
243.684	24.00																---	---					
240.684	27.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											63	45		---	---					
238.684	30.00																---	---					

Geotechnical Investigation Report			
Consultant:			*Client :*
S.M. CONSULTANTS BHUBANESWAR	Job No:- 830	Report No:- SMC/2050	Haryana Rail Infrastructure Development Corporation Ltd

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

Geological Log of Drill Hole BH-33

S M CONSULTANTS
AN ISO 9001 COMPANY
BHUBANESHWAR

BORE HOLE NO	: BH-33	CO-ORDINATES	X : 696072.339	LOCATION	: Patuka
CHAINAGE (m.)	: 30125		Y : 3123363.526	TOTAL DEPTH	: 20.00 m
COLLAR ELEVATION	: ---	GROUND ELEVATION	: 265.581 m	TYPE OF CORE BARREL	: ---
RAIL LEVEL	: ---	AZIMUTH	: ---	DEPTH OF WATER TABLE (m)	: Absent
START DATE	: 20-04-2021	ANGLE WITH HORIZONTAL	: 90°	DRILLING AGENCY	: S.M. Consultants
ENDING DATE	: 21-04-2021			NAME OF GEOLOGIST	: Gaurav Chunekar

Elevation (m)	Depth (m)	Litho-Log	Lithological Description	Size of Core Pieces					% of Core-Recovery					Standard Penetration Test		Type of BIT	RQD %	Fracture Freq. / m	Casing	Depth of water level	Water Loss		Colour of Returned Water	REMARK / OBSERVATIONS
				<10mm	10-25mm	25-75mm	75-150mm	>150mm	20	40	60	80	100	N Value	Depth of Penetration in cm						Partial	Complete		
265.581																								
265.081	0.50		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility.														---	---						**General Description:** This Borehole is Located on the upland part of the Alignment on a ground elevation of 265.581 m. The stratigraphy of area is prominently of Silty Sand which comes under Alluvial Type of Category. Silty Sand and Clay is majorly tracked in the borehole.
264.081	1.50													18	45		---	---						
262.581	3.00																---	---						
261.081	4.50													28	45		---	---						
259.581	6.00																---	---						
256.581	9.00													39	45		---	---		Absent	Partial		BROWN	
253.581	12.00																---	---						
250.581	15.00		Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility											50	45		---	---						
247.581	18.00																	---						
245.581	20.00													63	45		---	---						

ANNEXURE L

CORE SAMPLES

Borehole 13 (Ch no. 25000)

BH 13. Box 1 (Depth 0m-15.0m).

BH 13. Box 2 (Depth 15.0m-28.50m)

BH13. Box 3. (Depth 28.5m-43.5m)

BH13. Box 4. (Depth 43.5m- 60.0m)

Borehole 14 (Ch no. 25195)

BH 14. Box 1. (Depth 0m-10.5m)

BH 14. Box2. (Depth 10.5m-27.5m)

BH 14. Box 3. (Depth 27.5m-43.5m)

BH 14. Box 4. (Depth 43.5m-63.0m)

Borehole 15 (Ch no. 25380)

BH 15. Box 1. (Depth 0m- 16.5m)

BH 15. Box 2. (Depth 16.5m -33.0m)

BH 15. Box 3. (Depth 33.0m- 48.0m)

BH 15. Box 4. (Depth 48m-66m)

BH 15. Box 5. (Depth 66.0m-70.0m)

Borehole 15(A) (Ch no. 25488)

BH 15(A) Box 1. (Depth 0-13.5m)

BH 15(A) Box 2. (Depth 13.5m-27.0m)

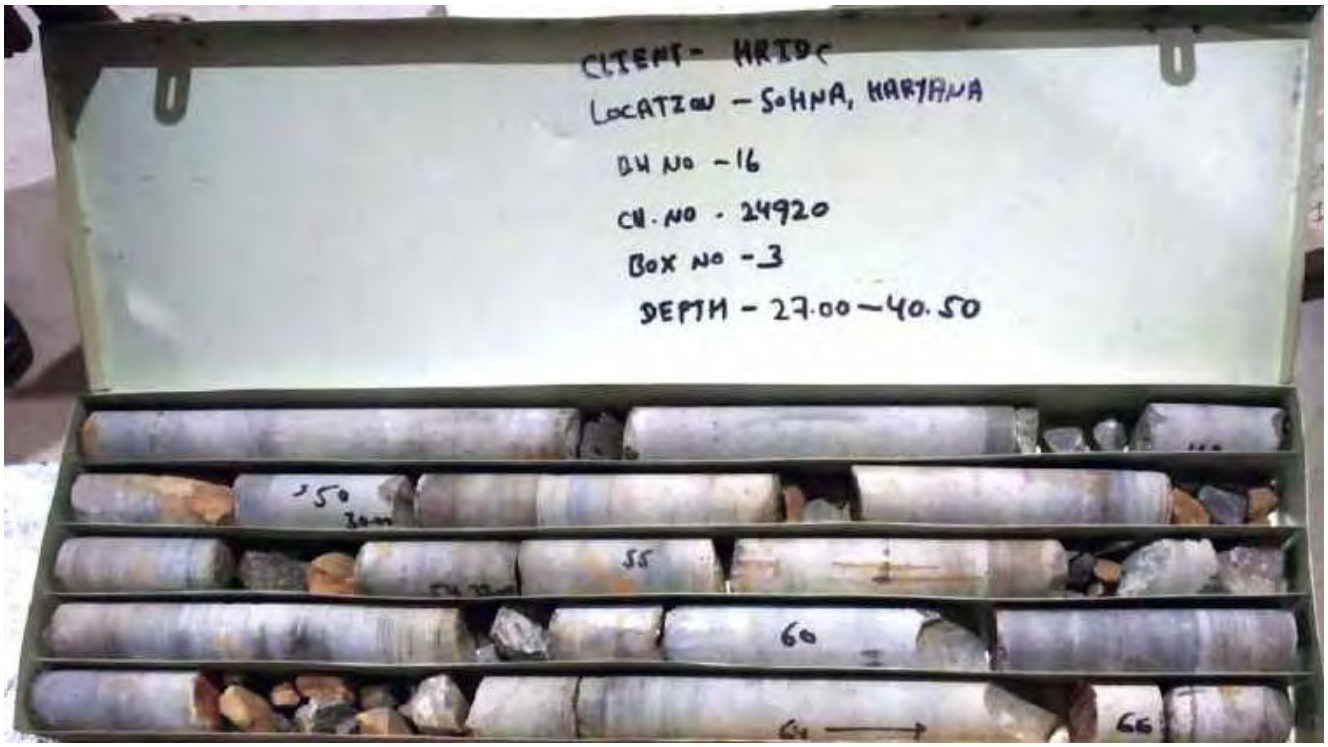
Bh 15(A) Box 3. (Depth 27.0m-40.5m)

BH 15(A) Box 4. (Depth 40.5m-50.0m)

Borehole 16. (Ch no. 25586)

BH 16. Box 1. (Depth 0 m- 15.0m)

BH 16. Box 2. (Depth 15.0m-27.0m)



BH 16. Box 3. (Depth 27.0m- 40.5m)

BH 16. Box 4. (Depth 40.5m -51.0m)

Bh 16. Box 5. (Depth 51.0m- 62.0

Borehole 17. (Ch no. 25785)

BH 17 Box 1. (Depth 0.00m -27.50m)

BH 17 Box 2. (Depth 27.50m -39.50m)

BH 17 Box 3. (Depth 39.50m -51.50m)

BH 17 Box 4. (Depth 51.50m -62.00m)

ii. Geological Interpretive Report No. SMC/2050

GEOLOGICAL INTERPRETIVE REPORT

EXPLORING ALTERNATE ALIGNMENTS, FINAL LOCATION SURVEY, GEOLOGICAL MAPPING, GEO-TECHNICAL INVESTIGATION, DETAIL DESIGN OF TUNNEL & ITS APPROACHES INCLUDING VIADUCT IF ANY AND OTHER ANCILLARY WORK IN SOHNA-MANESAR SECTION OF HRDC PROJECT.

Client:

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

Prepared By:

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010, ODISHA

GEOLOGICAL INTERPRETIVE REPORT

Prepared & Submitted By	
M/s. S. M. Consultants	
GEOTECHNICAL ENGINEER	Shreeesto
GEOLOGIST	Dr Dipanjan Bhattacharjee Assistant Professor Department of Geology Indira Gandhi National Tribal Univ.
SENIOR CONSULTANT	Senior Consultant (A central university established by an act of Parliament) Amarkantak, Madhya Pradesh-484887

For S.M. Consultants

General Consultant	
PD/GC	
DPD/GC/CIVIL	

Client		
CPM/HRIDCL		
DGM/CIVIL/S/ HRIDCL		
EXE/CIVIL/ HRIDCL		

Client:

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LIMITED.

Consultant:

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010

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List of Figures:

1 Introduction:

1.1 Scope of the Geological Interpretative Report

This GIR presents the status of knowledge regarding the geological, structural and hydrogeological conditions along the alignment. In order to optimize the design, a geological assessment was done as part of the work. The assessment included field and laboratory work. This report summarizes subsurface and site conditions that are expected to be encountered during the tunnelling works. The subsurface and site conditions are derived from geotechnical information and data gathered from field.

1.2 Reference of Published Literature

[1] Bieniawski, Z. T. (1989). Engineering rock mass classifications: a complete manual for engineers and geologists in mining, civil, and petroleum engineering. John Wiley & Sons.

[2] Heron, A. M. (1953). The geology of central Rajputana. Mem. Geol. Soc. Ind., 79.

[3] Karol, R. H. (1960). Soils and soil engineering.

[4] Naha, K., Mukhopadhyay, D. K., Mohanty, R., Mitra, S. K., & Biswal, T. K. (1984). Significance of contrast in the early stages of the structural history of the Delhi and the pre-Delhi rock groups in the Proterozoic of Rajasthan, western India. Tectonophysics, 105(1-4), 193-206.

[5] Naha, K., & Mohanty, S. (1988). Response of basement and cover rocks to multiple deformations: a study from the Precambrian of Rajasthan, western India. Precambrian research, 42(1-2), 77-96.

[6] Roy, A. B., & Das, A. R. (1985). A study on the time relations between movements, metamorphism and Granite emplacement in the Middle Proterozoic Delhi Supergroup rocks of Rajasthan. Journal of Geological Society of India (Online archive from Vol 1 to Vol 78), 26(10), 726-733.

[7] Wei, B. Z., Pezeshk, S., Chang, T. S., Hall, K. H., & Liu, H. P. (1996). An empirical method to estimate shear wave velocity of soils in the New Madrid seismic zone. Soil Dynamics and Earthquake Engineering, 15(6), 399-408.

1.3 Indian Standard codes

[1] IS 1893 (part-1): 2016, Criteria for earthquake resistance design of structure.
[2] IS: 2720(part-1)-1983 (Reaffirmed 2015): Preparation of soil sample
[3] IS: 2720(part-2)-1973 (Reaffirmed 2015): Moisture Content
[4] IS: 2720(part-3) (sec-1)-1980 (Reaffirmed 2016): Specific Gravity
[5] IS: 2720(part-4)-1985 (Reaffirmed 2015): Grain Size Analysis
[6] IS: 2720(part-5)-1985 (Reaffirmed 2015): Atterberg's Limits
[7] IS: 2720(part-11)-1993 (Reaffirmed 2016): Triaxial Shear Strength
[8] IS: 2720(part-13)-1986 (Reaffirmed 2016): Direct Shear Strength
[9] IS: 2720(part-15)-1986 (Reaffirmed 2016): Consolidation Test

2 Geological Overview:

2.1 Introduction:

The area in the report lies within the district of Gurgaon of Haryana. The concerned region is a part of the survey of India toposheet No. 53H/04 and spanned between longitude 77°58′36″& 77°06′00″and latitude 28°14′0″ & 28°10′30″ (Figure 2.1). The area is 20km away from Gurgaon. The important towns in the area are Sohna, Gurgaon, Palwal. These towns are connected with important cities of the state and Delhi by metaled roads.

Figure 2.1: District Map of Haryana.

Delhi Bombay National Highway (NH-6) passes through Gurgaon State Highway No 43 passes through Sohna. Gurgaon is a railway station on the Delhi Rewari section of the meter gauge line of the Northern Railway whereas Faridabad and Palwal are on Delhi Bombay broad gauge line. Most of the villages in the area are connected by all-weather metaled roads. The area has a semi-arid type of climate. Summer is extremely hot with the temperature up to 47°C. The winters are quite cold. The minimum temperature recorded in Gurgaon during

1968-70 was 2.0°C. The related humidity is maximum in August (above 80%) and minimum in June (above 35%). In the month of November, the wind velocity in the morning remains about2.5km/hr. whereas in June it is generally 8 km/hr. The general wind direction is westerly. The summer monsoon starts at the end of June or early July and lasts up to September. Rainfall is generally restricted to this monsoon, though winter months also get some scanty rains.

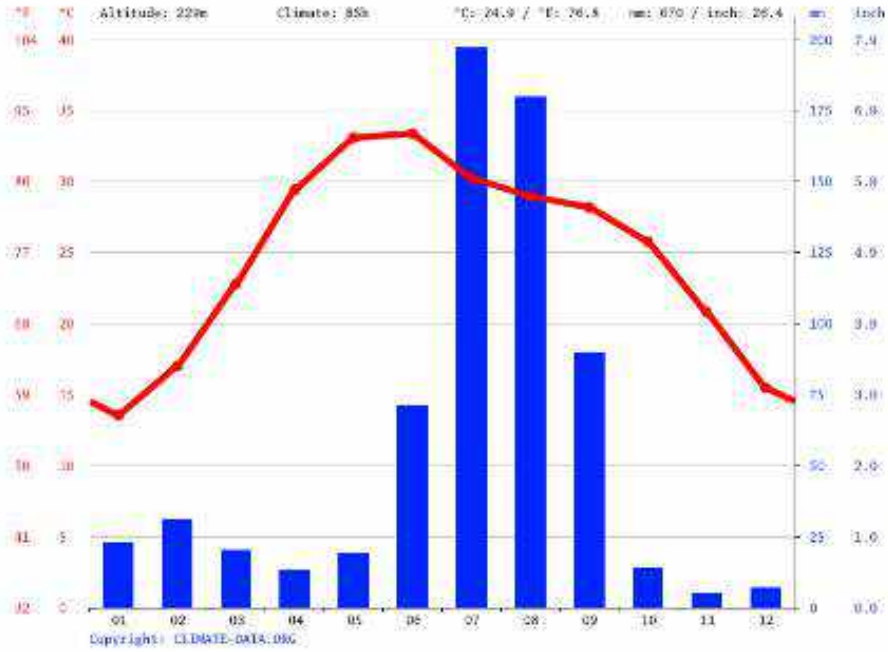


Figure 2.2: Graph showing month wise rainy days for Gurgaon district. (Climate-data.org).

The average annual rainfall is about 600 mm. The climatic condition of the area is much varied characterized by hot and moist sub-humid climate. It has mainly 4 seasons. The summer season is from March to Mid-June, the period from Mid-June to September is the Rainy season, October and November constitute the post-monsoon season, and winter is from December to February as shown inFigure 2.2. The best time to visit this district is during winter. Ministry of housing and urban affair, Government of India has done vulnerability mapping for Haryana state which includes multiple hazard zonation maps. The results are given below inFigure 2.3.

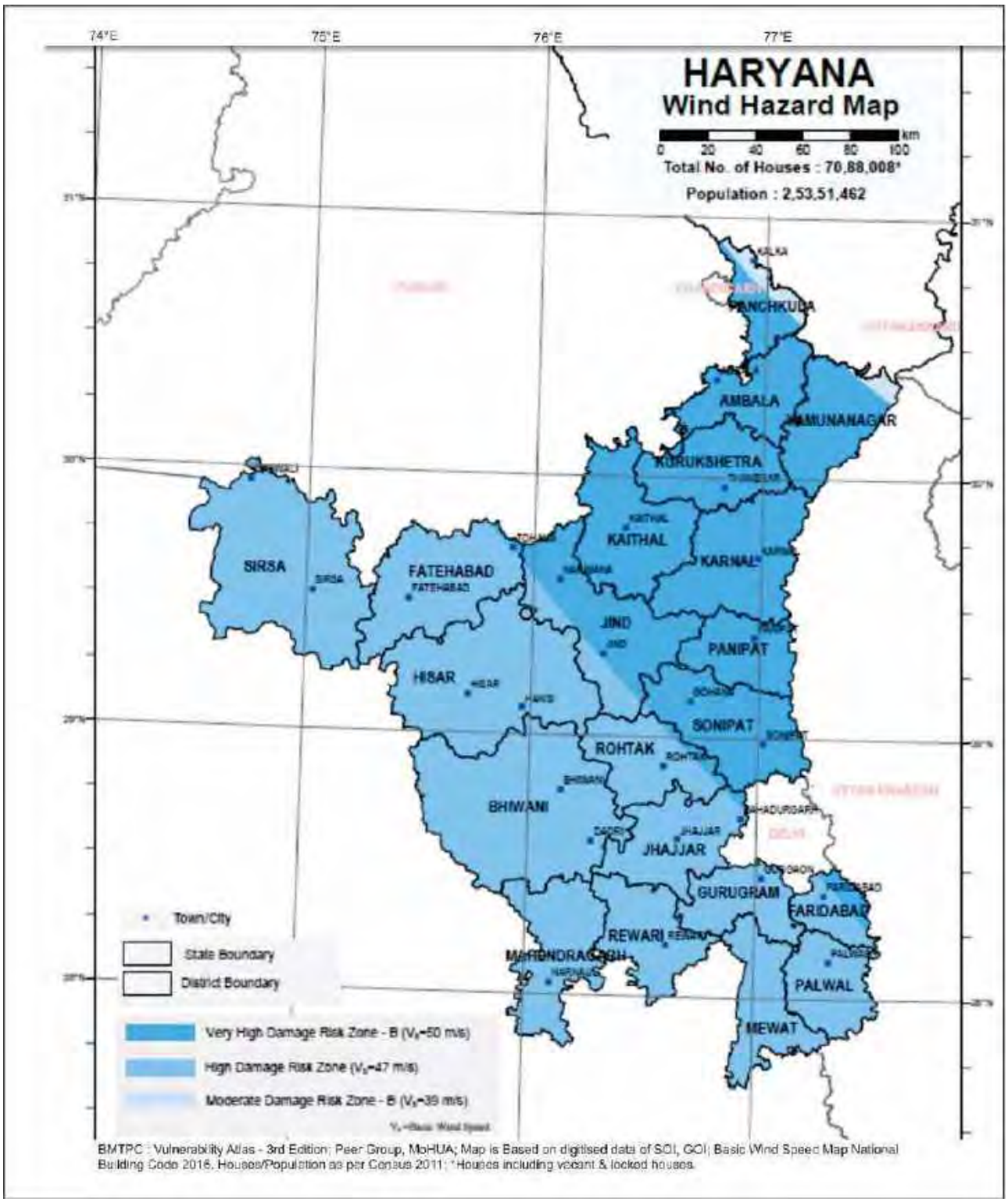


Figure 2.3: Wind Hazard map of Haryana (adopted from BMTPC.

Name of the Project: Exploring alternate alignments, final location survey, geological mapping, geotechnical investigation, detailed design of tunnel & its approaches including Viaduct if any, and other ancillary work in Sohna-Manesar Section of HORC project.

2.2 Seismicity

According to National Center for Seismology the state of Haryana comprises three earthquake zone. The western part comes under zone II, the central part zone III and the eastern- south-eastern part in zone IV. The region around the site of construction comes under the zone IV of earthquake. Being within the earthquake zone IV the area of interest is at high risk with reference to the seismic activity. This region is liable to MSK VIII on Medvedev–Sponheuer–Karnik Scale, a macro seismic intensity scale or lower, and is classified as the High Damage Risk Zone. Map below shows the seismic zones of Haryana State (Figure 2.4).

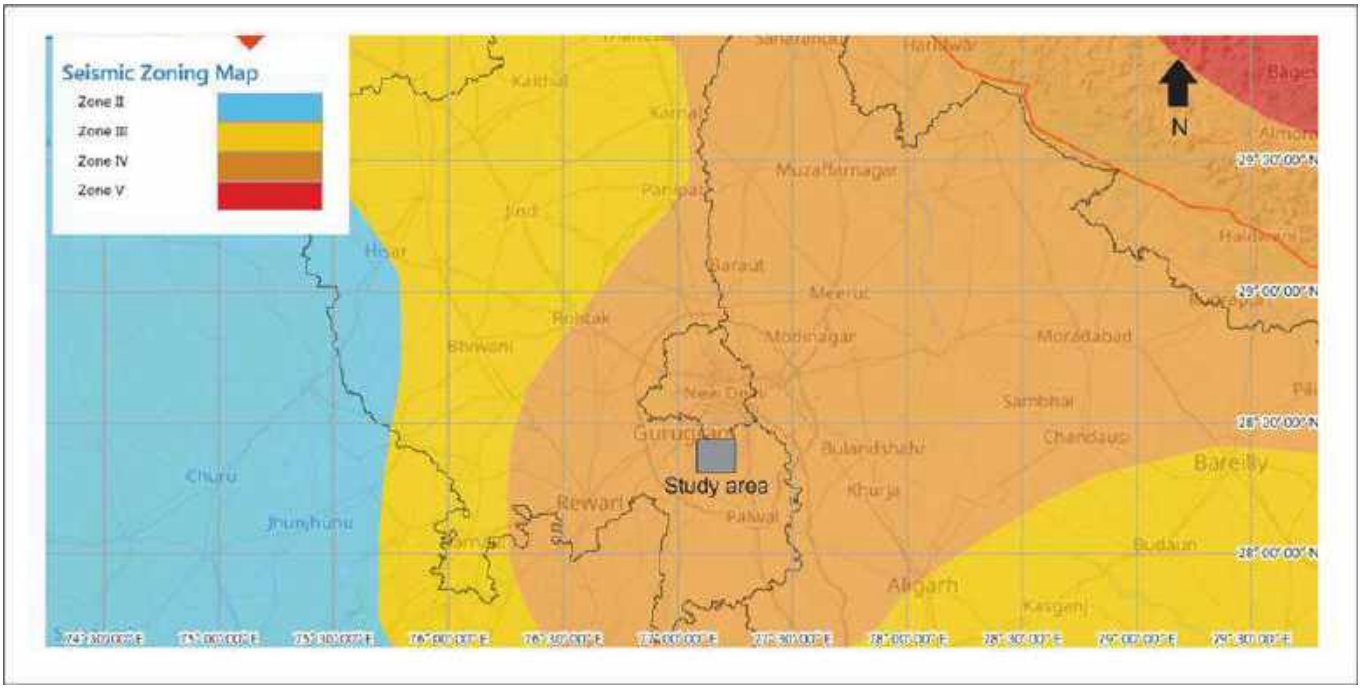


Figure 2.4: Seismic map of state Haryana (adopted from National Centre for seismology).

2.3 Regional Geology:

The rocks exposed in the area consist of Mesoproterozoic rocks of the North Delhi Fold belt which occur as long, linear, discontinuous chain of hills. The overall Delhi fold belt shows a NE-SW trend and extends from Gujrat (Deri- Ambaji) in the south to Delhi in the north. In the north and south the belt is overlain by Indo-Gangatic alluvium with sparse outcrop jutting out from the plain. Towards west it shows an unconformable contact with Marwar craton along a Phulad lineament and in the east the belt shows a faulted contact with Banded Gneissic Complex of pre-Delhi origin along Kaliguman lineament. The North Delhi Fold Belt has been divided into two groups by Heron (1935): the lower arenaceous Alwar Group and the upper argillaceous Use the "Insert Citation" button to add citations to this document.

Ajabgarh Group. The Alwar Group comprises arkosic schists, phyllites, quartzites and meta- conglomerates whereas, the Ajabgarh Group comprises calc-schists, biotite schists, calc-silicates and marbles.

The regional structure of Delhi fold belt is considered as a broad synclinorium having N to NNE trend (Heron 1953) with core occupied by Delhi group, within the broad synclinorium four generations of deformation (D1 – D4) (Figure 2.5) are seen in Delhi fold belt (Naha and Mohanty 1988). D1 and D2 are ubiquitous in all scales while D3 and D4 are seen only in some sectors. D1 folds are tight to isoclinal with a pervasive axial planar cleavage (S1). There are multiple occurrences of boudinage in D1 fold, which are parallel to axial planer cleavage (Naha et al.,1984). D2 folds ranges from open to isoclinal with vertical axial plane striking NNE -SSW to NE-SW. A crenulation cleavage (S2) is developed parallel to axial planes of the fold. D2 fold is coaxial with DF1 fold. Due to D2 various superposed folds have been developed in DFB, most common is Ramsay Type III fold (non-planar cylindrical) (Roy and Das 1985). DF3 folds are kink folds with sub horizontal axial planes. It has affected S1 and S2 cleavages and axial surfaces of DF1 and DF2 folds. At some places DF3 has conjugate axial plane striking NE-SW and SE-NW. It is formed by vertical compression (Naha and Mohanty 1988). Due to interference from D3 fold there is development of Ramsay Type II fold (non-planer non-cylindrical fold) in the DF1 and Ramsay Type-I fold (planer non-cylindrical fold) in DF2 (Roy and Das 1985).DF4 fold are

upright chevron fold, having NW-SE striking axial plane. They are formed by horizontal compression in an NE-SW direction (Naha and Mohanty 1988).

The different phases of deformation have led to metamorphism ranging from greenschist to amphibolite facies.

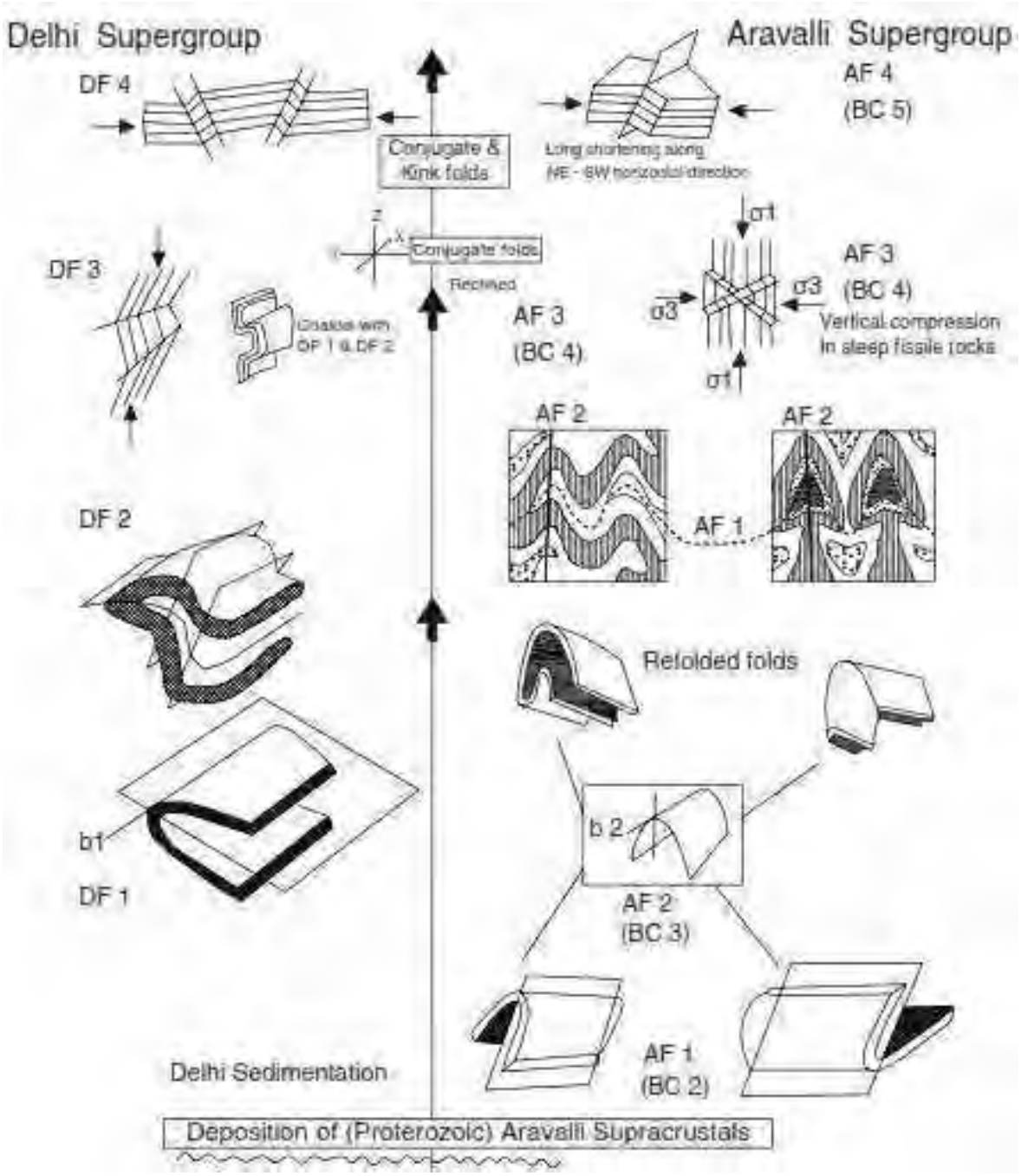


Figure 2.5: Regional structure of Delhi fold belt (Naha and Mohanty 1988).

3 PROJECT GEOLOGY

3.1 Local Site Geology:

The region around the site consists of metamorphosed arenaceous rocks of the Alwar group. The Lithology is dominated by Quartzites with some intercalations of phyllites near the southern portal.

The Quartzites are metasedimentary rocks that comprise greater than 80% quartz along with feldspar and mica minerals, the mineral grains show an equigranular interlocking texture.

The phyllites are low-grade metamorphic rocks, they have a marked fissility (a tendency to split into sheets or slabs) due to the parallel alignment of platy minerals; they have a sheen on their surfaces due to tiny plates of micas.

The quartzites near to surface showed high weathering and were highly friable and non-cohesive while as we move deeper (> 15 m) the quartzite becomes more resistive and less weathered. Quartz is a tectosilicate mineral that ranks 7 on the Mohr hardness scale, since it crystallizes later according to the Bowen reaction series it is also resistive to weathering. Feldspar on the other hand ranks 6 on the Mohr hardness scale and crystallizes earlier thus is prone to weathering.

In the southern part intercalation of phyllites/schist along with quartzite are observed.

3.2 Structural Study:

The compositional changes in quartzite beds defines the bedding in the area and the regional trend of bedding plane is NE-SW with a steep dip towards SE.

A superposed fold was observed at 28°12′33.57″, 77°02′57.08″. DF2 and DF3 deformation phases of Delhi group was observed in the area. DF1 is the prominent fold pattern which was super posed with DF2 folding phase. Signatures of later brittle shearing, possibly related to DF4 phase, was also observed near the proposed portal face. The fold showed Ramsay's Type III folding pattern i.e., nonplanar cylindrical (Figure 3.1). The fold

hinge showed a plunge of 20° towards 220. The Type III fold pattern in the rest of the Delhi system of rocks are result of superposition of DF2 over DF3 deformation. The portal face lies perpendicular to the axial plane of the fold. The earlier generation of fold is isoclinal in nature where both the limbs dip towards south.

Near the fold area some quartz tension gashes were observed. Gash veins open up when rock gets stretched due to shearing and the tension fractures forms oblique to the shear zone which is later filled with mineral precipitate. In the present area the gash veins indicate a dextral shearing.

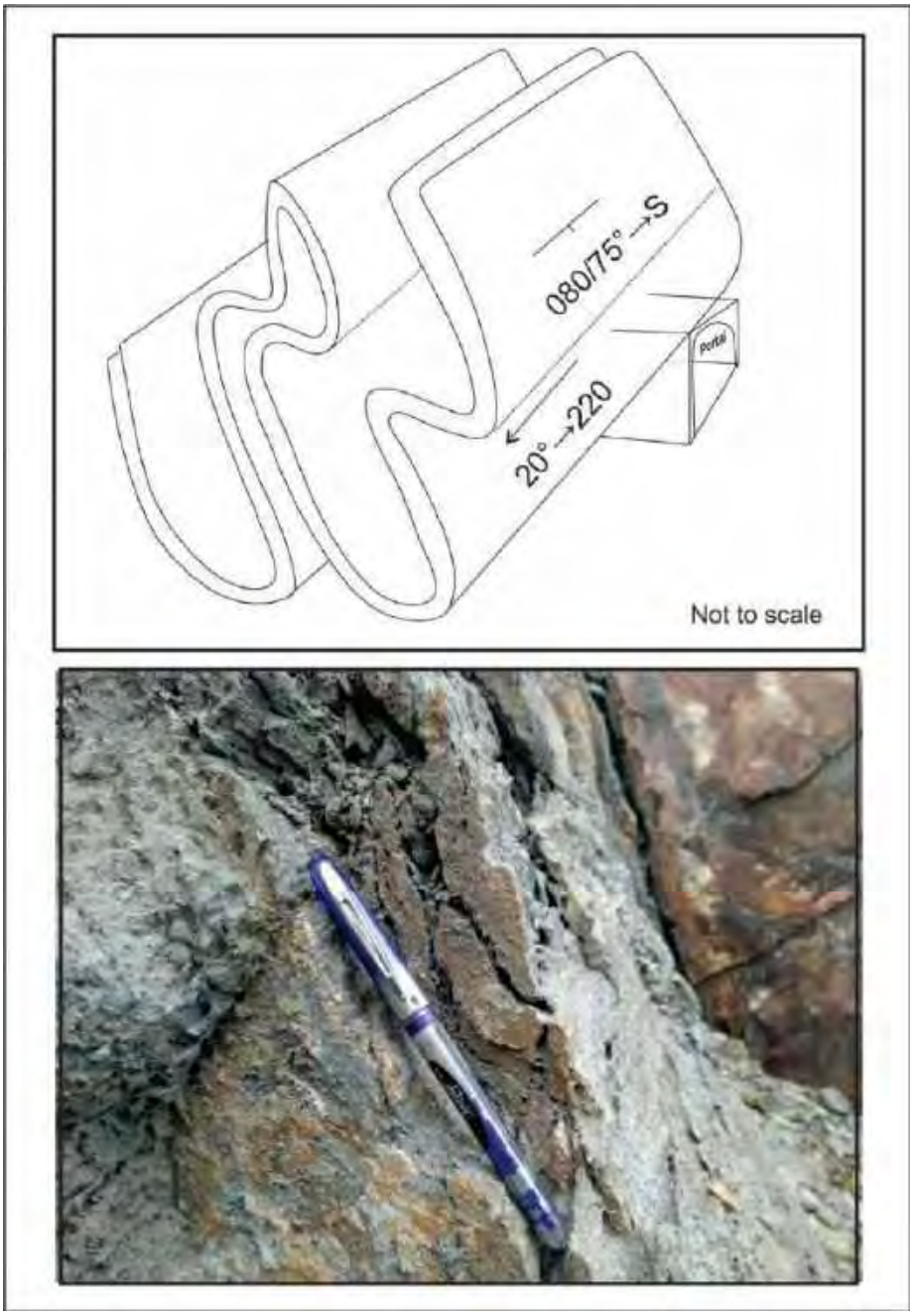


Figure 3.1: Superposed fold observed at 28 12' 33.57'', 77 02'57.08''

At location 28° 12' 20.93'', 77° 02' 40.50'' another evidence of brittle-ductile shear zone was observed within the quartzite outcrop (Figure 3.2). Prominent en-echelon fractures were observed within the outcrop which were rotated to form a sigmoidal structure, the fractures were not filled with mineral precipitate. The shear plane was dipping towards NE with a normal slip where the eastern block was showing a downthrown movement and the

western block an upthrown movement. The last phase, in the mode of brittle shearing, led to the DF4 deformation. The joints are also encountered persistently at places around the site (Figure 3.4, Figure 3.5).

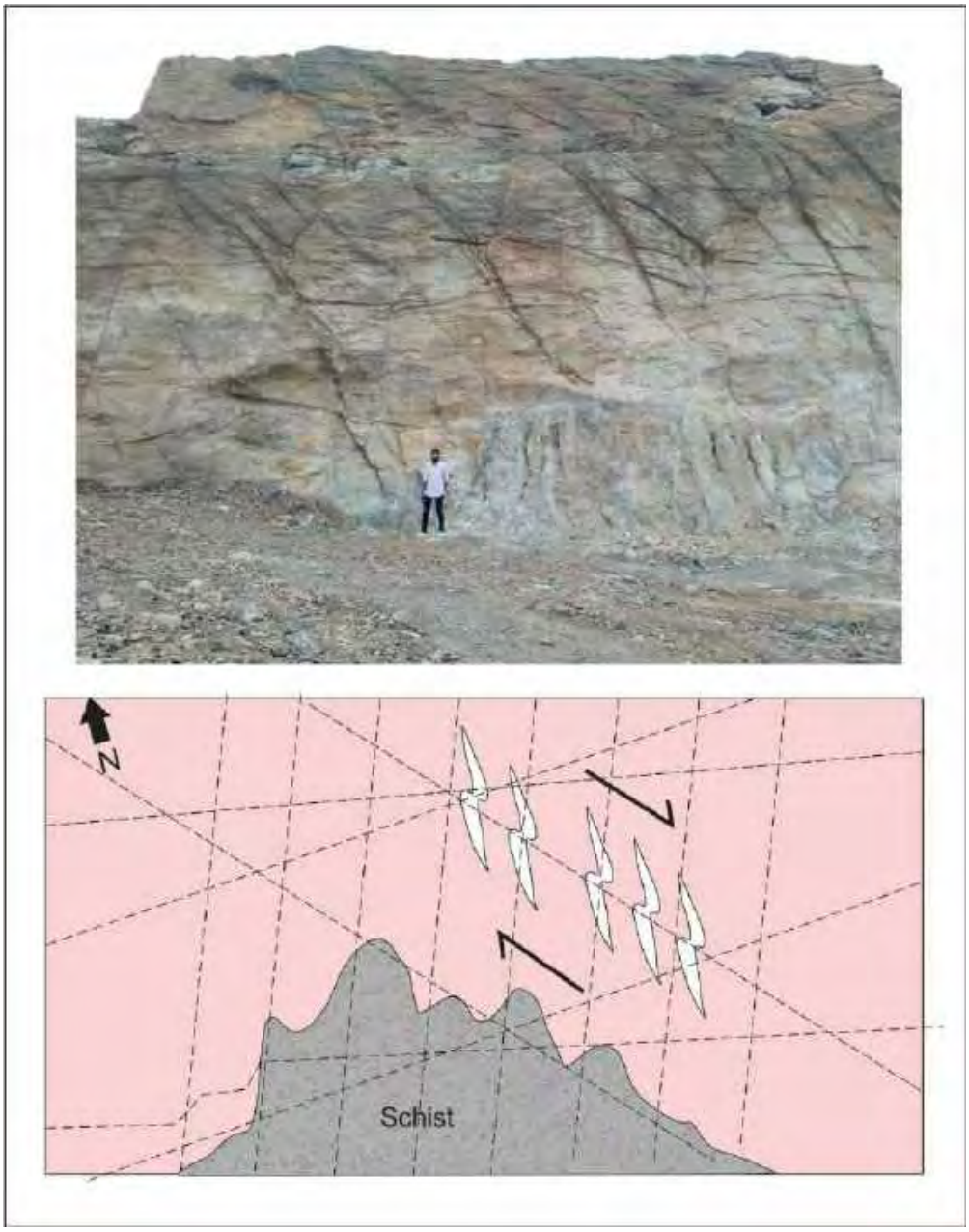


Figure 3.2: Shear zone observed at location 28 12' 20.93'', 77 02' 40.

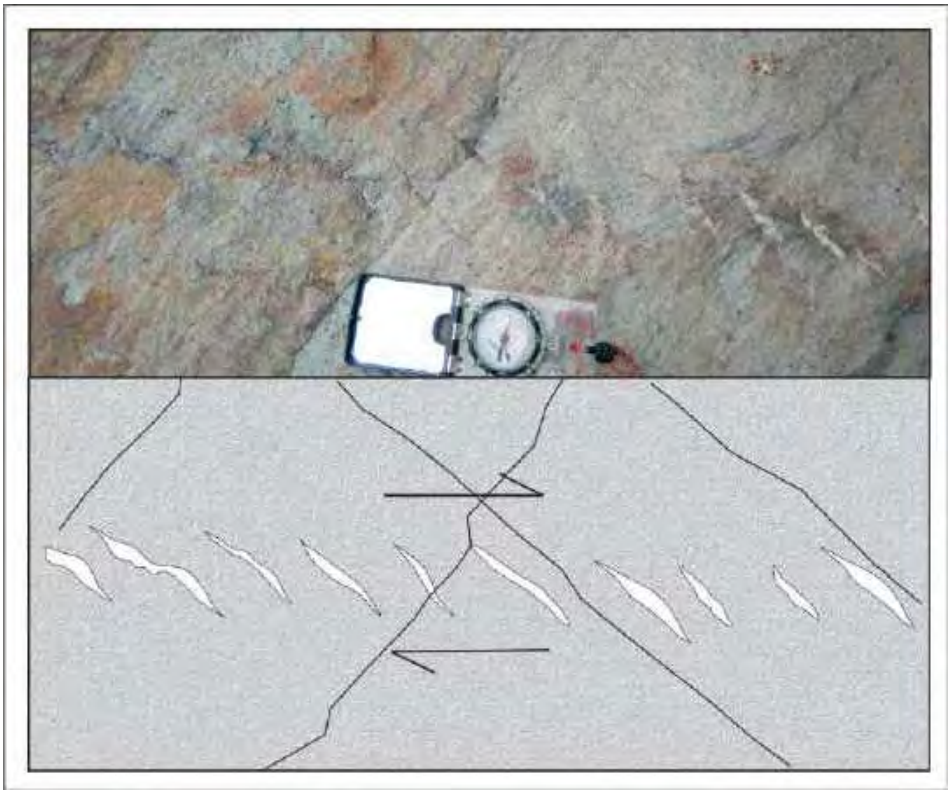


Figure 3.3: Gash veins showing a dextral slip.

Figure 3.4: Multiple joint sets observed throughout the area.

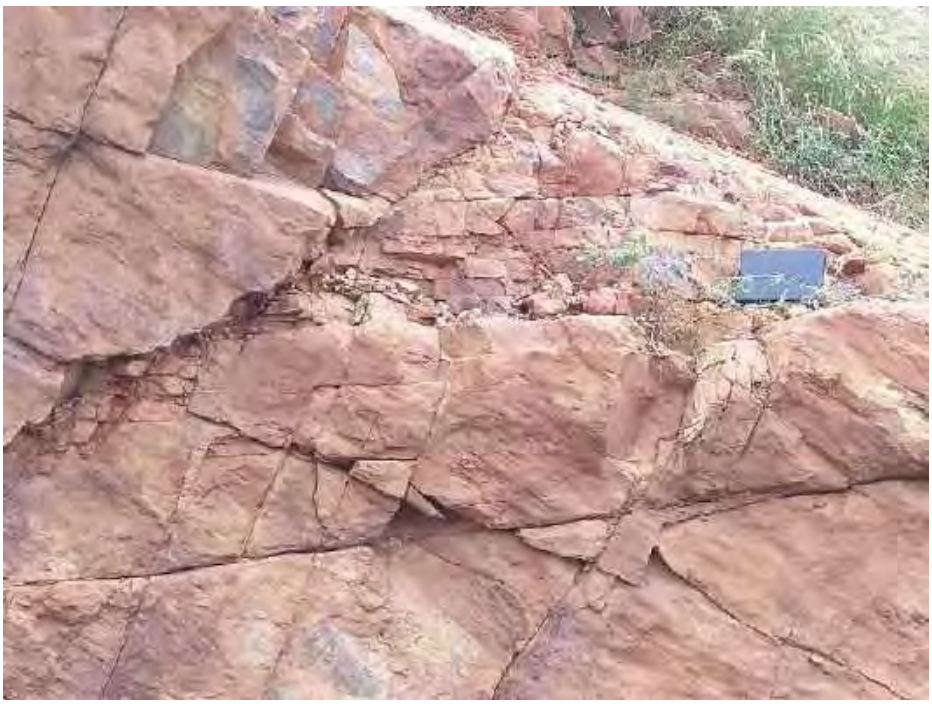


Figure 3.5: Multiple joint sets were observed throughout the area.

Orientation of the joints measured in field (Table 3.1) has been plotted on stereonet and contouring was done following Schimidt's 1% area rule (Figure 3.6) .The diagram shows 6 distinct cluster of the poles to the joint planes, hence we designate the sets as J1, J2, J3, J4, J5, and J6 (Table 3.2).

Table 3.1: Orientation of the joints at places around the site.

S. NO	Strike	Dip	Dip Direction
1.	034	11	NW
2.	028	13	NW
3.	029	13	NW
4.	027	15	NW
5.	027	15	NW
6.	026	16	NW
7.	029	18	NW
8.	033	18	NW
9.	028	19	NW
10.	032	19	NW
11.	042	21	NW
12.	040	22	NW
13.	036	23	NW
14.	041	24	NW
15.	037	25	NW

S. NO	Strike	Dip	Dip Direction
16.	036	26	NW
17.	043	27	NW
18.	040	28	NW
19.	037	30	NW
20.	038	30	NW
21.	178	31	W
22.	172	32	W
23.	175	32	W
24.	170	34	W
25.	174	34	W
26.	172	36	W
27.	178	37	W
28.	172	38	W
29.	178	38	W
30.	178	39	W
31.	003	40	W
32.	006	40	W
33.	004	41	W
34.	005	43	W
35.	008	43	W
36.	119	45	NE
37.	008	46	W
38.	009	46	W
39.	119	46	NE
40.	008	47	W
41.	002	49	W
42.	116	49	NE
43.	007	50	W
44.	110	50	NE
45.	110	51	NE
46.	111	51	NE
47.	114	51	NE
48.	117	51	NE
49.	115	52	NE
50.	119	52	NE
51.	122	57	NE
52.	126	59	NE
53.	127	60	NE
54.	130	60	NE
55.	121	62	NE
56.	129	62	NE

S. NO	Strike	Dip	Dip Direction
57.	122	63	NE
58.	128	63	NE
59.	124	64	NE
60.	126	65	NE
61.	117	70	NE
62.	117	70	NE
63.	029	71	SE
64.	032	71	SE
65.	026	72	SE
66.	111	72	NE
67.	028	73	SE
68.	030	73	SE
69.	035	73	SE
70.	116	73	NE
71.	119	74	NE
72.	117	75	NE
73.	178	76	E
74.	030	76	SE
75.	170	77	E
76.	174	77	E
77.	030	77	SE
78.	110	77	NE
79.	113	77	NE
80.	171	79	E
81.	178	79	E
82.	179	79	E
83.	027	79	SE
84.	032	79	SE
85.	174	80	E
86.	176	80	E
87.	114	80	NE
88.	116	80	NE
89.	040	81	SE
90.	042	81	SE
91.	122	81	NE
92.	171	82	E
93.	175	82	E
94.	045	82	SE
95.	126	82	NE
96.	039	83	SE
97.	122	83	NE

S. NO	Strike	Dip	Dip Direction
98.	125	83	NE
99.	125	83	NE
100.	005	84	E
101.	038	84	SE
102.	001	85	E
103.	008	85	E
104.	129	85	NE
105.	124	86	NE
106.	127	86	NE
107.	002	87	E
108.	006	87	E
109.	037	87	SE
110.	042	87	SE
111.	127	87	NE
112.	009	88	E
113.	002	89	E
114.	043	89	SE
115.	130	89	NE
116.	001	90	E
117.	036	90	SE
118.	040	90	SE
119.	006	91	E
120.	007	93	E
121.	045	82	SE
122.	126	82	NE
123.	039	83	SE
124.	122	83	NE
125.	130	89	NW

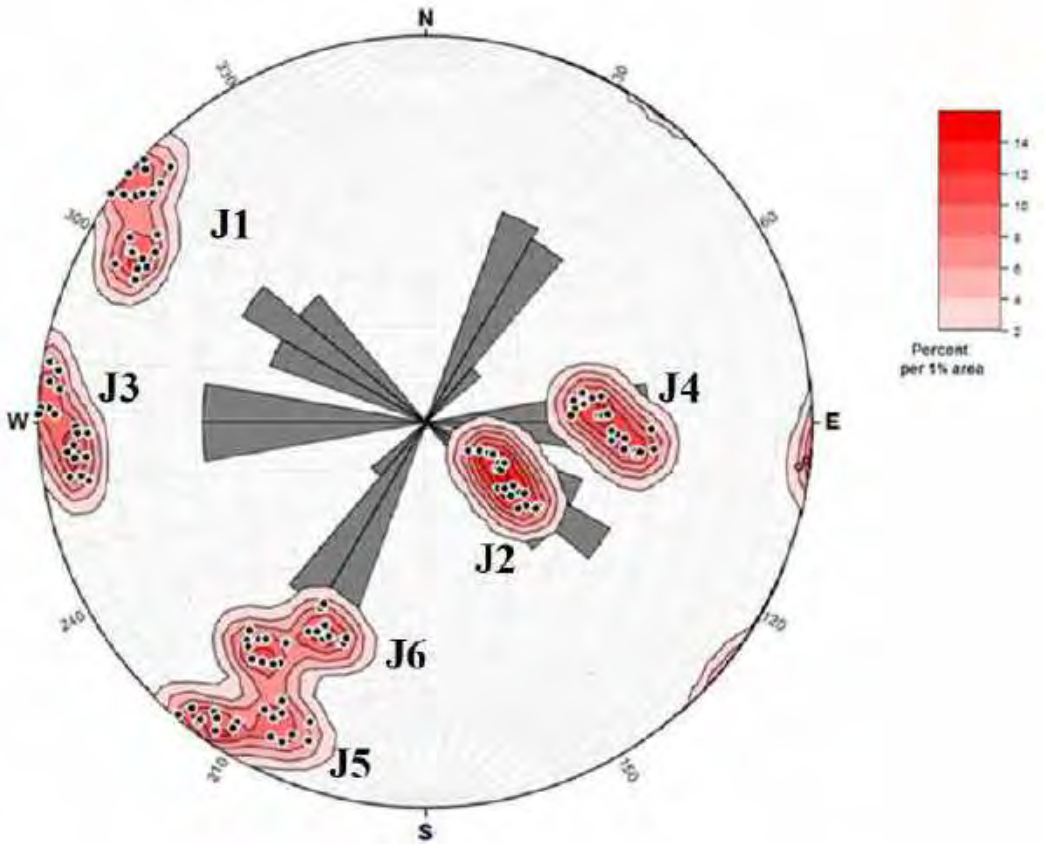


Figure 3.6: Rose and contour diagram of the orientation of the 6 sets of joints (no. of samples N=125)

Table 3.2: Details of joint sets.

Joint Set	Average Strike	Average True Dip amount	Average True Dip direction
J1	035	80	SE
J2	035	20	NW
J3	000	84	E
J4	000	40	W
J5	300	55	NE
J6	300	80	NE

A detailed geological map in a scale 1:25000 (Figure 3.7) and in 1:2000 scale (Figure 3.8) showing all structural elements which includes faults, thrusts, shear zones, folds, joints, lithological boundaries along with finalized tunnel alignment, L-Section (Figure 3.9) along the hilly terrain (1:25000 H and 1:2500 V), Graphical representation of the distribution of RQD, Core Recovery, SPT N Values and Soil types along each boreholes intersecting the tunnel (Figure 3.10), magnified parts of the L section showing chainage wise variation in RMR and RQD values in rock portion and C and phi values in soil portion (Figure 3.11 to Figure 3.15) a detailed cross section of the portal face on the mountain front (Figure 3.16),cross-section of the exit end of the NATM structure in soil (Figure 3.17), and the cross section of the portal 2 in the cut and cover region (Figure 3.18) are given below;

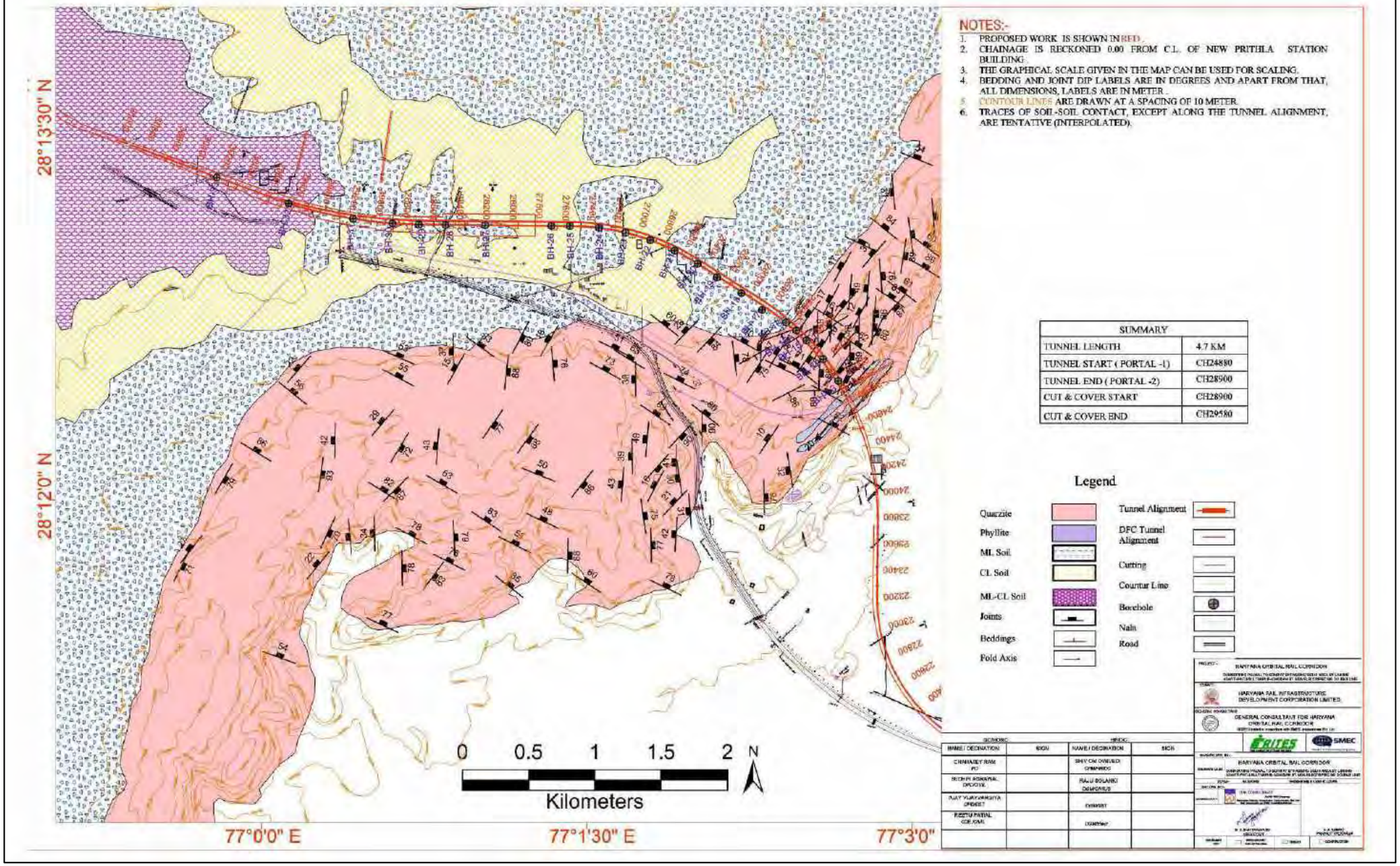


Figure 3.7: Geological map of the area at 1:25000 scale.

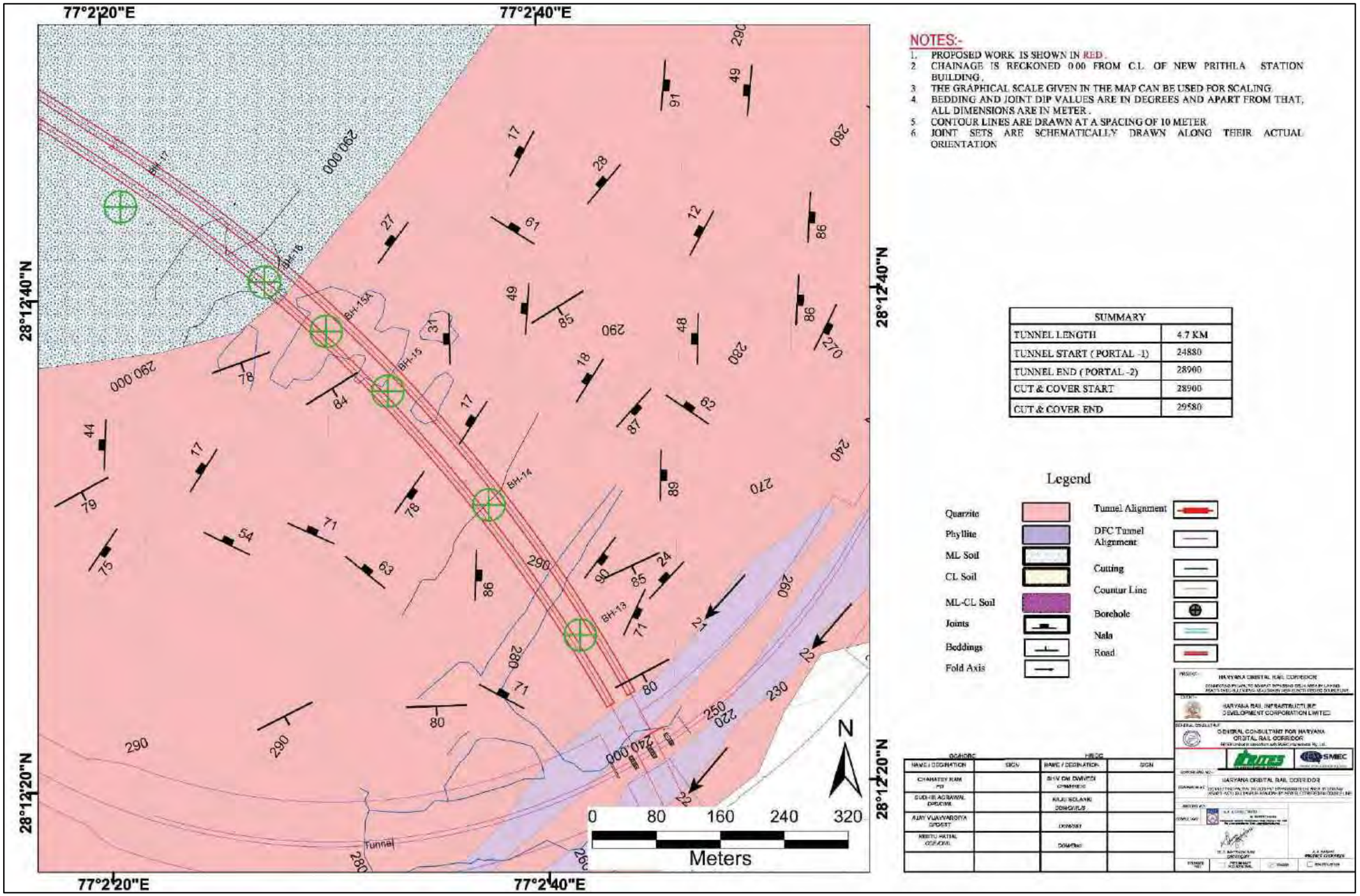


Figure 3.8: Detailed structural map of the major rocky area at 1:2000 scale. Joint sets are schematically drawn with their actual orientation. Average spacing between the joints are as follows J_1: 300 cm, J_2:252.78cm, J_3:160cm, J_4:80cm, J_5:32cm, J_6:100cm.

Name of the Project: Exploring alternate alignments, final location survey, geological mapping, geotechnical investigation, detailed design of tunnel & its approaches including Viaduct if any, and other ancillary work in Sohna-Manesar Section of HORC project.

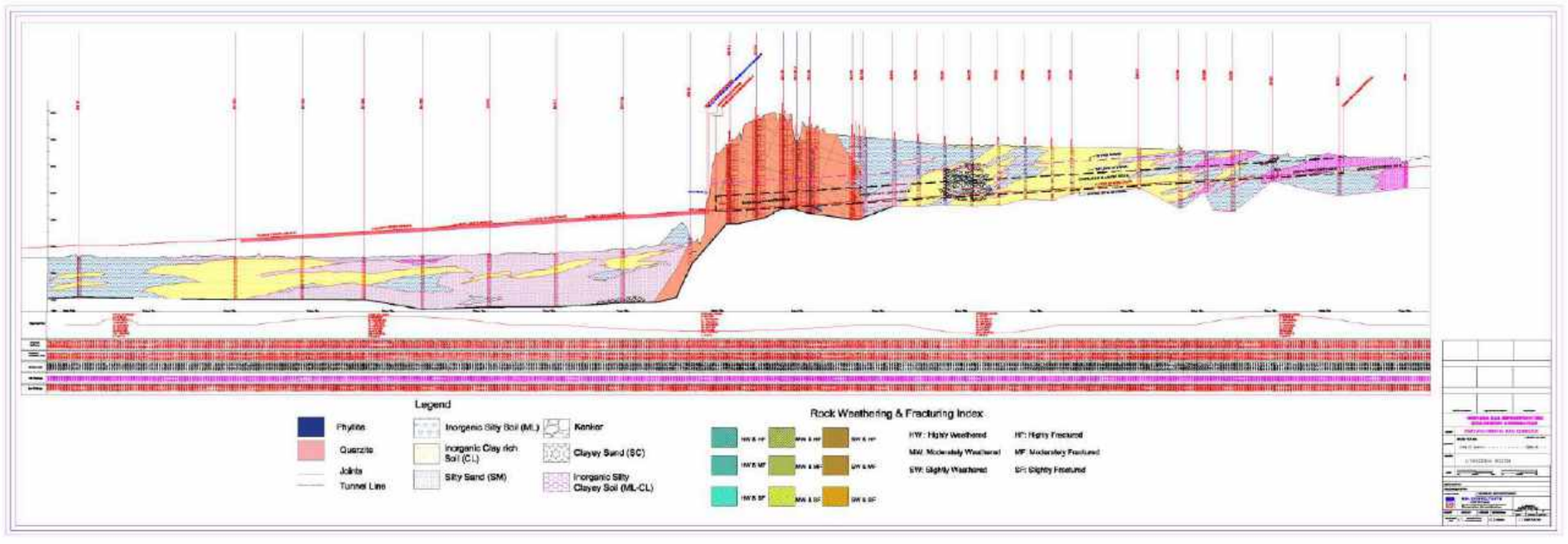


Figure 3.9: L-Section along the tunnel alignment (1:25000 H and 1:2500 V). Joint sets are schematically drawn with their actual orientation.

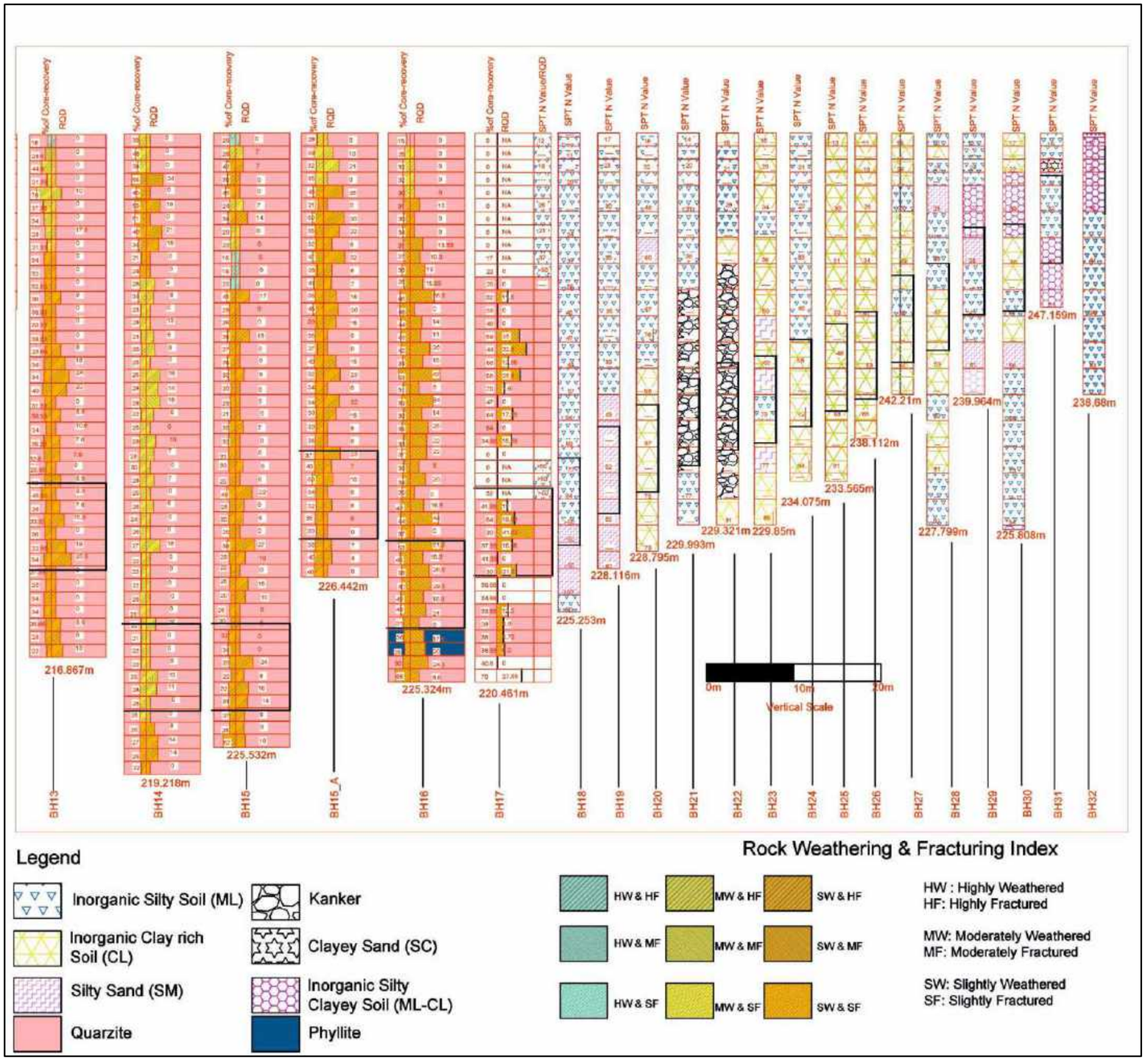


Figure 3.10: Graphical representation of the distribution of RQD, Core Recovery, SPTN Values and Soil types along each boreholes intersecting the tunnel (BH13-BH32). Thick black lines indicate the position of the tunnel.

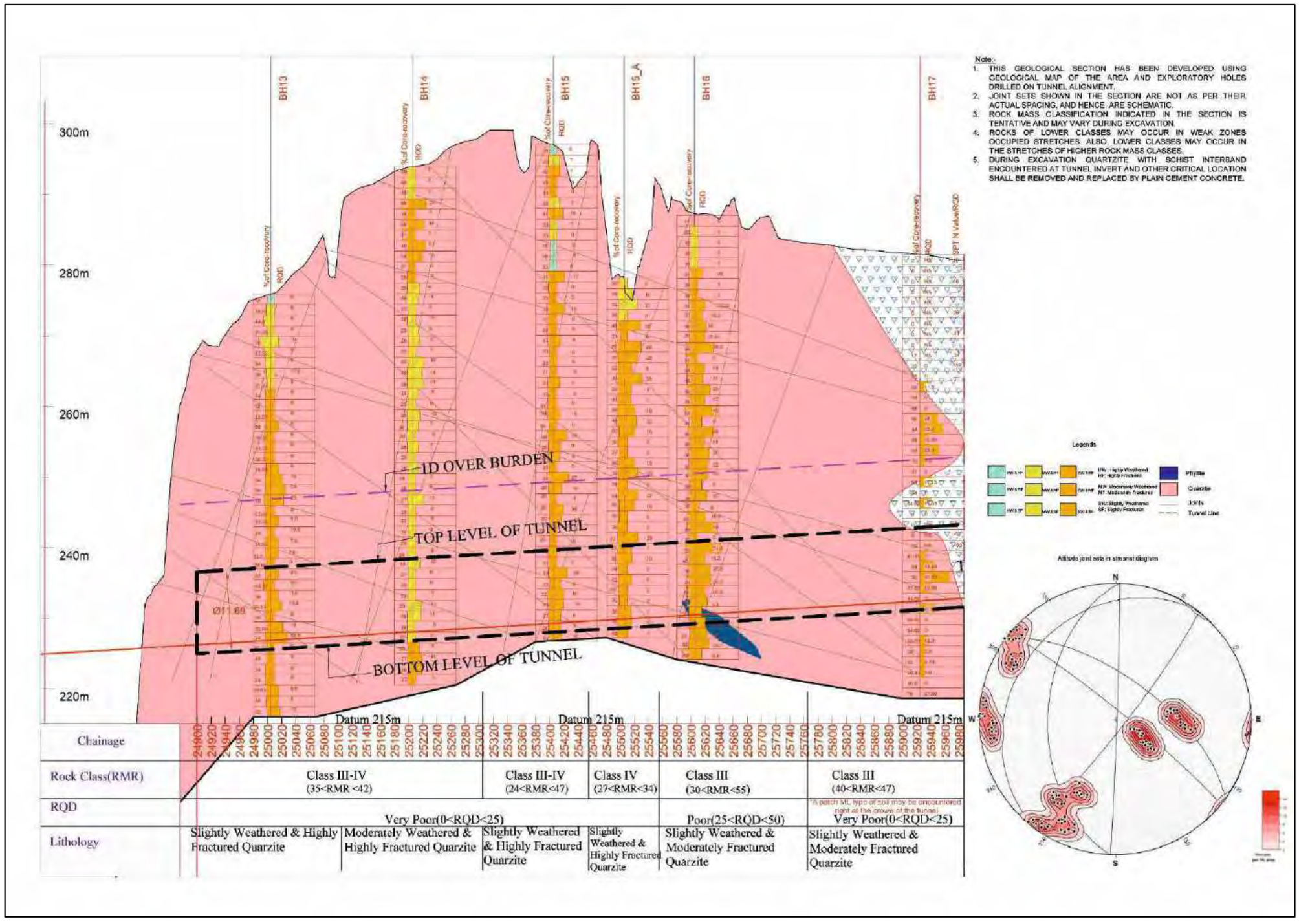


Figure 3.11: Chainage-wise variation in RQD and RMR (Samples from 2D depth considered only).

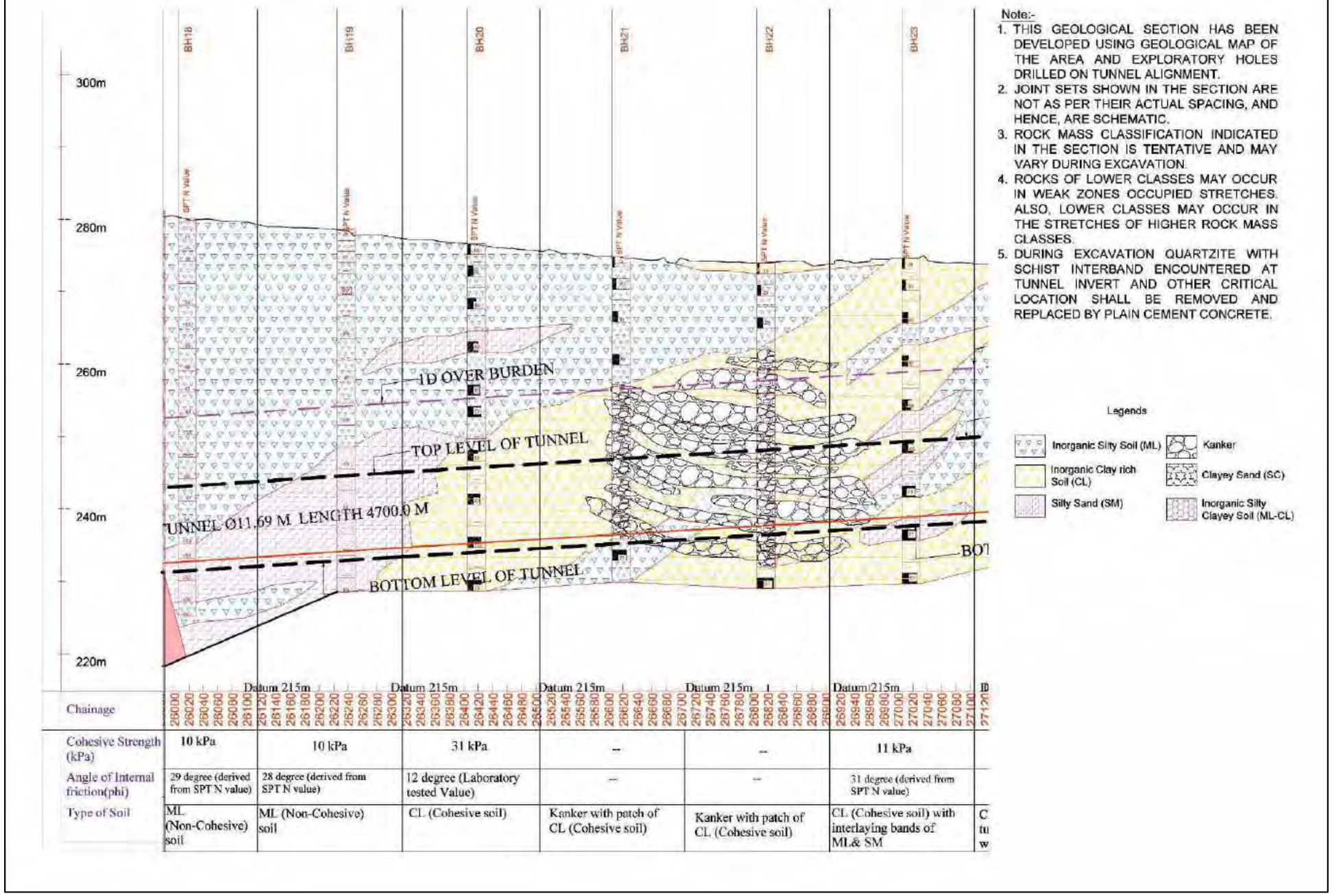
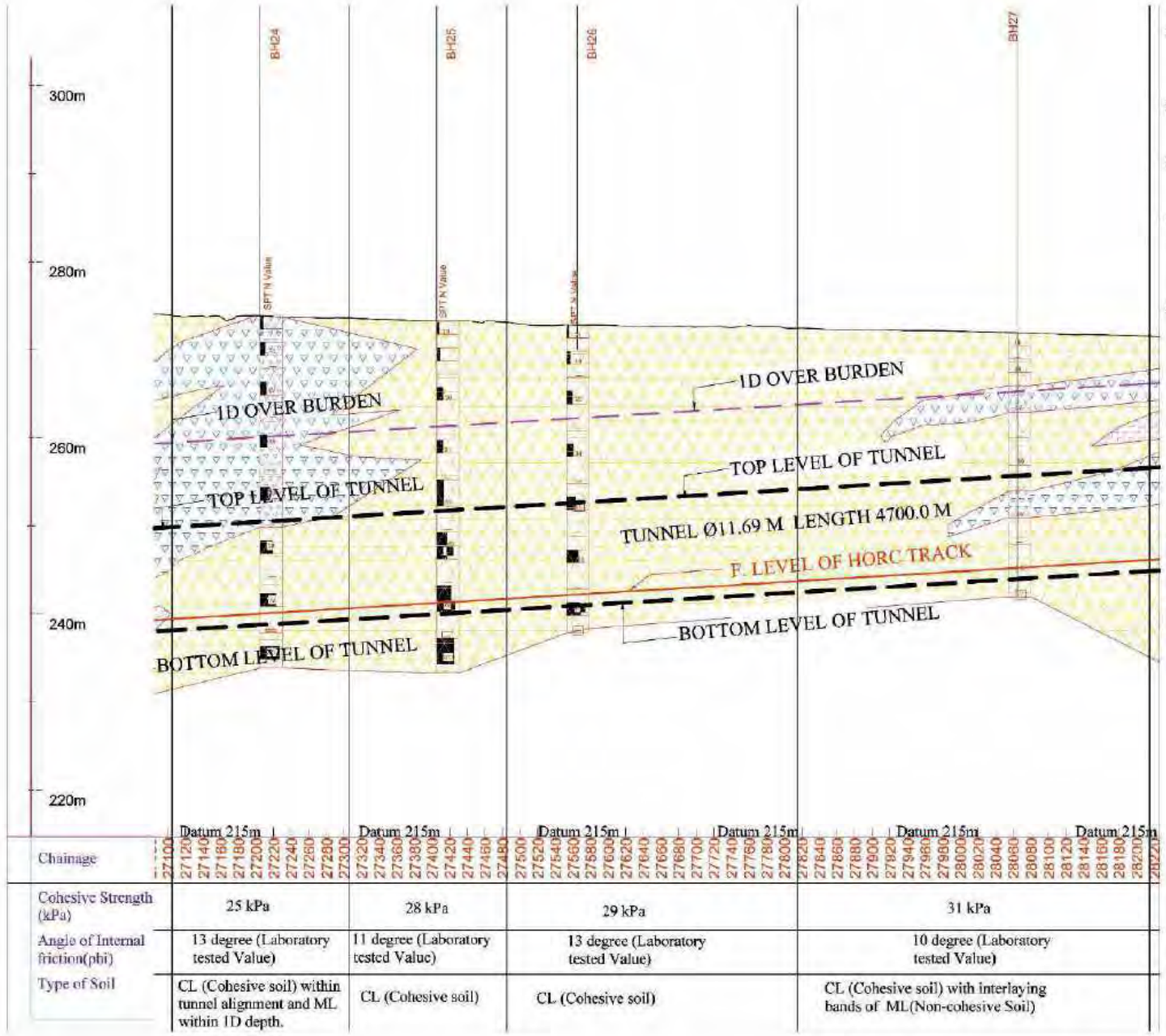


Figure 3.12: Chainage-wise variation in C and ϕ. (Samples from 2D depth considered only).



Note:-

1. THIS GEOLOGICAL SECTION HAS BEEN DEVELOPED USING GEOLOGICAL MAP OF THE AREA AND EXPLORATORY HOLES DRILLED ON TUNNEL ALIGNMENT.
2. JOINT SETS SHOWN IN THE SECTION ARE NOT AS PER THEIR ACTUAL SPACING, AND HENCE, ARE SCHEMATIC.
3. ROCK MASS CLASSIFICATION INDICATED IN THE SECTION IS TENTATIVE AND MAY VARY DURING EXCAVATION.
4. ROCKS OF LOWER CLASSES MAY OCCUR IN WEAK ZONES OCCUPIED STRETCHES. ALSO, LOWER CLASSES MAY OCCUR IN THE STRETCHES OF HIGHER ROCK MASS CLASSES.
5. DURING EXCAVATION QUARTZITE WITH SCHIST INTERBAND ENCOUNTERED AT TUNNEL INVERT AND OTHER CRITICAL LOCATION SHALL BE REMOVED AND REPLACED BY PLAIN CEMENT CONCRETE.

Legends

- Inorganic Silty Soil (ML)
- Kanker
- Inorganic Clay rich Soil (CL)
- Clayey Sand (SC)
- Silty Sand (SM)
- Inorganic Silty Clayey Soil (ML-CL)

Figure 3.13: Chainage-wise variation in C and ϕ. (Samples from 2D depth considered only).

Name of the Project: Exploring alternate alignments, final location survey, geological mapping, geotechnical investigation, detailed design of tunnel & its approaches including Viaduct if any, and other ancillary work in Sohna-Manesar Section of HORC project.

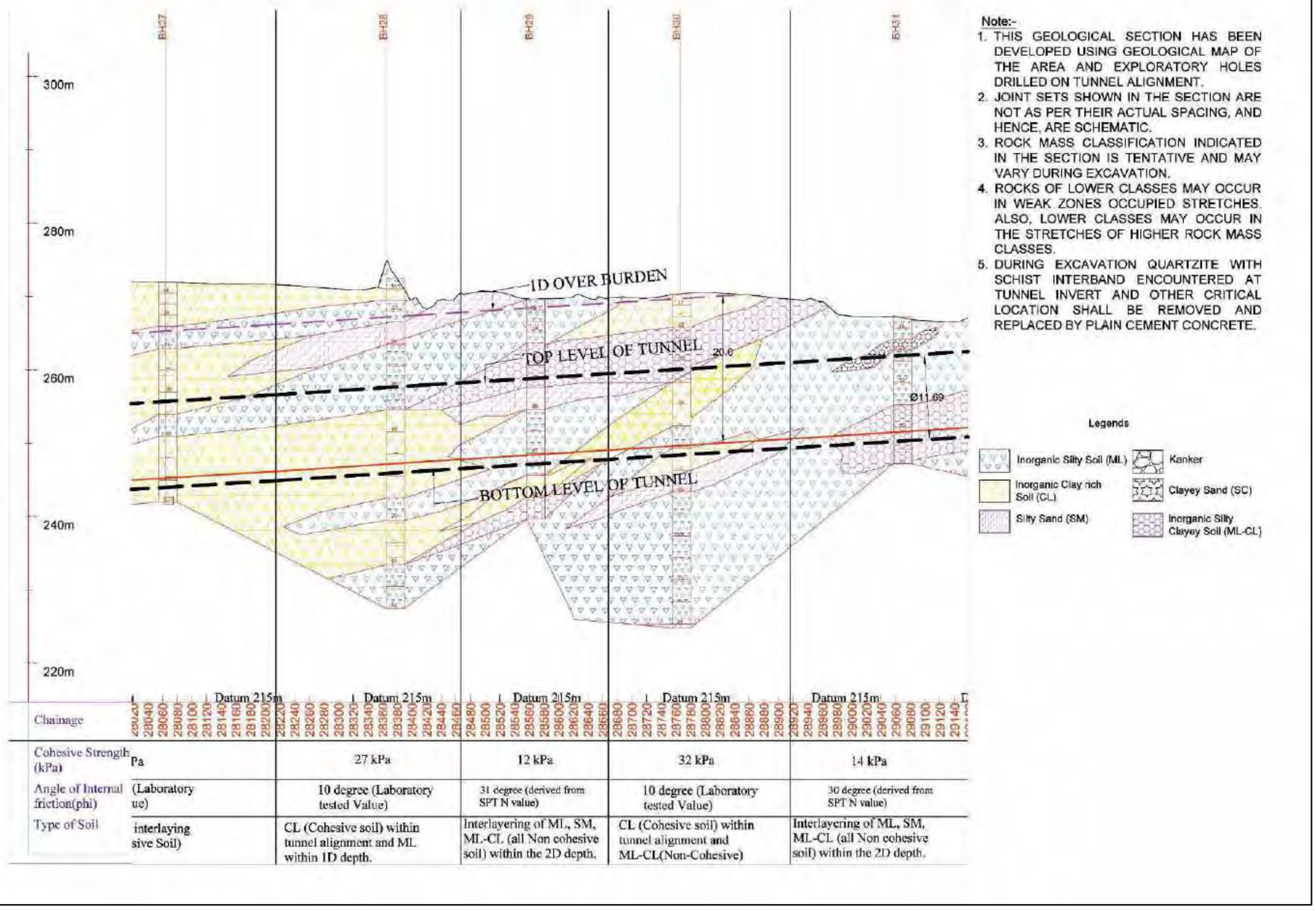
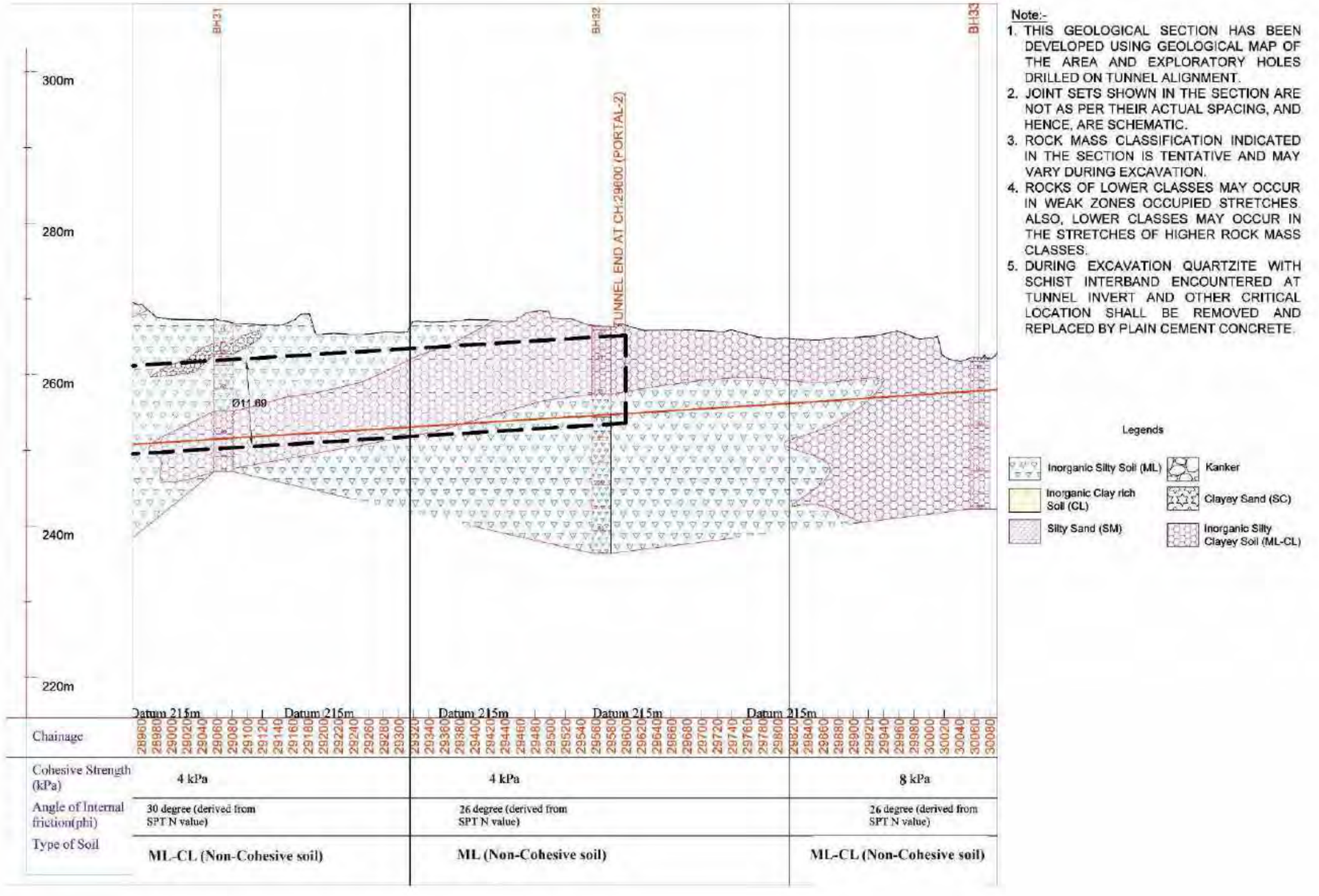


Figure 3.14: Chainage-wise variation in C and ϕ. (Samples from 2D depth considered only).

Name of the Project: Exploring alternate alignments, final location survey, geological mapping, geotechnical investigation, detailed design of tunnel & its approaches including Viaduct if any, and other ancillary work in Sohna-Manesar Section of HORC project.



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4. ROCKS OF LOWER CLASSES MAY OCCUR IN WEAK ZONES OCCUPIED STRETCHES. ALSO, LOWER CLASSES MAY OCCUR IN THE STRETCHES OF HIGHER ROCK MASS CLASSES.
5. DURING EXCAVATION QUARTZITE WITH SCHIST INTERBAND ENCOUNTERED AT TUNNEL INVERT AND OTHER CRITICAL LOCATION SHALL BE REMOVED AND REPLACED BY PLAIN CEMENT CONCRETE.

Figure 3.15: Chainage-wise variation in C and ϕ values, along the cut & cover region, for the strata below formation level.

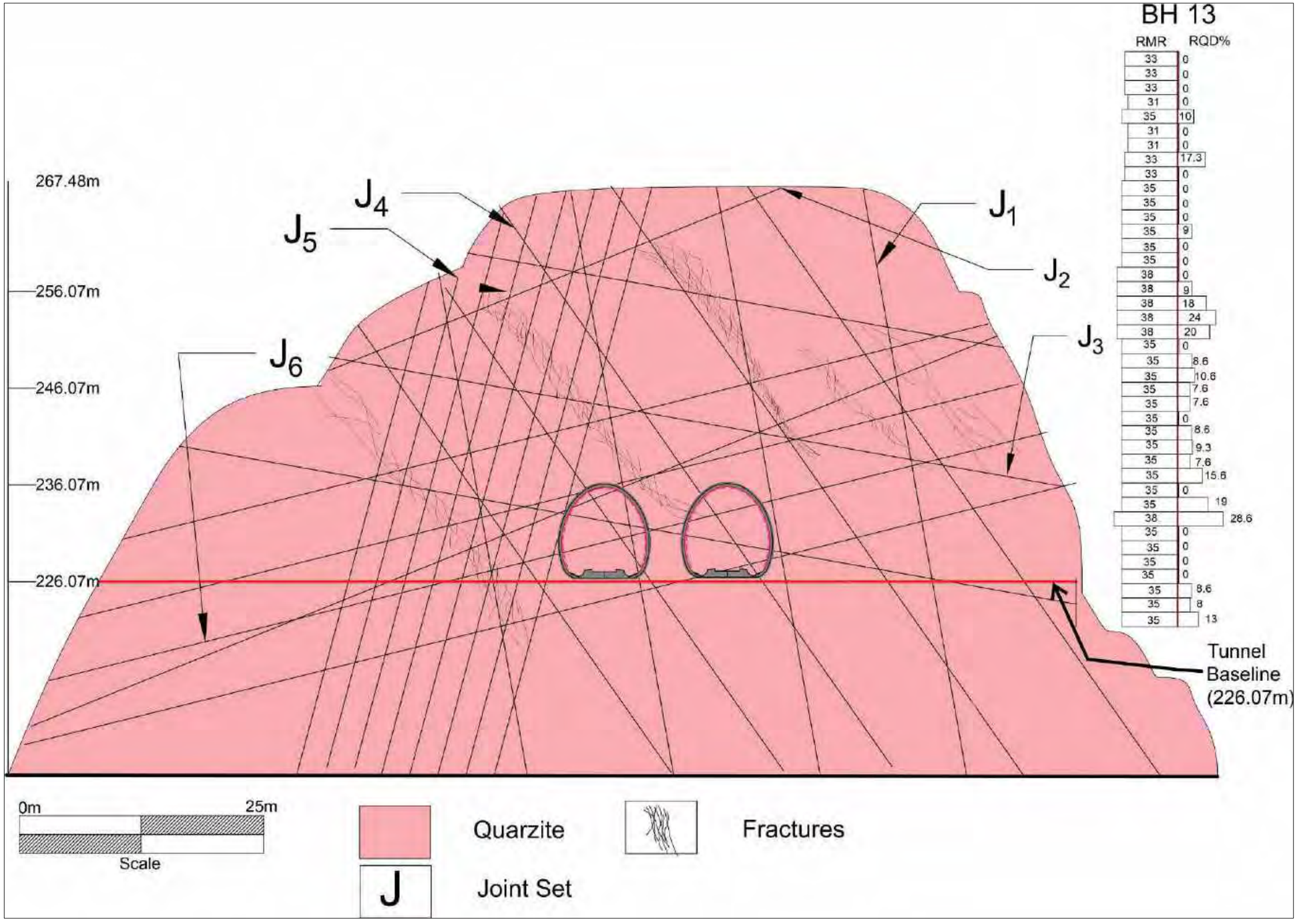

Figure 3.16: Detailed cross section of the Portal-I, on the mountain front. Joint sets are schematically drawn maintaining their actual orientation. Average spacing between the joints are as follows J_1: 300 cm, J_2:252.78cm, J_3:160cm, J_4:80cm, J_5:32cm, J_6:100cm.

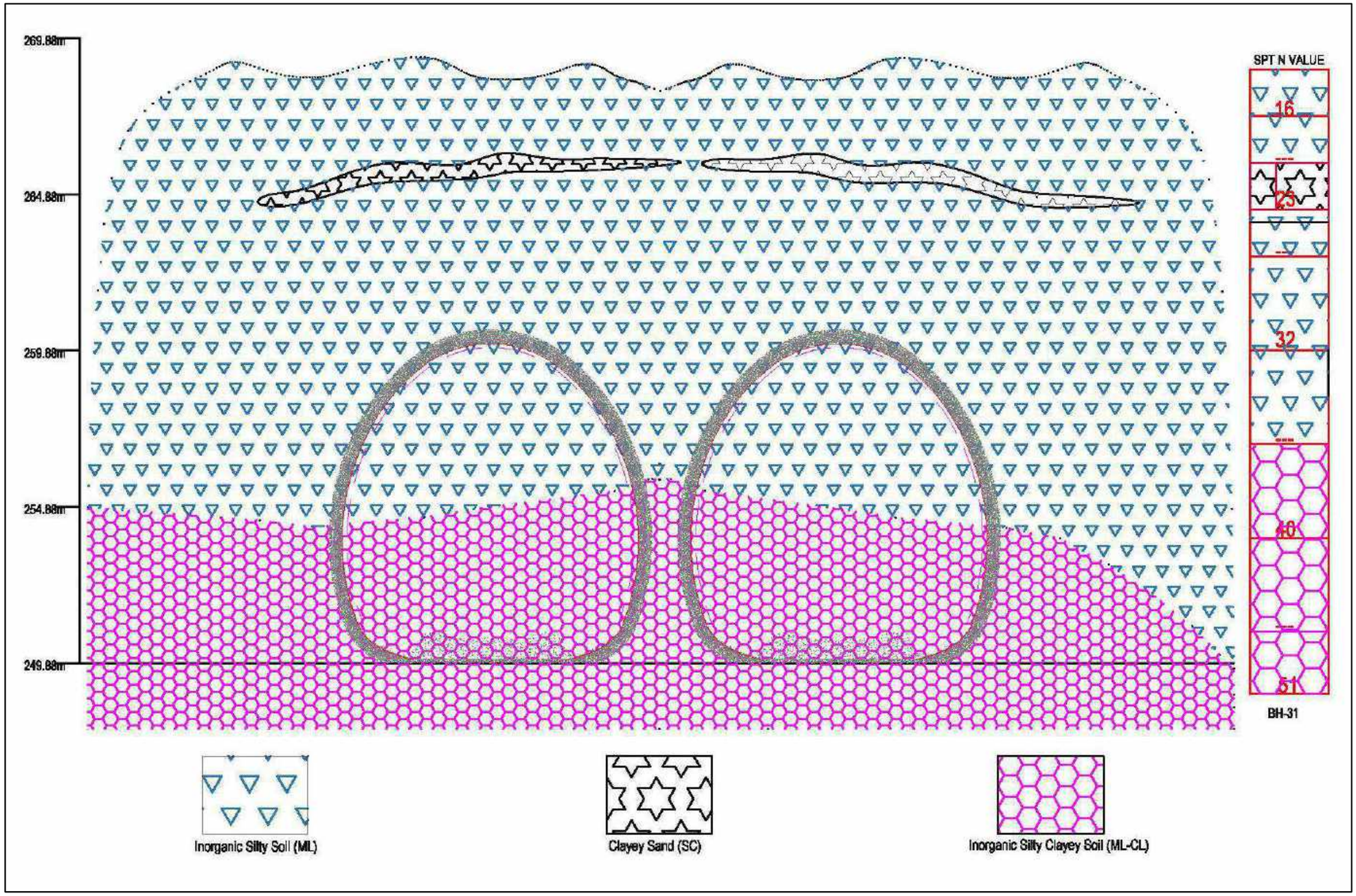

Figure 3.17: Detailed lithological cross section at the end of NATM Structure in soil (CH 28900).

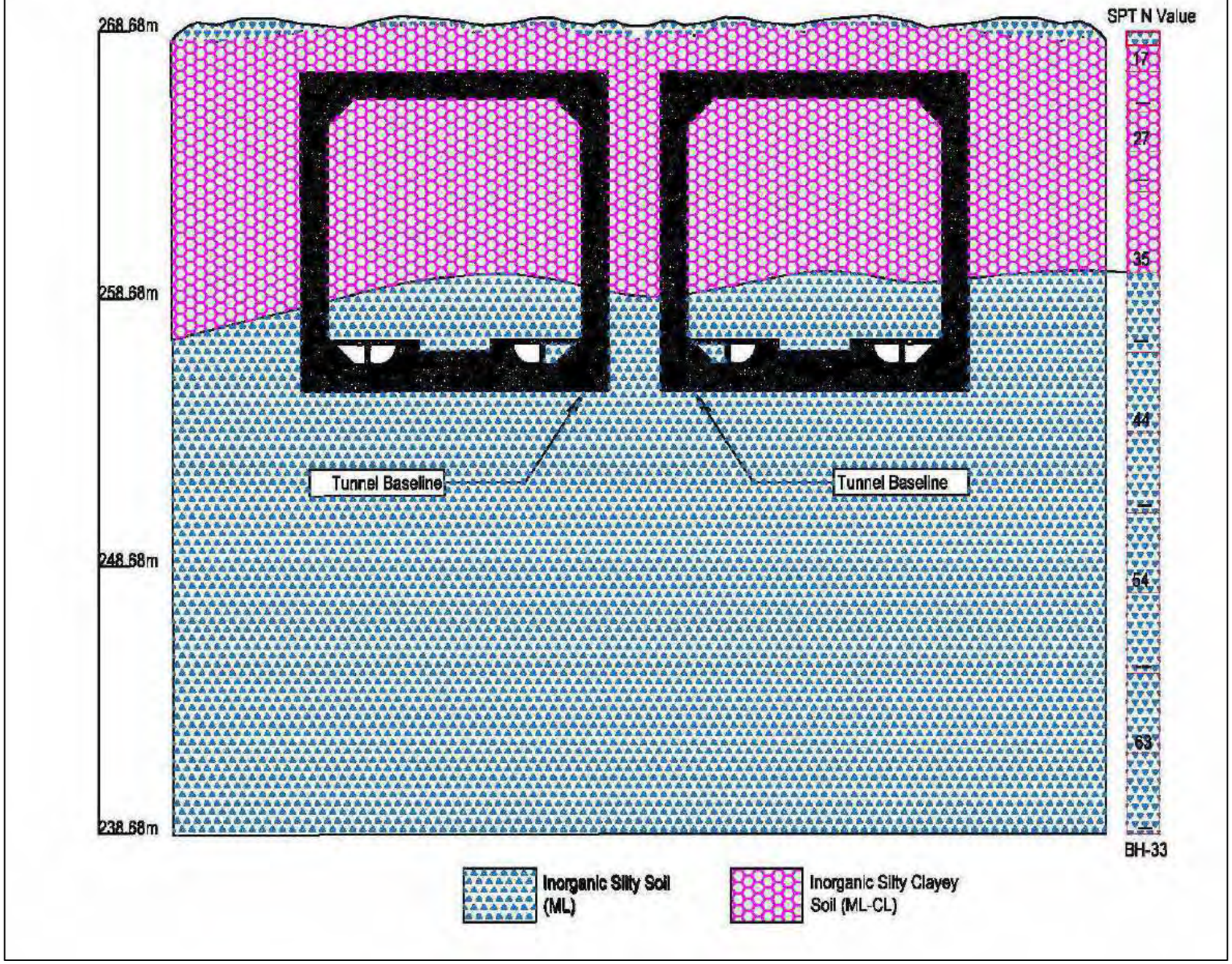

Figure 3.18: Cut and Cover structure at the end of tunnel – Portal II (CH29600).

Table 3.3: Abstract of Safe Bearing Pressure for cut and cover portion (BH-32 & 33).

Location	Depth from N.G.L in m.	Type of Soil	Field SPT value	Group of sample	Cohesion (C) in KPa	Angle of internal friction (ϕ))	E (in MPa)	Net Safe Bearing Capacity in T/m^2	Settlement in mm	Safe Bearing Pressure for 25 mm settlement in T/m^2	Recommended SBC in T/m^2
BH-32	21.0	S.P.T	N>50	ML	4	26	31	1100	709	39.0	35
	24.0	S.P.T	N>50					1101	793	35.0	35
BH-33	20.0	SPT	N>30	ML-CL	8	26	27.6	262	245	27	27

4 GEOTECHNICAL INVESTIGATION OF ROCK MASS:

Based on the available information from Geotechnical Report, geotechnical investigations have been carried out at different locations along the tunnel alignment and at stations.

4.1 Summary of the Boreholes within ROCK MASS:

The boreholes relevant to this project are mentioned in table below (Table 4.1).

Table 4.1: Details of Boreholes drilled for the project along the tunnel line.

BH No.	Chainage No.	Ground Elevation, RL (m)	Formation Level as Per Alt.2A	Total depth (m)
BH-13	25000	276.867	226.801	60
BH-14	25195	294.218	228.013	75
BH-15	25380	295.532	229.225	70
BH-15A	25488	276.442	229.833	50
BH-16	25586	287.324	230.437	62
BH-17	25785	282.461	231.650	62

4.2 Field Tests for ROCK MASS:

Field tests are conducted in boreholes that are taken along the proposed tunnel alignment and the station locations. The following table shows the summary of field tests conducted in Rock mass

Table 4.2: Details of test conducted at site.

Field Tests	Type of Test
In Rock	Core recovery and RQD
	Permeability Test

4.3 Field Test Result for ROCK MASS:

For the rock masses, during the drilling activity the percentage of core recovery and RQD has been calculated. These on field results has been summarized in Table 4.3.

Table 4.3: Result for the field tests.

BH No.	Chainage No.	Ground Elevation, RL (m)	Depth (m)	For Rock		
				% of Core recovery	RQD %	Avg. RMR from 2D Depth (*refer to section 5.5.2)
BH-13	25000	276.867	0.5-60	30.96	6.5	38
BH-14	25195	294.218	0.5-75	28.94	5.9	37
BH-15	25380	295.532	0.5-70	28.91	5.91	34
BH-15A	25488	276.442	0.5-50	35.79	10.67	29
BH-16	25586	287.324	0.5-62	36.52	16.02	41
BH-17	25785	282.461	0.5-62	30.02	10.98	42

The packer test method was carried out as per IS 5529 (Part 2): 2006 to determine the permeability of the rock strata at site presented in Table 4.4.

Table 4.4: Result for permeability tests

BH No.	Packer test section 1		Lugeon Value	Packer test section 2		Lugeon Value
	Upper part (m)	Lower part (m)		Upper part (m)	Lower part (m)	
BH-13	36	39	30.20	48	51	25.62
BH-14	54	57	24.46	63	66	21.88
BG-15	55	58	24.34	64	67	18.42
BH-16	44	47	27.38	56	59	21.14

4.4 Laboratory Tests:

Laboratory tests were also carried out on rock samples, the details of different laboratory tests conducted as part of the project are given in the table below (Table 4.5)

Table 4.5: The laboratory tests conducted for rock.

Laboratory tests conducted for rock	1. Unconfined Compressive Strength,
	2. Point Load Index Test
	3. Tensile Strength
	4. Specific Gravity
	5. Modulus of elasticity
	6. Water absorption
	7. Poisons' ratio
	8. Triaxial Test
	9. Hardness test
	10. Abrasive test

4.5 Laboratory Test Result for Rock Mass:

This section comprises depth wise results of the tests conducted in laboratory for rock masses in accordance with relevant standard codes of practices. Multiple tests in laboratory (Table 4.5) are adopted to ascertain the different essential characteristics of sub-surface using field samples obtained in during field investigations and borehole drilling. The tests as under have been conducted to ascertain the parameters indicated in the test. The findings of these test are required for use in relevant engineering designs and summarized in following tables (Table 6.1).

Representative core samples have been taken from the boreholes along the tunnel alignment. The samples were properly labelled and packed carefully and sent NABL accredited laboratory for determining the physico-mechanical engineering properties as per Indian standardized regulation. Summary of results from the laboratory testing has been graphically presented below.

4.5.1 Uniaxial Compressive Strength

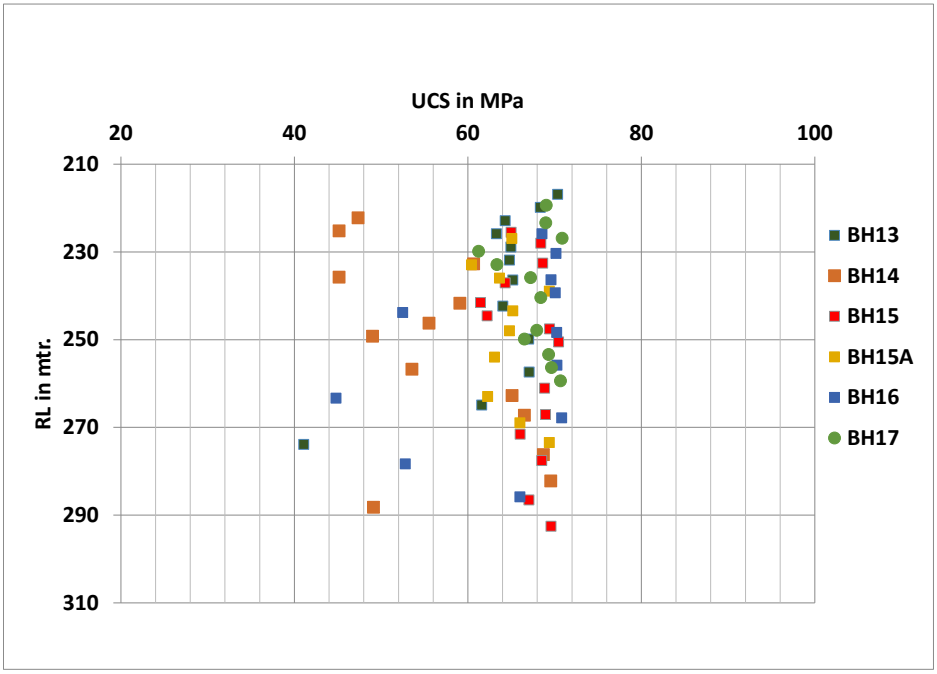

Figure 4.1: Unconfined Compressive Strength (UCS) of rock mass from entire borehole length vs RL (Refer to Annexure C in Geotechnical Report for detail).

To make recommendation related to the engineering property of the surrounding rock material, which is going to directly influence the tunnel built, samples from 2D has been considered. Pareto chart has been prepared to identify the most frequent and categorically influential data set out of the scattered values. It is based on 80/20 rule, i.e., "Vital few and trivial many" principle. The idea is that the few identified vital values will always statistically dominate over many.

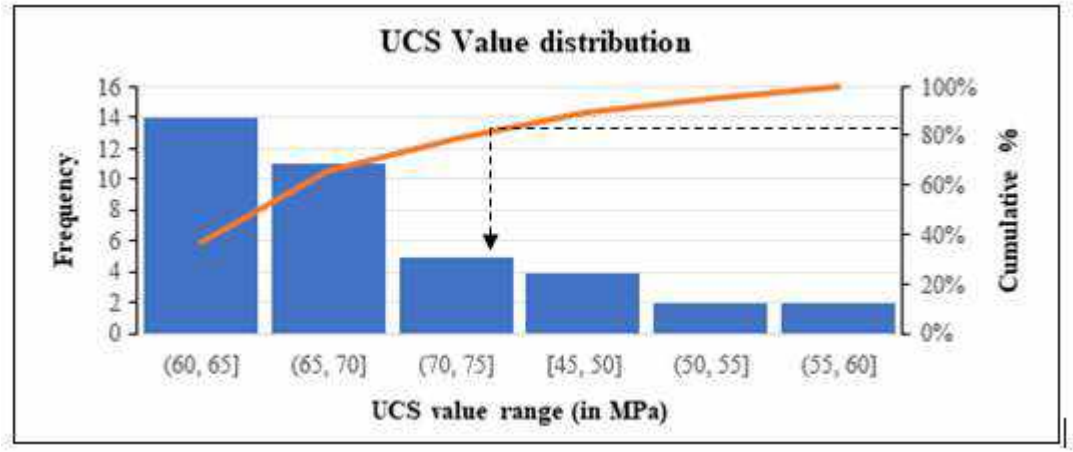

Figure 4.2: Pareto Chart showing recommended UCS value for the rock mass from 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the UCS value ranging 60-75 MPa. For safer construction the lower value of the range **60 MPa** is recommended as UCS value for the rock mass.

4.5.2 Assessment of Rock Mass Rating (RMR):

The outcrops encountered along the stretch of the alignment in this project is homogenously Quartzite. The classification of rock types with Rock Mass Rating (RMR) is done based on RQD%, Uniaxial compressive strength of rock material, spacing of discontinuities/joints, Smoothness, Infilling, Alteration/weathering along the discontinuity/joints and ground water condition and borehole wise average index values are tabulated below (For detailed result refer Annexure from Geotechnical Report on this project). Based on the results the rock mass has been broadly classified as **CLASS IV (Poor Rock Mass)**. However, in some of the cases, the RMR value being close to 40, it may be considered as Class III.

Q tunnelling index was also evaluated and the rock mass were found to be in same "POOR ROCK MASS" category. However, accessing Q parameters from boreholes, instead of excavated wall, is considerably subjective and unprecise. Therefore, the Q parameters has not been used for recommending the tunnel support.

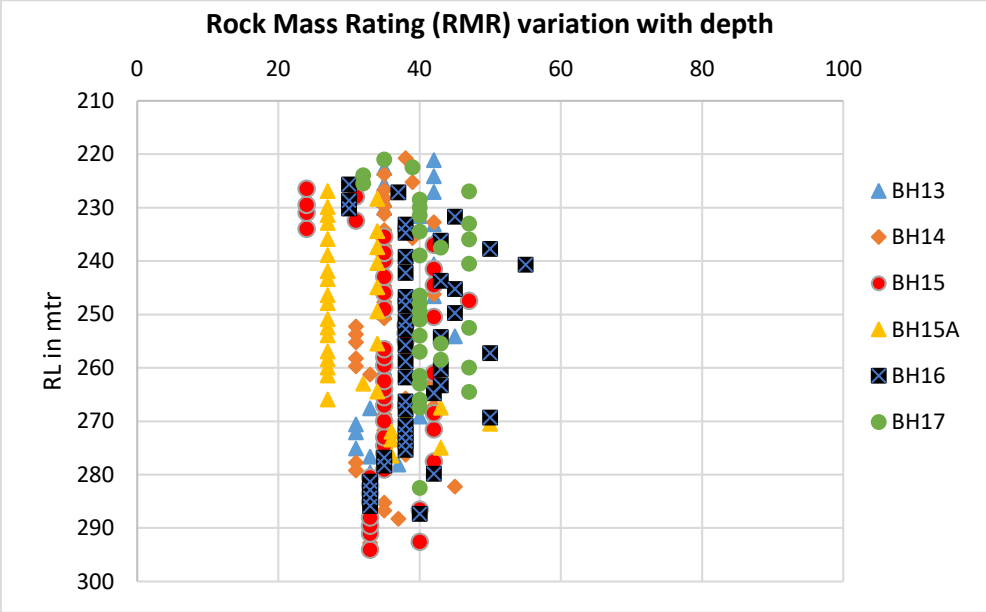

Figure 4.3: Graphical representation of RMR of rock mass from entire borehole length with depth. (Refer to Annexure A in Geotechnical Report for detail).

RMR value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

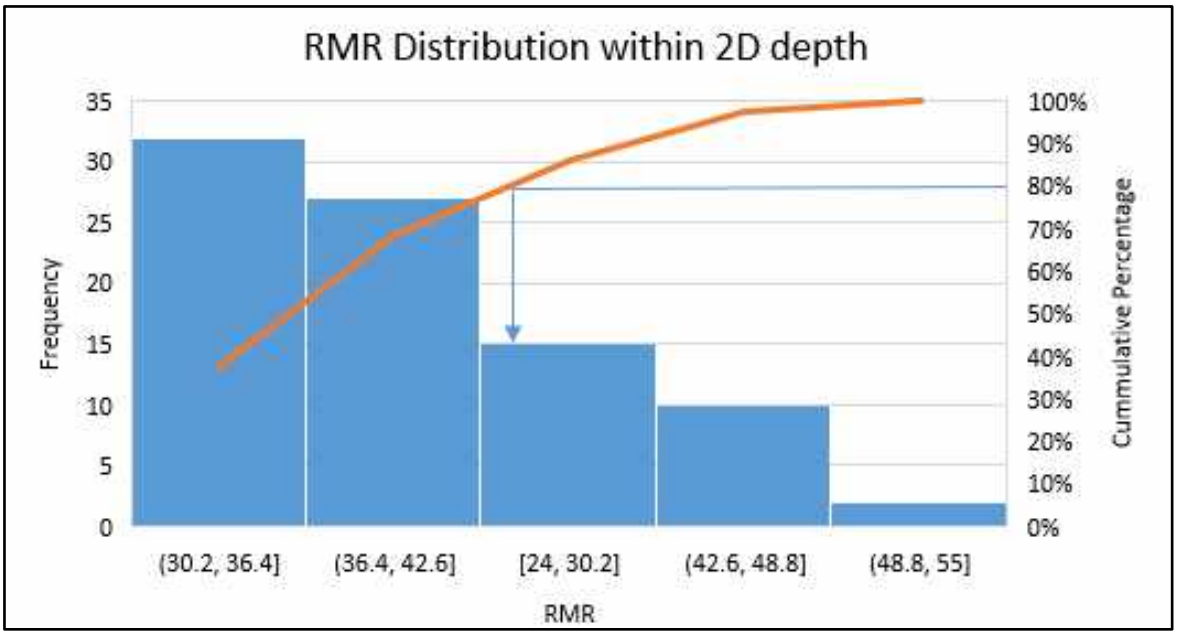

Figure 4.4: Pareto Chart showing recommended RMR value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the RMR value ranging 24-43, only 20% data has RMR value >40. Therefore, the entire rock mass up to 2D height from the formation level statistically belong to **"CLASS IV"**. Hence, as per Bieniawski, 1989, systematic bolts 4-5m long, spaced 1-1.5 m in crown and walls with wire mesh, 100-150 mm shotcrete in crown and 100mm shotcrete in sides, light to medium steel ribs spaced 1.5 m is recommended as tunnel support. However, along some chainage interval the support system of Class III may be used by the discretion of the design engineer.

****For chainage wise variation in RMR value refer to Figure 3.11**.

4.5.3 Point Load Index:

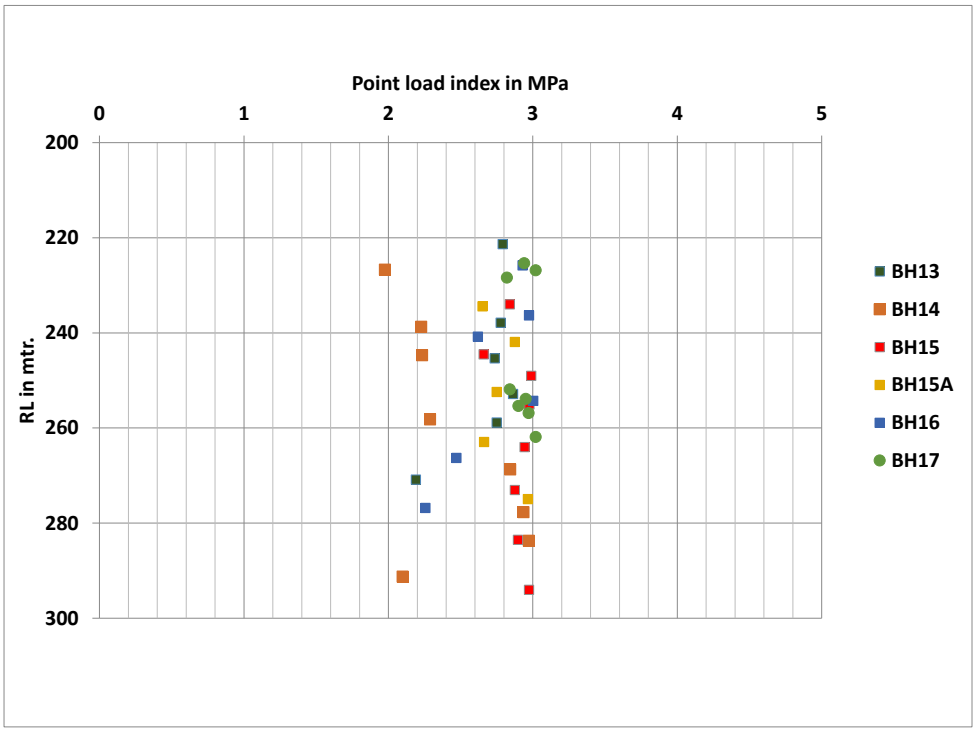

Figure 4.5:Point Load Index (PLI) of rock mass from entire borehole length vs RL. (Refer to Annexure E in Geotechnical Report for detail).

PLI value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

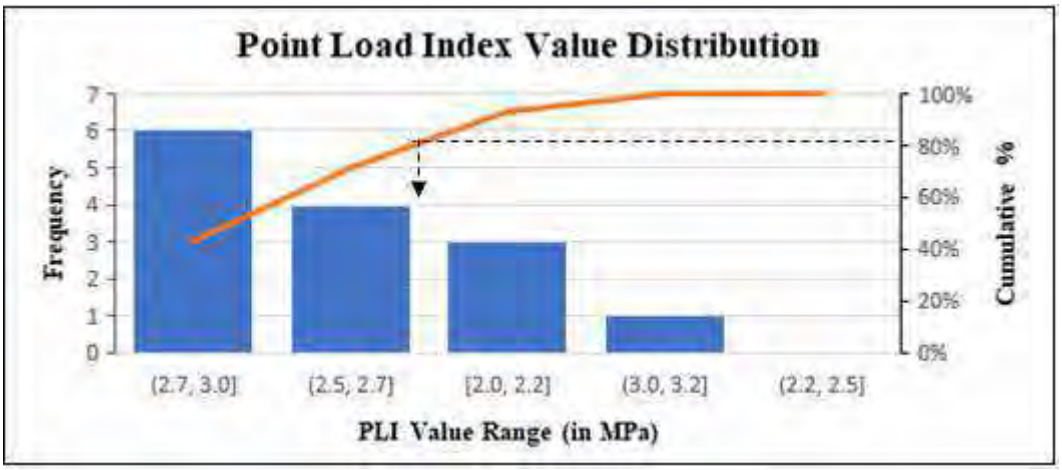

Figure 4.6: Pareto Chart showing recommended PLI value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the PLI values are ranging 2.5 to 3.0 MPa. For safer construction the lower value of the range **2.5 MPa** is recommended as PLI value for the rock mass.

4.5.4 Tensile Strength:

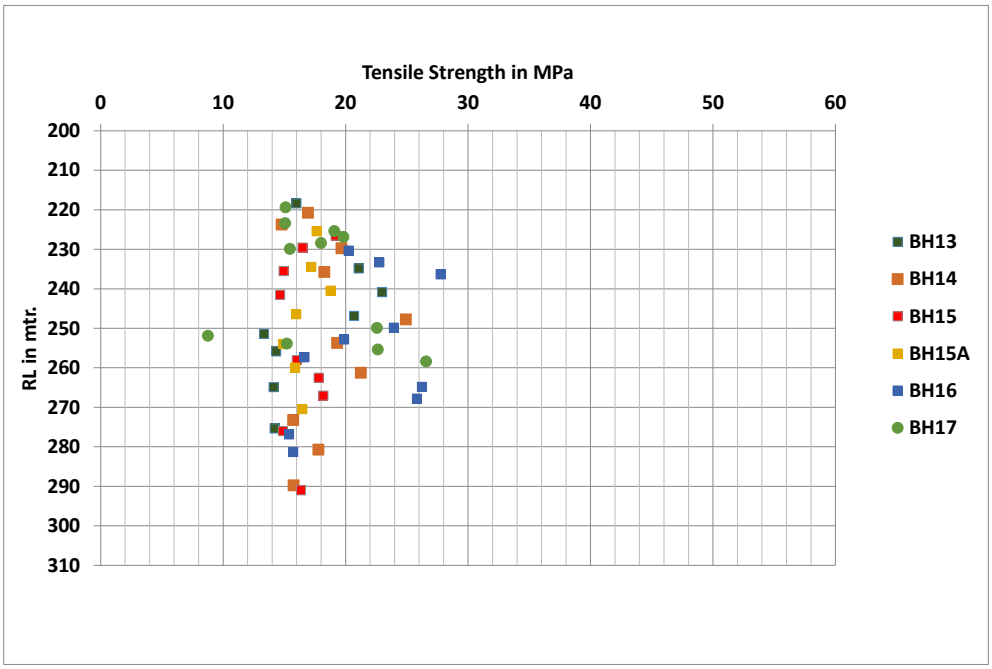

Figure 4.7:Tensile Strength of rock mass from entire borehole length vs RL. (Refer to Annexure B in Geotechnical Report for detail).

Tensile strength value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

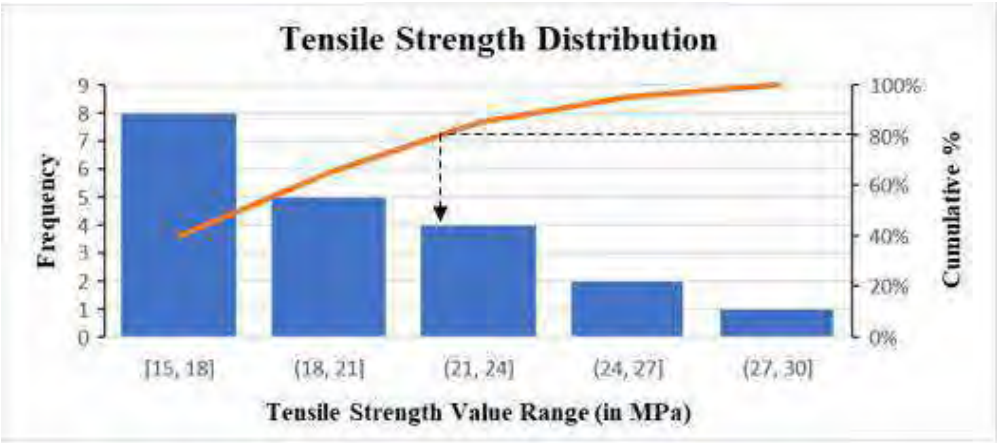

Figure 4.8: Pareto Chart showing recommended tensile strength value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Tensile strength value ranging 15-21 MPa. For safer construction the lower value of the range **15 MPa** is recommended as Tensile Strength value for the rock mass.

4.5.5 Modulus of Elasticity:

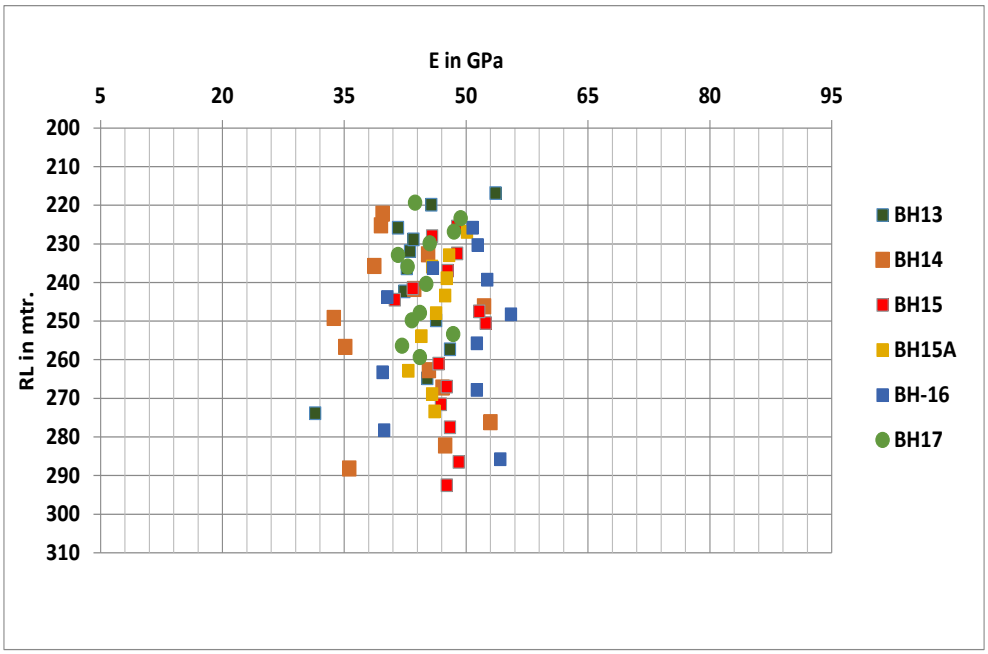

Figure 4.9: Modulus of Elasticity (E) of rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).

Modulus of Elasticity value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

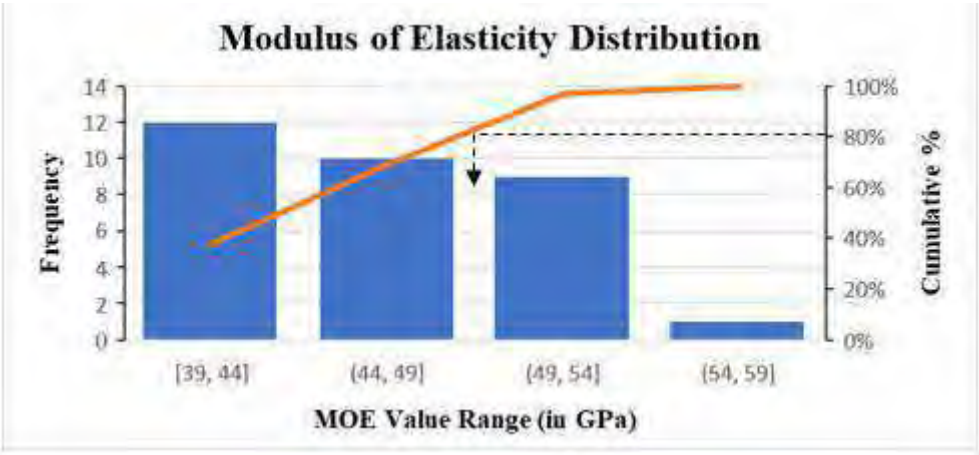

Figure 4.10: Pareto Chart showing recommended Modulus of Elasticity (E) value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Modulus of Elasticity value ranging 39-49 GPa. For safer construction the lower value of the range **39 GPa** is recommended as Modulus of Elasticity value for the rock mass.

4.5.6 Poison's ratio:

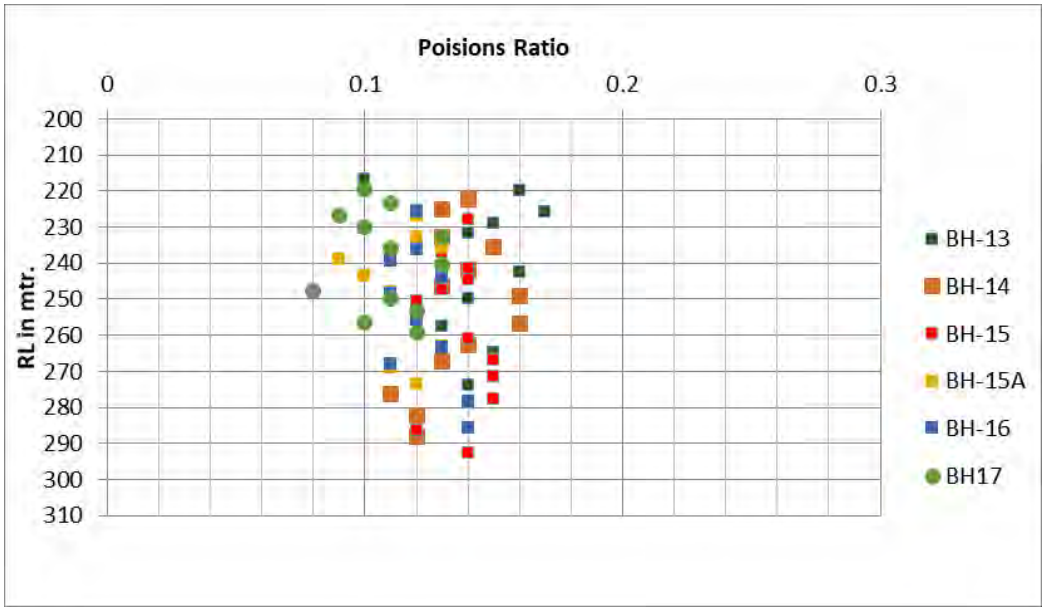

Figure 4.11: Poisson's Ratio distribution for the entire rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).

Poison's ratio value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

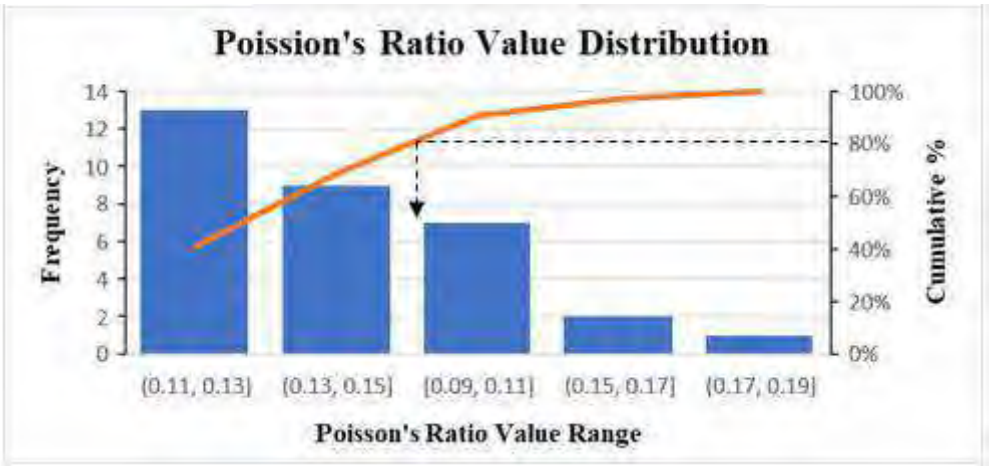

Figure 4.12: Pareto Chart showing recommended Poisson's Ratio value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Tensile strength value ranging 0.11-0.15. For safer construction the higher value of the range **0.15** is recommended as Poisson's Ratio value for the rock mass.

4.5.7 Hardness:

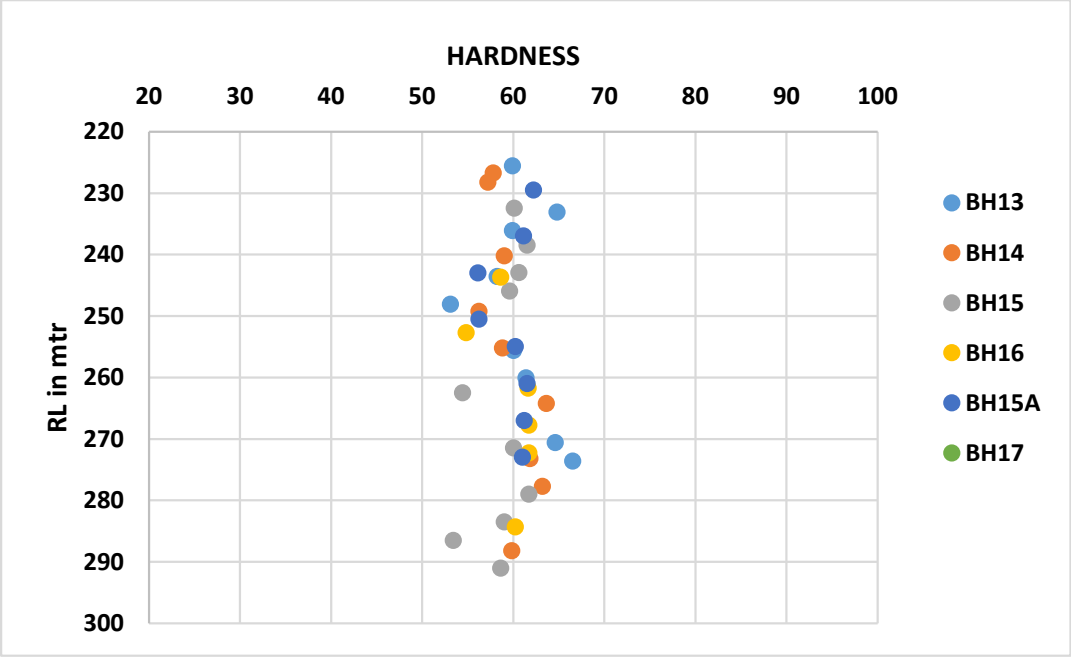

Figure 4.13: Hardness of rock mass from entire borehole length vs RL. (Refer to Annexure H in Geotechnical Report for detail).

Hardness value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

Figure 4.14: Pareto Chart showing recommended Hardness value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Hardness value ranging 55-61. For safer construction the lower value of the range **55** is recommended as Hardness value for the rock mass.

4.5.8 Abrasive Index:

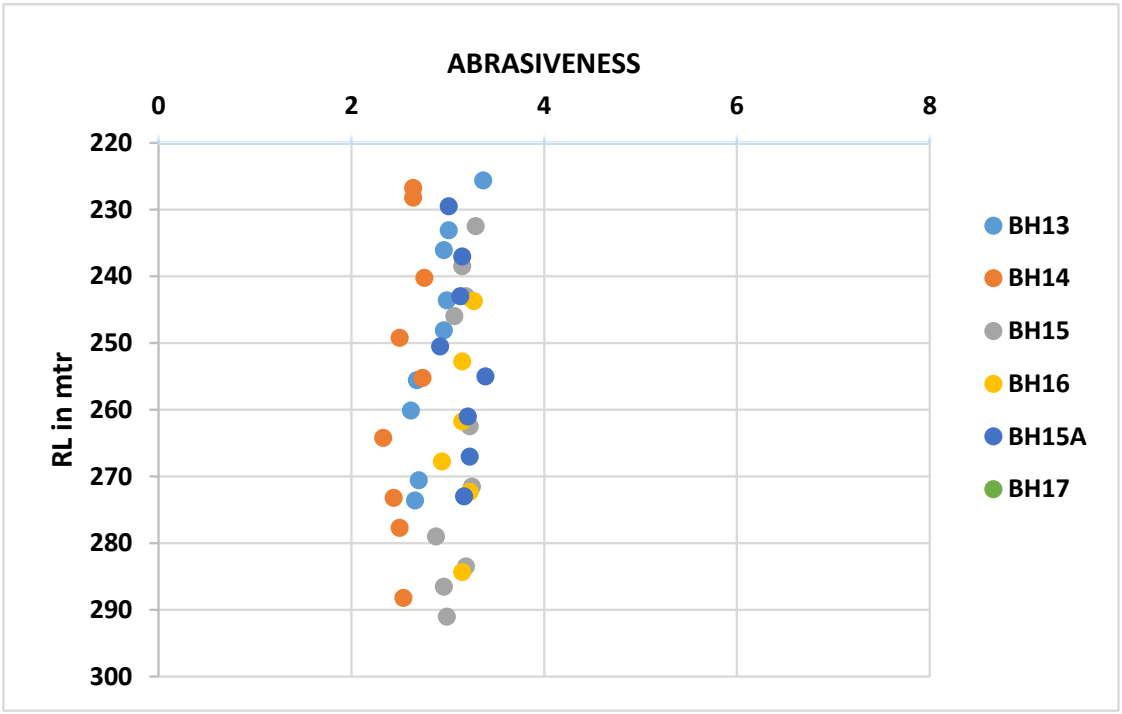

Figure 4.15:Abrasiveness of rock mass from entire borehole length vs RL. (Refer to Annexure I in Geotechnical Report for detail).

Abrasive Index value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

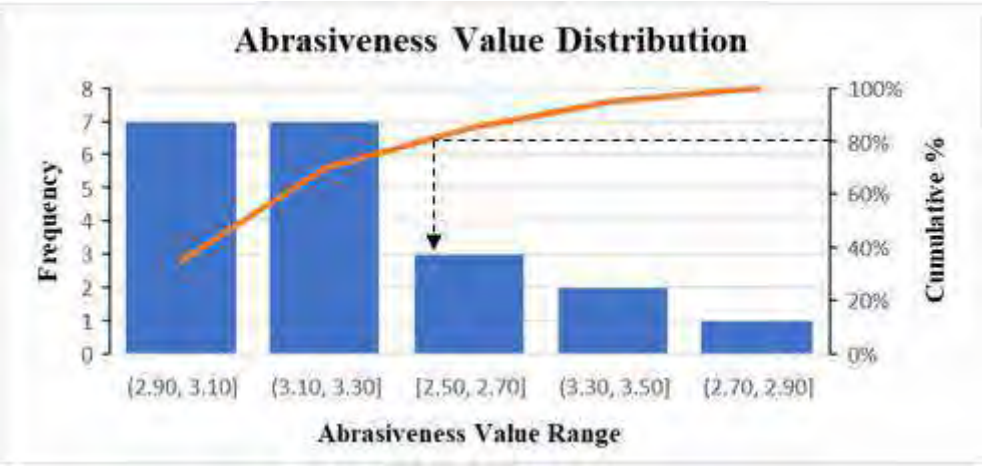

Figure 4.16: Pareto Chart showing recommended Abrasiveness index value for the rock mass within 2D depth.

As shown in the *Pareto Chart* above, 80% of the total collected samples from 2D depth has the Hardness value ranging 2.50-3.30. For safer construction the higher value of the range **3.30** is recommended as Abrasiveness index value for the rock mass.

4.5.9 Angle of Internal Friction (ϕ):

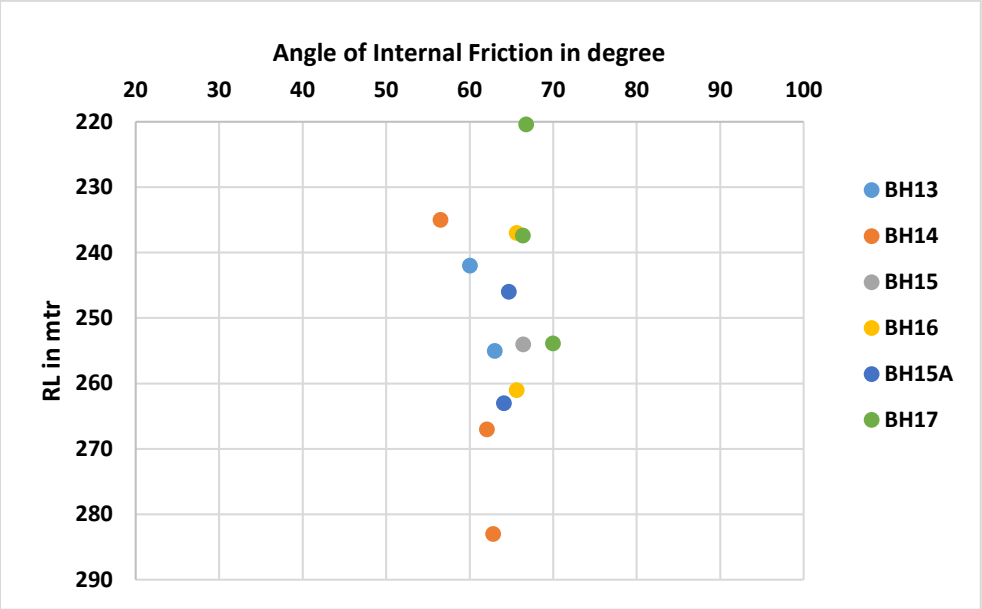

Figure 4.17: Angle of internal friction of rock mass from entire borehole length vs RL (Refer to Annexure G in Geotechnical Report for detail).

Angle of Internal Friction (ϕ) value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

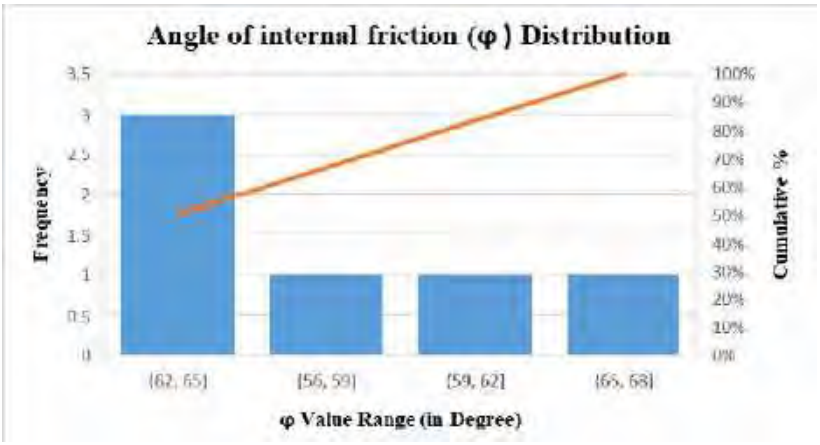

Figure 4.18: Pareto Chart showing recommended angle of internal friction value for the rock mass within 2D depth. (The straight cumulative frequency curve, in orange, indicates that all of the classes contribute significantly. Therefore, entire range of the population needs to be considered.)

Laboratory tested angle of internal friction value for the rock mass samples from 2D depth are quite scattered ranges between 55°-65°. For safer construction the Lower value of the range **55°** is recommended as angle of internal friction value for the rock mass.

4.5.10 Cohesion:

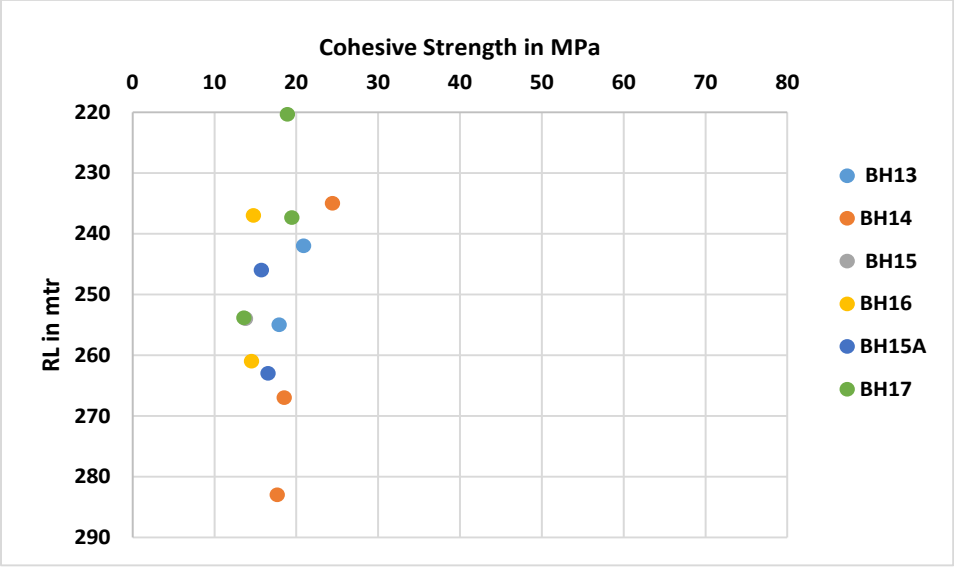

Figure 4.19: Cohesive strength of rock mass from entire borehole length vs RL (Refer to Annexure F in Geotechnical Report for detail).

Cohesion value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

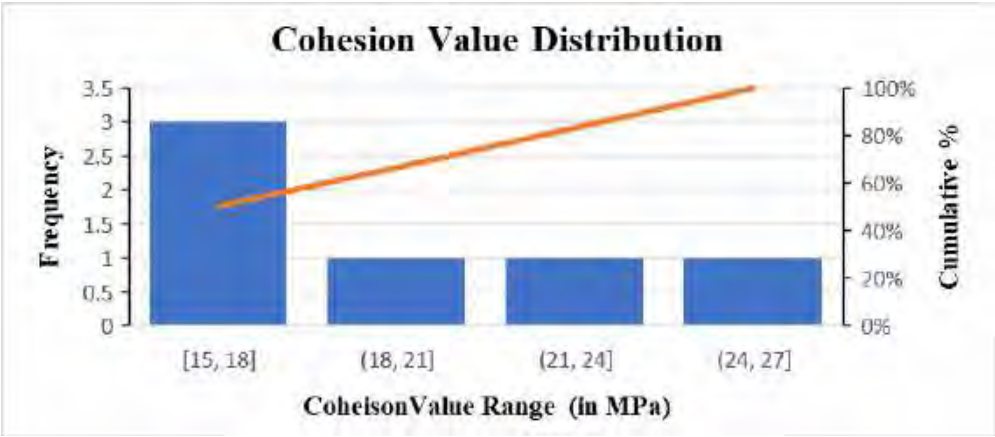

Figure 4.20: Pareto Chart showing recommended Cohesion value for the rock mass within 2D depth. (The straight cumulative frequency curve, in orange, indicates that all of the classes contribute significantly. Therefore, entire range of the population needs to be considered.)

Laboratory tested cohesion value for the rock mass sample from 2D depth are quite scattered ranges between 15-25 MPa. For safer construction the Lower value of the range **15 MPa** is recommended as Cohesion value for the rock mass.

4.5.11 Lugen Value:

Lugen value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

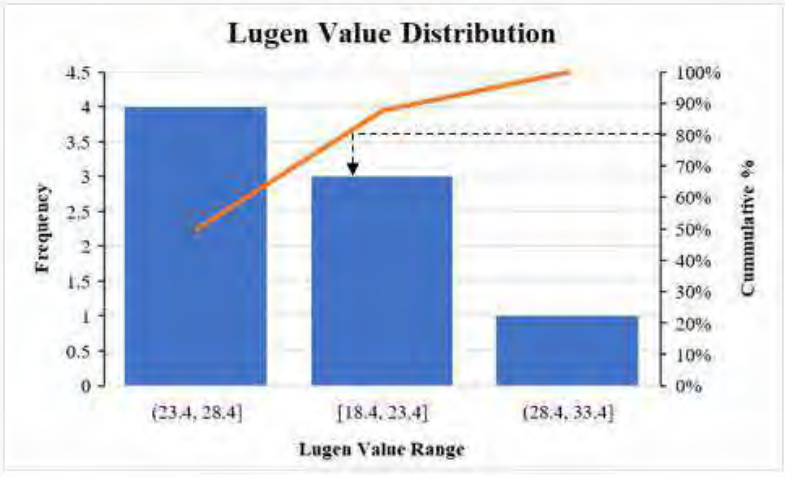

Figure 4.21: Pareto Chart showing recommended Lugeon value for the rock mass within 2D depth

As shown in the *Pareto Chart* above, 80% of the total collected samples has the Packer test Lugeon value ranging 18.4-28.4. For safer construction the higher value of the range 28.4 is recommended as Lugeon value for the rock mass.

4.5.12 Wet Density:

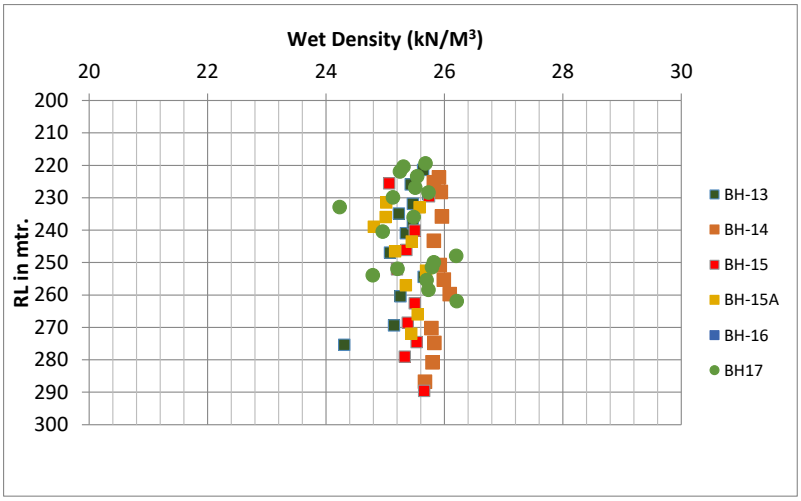

Figure 4.22: Wet Density for rock mass from entire bore hole length vs RL. (Refer to Annexure D in Geotechnical Report for detail).

Wet density value being clustered between a maximum of 26.52 kN/m^3 and minimum of 24.23 kN/m^3, we can safely recommend the average value 25.55 kN/m^3 as the representative of the entire rock mass.

4.6 Petrographic Test:

Petrographic test performed to study the mineralogical, textural and micro-structural property of rock. The rock samples are cut up to 30-micron size and their optical properties are observed. In the present test Grain size analysis is done to study the textural property of rock and the relative abundance of minerals are calculated to study the chemical and mineralogical property of the rock.

Quartz is the most abundant mineral (mostly 94% $\pm$ 5%) found in most of the samples from the drillhole and Feldspar followed by Mica is present as accessory minerals. Borehole BH-16 shows an abrupt compositional change with depth. Abundance of mica raises steeply with depth, from the accessory mineral of 2% volume at 46.5m to second most abundant mineral (after Quartz with volume 55%) with 27% volume at 52m depth. Garnet with volume of 8% is also found at 52m depth of same borehole. Grain size analysis of the samples from all the boreholes exhibit a negatively skewed distribution of mineral grains in the sample mostly with a mean radius of 0.3 mm.

***** All the recommended values for different rock parameters are tabulated in Table 6.1, Chapter-6: Conclusion and Recommendations**.

5 GEOTECHNICAL INVESTIGATION OF SOIL MASS:

Soil mass encountered along the tunnel alignment has been categorised in two group i.e., 1) Noncohesive Soil comprising Silty Sand (SM) and Inorganic Silt (ML) and 2) Cohesive Soil comprising Inorganic clay (CL). The values for the engineering property of soil have been interpretated categorically from the pareto chart presented below. Based on the available information from Geotechnical Report, geotechnical investigations have been carried out at different locations along the tunnel alignment and at stations.

5.1 Summary of the Boreholes within SOIL:

The boreholes relevant to this project are mentioned in table below Table 5.1.

Table 5.1: Details of Boreholes drilled for the project along the tunnel line within SOIL.

BH No.	Chainage No.	Ground Elevation, RL (m)	Formation Level as Per Alt.2A	Total depth (m)
BH-18	25990	280.253	232.939	55
BH-19	26210	278.116	234.379	50
BH-20	26387	276.795	235.522	48
BH-21	26587	274.993	236.734	45
BH-22	26787	274.321	237.946	45
BH-23	26980	274.85	239.158	45
BH-24	27187	274.075	240.370	40
BH-25	27410	273.565	241.582	40
BH-26	27550	273.112	242.588	35
BH-27	28050	272.210	245.878	30
BH-28	28350	272.799	247.851	45

BH No.	Chainage No.	Ground Elevation, RL (m)	Formation Level as Per Alt.2A	Total depth (m)
BH-29	28550	269.964	249.134	30
BH-30	28750	270.808	250.384	45
BH-31	29050	267.159	252.259	20
BH-32	29550	266.684	255.384	30
BH-33	30125	265.581	258.588	20

5.2 Field Tests for SOIL:

Field tests are conducted in boreholes that are taken along the proposed tunnel alignment and the station locations. The following table shows the summary of field tests conducted in Soil & Rock as part of the

Field Tests	Type of Test
In Soil	Standard Penetration Test

5.3 Laboratory Tests for SOIL:

Laboratory tests were also carried out on soil and rock samples, the details of different laboratory tests conducted as part of the project are given in the table below

Table 5.2: Details of laboratory test conducted for soil.

Sl. No.	Laboratory tests	IS Codes
1	Preparation of soil sample	IS: 2720(part-1)-1983 (Reaffirmed 2015)
2	Moisture Content	IS: 2720(part-2)-1973 (Reaffirmed 2015)
3	Specific Gravity	IS: 2720(part-3)(sec-1)-1980 (Reaffirmed 2016)
4	Grain Size Analysis	IS: 2720(part-4)-1985 (Reaffirmed 2015)
5	Atterberg's Limits	IS: 2720(part-5)-1985 (Reaffirmed 2015)
6	Bulk Density	----
7	Triaxial Shear Strength	IS: 2720(part-11)-1993 (Reaffirmed 2016)
8	Direct Shear Strength	IS: 2720(part-13)-1986 (Reaffirmed 2016)
9	Consolidation Test	IS: 2720(part-15)-1986 (Reaffirmed 2016)

5.4 Laboratory Test Result of SOIL:

This section comprises depth wise results of the tests conducted in laboratory for soil masses in accordance with relevant standard codes of practices. Multiple tests in laboratory (Table 5.2)are adopted to ascertain the different essential characteristics of sub-surface using field samples obtained in during field investigations and borehole drilling. The tests as under have been conducted to ascertain the parameters indicated in the test.

Representative core samples have been taken from the boreholes (**BH18-BH33**) along the tunnel alignment. The samples were properly labelled and packed carefully and sent NABL accredited laboratory for determining the physico-mechanical engineering properties as per Indian standardized regulation. Summary of results from the laboratory testing has been graphically presented below.

5.4.1 Cohesion:

Cohesion values from all the all kinds of soil are found to 2 group. As shown in Figure 5.1 CL type soil mass has higher cohesion value (clustered green dots in graph) ranging between 25-35 kPa and other 3 types of soil are comprised of another group with values ranging from 4-12 kPa.

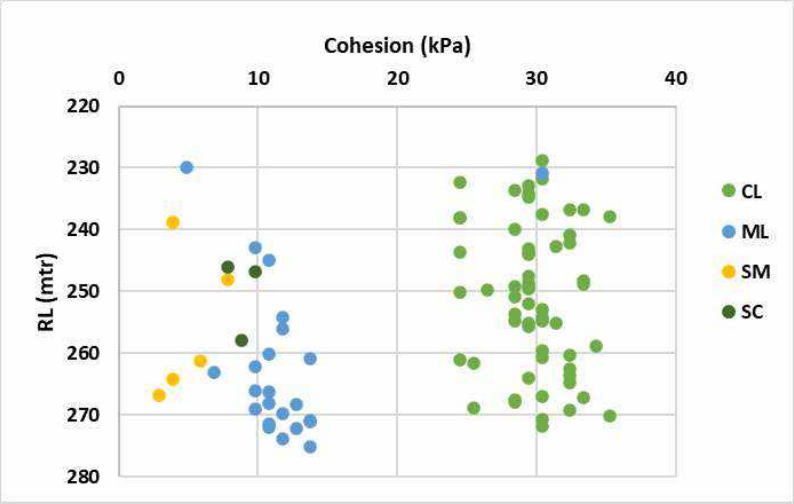

Figure 5.1 Graph showing laboratory tested cohesion for soil from entire borehole length vs RL. (Refer to Annexure J in Geotechnical Report for detail).

To make recommendation related to the engineering property of the surrounding soil, which is going to directly influence the tunnel built, samples from 2D has been considered. Pareto chart has been prepared to identify the most frequent and categorically influential data set out of the scattered values. It is based on 80/20 rule, i.e., "Vital few and trivial many" principle. The idea is that the few identified vital values will always statistically dominate over many.

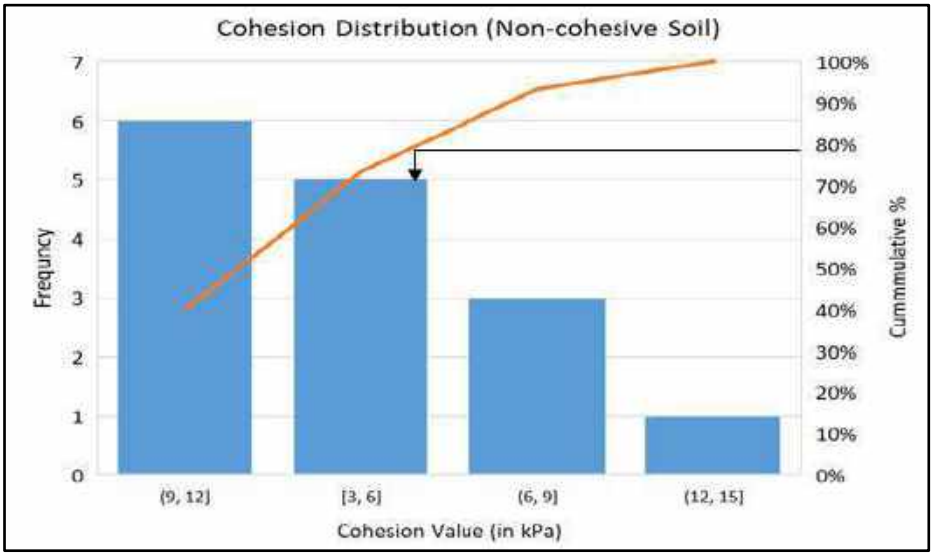

Figure 5.2: Pareto Chart showing recommended cohesion value for the non-cohesive soil within 2D depth.

80% of the laboratory tested cohesion value for SM and ML type of soil samples from 2D depth shows a scattered range of values ranging from 3-12 kPa. For safer construction the lower value of the range **3 kPa** is recommended for cohesive strength of the noncohesive soil.

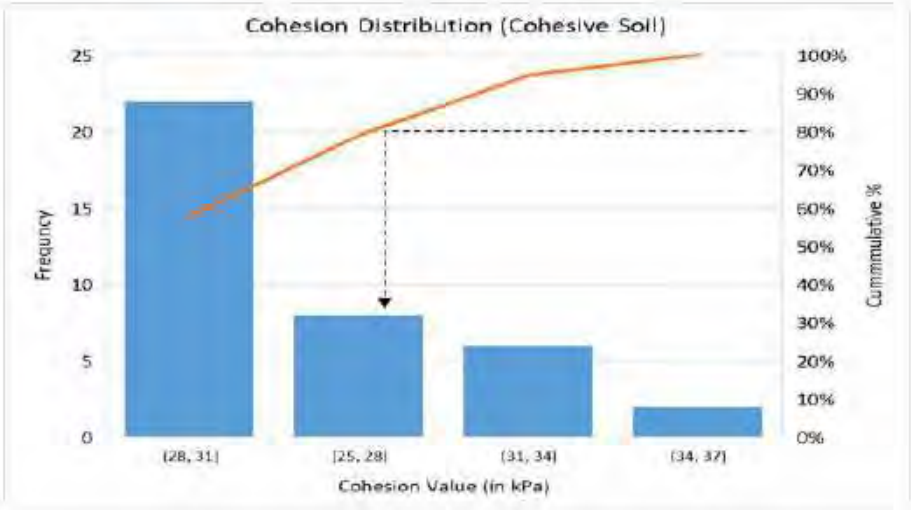

Figure 5.3: Pareto Chart showing recommended cohesion value for the cohesive soil within 2D depth.

80% of the laboratory tested cohesion value for the CL type of soil sample from 2D depth ranges between 25-31 kPa. For safer construction the lower value of the range **25 kPa** is recommended for cohesive strength of the cohesive soil.

5.4.2 Natural Weight:

Density (Natural Weight) of all kind of soil found to be linearly increasing with depth. The trend of variation with depth is shown below in Figure 5.4.

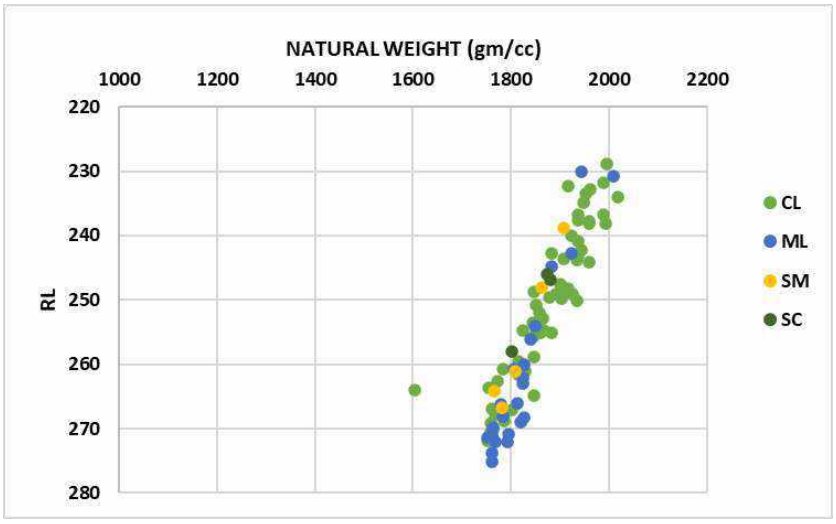

Figure 5.4: graph for Natural weight of soil from entire borehole length vs RL (Refer to Annexure J in Geotechnical Report for detail).

Natural weight value has been recommended (separately for both group of soil) using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

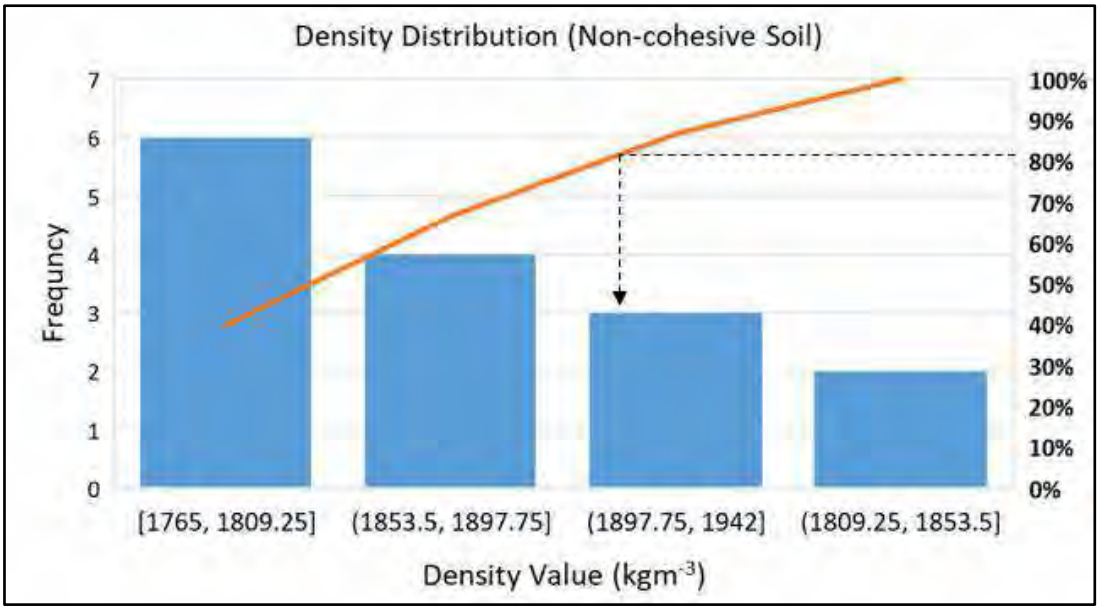

Figure 5.5: Pareto Chart showing recommended density value for the non-cohesive soil within 2D depth.

80% of the laboratory tested Density value for the SM and ML type of soil samples from 2D depth ranges between 1765 - 1942 kgm^{-3}. For safer construction the lower value of the range **1765 kgm^{-3}** is recommended for density of the noncohesive soil.

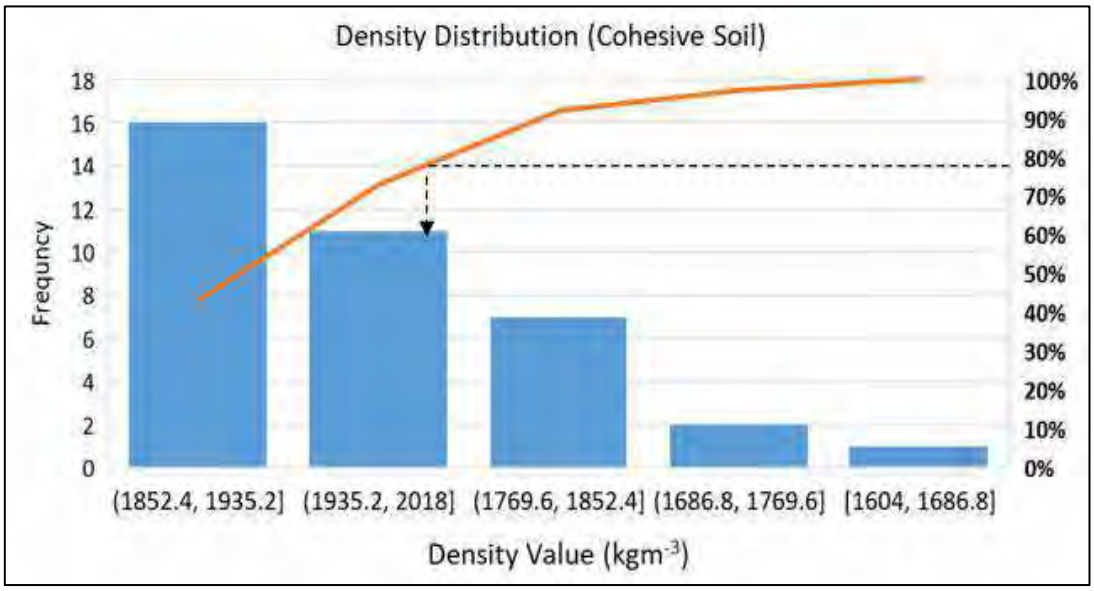

Figure 5.6: Pareto Chart for recommended density value for the cohesive soil within 2D depth.

80% of the laboratory tested density value for the CL type of soil samples from 2D depth ranges between 1852 -2018 kgm^{-3}. For safer construction the lower value of the range **1852 kgm^{-3}** is recommended for density of the cohesive soil.

5.4.3 Modulus of Elasticity (E):

The drained modulus (E') values are determined based on the corrected SPT N value –N_{60} for granular as well as cohesive soils. For cohesive soil– **$E' = 1.2\times N_{60}$ (MPa)**, and for cohesionless soil– **$E' = 1.0\times N_{60}$ (MPa). Modulus of elasticity** was found to be increasing from 10 MPa to 15 MPa with depth up-to first 15 meter from the surface (Figure 5.7), after which it falls within a constant range of value around 30±1 MPa up-to the floor of the tunnel.

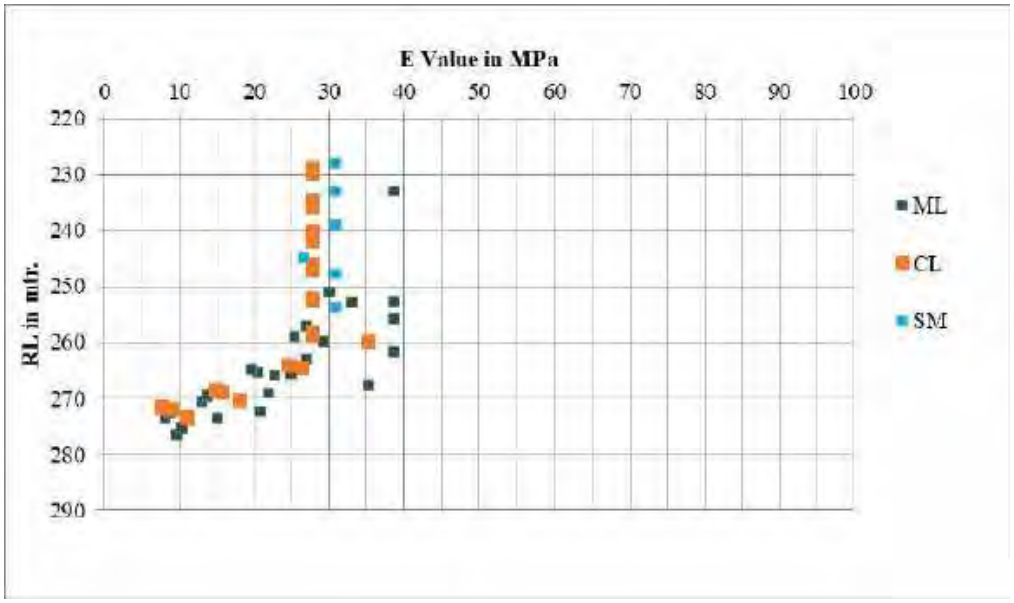

Figure 5.7: graph for Modulus of elasticity for soil from entire borehole length vs RL. (Refer to Annexure J in Geotechnical Report for detail).

Natural weight value has been recommended (separately for both group of soil) using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

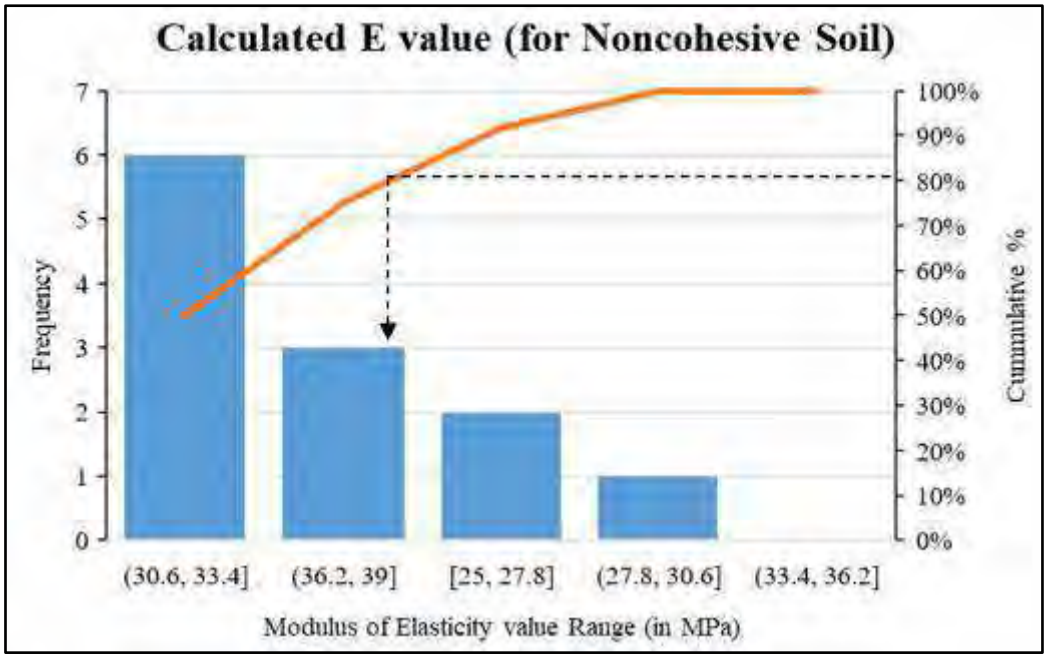

Figure 5.8: Pareto Chart for recommended E value for the non-cohesive soil within 2D depth.

As shown in the *Pareto Chart* above, 80% of the calculated Modulus of Elasticity (based on the equation $E=N_{60}$) for the noncohesive (SM & ML) soil sample from 2D depth ranges between 30.6-39 MPa. For safer construction, the lower value of the range **30 MPa** is recommended as the E value for the noncohesive soil. No pareto chart has been constructed for Cohesive Soil (CL), because they have consistent E value of 28 MPa for all the samples from 2D depth. Hence, **28 MPa** is the recommended Modulus of Elasticity for the cohesive soil.

5.4.4 Angle of internal friction (ϕ) for non-cohesive soil

Angle of internal friction (ϕ) for non-cohesive soil has been determined depth wise from the corrected field SPT N value as per IS2131. To make a recommendation for the phi value of non-cohesive soil samples (**from BH18-BH33**) were analyzed from 2D elevation from the tunnel formation level. As shown below in the Figure 5.9 , 95% of the phi values (2 Sigma) in the 2D lies within a range of ***31.53 ±2.72.*** The variation in phi values within the range being absolutely normally distributed, we can safely consider the mean value (rounded up) ***32°*** as the recommended phi value for construction.

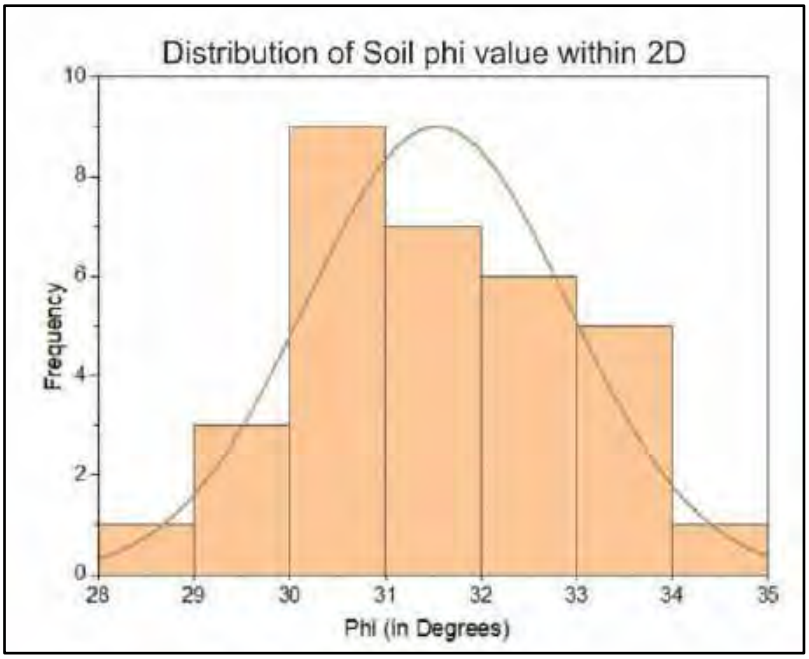

Figure 5.9: Distribution of non-cohesive soil Phi value within 2D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).

To be even more precise similar statistical analysis were carried out separately for the soil samples along the tunnel alignment and those are form 1D elevation from the crown. Results are graphically shown in the Figure 5.10 and Figure 5.11.

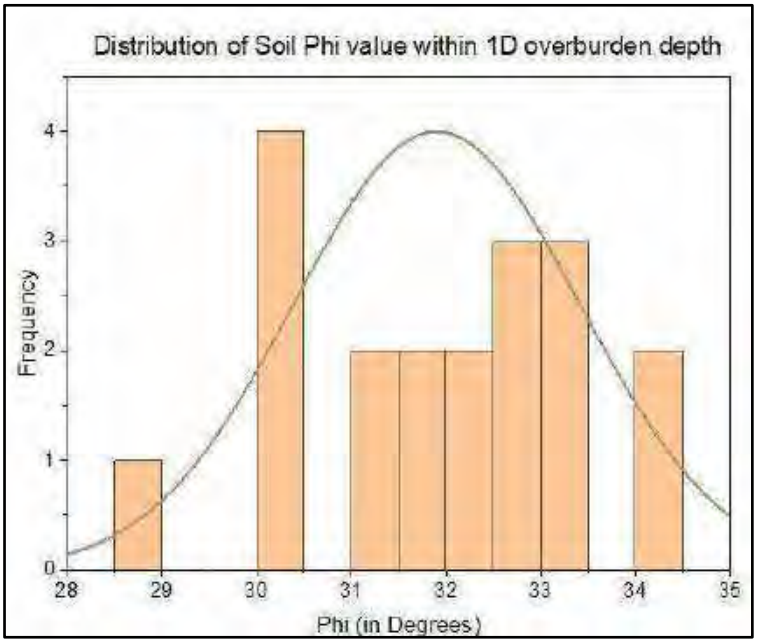

Figure 5.10: Distribution of non-cohesive soil Phi value within 1D overburden depth

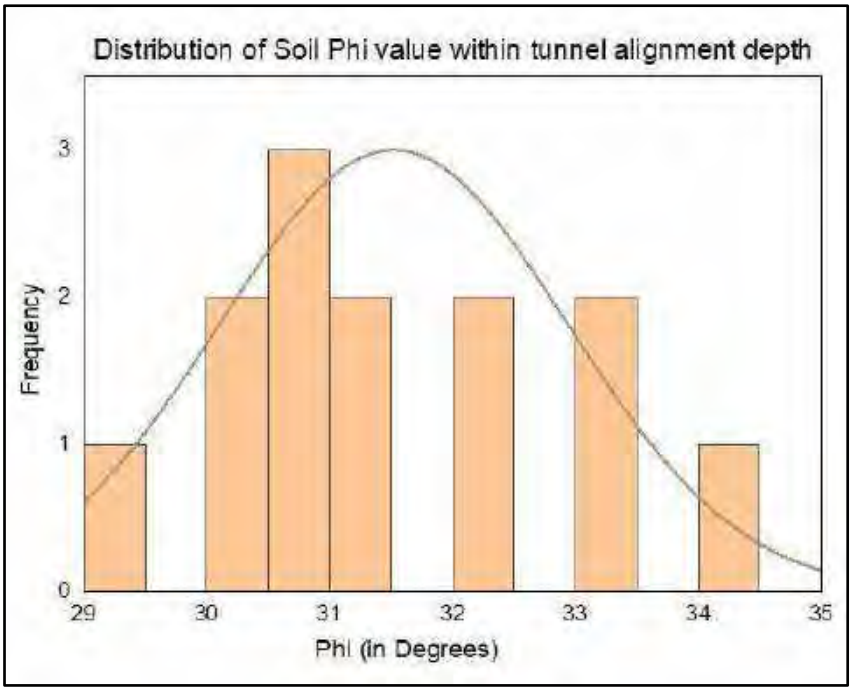

Figure 5.11: Distribution of non-cohesive soil Phi value within tunnel alignment.

It was found from above two graphs that, 95% of the samples have phi values in the range of ***31.68±2.8*** for the 1D depth (Figure 5.10), while ***31.32 ±2.64*** for the tunnel alignment (Figure 5.11). Therefore, **the recommended phi value of *32°*** still remains valid even if tunnel alignment and 1D above it are considered separately.

5.4.5 Angle of internal friction (ϕ) for cohesive soil

Angle of internal friction (ϕ) for cohesive soil has been determined depth wise from laboratory test. To make a recommendation for the phi value of cohesive soil samples (from **BH18-BH33**) were analysed from 2D and 1D elevation from the tunnel formation level. As shown below in the Figure 5.12 & Figure 5.13, 95% of the phi values (2 Sigma) in the 2D and 1D lies within a range of 11.6 ±2.06 and having a modal value of 10. Therefore, as a representative value of phi for the cohesive soil is recommended to be **12°.**

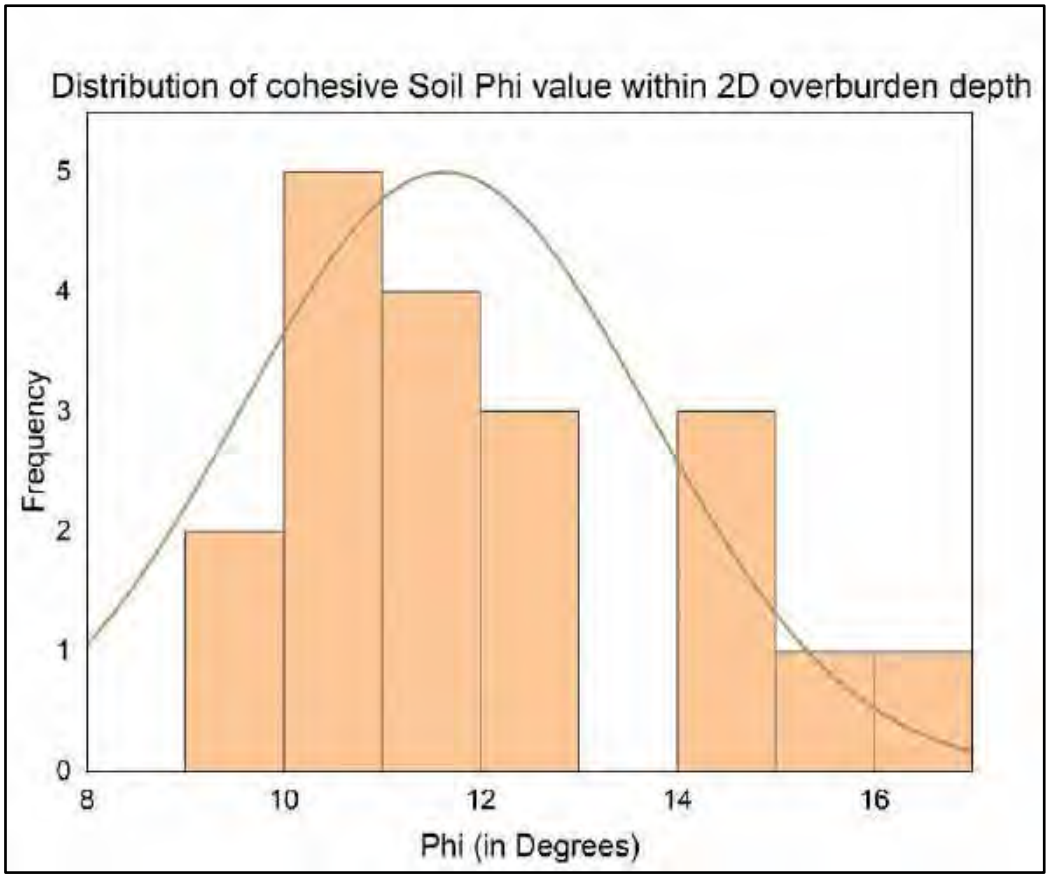

Figure 5.12: Distribution of cohesive soil Phi value within 2D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).

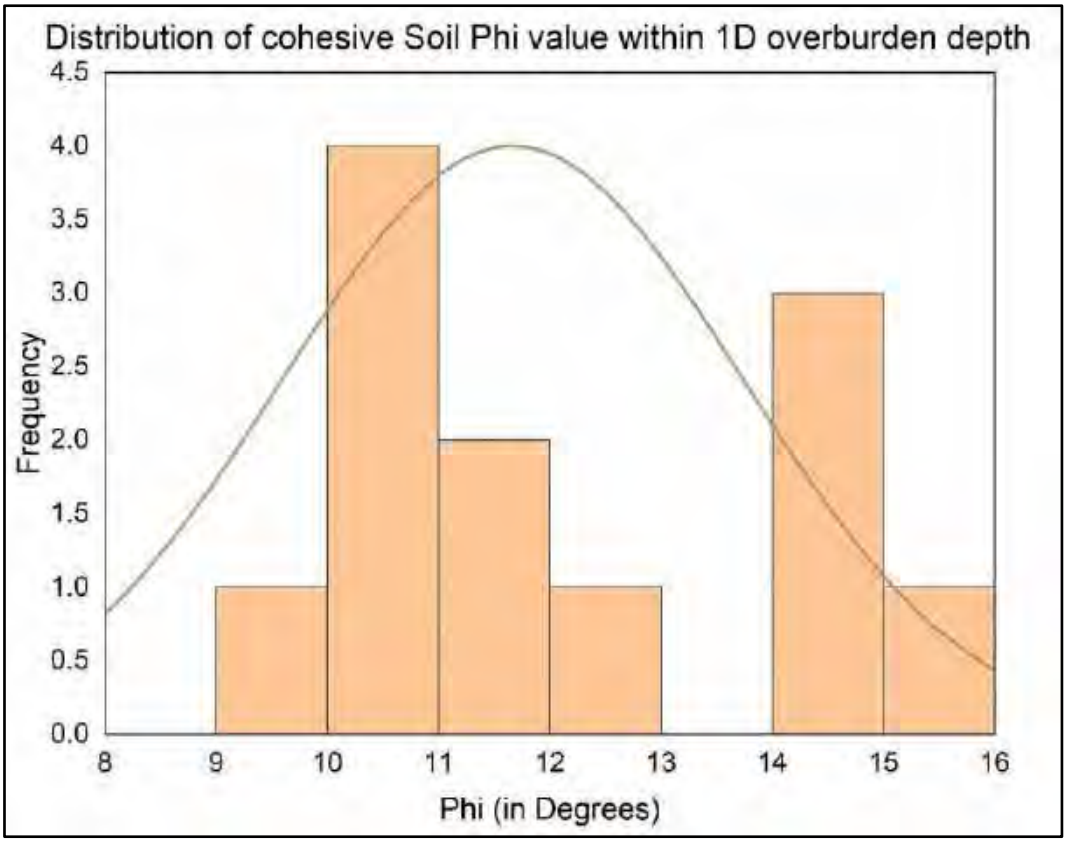

Figure 5.13: Distribution of cohesive soil Phi value within 1D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).

** **for chainage wise variation in C and ϕ values refer Figure 3.12 to Figure 3.15**

***** All the recommended values for different soil parameters are tabulated in Table 6.2, Chapter-6: Conclusion and Recommendations**.

6 Conclusion and Recommendations:

The total tunnel length is 4.7 km (CH24900-CH29600), out of which 1.1 km (CH24900-CH25980) km of tunnel will be within the quartzite rock mass of Delhi Supergroup with Portal-I at CH24900. 2.9 km (CH25980-CH28900) km of the tunnel will be through soil and a NATM structure will be built at CH28900. 700m after this structure will be cut & cover in soil and the Portal-II will be built at CH29600.

Based on the available surface information from the geological field investigation and close observation of the drilled cores from the litho-logs, it has been observed that after crossing the soil the tunnel will enter into a folded rock mass where the axis of the tunnel will be perpendicular to the fold axis, thus favorably oriented with respect to the folded bedding planes. However, the folded rock layer has suffered extreme level of later brittle fracturing, which has been testified by the presence of 6 sets of joints of different orientation and a few late brittle discrete shear zones (which is certainly not active in nature). These joints and the fractures have significantly reduced the strength of the otherwise sufficiently cohesive metamorphic rock mass. Presence of the intersecting closely spaced joint sets make the tunnel part within the rock body highly susceptible to wedge failure.

From the results of different on-site and laboratory tests of the rock samples, the recommended values for the different parameters are tabulated below;

Table 6.1: Recommended values for engineering properties of rock

ROCK	
Properties	**Values**
Lugeon Value	28.4
UCS (MPa)	60 MPa
RMR	20-40 (CLASS IV)
Tensile Strength (MPa)	15 MPa
Point Load Strength (MPa)	2.5 MPa
Modulus of Elasticity (GPa)	39 GPa
Poisson's Ratio	0.15
Hardness	55
Abrasion index	3.30
Cohesion (MPa)	15 MPa
Phi (degree)	55°
Water absorption	0.54 %

The rock mass as a whole statistically belong to Class-IV. Therefore, as per Bieniawski, 1989, systematic bolts 4-5m long, spaced 1-1.5 m in crown and walls with wire mesh, 100-150 mm shotcrete in crown and 100mm shotcrete in sides, light to medium steel ribs spaced 1.5 m is recommended as tunnel support. However, along some chainage interval the support system of Class III may be used by the discretion of the design engineer. For chainage wise variation in RMR value refer to Figure 3.11.

Almost 2.5 km of tunnel will be running through the soil, which constitutes 44% of Inorganic Clay rich Soil (CL), 33% of Inorganic Silty Soil (ML) and kanker and 23% is Silty Sand (SM). The recommended values for the different parameters for soil are tabulated below;

Table 6.2:Recommended values for engineering properties of soil.

	TYPE OF SOIL	MIN.	MAX.	Recommended Values
FIELD N VALUE		11	50	
CORRECTED N VALUE		5.75	29	
Cohesion (C) (from Laboratory Test)	CL	23.54 kPa	35.30 kPa	25 kPa
	ML	1.96 kPa	18.63 kPa	3 kPa
	ML-CL	7.85 kPa	19.61 kPa	
	SM	1.96 kPa	3.92 kPa	
Φ for cohesive soil (from Laboratory Test)	CL	9°	16°	12°
Φ for non-cohesive soil (from corrected N Value)	ML	28°	36°	32°
	ML-CL	29°	34°	
	SM	29°	32°	
Modulus of Elasticity (E)	Cohesive (CL)	28 MPa	28 MPa	28 MPa
	Non-Cohesive (ML, SM, ML-CL)	25 MPa	39 MPa	30 MPa
Density	Cohesive (CL)	1604 kg/m^3	2018 kg/m^3	1852 kg/m^3
	Non-Cohesive (ML, SM, ML-CL)	1752 kg/m^3	2009 kg/m^3	1765 kg/m^3

None of the boreholes reached the ground water table. Therefore, based on the preliminary survey, it can be predicted that the tunnel will not face any difficulty due to encounter of ground water table during the construction. However, the overlying rock strata having significant nos. of joint set is quite capable of percolating rain waters during the rainy seasons. There is also a ditch around CH 25500, which is situated almost 31.87m above the roof of the tunnel. This ditch may be connected to a perched water table with a limited water resource. The joint sets and the ditch may act as efficient path ways of rainwater recharge into the tunnel during the rainy season. Therefore, it may be recommended that suitable drainage system should be designed along with the tunnel to drain out that percolated water to avoid water logging during and after the construction of the tunnel. However, such kind of ingress of water is purely seasonal and temporary. Therefore, the water-proofing membrane may also be dispensed with.

iii. Geotechnical Investigation Report
SR NO.: 544_21-22
Old Ch. 27+620 to Old Ch.28+900 km

Geotechnical Investigation Report

Old Ch. 27+620 to Old Ch. 28+900 km
(New CH: 28+287 to 29+567) km

SR NO. : 544_21-22

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA

CLIENT

M/S. HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (HRIDCL)

PROGRAMME

JUNE - 2022

SR. No.	Report No.	Revision No.	Date
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/938_(18 BHs)	00	03.10.2022

CEGTH
CEG TEST HOUSE
AND RESEARCH CENTRE PVT LTD

B-11(G), Malviya Industrial Area, Jaipur-302017
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E-mail : info@cegtesthouse.com., www.cegtesthouse.com

CEGTH/HRIDCL/SR-544/2022-23/938 Date:- 03.10.2022

To,

Haryana Rail Infrastructure Development Corporation Ltd. (HRIDCL)
SCO No.-17-19, 3rd & 4th Floor,
Sector - 17-A,
Chandigarh - 160017
Tele:- 0172-2715644
Email: hridc2017@gmail.com

Subject :- Geotechnical investigation work for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana.

Dear Sir,

We are pleased to submit this report of the subject work based on 18 borehole carried out at Old Ch. 27+620 to Old Ch. 28+900 (New CH: 28+287 to 29+567) for the proposed project site.

The accompanying report presents results of various field tests and laboratory tests conducted on selected soil samples and their interpretation.

Should there be any clarifications regarding the contents please contact us at your most convenient time.

We value the opportunity to participate in this project and look forward a pleasant association on future projects.

Very truly yours,
CEG Test House & Research Centre Pvt. Ltd.

Nehal Jain
General Manager - Geotechnical
Authorized Signatory

Prepared By:-

Ankur Mudgal
Sr. Manager

SR. No.	Report Ref. No.	Revision No.	Date
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/938_(18 BHs)	00	03.10.2022

CONTENTS

LIST OF FIGURES / TABLES

CHAPTER 1 GENERAL

1.0 INTRODUCTION:

The work of conducting "**Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana"** was awarded to "**CEG Test House & Research Centre Pvt. Ltd., Jaipur" by M/S.** "**Haryana Rail Infrastructure Development Corporation Ltd. (HRIDCL)"** as per work order no. HRIDC/ HORC/ GT/ CEG/ 237/ 2021/ 577-M dated 29th July 2021.

Field work including drilling of boreholes, conducting field tests such as Electrical Resistivity Test, & Plate Load Test and sample collection was carried out in the presence of representative of Client. Laboratory tests were conducted on selected soil samples to determine the design parameters, confirming to relevant IS specifications and the guidelines received from time to time from representative of Client.

This report includes the details of Methodology of Investigation, collection of samples of soil, field test results, laboratory test results, analysis of results and recommendations for proposed structure carried out at Old Ch. 27+620 to Old Ch. 28+900 (New CH: 28+287 to 29+567). based on soil sample collected from the locations of 18 boreholes.

2.0 SITE LOCATION & GENERAL GEOLOGICAL HISTORY:

The details of the site & test locations for the proposed project are shown in location plan attached vide **Appendix A-1**. The site of proposed project is located from Palwal to Harsana Kalan (Sonipat) in the State of Haryana falls in seismic zone – IV (Zone factor=0.24) of India.

Soil of the Haryana Sub-Region have been classified and described under the following major soil types as shown below:-

- Typic Ustochrepts : Soil of old alluvial plains
- Typic Ustipsamments : Soil of Aravali plains
- Typic Ustifluvents : Soil of recent alluvial plains and flood plains
- Typic Torripsamments : Soil of Aeofluvial plains
- Rocky Outcrops : Aravali rocky hills

The district wise details of soil characteristics are described below:-

Panipat: The soils are well drained, Sandy loam to clay loam/silty clay loam in plains and loam to clay loam/ silty/ loose clay loam in relic channels/depressions/basins.

Sonipat: The district comprises of recent flood plains, young meander plains, old meander plains and old alluvial plains. Recent flood plains occur along the Yamuna River and clearly show fluvial features. The soils are loamy sand to sandy loam on the surface and sandy loam to clay loam in the sub surface.

Rohtak: The district mainly comprises of old alluvial plains. The soils are loamy sand to sandy loam on the surface and sandy loam to clay loam in the sub surface. Old meander plains are almost flat with loamy sand to silty clay loam soils. Oldest among all the land forms are old alluvial plains, which cover major areas in the district. These soils are sand to loamy sand/sandy loam (surface) to silt loam/silty clay loam (sub-surface).

Jhajjar: The district mainly comprises of old alluvial plains and some parts of the district also have soil belonging to Aravali plains.

Rewari: The soils of the district fall under Entisols and Inceptisols orders. The surface soil texture varies from sand to fine loamy sand.

Gurgaon: The district comprises of sand dunes, sandy plains, alluvial plains, salt affected areas,

low lands, lakes, hills and pediments. The soil varies from sand to loamy sand in sand dunes and sandy plain areas, sandy loam to clay loam / silty clay loam in alluvial plains, calcareous, loamy sand to loam in salt affected plains, silty loam to loam in low lands and calcareous, loamy sand to loam in hills.

Mewat: The soils of the area are generally sandy loam to loam. In parts of the low-lying areas, they are clayey and saline. The upper hills are mostly barren.

Faridabad and Palwal: The district comprises of recent Yamuna flood plains, low lying plains, depressions, sand dunes and hills. The texture of the soil is sand to loamy sand in recent Yamuna flood plains, sandy loam in plains, sandy loam to clay loam in alluvial plains, sandy loam to loam

(surface), clay loam/silty clay (sub-surface) in low lying plains and depressions.

3.0 SCOPE OF WORK:

The stipulated scope of work involved carrying out the following operations:-

a) Mobilisation of necessary plant equipment, men and materials for the complete Geotechnical investigation work as per specifications, drawings and instructions of the Engineer and to complete the same within the stipulated time schedule and demobilisation after completion of field work.

b) Shifting of Equipments from one structure location to another including Ereaction, installation of rigs at site and dismantling of the same after completion of field work. Shifting of setup for each borehole location and associated preparation for borehole under water

c) Making 150 mm nominal diameter boreholes at various locations in all types of soils except hard rock and large boulders using suitable approved method of boring including chiselling, cleaning, providing casing pipe as required; performing Standard Penetration Test at every 3.0m interval and at change of strata; collection of water samples and disturbed soil samples, observation such as ground water, etc., collection of undisturbed soil samples at every 3.0 m interval and at change of strata; transportation of all the collected samples to the laboratory and back filling of boreholes on completion of the same, complete as per specification and instructions of the Engineer, for depths below natural ground level.

d) Conducting Electrical resistivity tests at various locations all complete as per specification and directions of the Engineer.

e) Conducting plate load test at various locations, all complete as per specification and directions of the Engineer.

f) Drilling of Nx size boreholes (75mm dia.) in all types of hard rock, collection of core samples, maintaining continuous record of core recovery/ RQD, keeping the cores in wooden core boxes, transporting to laboratory, backfilling on completion of the same, all complete as per specification and instructions of the EIC.

g) Conducting various laboratory tests on soil samples at an approved laboratory including preparation of soil samples to determine the following properties of soil, all complete as per specification.

<u>On soil Samples</u>

- Dry density test
- Bulk Density and Moisture Content.
- Sieve Analysis
- Hydrometer Analysis
- Liquid Limit and Plastic Limit
- Specific gravity
- Shrinkage Limit

- Free Swell Index
- Direct Shear Test
- Triaxial Shear Test
- One Dimensional consolidation test
- Chemical Analysis of soil samples (pH, chloride, Sulphate)

h) Conducting laboratory tests on rock samples including preparation of the samples to determine the following properties, all complete as per specification

<u>On Rock Samples</u>

- Moisture content, porosity & Density
- Specific gravity
- Hardness
- Unconfined compression test
- Point load strength index
- Modulus of Elasticity and Poission's Ratio
- Abrasion Test

i) Conducting chemical tests on water samples to determine the Sulphate, chloride and pH value all complete as per specification.

j) Submitting draft report in soft copy including all field records and laboratory test results, graphs, etc., all complete as per specifications.

k) Submitting final report in three hard copies in after the approval of the draft report including all field records and laboratory test results, graphs, etc., all complete as per specifications.

4. FIELD INVESTIGATION IN SOIL STRATA:

The investigation was planned to obtain the subsurface stratification in the proposed project site and collect soil / rock core samples for laboratory testing to determine the engineering properties such as shear strength, along with basic engineering classification of the subsurface stratum.

For geotechnical investigation work, required equipements along with rotary drilling rigs and manpower were mobilized at site to carry out various field activities as per the scope of work. These were shifted from one test location to another location during execution of field work and were demobilized on satisfactory completion of field work.

For conducting the field investigations the following practices were followed at site:

- The locations of 18 boreholes carried out at Old Ch. 27+620 to Old Ch. 28+900 (New CH: 28+287 to 29+567) were marked at site at specified locations. These locations are shown in **Appendix A-1** attached subsequently.

The details of various boreholes along with their coordinates are provided herein below:

Table 1.1: Details of Borehole Locations

S. No.	Chainage Old (km)	Chainage New (km)	Structure	BH.No.	Depth of Water Table below EGL (m)	Depth of Borehole below EGL (m)	Co-ordinates (m)		(+) R.L. (m)
							E	N	
1.	27+620	28+287	Major Bridge	BH-A1	33.10	40.00	697786.663	3123079.115	270.946
2.				BH-P1	32.90	40.00	697786.520	3123062.116	271.001
3.				BH-P2	33.00	60.00	697786.377	3123047.116	271.080
4.				BH-P3	33.13	60.00	697786.129	3123021.117	270.749
5.				BH-P4	33.14	50.00	697785.986	3123006.118	271.774
6.				BH-A2	33.12	40.00	697785.825	3122989.119	271.929
7.	28+075	28+743		BH-A1	32.67	55.00	697330.702	3123086.726	269.806
8.				BH-P1	32.68	55.00	697330.717	3123064.726	270.070
9.				BH-P2	33.20	55.00	697330.724	3123026.726	270.499
10.				BH-A2	33.21	55.00	697330.724	3123004.726	270.616
11.	28+360	29+028		BH-A1	34.78	40.00	697053.722	3123109.166	268.602
12.				BH-P1	34.10	50.00	697050.915	3123091.386	267.861
13.				BH-P2	33.85	50.00	697046.700	3123064.680	267.285
14.				BH-A2	34.20	40.00	697043.901	3123046.953	267.528
15.	28+900	29+567		BH-A1	36.90	40.00	696531.197	3123223.834	262.678
16.				BH-P1	38.10	50.00	696528.146	3123214.311	263.022
17.				BH-P2	34.55	50.00	696520.214	3123189.550	263.955
18.				BH-A2	34.50	40.00	696517.163	3123180.027	263.847

***Not Encountered:-NE**

- In soil, boreholes of 150mm dia. were drilled as per the standard procedure laid in IS: 1892.
- Borehole was properly cleaned before taking any sample in soil.
- Casing was used as per the prevailing soil conditions, to stabilize the borehole.
- Standard Penetration Tests were conducted in bore holes at regular intervals or at every change of strata as per Technical specification.
- Undisturbed were collected wherevery feasible as per the requirements and at specified depths. The same has been discussed in detail in soil characteristics sheets attached with the report.
- The Ground Water Table was met at depths of from 32.67m to 38.10 m below EGL. The detailed procedure adopted for conducting various field tests is given here in below:

(i) Standard Penetration Test:

The Standard Penetration Test was conducted in boreholes as per IS 2131. The test was carried out using the standard split spoon sampler to measure the number of blows 'N'.

Standard split spoon sampler was attached to an 'A' rod. It was driven from borehole bottom to a distance of 45 cm using a standard hammer of 63.5 kg falling freely from a height of 75 cm to the required depth. While driving, the number of blows required to penetrate every 15 cm are recorded. The total number of blows required for the last 30 cm is taken as 'N' value at that particular depth of the borehole. Wherever the total penetration was less than 45cm, the no. of blows & the depth penetrated is recorded in the respective borelog.

SPT 'N' values were correlated with relative density of non-cohesive stratum and with consistency of cohesive stratum as given below:-

Table 1.2: Soil compactness as per SPT N values (cl. 9.7, table 9.3 & 9.4, page 330_text book of V.N.S. Murthy)

Correlation for Clay / Plastic silt		Correlation for Sand / Non-Plastic silt	
Consistency	**SPT "N" Value**	**Compactness**	**SPT "N" Value**
Very Soft	0 - 2	Very Loose	0 - 4
Soft	2 - 4	Loose	4 - 10
Medium	4 - 8	Medium	10 - 30
Stiff	8 - 15	Dense	30 - 50
Very Stiff	15 - 30	Very Dense	> 50
Hard	> 30		

The field SPT N values obtained were further corrected as per the guidelines given in IS: 2131 as follows:

(a) For overburden: - The N value for cohesionless soil is corrected with the help of fig. 1 given in IS-2131.

(b) Due to dilatancy :- Wherever N values observed below water table in fine sand, silty sand or silt was greater than 15, then corrected N values were corrected as under:

$$N' = 15 + \tfrac{1}{2}(N-15)$$

(ii) Undisturbed Sampling (Soil) in boreholes:

Undisturbed samples were collected using MS tubes of suitable diameter and length with Area ratio as per clause 4.1.1 (c) of IS: 1892 (latest) fitted to an adopter with ball and socket arrangement. Before taking any sample, sampling tube was properly greased. Immediately after taking on undisturbed sample in a tube, the adopter head was removed along with the disturbed material. The visible ends of the sample were trimmed off any wet disturbed soil. The ends were coated alternately with four layers of just molten wax. More molten wax was added to give a total thickness of min. 25

mm. The samples were carefully labeled and transported to the laboratory for testing. Undisturbed samples wherever slipped during lifting were duly marked in the field logs as well as in the soil profile.

5.0 LABORATORY TESTS ON SOIL SAMPLES:

The following laboratory tests were conducted on selected soil samples:

Table 1.3: Description of Tests

Description of Test	Reference	Undisturbed (UDS) Soil Samples	Disturbed (DS/SPT) Soil Samples
Grain Size Analysis / Hydrometer	IS: 2720 (Part - 4)	√	√
Natural Moisture Content / Bulk / Dry density	IS : 2720 (Part – 2)	√	-
Atterberg Limits • Liquid Limit • Plastic Limit	 IS: 2720 (Part - 5) IS: 2720 (Part - 5)	 √ √	 √ √
Specific Gravity	IS : 2720 (Part – 3)	√	√
Direct Shear Test	IS : 2720 (Part – 13)	√	√
Triaxial compressive shear test	IS : 2720 (Part – 11 & 12)	√	√
Chemical Analysis of Soil Samples	IS : 2720 (Part – 26, 27)	√	-

Note:- The detailed procedure adopted for conducting various laboratory tests is described in the following paragraphs:

5.1.1 Dry density and Bulk density

For determination of bulk density and dry density, a sample of known volume 'V' was extracted from the undisturbed sampling tube and it's bulk weight 'W' was noted down.Moisture content 'Wn' was determined by oven drying method.

The bulk density and dry density were determined by following equation-

Bulk density (γ_b) = W/V

Dry density (γ_d) = γ_b/ (1+Wn)

5.1.2 Natural water content

For this test, the soil sample of known quantity (Wm) was taken in a container.The container with soil sample was placed into an oven for drying at 105-110°c temperature for 16-24 hours. After drying, the dry sample was again weighted to determine the dry weight of sample (Wd).

The natural water content was computed by the following equation-

Wn = (Wm-Wd)*100/Wd

5.1.3 Grain Size Analysis (IS: 2720- Part-4)

Wet sieve analysis:

For determination of particle sizes finer than 75 micron, wet sieve analysis test was conducted. For this test, oven dried sample of known quantity was taken in a container and soaked with dispersing agent. The soaked soil sample was washed thoroughly over 75 micron IS sieve until the water passing sieve was substantially clean.

Fraction retained on 75 micron IS sieve was carefully collected in a container without any loss in material and placed into oven for drying.

Dry sieve analysis:

For this test, the oven dried soil sample after wet sieving was sieved through the set of IS sieves 20 mm, 10 mm, 4.75 mm, 2.0 mm, 1.0 m , 425 micron , 300 micron, 150 micron and 75micron. The amounts of soil retained on each sieve were noted down. The % retained, cumulative % retained and % passing were computed accordingly. Wherever the soil sample % passing 75 micron sieve was significant, Hydrometer method was used to find the percentage of silt and clay fraction.

Grain size analysis for the fraction passing 75 micron IS Sieve (Hydrometer method)

Calibration of Hydrometer

Hydrometer was calibrated to determine a relationship (an equation) between the effective depth H_R and corresponding hydrometer reading R_h (obtained during test).

50 to 100 gm of soil sample passing through 75 micron IS Sieve was taken. It was mixed with 100 ml of sodium hexametaphesphate solution and the mixture was warmed for about 10 minutes. It was then transferred to the cup of the mechanical mixer and the soil suspension was stirred for 15 minutes. The soil suspension was transferred into 1000 ml measuring cylinder and distilled water was added to make 1000ml solution. This solution was mixed vigorously. The measuring cylinder was then allowed to stand and the stopwatch was started. Hydrometer was immersed in the solution and reading were taken after half, one, two and four minutes. The hydrometer was then removed slowly and kept in distilled water at the same temperature as the soil suspension. Readings were taken after the periods of 8, 15 and 30 minutes, and one, two and four hours. Hydrometer was removed, rinsed and placed in the distilled water after each reading. After 4 hours reading was taken once or twice within 24 hours. Finally a reading was taken at the end of 24 hours. The temperature of the suspension was observed and recorded.

Calculations

Diameter of the particles (D):

$$D = \sqrt{\frac{30\mu}{980(G-1)}} \times \sqrt{\frac{H_R}{t}} = M\sqrt{\frac{H_R}{t}}$$

Where,

D = diameter of particle in suspension, in mm;

μ = co-efficient of viscosity of water at the temperature of the suspension at the time of taking the hydrometer reading, in poise;

G = specific gravity of the soil fraction used in the sedimentations analysis;

H_R = effective depth corresponding to R_n, in cm.

t = time elapsed between the beginning of sedimentation and taking of hydrometer reading in minutes

$M = \sqrt{\frac{30\mu}{980(G-1)}}$ = a constant factor for given values of μ and G at the temperature of the suspension.

Percentage finer than diameter D:

The percentage by mass (w) of particles smaller than corresponding equivalent particle diameters (D) was calculated from the formula:

$$w = \frac{100G_s}{W_b(G_s-1)} \times R_h$$

Where

w = percentage finer

G_s = specific gravity of soil particle

W_b = weight of soil

R_h = Hydrometer reading

5.1.4 Specific Gravity (IS: 2720-Part-3 Sec-1)

The specific gravity of soil sample was determined by density bottle method. For this test 5-10g oven dried and cooled soil sample was taken in 50ml capacity density bottle and its weight was noted down as W_2 .The soil was covered with distilled water and left for sufficient period for suitable soaking. The entrapped air was removed by vacuum. The bottle with soil was filled fully with water and its weight was noted down (W_3). The mass of empty bottle and bottle filled with distilled water were noted down as W_1 and W_4 respectively.

The Specific Gravity was determined by using following equation :

$G=W_2-W_1/[(W_2-W_1)-(W_3-W_4)]$

5.1.5 Liquid Limit (IS: 2720- Part-5)

By Cone Penetrometer Method

The 'Cone Penetrometer Apparatus' is a variant of the fall-cone and consists of a cone with a smooth polished surface and angle of 30° ± 1/2°. The weight of the cone, together with its associated shaft is 80g ± 0.5g. A support assembly with an automatic cone release mechanism and cone height adjustment mechanism used to hold the cone vertically. The angle and weight of the cone were calibrated at regular intervals, and the sharpness of the cone tip was checked daily.

Distilled water was added and thoroughly mixed with the soil sample to produce a homogeneous paste. The paste was then placed in a cup with a diameter of at least 55mm and a depth of at least 40mm. The surface of the soil was smoothed off level and parallel to the base. The support assembly was used to position the tip of the cone so that it was just touching the top surface of the soil, and the automatic tripping mechanism was released. The cone was allowed to penetrate into the soil for a period of 5 (± 1) s, then the cone was locked off to stop further movement and the penetration was recorded. The cup was refilled and the test was repeated. The two recorded penetrations need to be within 0.5mm of each other, otherwise a third test is performed. when the three test vary by more than 1mm the test was repeated.

Further tests were conducted, at varying water contents, in order to produce a series of cone penetrations (usually 4) in the range 15mm to 25mm. The resulting cone penetrations were plotted verses the water content of the test specimens. The Liquid Limit (W_L) was read off the graph, being the water content at which the line of best fit through the test points crosses 20mm penetration.

5.1.6 Plastic Limit (IS: 2720-Part-5)

For this test, soil sample was prepared in the same way as for liquid limit test. A ball of soil sample weighed about 5 gm was formed. The ball was rolled between the fingers of one hand and the glass plate with pressure sufficient to reduce the mass into a thread of about 3 mm in 5 to 10 complete forward and back movements. When a diameter of 3 mm was reached, soil was again remolded into a ball. The process of rolling and remolding was repeated until the thread started just crumbing at a diameter of 3 mm. The crumbled thread was immediately transferred to an airtight container for determination of its moisture content by oven drying method.

This water content has been termed as plastic limit. (W_P)

5.1.7 Plasticity Index (IS: 2720-Part-5)

The plasticity index Ip was given by

$I_p=W_L-W_P$ (in percent)

5.1.8 Direct Shear Test (IS:2720-Part-13):

For this test shear box test apparatus was used. The prepared specimen from remolded/undisturbed sample was placed carefully in the box. The plain grid was kept on top of the specimen with its directions at right angles to the direction of shear. The upper porous stone was placed on the grid and loading pad on the stone. The box with specimen was gently placed in the container (water jacket). The specimen was submerged with water. The container was mounted with the shear box and the specimen inside, on the shearing machine. The upper part of the box was so adjusted that it touchéd the proving ring. The jack was brought forward to bear up against the box container. The proving ring dial gauge was set to read zero.

The steel ball was placed in the recess of the loading pad. The loading yoke was set in contact with the steel ball on the loading pad. Vertical displacement dial gauge to read zero in contact with the top of the yoke. The normal load was applied and any change in thickness of specimen was recorded. Shear displacement dial gauge was also set to read zero. The locking screw was now removed and two parts of the shear box were separated by advancing the spacing screws.

The specimen was sheared at constant rate of strain. The readings of the proving ring dial gauge were noted down every 15 seconds for the first one-minute and then every 30 seconds thereafter. The reading of change in the thickness dial gauge and shear displacement dial gauge were also recorded at the same time interval. The test was continued until the specimen fails. The specimen was assumed to fail when the proving ring dial gauge started receding or at shear displacement of approximately 15% of the length took place.

The soil was removed from the box and test was repeated on the identical specimen under increased normal load.

The rate of strain for conducting Direct Shear Test is kept as 0.25 mm/min as per codal/literature provision based on strata.

5.1.9 Triaxial Shear Test_UUT (IS: 2720-Part-11)

For this test, Triaxial Shear Test apparatus was used. The plain disc was placed on the pedestal of the triaxial cell. The specimen was placed centrally on the disc. A correct size rubber membrane was fitted inside the stretcher with ends of membrane folded over those of the stretcher. Vacuum was applied to stretch the membrane to the inside surface of the stretcher which was carefully slipped around the specimen kept on the pedestal. The vacuum on the membrane was released. Its bottom part was rolled down into the pedestal. plain disc was placed on the top of the specimen and then loading pad was placed. The top part of membrane was rolled on to the loading pad. Then the stretcher was removed and ends were sealed with ‘O’ rings. With the properly sealed specimen placed centrally on the pedestal, the cell was assembled, keeping the loading piston initially clear of the loading pad of the specimen, the assembly was placed in the loading frame.

For unconsolidated undrained test, the bottom drainage value (BDV) and top drainage value (TDV) of cell, was closed and air release valve (ARV) was opened. The cell was filled with water through the cell water value CWV. ARV was closed when water begins to escape through it. The cell pressure was raised to the desired value and kept constant till the end of the test.

When the cell pressure was applied, the load piston rises upward, the loading machine was operated at the anticipated rate to bring the load piston slightly above the loading pad of the specimen and the load measuring dial gauge on proving ring was set to zero.

The piston was brought just in contact with loading pad by hand operation of the machine. The axial compression dial gauge was mounted and set to read zero.

The axial loading was started at 1.25 mm/min rate of strain. Simultaneous readings on the load and compression dial gauges were noted down. The test was continued until a recession of the axial load is observed or 20% of strain.

After failure, the specimen was unloaded by reversing the loading machine, cell pressure was reduced and cell water was drained out through BRV. The cell was dismantled and the specimen was taken out, rubber membrane was removed and weight of the failed sample and its water content was determined. The test was repeated on two more identical specimens with increasing cell pressure.

The rate of strain for conducting UUT is kept as 1.25 mm/min as per codal/literature provision based on strata.

5.1.10 Chemical Testing

Chemical Testing was generally performed in accordance with IS: 2720, but the different parts of method as described below:

a) Total Sulphate Content Of Soil

Samples were tested according to IS 2720 (Part 27). The dried soil was extracted with a 10% solution of hydrochloric acid. The extract was adjusted to slightly alkaline pH with ammonia, and then barium chloride solution was added to precipitate the sulphate. The barium sulphate precipitate was collected by filtration, and it was washed, dried and weighed. The mass of barium sulphate recovered was used to calculate the sulphate content of the original soil.

b) pH Value

Samples were tested according to IS: 2720 (Part 26). The soil sample (30 ± 0.1g) was extracted with 75 ml of distilled water and the pH of the resulting suspension was measured with a calibrated (by means of Standard buffer solution) pH meter.

c) Chloride Content

For the water soluble content, soil samples were extracted with a volume of water equal to twice the mass of the soil. The extract was filtered and acidified with a small amount of nitric acid.

Standardized silver nitrate solution was then added to precipitate the chloride as its silver salt. The amount of precipitated silver remaining in solution was then determined by titration.

An acid-soluble version of the test was also available, with the initial extraction being with nitric acid instead of water.

CHAPTER 2 ANALYSIS OF TEST RESULTS AND INTERPRETATION

6.0 STRATIFICATION

From the study of the borehole carried out at Old Ch. 27+620 to Old Ch. 28+900 (New CH: 28+287 to 29+567).

At location of O.C. 27+620 (N.C. 28+287) :-

The sub strata of BH-A1 mainly consist of Silty Clay of low plasticity (CL) and sandy silt of low plasticity (ML-CL).

The sub strata of BH-A2 mainly consist of sandy silt of low plasticity (ML-CL) followed by Silty Clay of low plasticity (CL).

The sub strata of BH-P1 mainly consist of Silty Clay of low plasticity (CL).

The sub strata of BH-P2 mainly consist of sandy silt of low plasticity (ML-CL) followed by Silty Clay of low plasticity (CL).

The sub strata of BH-P3 mainly consist of Silty Clay of low plasticity (CL).

The sub strata of BH-P4 mainly consist of sandy silt of low plasticity (ML-CL) followed by Silty Clay of low plasticity (CL).

At location of O.C. 28+075 (N.C. 28+743) :-

The sub strata of BH-A1 mainly consist of Sandy silt of low plasticity (ML-CL) and Silty Clay of low plasticity (CL).

The sub strata of BH-A2 mainly consist of Sandy silt of low plasticity (ML-CL) and Silty Clay of low plasticity (CL).

The sub strata of BH- P1 mainly consist of Silty Clay of low plasticity (CL), Sandy silt of low plasticity (ML-CL) and Silty sand (SM).

The sub strata of BH-P2 mainly consist of sandy silt of low plasticity (ML-CL) and Silty sand with clay (SM-SC).

At location of O.C. 28+360 (N.C. 29+028):-

The sub strata of BH-A1 mainly consist of Sandy silt of low plasticity (ML-CL) Silty sand with clay (SM-SC) and Silty sand (SM).

The sub strata of BH-A2 mainly consist of Silty sand (SM) and Sandy silt of low plasticity (ML-CL).

The sub strata of BH-P1 mainly consist of Silty sand (SM) and Sandy silt of low plasticity (ML-CL) Silty sand with clay (SM-SC).

The sub strata of BH-P2 mainly consist of Sandy silt of low plasticity (ML-CL) Silty sand with clay (SM-SC).

At location of O.C. 28+900 (N.C. 29+567):-

From the study of the borehole logs of 04 BHs, it is revealed that the sub strata from EGL to 40.0-50.0m depth mostly consist of fine grained soil i.e. silty clay of low plasticity (CL) with some layers of coarse grained soil i.e. sandy silt of low plasticity (ML-CL) embedded in between.

6.1 GROUND WATER TABLE DEPTH

The Ground Water Table was met at depths of from 32.67m to 38.10 m below EGL as given in Table 2.1, it may rise up during heavy rains / rainy season. Therefore, for the analysis of various foundations, the water table has been considered to rise by about 2 to 3.0m at the locations of boreholes.

6.2 RESULTS OF CHEMICAL ANALYSIS

Results of chemical analysis of soil samples (as per **Appendix – B2**) indicates that the soil sample falls under Class I for sulphates and chlorides concentration (As per IS 456-2000 and CIRIA Sp. Publication No. 31). The results are summarized here in below :-

Summary of chemical analysis of soil samples

Chemical Property	Findings (Min. to Max.)	Remarks (Required limits as per IS 456-2000)
pH	6.85 to 8.61	> 6.0
Sulphite as SO_3^{2-} (%)	0.0022 (%) to 0.0035 (%)	< 0.2% (Class I)
Chlorides as Cl^- (%)	0.047 (%) to 0.078 (%)	No limit specified in IS 456. However, a limit of 0.10% specified for class I in CIRIA Sp. Publication No. 31)

Note :- All the chemical contents are within permissible limit hence no special precautions are required.

6.3 INTERPRETATION OF LAB TEST RESULTS

Grain Size Analysis

- **Clay content:** It generally varies from 4 to 14%.
- **Silt content:** It generally varies from 22 to 68%.
- **Sand content:** It generally varies from 23 to 86%.
- **Gravel content:** It generally varies from 2 to 10%.

Atterberg's Limit

- **Liquid limit:** The test results of liquid limit of the soil samples reveal that it generally varies from 27 to 29% in ML-CL type of soil, 30 to 35% in CL type of soil.

- **Plastic Limit*:*** The plastic limit of the soil sample varies from 20 to 21% in ML-CL type of soil, 20 to 23% in CL type of soil. However ML-CL type of soil is considered as non-plastic.
- **Plasticity index*:*** The plasticity index of the soil samples generally varies from 6 to 7% in ML-CL type of soil, 10 to 12% in CL type of soil whereas ML-CL and SM/ SM-SC/ SC type of soil are non-plastic.

Natural moisture content & Bulk density

The bulk density of soil samples generally varies from 1.64gm/cc to 1.98gm/cc whereas natural moisture content varies from 9.22% to 18.26%.

Direct shear tests:

Direct shear test under drained condition have been conducted in sandy silty (ML-CL) / sandy stratum (SM/ SM-SC/ SC) type of soil.

For Sandy strata (SM/ SM-SC/ SC), the value of angle of internal friction varies from 25^o to 32^o, whereas cohesion varies from 0.00 kg/cm^2 to 0.11 kg/cm^2.

For Silty strata (ML-CL), the value of angle of internal friction varies from 22^o to 27^o, whereas cohesion varies from 0.19 kg/cm^2 to 0.22 kg/cm^2.

Triaxial shear tests:

Triaxial shear test under undrained condition have been conducted in silty clay (CL) type of soil.

For silty clay (CL) strata, the value of angle of internal friction varies from 4^o to 5^o, whereas cohesion varies from 1.42kg/cm^2 to 2.24kg/cm^2.

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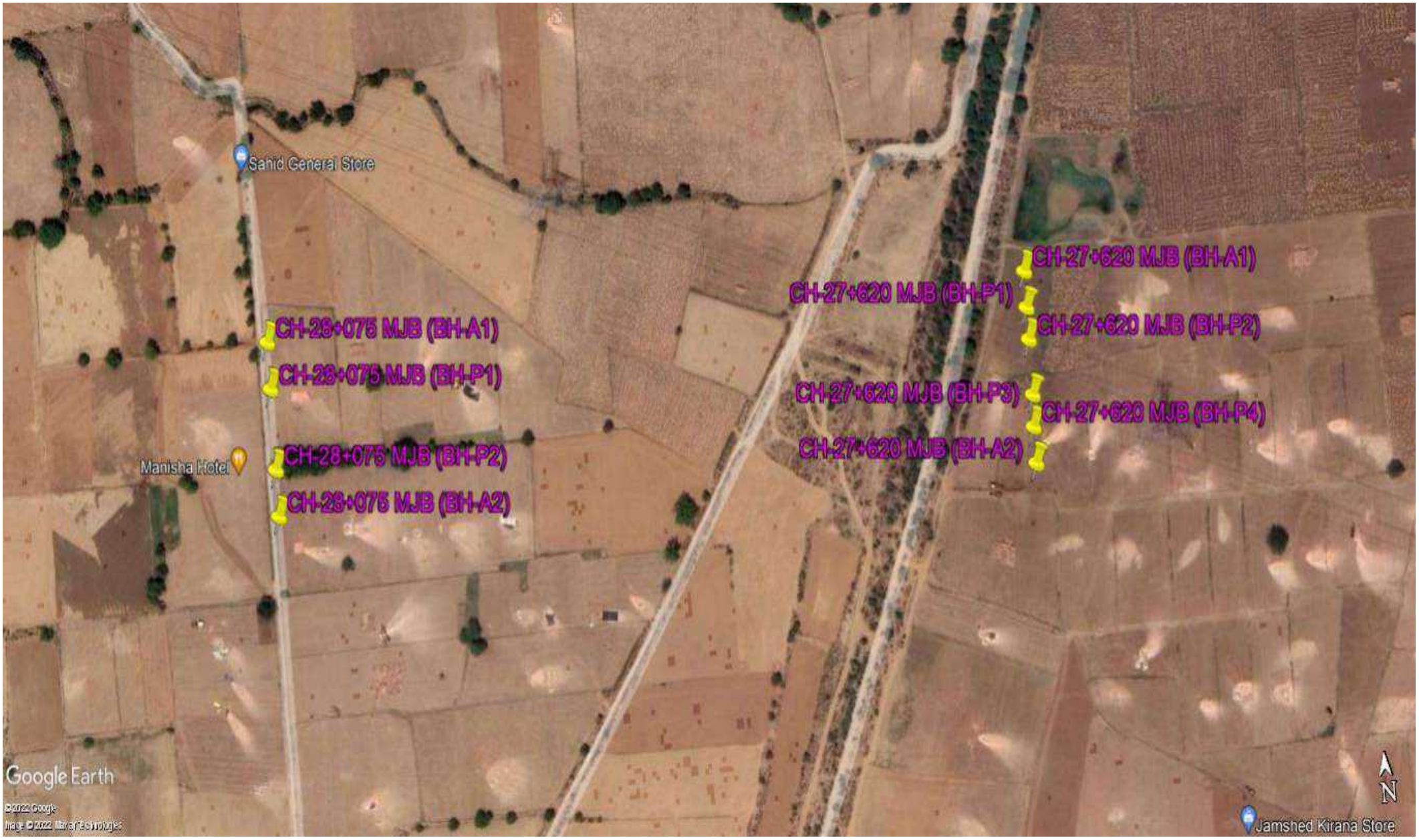
Abbreviations

BH	Borehole
ERT	Electrical Resistivity Test
EGL	Existing Ground Level
GWT	Ground Water Table
IS	Indian Standards
SPT	Standard Penetration Test
DS	Disturbed Soil
R.L.	Reduced Level
m	Metre
sp. gr.	Specific Gravity
%	Percentage
mg /l	Milligram per litre
mg /kg	Milligram per kilogram

APPENDIX – A (FIELD DATA RESULTS)

Appendix No.	ITEMS
A-1	LOCATION PLAN
A-2	FIELD BORE HOLE LOGS
A-3	SUB SOIL PROFILE DIAGRAM

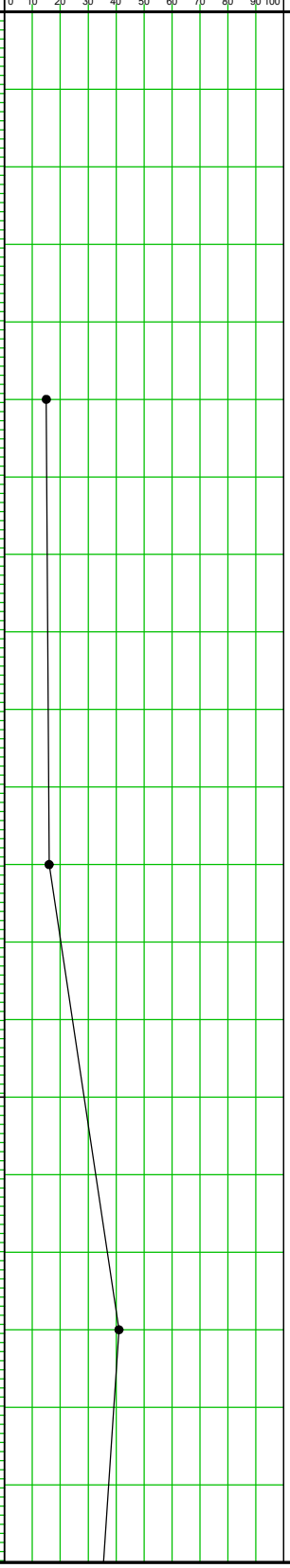

Sahid General Store
CH-28+075 MJB (BH-A1)
CH-28+075 MJB (BH-P1)
Manisha Hotel
CH-28+075 MJB (BH-P2)
CH-28+075 MJB (BH-A2)
CH-27+620 MJB (BH-A1)
CH-27+620 MJB (BH-P1)
CH-27+620 MJB (BH-P2)
CH-27+620 MJB (BH-P3)
CH-27+620 MJB (BH-P4)
CH-27+620 MJB (BH-A2)
Google Earth
N
Jamshed Kirana Store


Majid Khan Shop
CH-28+300 MJB (BH-A1)
CH-28+900 MJB (BH-P1)
CH-28+900 MJB (BH-P2)
CH-28+900 MJB (BH-A2)
CH-28+360 MJB (BH-A1)
CH-28+360 MJB (BH-P1)
CH-28+360 MJB (BH-P2)
CH-28+360 MJB (BH-A2)
Google Earth
N

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123079.115 m	*Easting :*697786.663 m
Reduced Level (m):(+)270.946	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	2	7	8	15					
3.0											
3.5							Brown, Very stiff, Silty clay of low plasticity	CL			
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	7	7	9	16					
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	12	17	24	41	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
9.0											
9.5											
10.0	10	UDS-4									



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123079.115 m	*Easting :*697786.663 m
Reduced Level (m):(+)270.946	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	SPT-4	9	14	16	30					
12.0											
12.5											
13.0	13	UDS-5					Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
13.5											
14.0											
14.5	14.5	SPT-5	14	21	25	46					
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	22	40	43	83					
18.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
18.5											
19.0	19	UDS-7									
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123079.115 m	*Easting :*697786.663 m
Reduced Level (m):(+)270.946	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0										0 10 20 30 40 50 60 70 80 90 100	
20.5	20.5	SPT-7	14	19	22	41					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	32	69	31 (3cm)	>100					
24.0											
24.5											
25.0	25	UDS*					Brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	SPT-9	27	40	60 (12cm)	>100					
27.0											
27.5											
28.0	28	SPT-10	36	74	26 (5cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-11	38	68	32 (9cm)	>100					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123079.115 m	*Easting :*697786.663 m
Reduced Level (m):(+)270.946	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0										0 10 20 30 40 50 60 70 80 90 100	
30.5											
31.0	31	SPT-12	40	100 (15cm)	-	>100					
31.5											
32.0											
32.5	32.5	UDS*									
33.0									33.10m		
33.5											
34.0	34	SPT-13	32	36	48	84					
34.5											
35.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5	35.5	SPT-14	30	39	52	91					
36.0											
36.5											
37.0	37	SPT-15	46	100 (13cm)	-	>100					
37.5											
38.0											
38.5	38.5	SPT-16	30	82	18 (3cm)	>100					
39.0											
39.5											
40.0	40	SPT-17	25	40	48	88					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123062.116 m	*Easting :*697786.52 m
Reduced Level (m):(+)271.001	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	2	3	3	6					
1.5											
2.0							Brown, Medium stiff, Silty clay of low plasticity	CL			
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	9	16	18	34					
4.5											
5.0							Brown, Dense, Silty sand	SM			
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	7	12	14	26					
7.5											
8.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	9	11	15	26					

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123062.116 m	*Easting :*697786.52 m
Reduced Level (m):(+)271.001	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	18	24	26	50					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	SPT-6	10	14	20	34					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	18	21	32	53					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123062.116 m	*Easting :*697786.52 m
Reduced Level (m):(+)271.001	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0										0 10 20 30 40 50 60 70 80 90 100	
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	24	38	43	81					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
24.5											
25.0	25	SPT-9	13	20	24	44					
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	32	52	48 (10cm)	>100					
28.5											
29.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
29.5	29.5	SPT-11	40	65	35 (8cm)	>100					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123062.116 m	*Easting :*697786.52 m
Reduced Level (m):(+)271.001	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*12-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-12	53	75	25 (2cm)	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
31.5											
32.0											
32.5	32.5	SPT-13	21	34	46	80					
33.0									32.90m		
33.5											
34.0	34	SPT-14	26	38	52	90					
34.5											
35.0											
35.5	35.5	SPT-15	30	42	56	98					
36.0											
36.5							Brown, Hard, Silty clay of low plasticity with gravel	CL			
37.0	37	SPT-16	25	46	54 (10cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-17	30	52	48 (8cm)	>100					
39.0											
39.5											
40.0	40	SPT-18	24	42	49	91					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Medium dense, Sandy silt of low plasticity	ML-CL			
2.5	2.5	SPT-1	3	5	6	11					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	10	15	18	33					
6.0											
6.5											
7.0	7	UDS-3					Brown, Hard, Silty clay of low plasticity with gravel	CL			
7.5											
8.0											
8.5	8.5	SPT-3	12	13	18	31					
9.0											
9.5											
10.0	10	UDS-4									

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

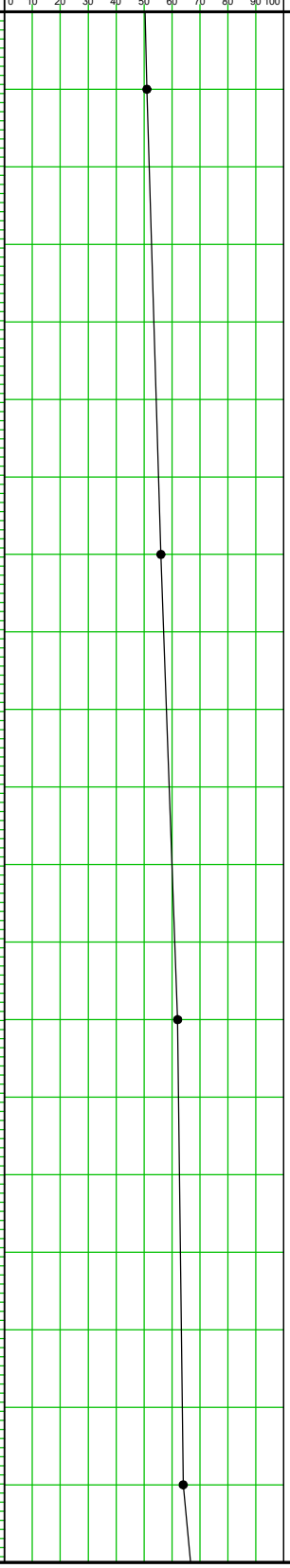
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	SPT-4	12	15	20	35					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	15	19	22	41					
15.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	16	19	28	47					
18.0											
18.5											
19.0	19	UDS-7									
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-7	18	21	30	51					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	22	26	30	56					
24.0											
24.5											
25.0	25	UDS-9					Brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	SPT-9	25	28	34	62					
27.0											
27.5											
28.0	28	UDS-10									
28.5											
29.0											
29.5	29.5	SPT-10	25	29	35	64					
30.0											

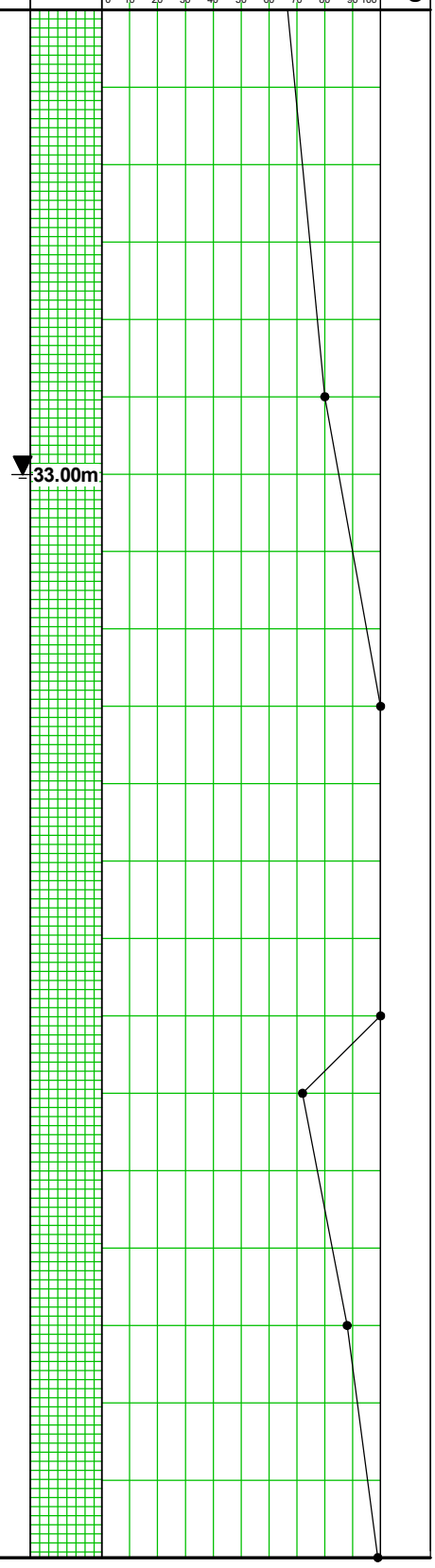


UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	UDS-11									
31.5											
32.0											
32.5	32.5	SPT-11	30	35	45	80					
33.0									33.00m		
33.5											
34.0	34	UDS-12									
34.5	34.5	SPT-12	39	51	49 (10cm)	>100					
35.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5											
36.0											
36.5	36.5	SPT-13	44	59	41 (7cm)	>100					
37.0	37	SPT-14	25	32	40	72					
37.5											
38.0											
38.5	38.5	SPT-15	32	40	48	88					
39.0											
39.5											
40.0	40	SPT-16	39	45	54	99					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0										0 10 20 30 40 50 60 70 80 90 100	
40.5											
41.0											
41.5	41.5	SPT-17	44	61	39 (8cm)	>100					
42.0											
42.5											
43.0	43	SPT-18	40	69	31 (8cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-19	48	75	25 (5cm)	>100					
45.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
45.5											
46.0	46	SPT-20	60	100 (6cm)	-	>100					
46.5											
47.0											
47.5	47.5	SPT-21	41	57	43 (9cm)	>100					
48.0											
48.5											
49.0	49	SPT-22	51	100 (7cm)	-	>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123047.116 m	*Easting :*697786.377 m
Reduced Level (m):(+)271.080	*BH. No. :*BH-P2	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*21-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
50.0											
50.5	50.5	SPT-23	43	55	45 (7cm)	>100					
51.0											
51.5											
52.0	52	SPT-24	40	61	39 (6cm)	>100					
52.5											
53.0											
53.5	53.5	SPT-25	47	100 (11cm)	-	>100					
54.0											
54.5											
55.0	55	SPT-26	52	100 (7cm)	-	>100	Brown, Hard, Silty clay of low plasticity with gravel	CL			
55.5											
56.0											
56.5	56.5	SPT-27	32	37	48	85					
57.0											
57.5											
58.0	58	SPT-28	27	33	47	80					
58.5											
59.0											
59.5	59.5	SPT-29	39	45	50	95					
60.0	60	-									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS-1									
0.5											
1.0	1	SPT-1	1	2	2	4					
1.5											
2.0											
2.5	2.5	UDS-1					Brown, Medium stiff to very stiff, Silty clay of low plasticity	CL			
3.0											
3.5											
4.0	4	SPT-2	5	7	9	16					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	10	13	18	31	Brown, Hard, Silty clay of low plasticity with gravel	CL			
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	9	12	15	27					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	10	15	18	33					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	SPT-6	14	18	35	53					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	18	19	24	43					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	16	22	26	48					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	18	25	28	53	Brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	21	29	33	62					
28.5											
29.0											
29.5	29.5	UDS-10									
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

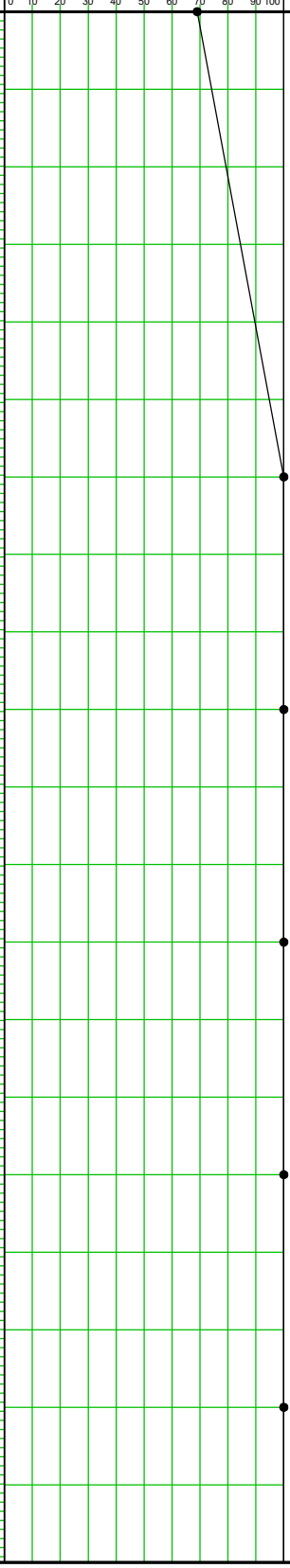
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-11	27	38	42	80					
31.5											
32.0											
32.5	32.5	UDS*									
33.0	33	SPT-12	35	58	42 (5cm)	>100			33.13m		
33.5											
34.0	34	SPT-13	48	69	31 (5cm)	>100					
34.5											
35.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5	35.5	SPT-14	44	75	25 (11cm)	>100					
36.0											
36.5											
37.0	37	SPT-15	22	28	34	62					
37.5											
38.0											
38.5	38.5	UDS-11									
39.0											
39.5											
40.0	40	SPT-16	29	32	37	69					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0											
40.5											
41.0											
41.5	41.5	UDS-12									
42.0											
42.5											
43.0	43	SPT-17	46	73	27 (12cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-18	40	68	32 (8cm)	>100					
45.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
45.5											
46.0	46	SPT-19	58	100 (5cm)	-	>100					
46.5											
47.0											
47.5	47.5	SPT-20	43	63	37 (5cm)	>100					
48.0											
48.5											
49.0	49	SPT-21	55	100 (7cm)	-	>100					
49.5											
50.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123021.117 m	*Easting :*697786.129 m
Reduced Level (m):(+)270.749	*BH. No. :*BH-P3	*BH Termination Depth (m):*60
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
50.0											
50.5	50.5	SPT-22	43	60	40 (6cm)	>100					
51.0											
51.5											
52.0	52	SPT-23	35	66	34 (5cm)	>100					
52.5											
53.0											
53.5	53.5	SPT-24	47	100 (10cm)	-	>100					
54.0											
54.5											
55.0	55	SPT-25	55	100 (8cm)	-	>100	Brown, Hard, Silty clay of low plasticity with gravel	CL			
55.5											
56.0											
56.5	56.5	SPT-26	34	39	45	84					
57.0											
57.5											
58.0	58	SPT-27	28	35	43	78					
58.5											
59.0											
59.5	59.5	SPT-28	36	45	52	97					
60.0	60	DS-2									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

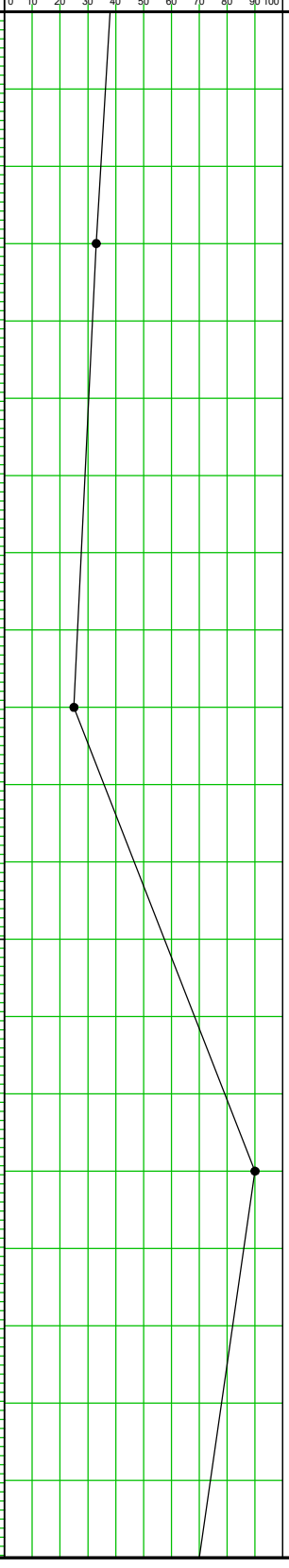
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Stiff, Silty clay of low plasticity	CL			
2.5	2.5	SPT-1	3	4	6	10					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	10	14	17	31					
6.0											
6.5											
7.0	7	UDS-3					Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
7.5											
8.0											
8.5	8.5	SPT-3	11	19	24	43					
9.0											
9.5											
10.0	10	UDS-4									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	8	14	19	33					
12.0											
12.5											
13.0	13	UDS-5					Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
13.5											
14.0											
14.5	14.5	SPT-5	7	11	14	25					
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	23	39	51	90					
18.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
18.5											
19.0	19	UDS-7									
19.5											
20.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

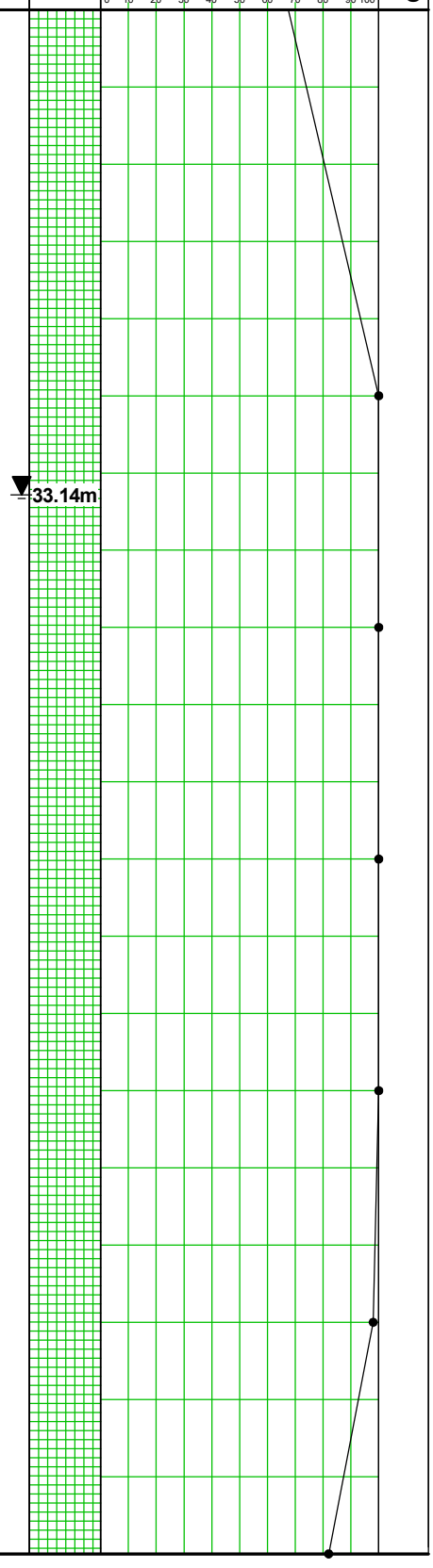
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-7	24	32	34	66					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	16	21	27	48					
24.0											
24.5											
25.0	25	UDS*					Brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5	25.5	SPT-9	17	50	50 (10cm)	>100					
26.0											
26.5	26.5	SPT-10	22	57	43 (8cm)	>100					
27.0											
27.5											
28.0	28	UDS-9									
28.5											
29.0											
29.5	29.5	SPT-11	15	24	37	61					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	UDS-10									
31.5											
32.0											
32.5	32.5	SPT-12	27	43	57 (13cm)	>100					
33.0									33.14m		
33.5											
34.0	34	SPT-13	30	47	53 (11cm)	>100					
34.5											
35.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5	35.5	SPT-14	37	54	46 (9cm)	>100					
36.0											
36.5											
37.0	37	SPT-15	22	45	55 (15cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-16	25	43	55	98					
39.0											
39.5											
40.0	40	SPT-17	22	37	45	82					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3123006.118 m	*Easting :*697785.986 m
Reduced Level (m):(+)271.774	*BH. No. :*BH-P4	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.14	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*20-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0											
40.5											
41.0											
41.5	41.5	SPT-18	21	35	43	78					
42.0											
42.5											
43.0	43	UDS-11									
43.5											
44.0											
44.5	44.5	SPT-19	22	43	57 (11cm)	>100					
45.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
45.5											
46.0	46	SPT-20	31	47	53 (8cm)	>100					
46.5											
47.0											
47.5	47.5	SPT-21	35	54	46 (7cm)	>100					
48.0											
48.5											
49.0	49	SPT-22	28	60	40 (7cm)	>100					
49.5											
50.0	50	SPT-23	25	65	35 (6cm)	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3122989.119 m	*Easting :*697785.825 m
Reduced Level (m):(+)271.929	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.12	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*19-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	4	5	7	12					
1.5											
2.0											
2.5	2.5	UDS-1					Brown, Medium dense, Sandy silt of low plasticity	ML-CL			
3.0											
3.5											
4.0	4	SPT-2	6	7	10	17					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	10	16	22	38					
7.5							Brown, Hard, Silty clay of low plasticity with gravel	CL			
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	12	18	25	43					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3122989.119 m	*Easting :*697785.825 m
Reduced Level (m):(+)271.929	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.12	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*19-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	11	14	26	40					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	SPT-6	13	20	28	48					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	24	35	47	82					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3122989.119 m	*Easting :*697785.825 m
Reduced Level (m):(+)271.929	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.12	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*19-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0										0 10 20 30 40 50 60 70 80 90 100	
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	22	28	35	63					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	19	24	32	56	Brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	25	38	48	86					
28.5											
29.0											
29.5	29.5	UDS-10									
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*27+620 km	*Northing :*3122989.119 m	*Easting :*697785.825 m
Reduced Level (m):(+)271.929	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.12	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-11-2021	*Date of Completion :*19-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0										0 10 20 30 40 50 60 70 80 90 100	
30.5											
31.0	31	SPT-11	33	52	48 (10cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-12	32	59	41 (7cm)	>100					
33.0									33.12m		
33.5											
34.0	34	SPT-13	36	62	38 (5cm)	>100					
34.5											
35.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5	35.5	SPT-14	54	56	44 (7cm)	>100					
36.0											
36.5											
37.0	37	SPT-15	20	34	45	79					
37.5											
38.0											
38.5	38.5	SPT-16	22	38	50	88					
39.0											
39.5											
40.0	40	SPT-17	29	38	48	86					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	7	9	10	19					
1.5											
2.0											
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	7	12	14	26					
4.5											
5.0							Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	10	14	15	29					
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	8	12	17	29					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

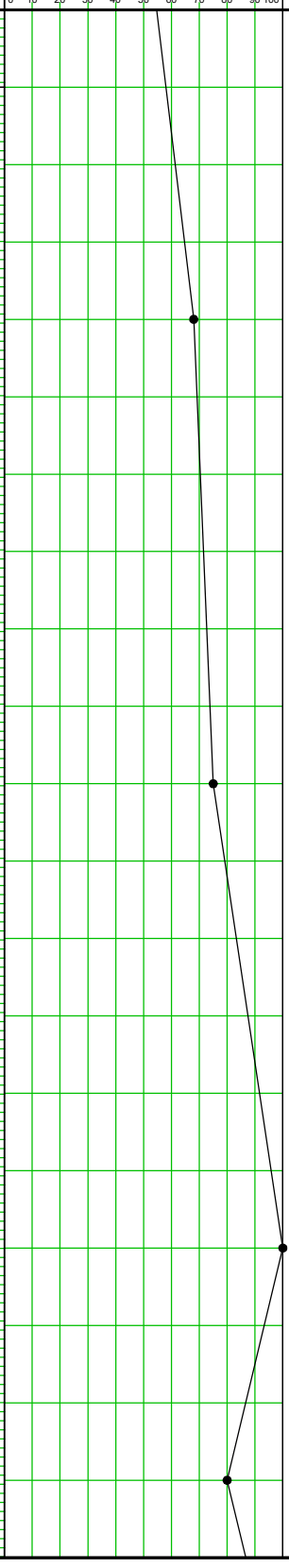
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5							Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
13.0	13	SPT-5	10	13	18	31					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0											
15.5											
16.0	16	SPT-6	13	18	24	42					
16.5											
17.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	15	20	28	48					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	14	31	37	68					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	18	30	45	75	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	37	62	38 (5cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-11	19	34	46	80					
30.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-12	31	50	50 (10cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-13	18	35	42	77					
33.0									32.67m		
33.5											
34.0	34	SPT-14	20	41	48	89					
34.5											
35.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
35.5	35.5	SPT-15	19	38	40	78					
36.0											
36.5											
37.0	37	SPT-16	19	35	50	85					
37.5											
38.0											
38.5	38.5	SPT-17	21	37	48	85					
39.0											
39.5											
40.0	40	SPT-18	18	48	52 (14cm)	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

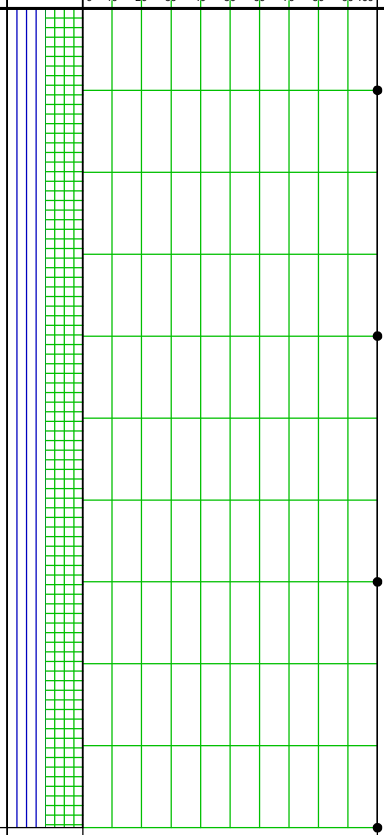
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0											
40.5											
41.0											
41.5	41.5	SPT-19	17	40	48	88					
42.0											
42.5											
43.0	43	SPT-20	22	43	57 (12cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-21	25	59	38 (10cm)	>100					
45.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
45.5											
46.0	46	SPT-22	27	51	49 (13cm)	>100					
46.5											
47.0											
47.5	47.5	SPT-23	37	53	47 (8cm)	>100					
48.0											
48.5											
49.0	49	SPT-24	36	100 (14cm)	-	>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123086.726 m	*Easting :*697330.702 m
Reduced Level (m):(+)269.806	*BH. No. :*BH-A1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.67	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
50.0											
50.5	50.5	SPT-25	30	80	20 (13cm)	>100					
51.0											
51.5											
52.0	52	SPT-26	39	75	25 (7cm)	>100					
52.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
53.0											
53.5	53.5	SPT-27	38	73	27 (8cm)	>100					
54.0											
54.5											
55.0	55	SPT-28	40	70	30 (7cm)	>100					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Medium dense, Silty sand	SM			
2.5	2.5	SPT-1	8	11	13	24					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	14	20	24	44	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	8	10	14	24	Brown, Very stiff to hard, Silty clay of low plasticity	CL			
9.0											
9.5											
10.0	10	UDS-4									

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	7	10	11	21					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	5	9	10	19	Brown, Very stiff to hard, Silty clay of low plasticity	CL			
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	10	15	22	37					
18.0											
18.5											
19.0	19	UDS-7									
19.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-7	15	22	33	55					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	21	30	36	66					
24.0											
24.5											
25.0	25	UDS-9					Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	SPT-9	17	28	38	66					
27.0											
27.5											
28.0	28	SPT-10	18	30	41	71					
28.5											
29.0											
29.5	29.5	SPT-11	20	35	45	80					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0										0 10 20 30 40 50 60 70 80 90 100	
30.5											
31.0	31	SPT-12	27	42	50	92					
31.5											
32.0											
32.5	32.5	SPT-13	29	45	52	97					
33.0									32.68m		
33.5											
34.0	34	SPT-14	18	40	50	90					
34.5											
35.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
35.5	35.5	SPT-15	14	33	44	77					
36.0											
36.5											
37.0	37	SPT-16	18	35	48	83					
37.5											
38.0											
38.5	38.5	SPT-17	20	36	47	83					
39.0											
39.5											
40.0	40	SPT-18	22	40	52	92					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0										0 10 20 30 40 50 60 70 80 90 100	
40.5											
41.0											
41.5	41.5	SPT-19	17	42	48	90					
42.0											
42.5											
43.0	43	SPT-20	16	40	42	82					
43.5											
44.0											
44.5	44.5	SPT-21	15	31	39	70					
45.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
45.5											
46.0	46	SPT-22	17	35	45	80					
46.5											
47.0											
47.5	47.5	SPT-23	18	36	46	82					
48.0											
48.5											
49.0	49	SPT-24	34	54	46 (10cm)	>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123064.726 m	*Easting :*697330.717 m
Reduced Level (m):(+)270.070	*BH. No. :*BH-P1	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*32.68	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
50.0										0 10 20 30 40 50 60 70 80 90 100	
50.5	50.5	SPT-25	36	61	39 (7cm)	>100					
51.0											
51.5											
52.0	52	SPT-26	38	68	32 (5cm)	>100					
52.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
53.0											
53.5	53.5	SPT-27	33	61	39 (8cm)	>100					
54.0											
54.5											
55.0	55	SPT-28	41	78	22 (3cm)	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	3	4	5	9					
1.5											
2.0							Brown, Loose, Sandy silt of low plasticity	ML-CL			
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	9	10	12	22					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	12	17	21	38	Brown, Medium dense to dense, Silty sand with clay & gravel	SM-SC			
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	10	16	25	41					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

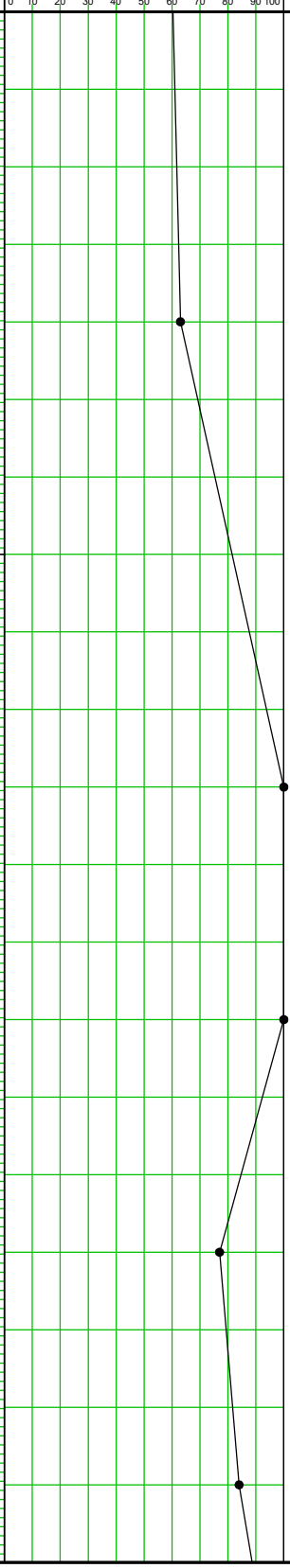
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5							Brown, Medium dense to dense, Silty sand with clay & gravel	SM-SC			
13.0	13	SPT-5	10	20	22	42					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0											
15.5											
16.0	16	SPT-6	14	21	30	51					
16.5											
17.0											
17.5	17.5	UDS-6					Brown, Hard, Silty clay of low plasticity with gravel	CL			
18.0											
18.5											
19.0	19	SPT-7	16	24	35	59					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	18	27	36	63	Brown, Hard, Silty clay of low plasticity with gravel	CL			
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	31	52	48 (9cm)	>100					
25.5											
26.0											
26.5	26.5	SPT-10	29	50	50 (9cm)	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
27.0											
27.5											
28.0	28	SPT-11	22	31	46	77					
28.5											
29.0											
29.5	29.5	SPT-12	24	34	50	84					
30.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-13	40	44	54	98					
31.5											
32.0											
32.5	32.5	SPT-14	25	100 (12cm)	-	>100					
33.0											
									33.20m		
33.5											
34.0	34	SPT-15	16	35	41	76					
34.5											
35.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
35.5	35.5	SPT-16	18	38	50	88					
36.0											
36.5											
37.0	37	SPT-17	19	40	48	88					
37.5											
38.0											
38.5	38.5	SPT-18	18	36	45	81					
39.0											
39.5											
40.0	40	SPT-19	15	34	43	77					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0											
40.5											
41.0											
41.5	41.5	SPT-20	22	31	45	76					
42.0											
42.5											
43.0	43	SPT-21	24	32	45	77					
43.5											
44.0											
44.5	44.5	UDS-9									
45.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
45.5											
46.0	46	SPT-22	40	40	60 (11cm)	>100					
46.5											
47.0											
47.5	47.5	SPT-23	32	62	38 (7cm)	>100					
48.0											
48.5											
49.0	49	SPT-24	36	73	27 (3cm)	>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123026.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.499	*BH. No. :*BH-P2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.20	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
50.0											
50.5	50.5	SPT-25	34	66	34 (6cm)	>100					
51.0											
51.5											
52.0	52	SPT-26	39	58	42 (8cm)	>100					
52.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
53.0											
53.5	53.5	SPT-27	43	75	25 (4cm)	>100					
54.0											
54.5											
55.0	55	SPT-28	33	51	49 (12cm)	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Stiff, Silty clay of low plasticity	CL			
2.5	2.5	SPT-1	5	6	6	12					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	12	18	22	40	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	7	11	14	25	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
9.0											
9.5											
10.0	10	UDS-4									

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

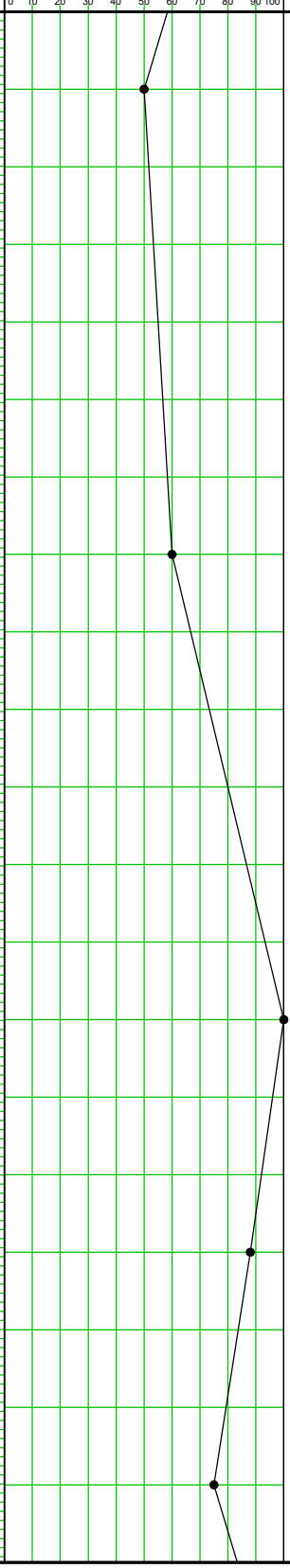
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	11	14	17	31					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
14.5	14.5	SPT-5	10	13	18	31					
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	100 (13cm)	-	-	>100					
18.0											
18.5											
19.0	19	UDS-7					Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-7	15	21	29	50					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	17	25	35	60					
24.0											
24.5											
25.0	25	UDS-9					Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	SPT-9	30	48	52 (14cm)	>100					
27.0											
27.5											
28.0	28	SPT-10	32	40	48	88					
28.5											
29.0											
29.5	29.5	SPT-11	21	32	43	75					
30.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-12	20	42	58 (14cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-13	19	34	45	79					
33.0											
33.5									33.21m		
34.0	34	SPT-14	20	35	42	77					
34.5											
35.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
35.5	35.5	SPT-15	28	40	52	92					
36.0											
36.5											
37.0	37	SPT-16	42	64	36 (7cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-17	38	61	39 (8cm)	>100					
39.0											
39.5											
40.0	40	SPT-18	20	40	42	82					

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0											
40.5											
41.0											
41.5	41.5	SPT-19	19	42	48	90					
42.0											
42.5											
43.0	43	SPT-20	22	41	47	88					
43.5											
44.0											
44.5	44.5	SPT-21	24	40	46	86	Brown, Hard, Silty clay of low plasticity with gravel	CL			
45.0											
45.5											
46.0	46	SPT-22	21	38	45	83					
46.5											
47.0											
47.5	47.5	SPT-23	28	42	50	92					
48.0											
48.5											
49.0	49	SPT-24	30	70	30 (10cm)	>100					
49.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+075 km	*Northing :*3123004.726 m	*Easting :*697330.724 m
Reduced Level (m):(+)270.616	*BH. No. :*BH-A2	*BH Termination Depth (m):*55
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.21	*Inclination :* Vertical
*Boring type :*Shell & Auger	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

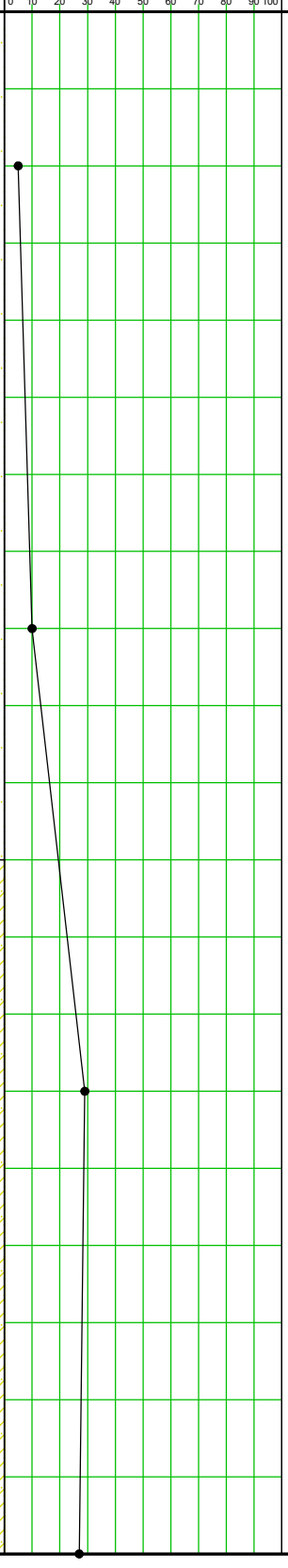
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
50.0											
50.5	50.5	SPT-25	33	68	32 (9cm)	>100					
51.0											
51.5											
52.0	52	SPT-26	36	72	26 (7cm)	>100					
52.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
53.0											
53.5	53.5	SPT-27	35	75	25 (8cm)	>100					
54.0											
54.5											
55.0	55	SPT-28	39	74	26 (8cm)	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123109.166 m	*Easting :*697053.722 m
Reduced Level (m):(+)268.602	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.78	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	2	2	3	5					
1.5											
2.0											
2.5	2.5	UDS-1					Brown, Loose, Silty sand	SM			
3.0											
3.5											
4.0	4	SPT-2	3	4	6	10					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	8	12	17	29					
7.5							Brown, Medium dense, Silty sand with clay	SM-SC			
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	7	12	15	27					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123109.166 m	*Easting :*697053.722 m
Reduced Level (m):(+)268.602	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.78	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5							Brown, Medium dense, Silty sand with clay	SM-SC			
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	12	18	24	42					
13.5											
14.0											
14.5	14.5	UDS-5					Brown, Dense, Silty sand with gravel	SM			
15.0											
15.5											
16.0	16	SPT-6	10	16	27	43					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
19.0	19	SPT-7	20	27	33	60					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123109.166 m	*Easting :*697053.722 m
Reduced Level (m):(+)268.602	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.78	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0										0 10 20 30 40 50 60 70 80 90 100	
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	24	33	45	78					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	22	42	58 (13cm)	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	SPT-10	31	49	52 (9cm)	>100					
27.0											
27.5											
28.0	28	SPT-11	28	58	42 (6cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-12	16	47	53 (8cm)	>100					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123109.166 m	*Easting :*697053.722 m
Reduced Level (m):(+)268.602	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.78	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value) 0 10 20 30 40 50 60 70 80 90 100	Special Observations
30.0											
30.5											
31.0	31	SPT-13	31	49	51 (7cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-14	23	54	46 (8cm)	>100					
33.0											
33.5											
34.0	34	SPT-15	38	74	26 (6cm)	>100					
34.5											
35.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL	▼34.78m		
35.5	35.5	SPT-16	24	55	46 (7cm)	>100					
36.0											
36.5											
37.0	37	SPT-17	27	64	36 (5cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-18	25	72	28 (8cm)	>100					
39.0											
39.5											
40.0	40	SPT-19	29	45	55 (13cm)	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Medium dense, Silty sand with clay	SM-SC			
2.5	2.5	SPT-1	3	5	7	12					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	13	15	19	34					
6.0											
6.5											
7.0	7	UDS-3					Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
7.5											
8.0											
8.5	8.5	SPT-3	16	20	25	45					
9.0											
9.5											
10.0	10	UDS-4									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	SPT-4	10	13	16	29	Brown, Very stiff, Silty clay of low plasticity with gravel	CL			
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	15	21	23	44					
15.0											
15.5											
16.0	16	UDS-6									
16.5							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
17.0											
17.5	17.5	SPT-6	18	25	28	53					
18.0											
18.5											
19.0	19	UDS-7									
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-7	28	33	36	69	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	16	18	21	39	Brown, Hard, Silty clay of low plasticity with gravel	CL			
24.0											
24.5											
25.0	25	UDS*									
25.5	25.5	SPT-9	32	43	50	93					
26.0											
26.5	26.5	SPT-10	31	45	53	98					
27.0											
27.5											
28.0	28	SPT-11	14	22	32	54	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
28.5											
29.0											
29.5	29.5	SPT-12	18	26	37	63					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	UDS-9									
31.5											
32.0											
32.5	32.5	SPT-13	21	27	35	62					
33.0											
33.5											
34.0	34	UDS-10							34.10m		
34.5											
35.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
35.5	35.5	SPT-14	40	53	47 (7cm)	>100					
36.0											
36.5											
37.0	37	SPT-15	45	57	43 (5cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-16	44	65	35 (7cm)	>100					
39.0											
39.5											
40.0	40	SPT-17	48	69	31 (6cm)	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123091.386 m	*Easting :*697050.915 m
Reduced Level (m):(+)267.861	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*13-10-2021	*Date of Completion :*15-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0										0 10 20 30 40 50 60 70 80 90 100	
40.5											
41.0											
41.5	41.5	SPT-18	35	53	47 (5cm)	>100					
42.0											
42.5											
43.0	43	SPT-19	37	60	40 (5cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-20	40	64	36 (7cm)	>100					
45.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
45.5											
46.0	46	SPT-21	50	80	20 (4cm)	>100					
46.5											
47.0											
47.5	47.5	SPT-22	40	70	30 (6cm)	>100					
48.0											
48.5											
49.0	49	SPT-23	40	100 (10cm)	-	>100					
	49.25	SPT-24				>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123064.68 m	*Easting :*697046.7 m
Reduced Level (m):(+)267.285	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.85	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	2	4	6	10					
1.5											
2.0							Brown, Loose, Sandy silt of low plasticity	ML-CL			
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	7	9	11	20					
4.5											
5.0											
5.5	5.5	UDS-2					Brown, Medium dense, Silty sand with clay	SM-SC			
6.0											
6.5											
7.0	7	SPT-3	11	15	19	34					
7.5											
8.0											
8.5	8.5	UDS-3					Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
9.0											
9.5											
10.0	10	SPT-4	13	17	23	40					

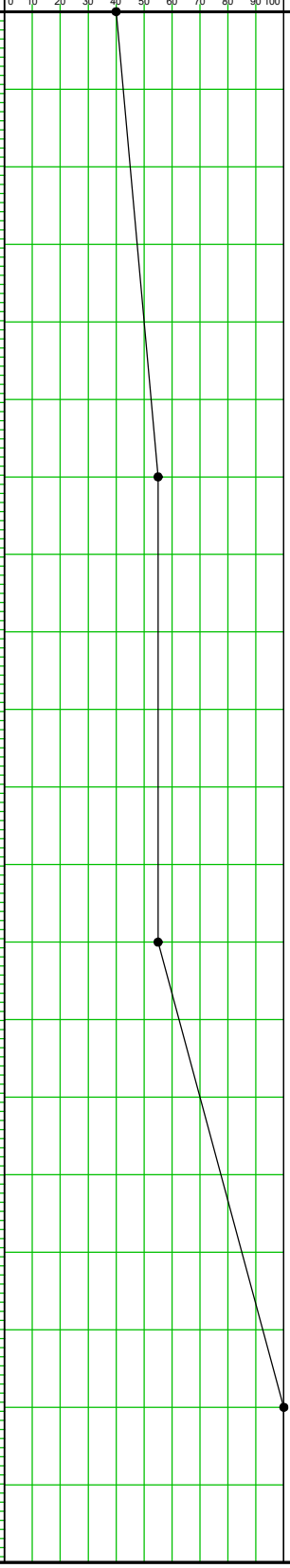
(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123064.68 m	*Easting :*697046.7 m
Reduced Level (m):(+)267.285	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.85	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	16	26	29	55					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
15.5											
16.0	16	SPT-6	19	24	31	55					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	31	60	40 (5cm)	>100					
19.5											
20.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123064.68 m	*Easting :*697046.7 m
Reduced Level (m):(+)267.285	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.85	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS*									
21.0											
21.5											
22.0	22	SPT-8	39	55	45 (5cm)	>100					
22.5											
23.0											
23.5	23.5	UDS*									
24.0											
24.5											
25.0	25	SPT-9	45	79	21 (4cm)	>100	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	UDS*									
27.0											
27.5											
28.0	28	SPT-10	43	65	35 (7cm)	>100					
28.5											
29.0											
29.5	29.5	UDS*									
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123064.68 m	*Easting :*697046.7 m
Reduced Level (m):(+)267.285	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.85	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-11	38	63	37 (4cm)	>100					
31.5											
32.0											
32.5	32.5	UDS*									
33.0											
33.5											
34.0	34	SPT-12	49	53	47 (6cm)	>100			33.85m		
34.5											
35.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
35.5	35.5	UDS*									
36.0											
36.5											
37.0	37	SPT-13	39	63	37 (5cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-14	48	69	31 (8cm)	>100					
39.0											
39.5											
40.0	40	SPT-15	45	72	28 (5cm)	>100					

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123064.68 m	*Easting :*697046.7 m
Reduced Level (m):(+)267.285	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*33.85	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*14-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0										0 10 20 30 40 50 60 70 80 90 100	
40.5											
41.0											
41.5	41.5	SPT-16	42	68	32 (7cm)	>100					
42.0											
42.5											
43.0	43	SPT-17	49	75	25 (9cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-18	52	100 (10cm)	-	>100					
45.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
45.5											
46.0	46	SPT-19	40	100 (15cm)	-	>100					
46.5											
47.0											
47.5	47.5	SPT-20	48	100 (3cm)	-	>100					
48.0											
48.5											
49.0	49	SPT-21	45	100 (8cm)	-	>100					
	49.23										
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123046.953 m	*Easting :*697043.901 m
Reduced Level (m):(+)267.528	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*13-10-2021	

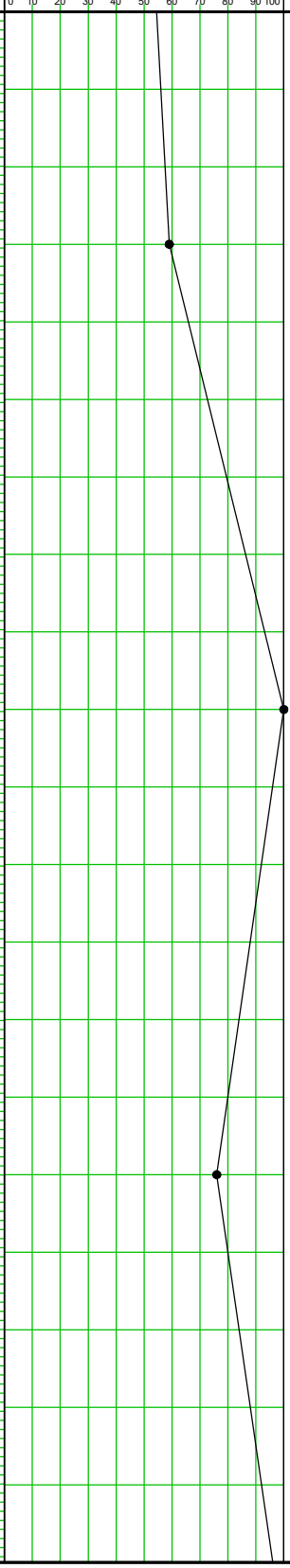
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Loose, Silty sand	SM			
2.5	2.5	SPT-1	3	4	5	9					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	12	19	25	44					
6.0											
6.5											
7.0	7	UDS-3					Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
7.5											
8.0											
8.5	8.5	SPT-3	14	22	28	50					
9.0											
9.5											
10.0	10	UDS-4									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123046.953 m	*Easting :*697043.901 m
Reduced Level (m):(+)267.528	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*13-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	16	27	32	59					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	37	100 (15cm)	-	>100					
15.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
15.5											
16.0	16	UDS*									
16.5											
17.0											
17.5	17.5	SPT-6	16	33	43	76					
18.0											
18.5											
19.0	19	UDS*									
19.5											
20.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123046.953 m	*Easting :*697043.901 m
Reduced Level (m):(+)267.528	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*13-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0										0 10 20 30 40 50 60 70 80 90 100	
20.5	20.5	SPT-7	44	100 (15cm)	-	>100					
21.0											
21.5											
22.0	22	UDS*									
22.5											
23.0											
23.5	23.5	SPT-8	39	52	48 (6cm)	>100					
24.0											
24.5											
25.0	25	UDS*					Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	SPT-9	44	70	30 (5cm)	>100					
27.0											
27.5											
28.0	28	UDS*									
28.5											
29.0											
29.5	29.5	SPT-10	45	100 (10cm)	-	>100					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+360 km	*Northing :*3123046.953 m	*Easting :*697043.901 m
Reduced Level (m):(+)267.528	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*12-10-2021	*Date of Completion :*13-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0										0 10 20 30 40 50 60 70 80 90 100	
30.5											
31.0	31	UDS*									
31.5											
32.0											
32.5	32.5	SPT-11	48	75	25 (4cm)	>100					
33.0											
33.5											
34.0	34	UDS*									
34.5									34.20m		
35.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
35.5	35.5	SPT-12	38	63	37 (10cm)	>100					
36.0											
36.5											
37.0	37	UDS*									
37.5											
38.0											
38.5	38.5	SPT-13	32	49	51 (13cm)	>100					
39.0											
39.5											
40.0	40	SPT-14	54	69	31 (10cm)	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123223.834 m	*Easting :*696531.197 m
Reduced Level (m):(+)262.678	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*36.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-10-2021	*Date of Completion :*21-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	7	12	15	27					
1.5											
2.0											
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	7	9	11	20					
4.5											
5.0							Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	9	13	16	29					
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	11	15	17	32					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123223.834 m	*Easting :*696531.197 m
Reduced Level (m):(+)262.678	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*36.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-10-2021	*Date of Completion :*21-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5							Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL			
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	18	52	48	100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
13.5											
14.0											
14.5	14.5	SPT-6	21	29	35	64					
15.0											
15.5											
16.0	16	SPT-7	19	31	37	68					
16.5											
17.0											
17.5	17.5	UDS-5					Brown, Hard, Silty clay of low plasticity with gravel	CL			
18.0											
18.5											
19.0	19	SPT-8	35	57	43 (8cm)	>100					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123223.834 m	*Easting :*696531.197 m
Reduced Level (m):(+)262.678	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*36.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-10-2021	*Date of Completion :*21-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-9	38	49	51 (6cm)	>100					
21.0											
21.5											
22.0	22	SPT-10	35	60	40 (9cm)	>100					
22.5											
23.0											
23.5	23.5	SPT-11	41	56	46 (6cm)	>100					
24.0											
24.5											
25.0	25	SPT-12	37	53	47 (8cm)	>100	Brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	SPT-13	40	51	49 (10cm)	>100					
27.0											
27.5											
28.0	28	SPT-14	38	53	47 (8cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-15	41	52	48 (7cm)	>100					
30.0											

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123223.834 m	*Easting :*696531.197 m
Reduced Level (m):(+)262.678	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*36.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*18-10-2021	*Date of Completion :*21-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0										0 10 20 30 40 50 60 70 80 90 100	
30.5											
31.0	31	SPT-16	26	52	48 (10cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-17	34	40	60 (8cm)	>100					
33.0											
33.5											
34.0	34	SPT-18	19	43	57 (15cm)	>100					
34.5											
35.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5	35.5	SPT-19	23	45	55 (8cm)	>100					
36.0											
36.5											
37.0	37	SPT-20	19	58	42 (5cm)	>100			36.90m		
37.5											
38.0											
38.5	38.5	SPT-21	100 (10cm)	-	-	>100					
39.0											
39.5											
40.0	40	SPT-22	60 (15cm)	100	-	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123214.311 m	*Easting :*696528.146 m
Reduced Level (m):(+)263.022	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*38.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*19-10-2021	*Date of Completion :*22-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Medium dense, Sandy silt of low plasticity with gravel	ML-CL			
2.5	2.5	SPT-1	7	9	13	22					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	15	24	29	53					
6.0											
6.5											
7.0	7	UDS-3					Brown, Hard, Silty clay of low plasticity with gravel	CL			
7.5											
8.0											
8.5	8.5	SPT-3	12	19	27	46					
9.0											
9.5											
10.0	10	UDS-4									

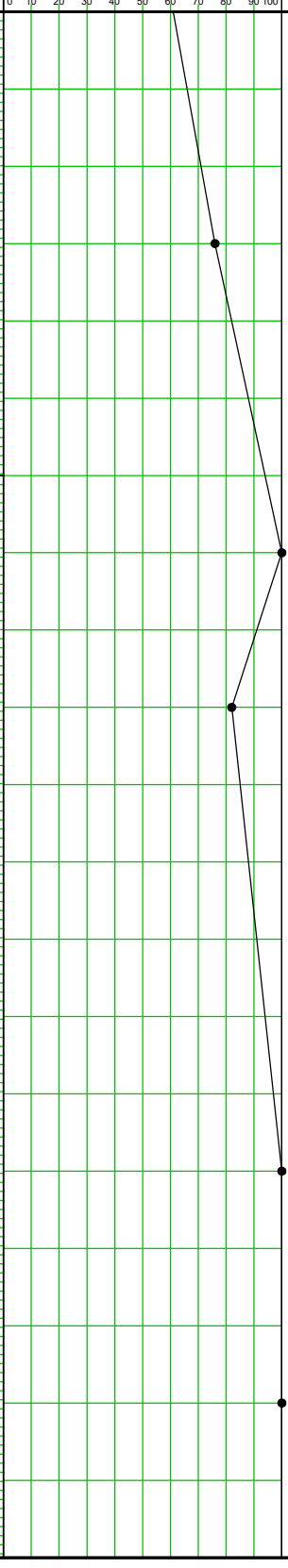
(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123214.311 m	*Easting :*696528.146 m
Reduced Level (m):(+)263.022	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*38.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*19-10-2021	*Date of Completion :*22-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	23	34	42	76	Brown, Hard, Silty clay of low plasticity with gravel	CL			
12.0											
12.5											
13.0	13	UDS-5									
13.5	13.5	SPT-5	29	45	55 (7cm)	>100					
14.0											
14.5	14.5	SPT-6	24	38	44	82					
15.0											
15.5											
16.0	16	UDS-6									
16.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
17.0											
17.5	17.5	SPT-7	28	47	53 (8cm)	>100					
18.0											
18.5											
19.0	19	SPT-8	32	50	50 (6cm)	>100					
19.5											
20.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123214.311 m	*Easting :*696528.146 m
Reduced Level (m):(+)263.022	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*38.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*19-10-2021	*Date of Completion :*22-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0										0 10 20 30 40 50 60 70 80 90 100	
20.5	20.5	SPT-9	36	53	47 (7cm)	>100					
21.0											
21.5											
22.0	22	SPT-10	35	100 (13cm)	-	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
22.5											
23.0											
23.5	23.5	SPT-11	30	46	54 (10cm)	>100					
24.0											
24.5											
25.0	25	SPT-12	25	47	53 (12cm)	>100					
25.5											
26.0											
26.5	26.5	SPT-13	28	48	52 (10cm)	>100					
27.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
27.5											
28.0	28	SPT-14	34	60	40 (7cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-15	42	56	44 (8cm)	>100					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123214.311 m	*Easting :*696528.146 m
Reduced Level (m):(+)263.022	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*38.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*19-10-2021	*Date of Completion :*22-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-16	19	36	54	90					
31.5											
32.0											
32.5	32.5	SPT-17	38	55	45 (9cm)	>100					
33.0											
33.5											
34.0	34	SPT-18	43	57	43 (7cm)	>100	Brown, Hard, Silty clay of low plasticity with gravel	CL			
34.5											
35.0											
35.5	35.5	SPT-19	35	44	56 (8cm)	>100					
36.0											
36.5											
37.0	37	SPT-20	41	62	38 (8cm)	>100					
37.5											
38.0									38.10m		
38.5	38.5	SPT-21	100 (15cm)	-	-	>100					
39.0							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
39.5											
40.0	40	SPT-22	46	100 (13cm)	-	>100					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123214.311 m	*Easting :*696528.146 m
Reduced Level (m):(+)263.022	*BH. No. :*BH-P1	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*38.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*19-10-2021	*Date of Completion :*22-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0										0 10 20 30 40 50 60 70 80 90 100	
40.5											
41.0											
41.5	41.5	SPT-23	51	100 (12cm)	-	>100	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
42.0											
42.5											
43.0	43	SPT-24	47	53	47 (9cm)	>100					
43.5											
44.0											
44.5	44.5	SPT-25	52	65	35 (8cm)	>100					
45.0											
45.5											
46.0	46	SPT-26	55 (10cm)	100	-	>100					
46.5							Brown, Hard, Silty clay of low plasticity with gravel	CL			
47.0											
47.5	47.5	SPT-27	100 (13cm)	-	-	>100					
48.0											
48.5											
49.0	49	SPT-28	80	100 (7cm)	-	>100					
	49.22	-									
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123189.55 m	*Easting :*696520.214 m
Reduced Level (m):(+)263.955	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	3	4	5	9					
1.5											
2.0											
2.5	2.5	UDS-1					Brown, Loose to medium dense, Sandy silt of low plasticity	ML-CL			
3.0											
3.5											
4.0	4	SPT-2	5	7	11	18					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	8	14	17	31					
7.5											
8.0							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	CL			
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	12	16	18	34					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123189.55 m	*Easting :*696520.214 m
Reduced Level (m):(+)263.955	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021	*Date of Completion :*18-10-2021	

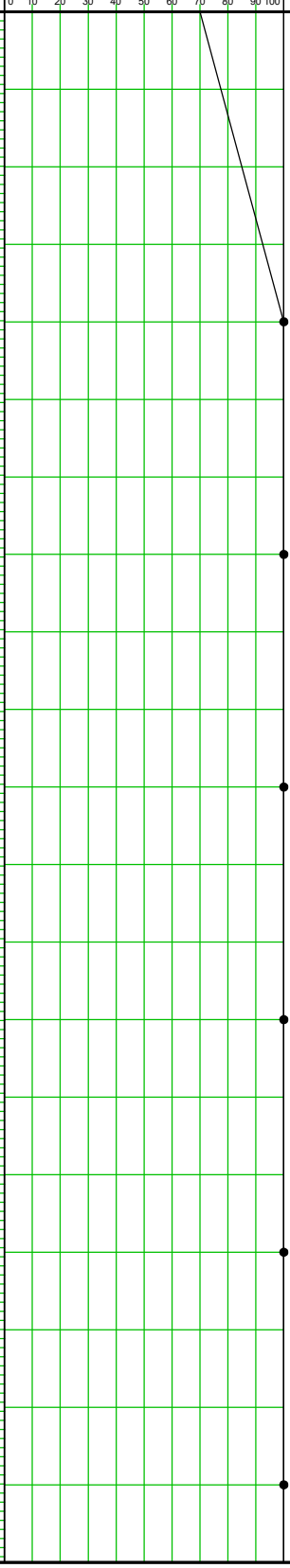
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	14	21	26	47					
13.5							Brown, Dense to very dense, Sandy silt of low plasticity with gravel	CL			
14.0											
14.5	14.5	UDS-5									
15.0											
15.5											
16.0	16	SPT-6	25	29	41	70					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5							Brown, Hard, Silty clay of low plasticity with gravel	ML-CL			
19.0	19	SPT-7	20	23	32	55					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123189.55 m	*Easting :*696520.214 m
Reduced Level (m):(+)263.955	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	58	100 (10cm)	-	>100					
22.5											
23.0											
23.5	23.5	SPT-9	70	100 (15cm)	-	>100					
24.0											
24.5											
25.0	25	SPT-10	34	45	55 (8cm)	>100	Brown, Hard, Silty clay of low plasticity with gravel	ML-CL			
25.5											
26.0											
26.5	26.5	SPT-11	50	82	18 (2cm)	>100					
27.0											
27.5											
28.0	28	SPT-12	25	52	48 (10cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-13	42	100 (15cm)	-	>100					
30.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123189.55 m	*Easting :*696520.214 m
Reduced Level (m):(+)263.955	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-14	44	60	40 (7cm)	>100					
31.5											
32.0											
32.5	32.5	SPT-15	26	44	56 (11cm)	>100					
33.0											
33.5											
34.0	34	SPT-16	30	85	15 (2cm)	>100					
34.5									34.55m		
35.0							Brown, Hard, Silty clay of low plasticity with gravel	ML-CL			
35.5	35.5	SPT-17	32	50	50 (7cm)	>100					
36.0											
36.5											
37.0	37	SPT-18	41	65	35 (8cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-19	47	100 (5cm)	-	>100					
39.0											
39.5											
40.0	40	SPT-20	45	100 (7cm)	-	>100					

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123189.55 m	*Easting :*696520.214 m
Reduced Level (m):(+)263.955	*BH. No. :*BH-P2	*BH Termination Depth (m):*50
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*15-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
40.0										0 10 20 30 40 50 60 70 80 90 100	
40.5											
41.0											
41.5	41.5	SPT-21	52	100 (4cm)	-	>100					
42.0											
42.5											
43.0	43	SPT-22	100 (15cm)	-	-	>100					
43.5											
44.0											
44.5	44.5	SPT-23	80	100 (9cm)	-	>100					
45.0							Brown, Hard, Silty clay of low plasticity with gravel	ML-CL			
45.5											
46.0	46	SPT-24	65	100 (7cm)	-	>100					
46.5											
47.0											
47.5	47.5	SPT-25	100 (14cm)	-	-	>100					
48.0											
48.5											
49.0	49 49.08	SPT-26 -	100 (9cm)	-	-	>100					
49.5											
50.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123180.027 m	*Easting :*696517.163 m
Reduced Level (m):(+)263.847	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Very stiff, Silty clay of low plasticity	CL			
2.5	2.5	SPT-1	7	9	13	22					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	12	16	21	37	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	9	12	24	36	Brown, Hard, Silty clay of low plasticity with gravel	CL			
9.0											
9.5											
10.0	10	UDS-4									

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123180.027 m	*Easting :*696517.163 m
Reduced Level (m):(+)263.847	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	14	18	22	40					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	18	35	42	77	Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	16	19	29	48					
18.0											
18.5											
19.0	19	UDS-7									
19.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123180.027 m	*Easting :*696517.163 m
Reduced Level (m):(+)263.847	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0										0 10 20 30 40 50 60 70 80 90 100	
20.5	20.5	SPT-7	34	100 (15cm)	-	>100					
21.0											
21.5											
22.0	22	SPT-8	37	100 (10cm)	-	>100					
22.5							Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
23.0											
23.5	23.5	SPT-9	100 (10cm)	-	-	>100					
24.0											
24.5											
25.0	25	SPT-10	33	75	25 (3cm)	>100					
25.5											
26.0											
26.5	26.5	SPT-11	45	100 (4cm)	-	>100					
27.0											
27.5							Brown, Hard, Silty clay of low plasticity with gravel	CL			
28.0	28	SPT-12	48	52	48 (4cm)	>100					
28.5											
29.0											
29.5	29.5	SPT-13	51	100 (7cm)	-	>100					
30.0											

UDS*-UDS not recovered

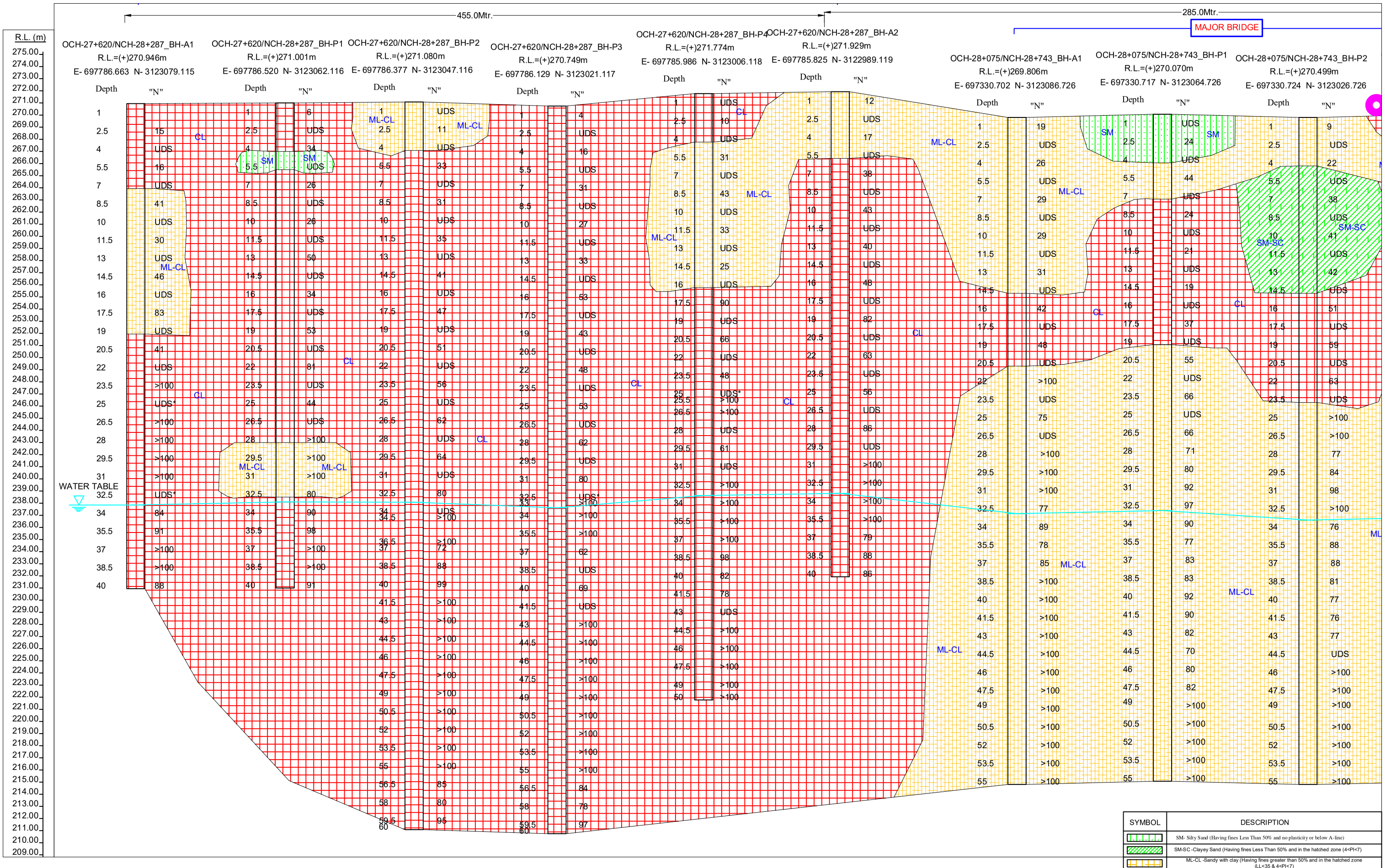
FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*28+900 km	*Northing :*3123180.027 m	*Easting :*696517.163 m
Reduced Level (m):(+)263.847	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*34.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*16-10-2021	*Date of Completion :*18-10-2021	

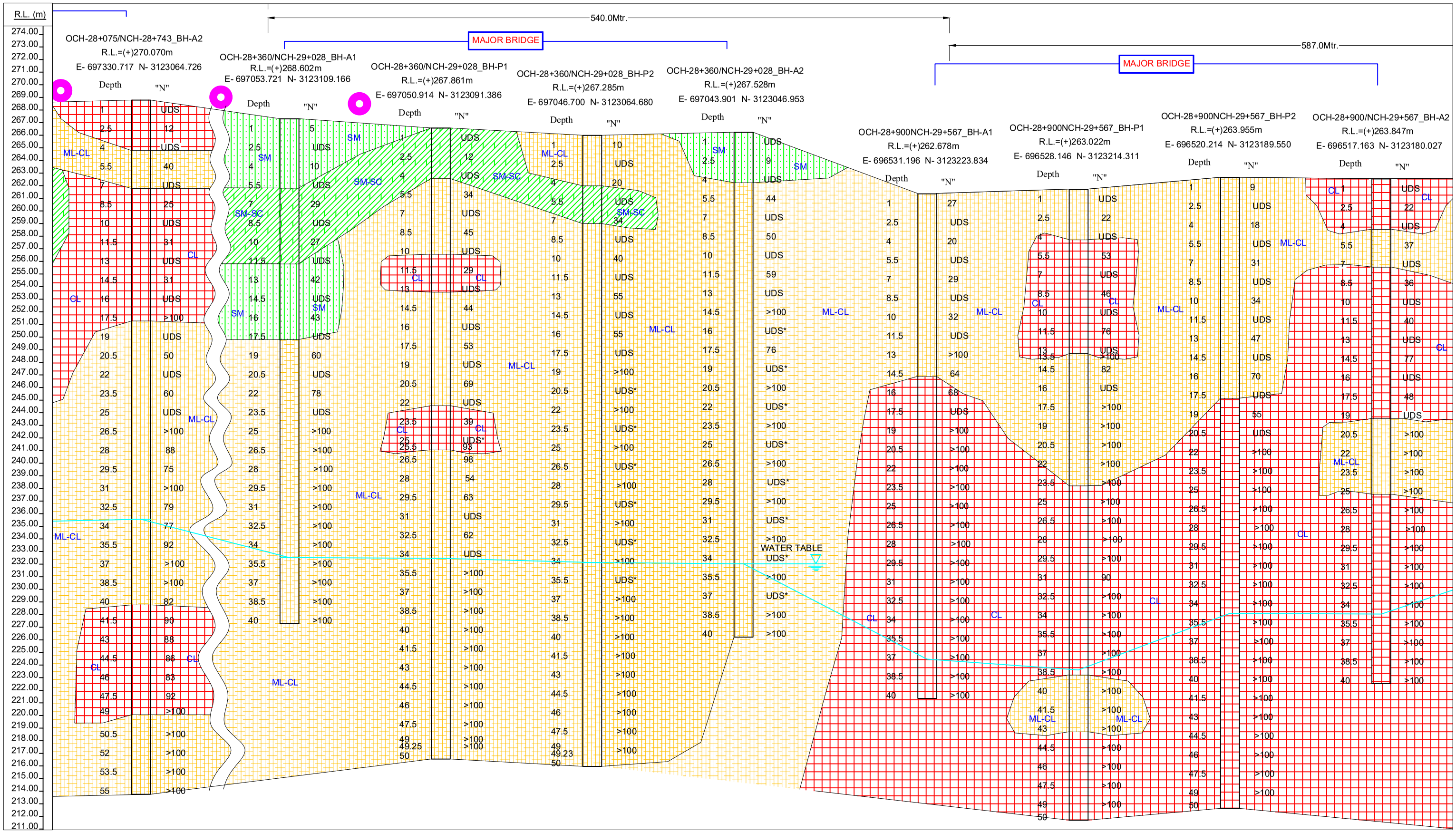
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-14	41	53 (7cm)	47	>100					
31.5											
32.0											
32.5	32.5	SPT-15	32	47	53 (4cm)	>100					
33.0											
33.5											
34.0	34	SPT-16	45	59	41 (6cm)	>100					
34.5									34.50m		
35.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5	35.5	SPT-17	58	100 (5cm)	-	>100					
36.0											
36.5											
37.0	37	SPT-18	35	48	52 (8cm)	>100					
37.5											
38.0											
38.5	38.5	SPT-19	38	55	45 (6cm)	>100					
39.0											
39.5											
40.0	40	SPT-20	33	100 (15cm)	-	>100					

UDS*-UDS not recovered

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



SYMBOL	DESCRIPTION
	SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line)
	SM-SC -Clayey Sand (Having fines Less Than 50% and in the hatched zone (4<PI<7)
	ML-CL -Sandy with clay (Having fines greater than 50% and in the hatched zone (LL<35 & 4<PI<7)
	CL-Silty Clay of low plasticity (Above A-line, LL<35)
	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)
	BOREHOLE REQUIRED / WATER TABLE

Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20)

SCALE:- HOR:- 1:2850 SCALE:- VER:- 1:285

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APPENDIX – B (LAB TEST RESULTS)

Appendix No.	ITEMS
B-1	SOIL CHARACTERISTICS SHEETS
B-2	RESULT OF CHEMICAL ANALYSIS OF SOIL SAMPLES
B-3	RESULT OF CHEMICAL ANALYSIS OF WATER SAMPLES
B-4	GSD CURVES
B-5	SHEAR CURVE
B-6	CONSOLIDATION CURVE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						11-10-2021	to	12-10-2021	27+620 Major Bridge	BH-A1	33.10 m	40.00 m	697786.663 m	3123079.115 m	(+)270.946 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS	0.00	-	-	Brown, Very stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		CL		9	52	30	3	4	2	0	30	21	9	-	1.72	13.26	1.52	2.68	UUT	0.53	4	-	-	-	-	-	-	-	-	-
SPT-1	2.50	15	15		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-		CL		10	54	26	5	3	2	0	31	21	10	-	1.73	13.80	1.52	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-2	5.50	16	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		8	47	35	4	3	3	0	28	21	7	-	1.82	13.34	1.61	2.66	DST	0.21	26	-	-	-	-	-	-	-	-	-
SPT-3	8.50	41	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		ML-CL		7	51	38	1	1	2	0	26	20	6	-	1.82	13.94	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	11.50	30	23		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		ML-CL		7	48	34	3	5	3	0	27	20	7	-	1.83	14.25	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	46	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	56	19	3	4	7	0	31	20	11	-	1.96	16.22	1.69	2.67	UUT	2.58	4	-	-	-	-	-	-	-	-	-
SPT-6	17.50	83	83		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL		10	57	21	5	2	5	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	20.50	41	41		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL		12	56	18	4	4	6	0	32	21	11	-	2.00	17.84	1.70	2.68	UUT	3.13	4	-	-	-	-	-	-	-	-	-
SPT-8	23.50	100 (18cm)	100 (18cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	80	80		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	100 (27cm)	100 (27cm)		CL		9	50	28	4	2	7	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		11-10-2021	to	12-10-2021	27+620 Major Bridge	BH-A1	33.10 m	40.00 m	697786.663 m	3123079.115 m	(+)270.946 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-11	28.00	100 (20cm)	100 (20cm)	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	100 (24cm)	100 (24cm)		CL		11	52	21	3	2	11	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	31.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	32.50	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	34.00	84	84		CL		12	49	20	3	5	9	2	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	35.50	91	91		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	37.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	38.50	100 (18cm)	100 (18cm)		CL		11	50	23	4	4	8	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	40.00	88	88		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							11-10-2021	to	12-10-2021	27+620 Major Bridge	BH-P1	32.90 m	40.00 m	697786.520 m	3123062.116 m	(+)271.001 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ °)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	6	6		CL		12	60	19	5	4	0	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		CL		13	63	18	3	2	1	0	34	23	11	-	1.63	12.30	1.45	2.67	UUT	0.23	5	-	-	-	-	-	-	-	-	-
SPT-2	4.00	34	39	Brown, Dense, Silty sand	SM		0	38	49	9	4	0	0	-	Nil	NP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		CL		11	68	14	2	3	2	0	31	20	11	-	1.79	13.46	1.58	2.68	UUT	0.88	4	-	-	-	0.695	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.44 6.30 5.16 4.57	1.79 1.39 0.92 0.59	0.1260
SPT-3	7.00	26	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		CL		12	66	16	1	2	3	0	32	21	11	-	1.80	14.06	1.58	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	26	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		CL		11	58	18	3	4	6	0	31	20	11	-	1.85	14.70	1.61	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	50	50		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		13	56	20	5	3	3	0	34	23	11	-	1.86	15.26	1.61	2.67	UUT	1.17	5	-	-	-	-	-	-	-	-
SPT-6	16.00	34	34	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		12	55	19	7	2	5	0	33	22	11	-	1.90	16.11	1.64	2.68	UUT	1.75	4	-	-	-	-	-	-	-	-
SPT-7	19.00	53	53		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		10	54	23	5	2	6	0	31	21	10	-	1.97	16.80	1.69	2.68	UUT	2.50	4	-	-	-	-	-	-	-	-
SPT-8	22.00	81	81		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		CL		11	59	22	2	2	4	0	32	21	11	-	1.92	17.67	1.63	2.67	UUT	1.46	5	-	-	-	-	-	-	-	-
SPT-9	25.00	44	44				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		CL		10	57	21	4	3	4	1	30	20	10	-	1.93	18.10	1.63	-	CUT Total Effective	0.26 0.21	22 26	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
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Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ °)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
SPT-10	28.00	100 (25cm)	100 (25cm)	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	29.50	100 (23cm)	-		ML-CL		7	49	28	3	5	8	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	100 (17cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	32.50	80	80	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	58	19	2	1	10	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	34.00	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	35.50	98	98		CL		12	52	20	4	3	7	2	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	37.00	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	38.50	100 (23cm)	100 (23cm)		CL		11	53	18	6	4	8	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	91	91		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P3	33.13 m	60.00 m	697786.129 m	3123021.117 m	-	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS-1	0.00	-	-	Brown, Medium stiff to very stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	4	4		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		CL		11	54	28	6	1	0	0	31	21	10	-	1.69	14.05	1.48	2.67	UUT	0.37	5	-	-	-	-	-	-	-	-	-
SPT-2	4.00	16	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	53	30	5	1	1	0	30	20	10	-	1.84	15.23	1.60	2.68	UUT	1.02	5	-	-	-	-	-	-	-	-	-
SPT-3	7.00	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		CL		12	53	26	4	2	3	0	33	22	11	-	1.85	15.47	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	27	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		CL		11	48	28	5	3	5	0	31	20	11	-	1.85	15.60	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	33	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		13	47	26	6	1	7	0	34	23	11	-	1.90	15.96	1.64	2.67	UUT	1.66	4	-	-	-	-	-	-	-	-	-
SPT-6	16.00	53	53		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		12	47	28	4	3	6	0	33	22	11	-	1.90	16.42	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	19.00	43	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		11	49	24	7	2	7	0	31	20	11	-	1.91	16.23	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		CL		10	48	30	5	1	6	0	30	20	10	-	1.91	16.74	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	53	53		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		CL		12	45	27	6	2	8	0	33	22	11	-	1.94	17.02	1.66	2.68	UUT	1.98	4	-	-	-	-	-	-	-	-	-
SPT-10	28.00	62	62		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P3	33.13 m	60.00 m	697786.129 m	3123021.117 m	-	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
UDS-10	29.50	-	-		CL		11	47	24	6	2	10	0	31	20	11	-	1.98	17.25	1.69	2.67	UUT	3.12	4	-	-	-	-	-	-	-	-
SPT-11	31.00	80	80		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	32.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	33.00	100 (20cm)	100 (20cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	34.00	100 (20cm)	100 (20cm)		CL		13	45	23	6	2	11	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	35.50	100 (26cm)	100 (26cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	37.00	62	62		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-11	38.50	-	-		CL		11	46	28	5	1	9	0	31	21	10	-	2.03	21.36	1.67	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	40.00	69	69		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-12	41.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		12	42	28	6	2	10	0	33	22	11	-	2.05	20.64	1.70	2.68	UUT	3.18	4	-	-	-	-	-	-	-	-
SPT-17	43.00	100 (27cm)	100 (27cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	44.50	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	46.00	100 (20cm)	100 (20cm)		CL		12	45	25	6	2	10	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	47.50	100 (20cm)	100 (20cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	49.00	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	50.50	100 (21cm)	100 (21cm)		CL		11	44	26	7	4	8	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	52.00	100 (20cm)	100 (20cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	53.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	55.00	>100	-		CL		10	42	28	5	3	12	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	56.50	84	84		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
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Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction ($\varphi°$)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-27	58.00	78	78	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	59.50	97	97		CL		11	47	26	4	3	9	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DS-2	60.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P4	33.14 m	50.00 m	697785.986 m	3123006.118 m	-	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction ($\varphi°$)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS	0.00	-	-	Brown, Stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		CL		11	50	33	6	0	0	0	31	20	11	-	1.66	12.40	1.48	2.67	UUT	0.37	5	-	-	-	-	-	-	-	-	-
SPT-1	2.50	10	10		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	ML-CL		7	44	34	10	2	3	0	27	20	7	-	1.81	13.22	1.60	2.66	DST	0.18	27	-	-	-	-	-	-	-	-	-
SPT-2	5.50	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		ML-CL		8	45	34	7	1	5	0	28	21	7	-	1.83	13.60	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	43	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		ML-CL		6	45	35	6	4	4	0	26	20	6	-	1.81	14.02	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	11.50	33	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		ML-CL		7	46	35	6	3	3	0	26	19	7	-	1.80	14.80	1.57	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	25	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		12	40	30	10	1	7	0	33	22	11	-	1.92	15.26	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL		11	49	26	7	1	6	0	32	21	11	-	1.92	15.40	1.66	2.68	UUT	2.24	4	-	-	-	-	-	-	-	-	-
SPT-7	20.50	66	66		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL		11	49	28	5	3	4	0	31	20	11	-	1.91	16.23	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	25.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.50	100 (25cm)	100 (25cm)		CL		10	47	27	4	3	9	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	20-11-2021	27+620 Major Bridge	BH-P4	33.14 m	50.00 m	697785.986 m	3123006.118 m	-	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction ($\varphi°$)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
UDS-9	28.00	-	-		CL		12	48	25	7	1	7	0	32	21	11	-	1.96	18.25	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	29.50	61	61		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	31.00	-	-		CL		11	43	26	10	0	10	0	31	21	10	-	2.05	20.34	1.70	2.68	UUT	3.15	4	-	-	-	-	-	-	-	-	-
SPT-12	32.50	100 (28cm)	100 (28cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	34.00	100 (26cm)	100 (26cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	35.50	100 (24cm)	100 (24cm)		CL		12	46	23	6	1	12	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	37.00	100 (30cm)	100 (30cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	38.50	98	98	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	40.00	82	82		CL		13	46	22	5	4	10	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	41.50	78	78		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-11	43.00	-	-		CL		11	47	22	12	0	8	0	30	20	10	-	2.04	20.85	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	44.50	100 (26cm)	100 (26cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	46.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	47.50	100 (22cm)	100 (22cm)		CL		13	45	23	8	2	9	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	49.00	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	50.00	100 (19cm)	100 (19cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							18-11-2021	to	21-11-2021	27+620 Major Bridge	BH-P2	33.00 m	60.00 m	697786.377 m	3123047.116 m	(+)271.080 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS	0.00	-	-	Brown, Medium dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		ML-CL		9	55	30	5	1	0	0	28	21	7	-	1.69	12.04	1.51	2.66	DST	0.20	24	-	-	-	-	-	-	-	-	-
SPT-1	2.50	11	14		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	52	28	4	2	3	0	32	21	11	-	1.81	13.25	1.60	2.67	UUT	1.12	5	-	-	-	-	-	-	-	-	-
SPT-2	5.50	33	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		CL		12	54	25	3	2	4	0	33	22	11	-	1.82	13.51	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		11	50	27	6	1	5	0	32	21	11	-	1.83	13.89	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	11.50	35	35		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		10	54	26	4	2	4	0	30	20	10	-	1.86	14.29	1.63	2.68	UUT	1.45	4	-	-	-	-	-	-	-	-	-
SPT-5	14.50	41	41		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		10	49	30	6	1	4	0	30	20	10	-	1.87	14.90	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	47	47		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL		13	48	24	7	2	6	0	34	23	11	-	1.90	15.34	1.65	2.67	UUT	1.78	4	-	-	-	-	-	-	-	-	-
SPT-7	20.50	51	51		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL		12	49	23	5	4	7	0	32	21	11	-	1.92	16.42	1.65	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	56	56		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		CL		11	51	25	4	3	6	0	31	21	10	-	1.94	17.12	1.66	2.68	UUT	2.02	5	-	-	-	-	-	-	-	-	-
SPT-9	26.50	62	62		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	28.00	-	-		CL		12	42	30	6	2	8	0	33	22	11	-	1.96	17.88	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	21-11-2021	27+620 Major Bridge	BH-P2	33.00 m	60.00 m	697786.377 m	3123047.116 m	(+)271.080 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-10	29.50	64	64		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-11	31.00	-	-		CL		12	48	28	3	2	7	0	32	21	11	-	2.04	20.45	1.69	2.67	UUT	3.15	5	-	-	-	-	-	-	-	-	-
SPT-11	32.50	80	80		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-12	34.00	-	-		CL		10	50	23	5	1	11	0	31	21	10	-	2.04	20.10	1.70	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	34.50	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	36.50	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	37.00	62	62		CL		11	47	26	7	1	8	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	38.50	88	88		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	40.00	99	99		CL		11	41	30	6	2	10	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	41.50	100 (23cm)	100 (23cm)	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	43.00	100 (23cm)	100 (23cm)		CL		13	47	26	6	1	7	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	44.50	100 (20cm)	100 (20cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	46.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	47.50	100 (24cm)	100 (24cm)		CL		11	49	24	4	3	9	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	49.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	50.50	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	52.00	100 (21cm)	100 (21cm)		CL		12	49	26	3	2	8	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	53.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	55.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	56.50	85	85		CL		13	45	22	7	2	11	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	21-11-2021	27+620 Major Bridge	BH-P2	33.00 m	60.00 m	697786.377 m	3123047.116 m	(+)271.080 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-28	58.00	80	80	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-29	59.50	95	95		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	60.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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							18-11-2021	to	19-11-2021	27+620 Major Bridge	BH-A2	33.12 m	40.00 m	697785.825 m	3122989.119 m	-	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS	0.00	-	-	Brown, Medium dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	12	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		9	52	32	7	0	0	0	28	21	7	-	1.74	13.26	1.54	2.66	DST	0.20	24	-	-	-	-	-	-	-	-	-
SPT-2	4.00	17	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	46	26	12	1	4	0	32	21	11	-	1.92	18.41	1.62	2.68	UUT	1.36	5	-	-	-	-	-	-	-	-	-
SPT-3	7.00	38	38		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		CL		12	50	25	6	2	5	0	33	22	11	-	1.93	18.96	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	43	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		CL		10	50	27	8	0	5	0	30	20	10	-	1.93	19.10	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	40	40		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		11	45	30	5	3	6	0	31	20	11	-	1.94	19.32	1.63	2.67	UUT	1.59	4	-	-	-	-	-	-	-	-	-
SPT-6	16.00	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		13	45	28	4	2	8	0	34	23	11	-	2.01	20.11	1.67	2.67	UUT	2.02	5	-	-	-	-	-	-	-	-	-
SPT-7	19.00	82	82		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		12	47	27	7	1	6	0	33	22	11	-	2.01	20.60	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	63	63		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		CL		10	43	33	6	1	7	0	30	20	10	-	2.03	20.78	1.68	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	56	56		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		CL		11	47	28	8	0	6	0	33	22	11	-	2.05	21.05	1.69	2.68	UUT	2.67	4	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-11-2021	to	19-11-2021	27+620 Major Bridge	BH-A2	33.12 m	40.00 m	697785.825 m	3122989.119 m	-	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-10	28.00	86	86	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	29.50	-	-		CL		13	46	23	7	1	10	0	34	23	11	-	2.05	20.60	1.70	2.67	UUT	3.17	4	-	-	-	-	-	-	-	-	-
SPT-11	31.00	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	32.50	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	34.00	100 (20cm)	100 (20cm)		CL		12	43	25	11	0	9	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	35.50	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	37.00	79	79		CL		11	44	26	9	2	8	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	38.50	88	88		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	40.00	86	86		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		16-10-2021	to	18-10-2021	28+075 Major Bridge	BH-A1	32.67 m	55.00 m	697330.702 m	3123086.726 m	(+)269.806 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	19	30		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		7	48	26	12	5	2	0	27	20	7	-	1.79	12.17	1.60	2.66	DST	0.22	27	-	-	-	-	-	-	-	-	-
SPT-2	4.00	26	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		ML-CL		8	53	31	3	2	3	0	28	21	7	-	1.79	12.80	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	29	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		6	51	23	13	3	4	0	26	20	6	-	1.79	13.24	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	29	23		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		ML-CL		7	49	26	9	4	5	0	26	19	7	-	1.80	13.76	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	31	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	54	16	11	4	5	0	31	20	11	-	1.88	15.06	1.63	2.67	UUT	1.39	5	-	-	-	-	-	-	-	-	-
SPT-6	16.00	42	42		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		12	56	18	4	3	7	0	33	22	11	-	1.88	15.29	1.63	2.68	UUT	1.59	5	-	-	-	-	-	-	-	-	-
SPT-7	19.00	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		8	51	27	4	3	5	2	28	21	7	-	1.88	16.23	1.62	2.66	DST	0.21	28	-	-	-	-	-	-	-	-	-
SPT-8	22.00	68	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		ML-CL		6	48	25	9	4	7	1	26	20	6	-	1.88	16.89	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	75	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		ML-CL		7	45	30	5	3	10	0	27	20	7	-	1.90	17.10	1.62	2.66	DST	0.18	30	-	-	-	-	-	-	-	-	-
SPT-10	28.00	100 (20cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		16-10-2021	to	18-10-2021	28+075 Major Bridge	BH-A1	32.67 m	55.00 m	697330.702 m	3123086.726 m	(+)269.806 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-11	29.50	80	37		ML-CL		8	44	22	10	3	13	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	100 (25cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	32.50	77	35		ML-CL		6	48	33	6	2	5	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	34.00	89	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	35.50	78	25		ML-CL		7	49	26	8	3	7	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	37.00	85	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	38.50	85	27		ML-CL		7	49	30	3	2	8	1	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	100 (19cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	41.50	88	28	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		6	49	25	9	1	10	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	43.00	100 (27cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	44.50	100 (25cm)	-		ML-CL		8	48	29	2	1	12	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	46.00	100 (28cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	47.50	100 (23cm)	-		ML-CL		7	49	30	3	2	8	1	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	50.50	100 (28cm)	-		ML-CL		6	55	27	1	0	11	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	52.00	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	53.50	100 (23cm)	-		ML-CL		7	47	30	3	1	12	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	55.00	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		11-10-2021	to	15-10-2021	28+075 Major Bridge	BH-P1	32.68 m	55.00 m	697330.717 m	3123064.726 m	(+)270.070 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium dense, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM		0	25	69	2	1	3	0	-	Nil	NP	-	1.77	10.34	1.60	2.62	DST	0.00	30	-	-	-	-	-	-	-	-	-
SPT-1	2.50	24	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		7	48	32	6	3	4	0	28	21	7	-	1.83	12.19	1.63	2.66	DST	0.22	26	-	-	-	-	-	-	-	-	-
SPT-2	5.50	44	44		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Brown, Very stiff to hard, Silty clay of low plasticity	CL		12	57	20	4	3	3	1	33	22	11	-	1.79	14.30	1.57	2.68	UUT	0.82	5	-	-	-	0.705	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	7.05 6.30 5.15 4.23	2.02 1.44 0.97 0.59	0.126
SPT-3	8.50	24	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		10	57	23	2	5	3	0	31	20	11	-	1.79	15.24	1.55	2.67	UUT	0.70	4	-	-	-	-	-	-	-	-	-
SPT-4	11.50	21	21		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		12	53	23	5	4	2	1	34	23	11	-	1.80	15.90	1.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	19	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		11	58	21	4	1	5	0	32	21	11	-	1.87	16.43	1.61	2.68	UUT	1.26	5	-	-	-	-	-	-	-	-	-
SPT-6	17.50	37	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		6	48	28	6	4	7	1	26	20	6	-	1.84	15.10	1.60	2.66	DST	0.21	27	-	-	-	-	-	-	-	-	-
SPT-7	20.50	55	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		ML-CL		8	51	30	3	2	6	0	28	21	7	-	1.86	15.76	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	66	34		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		ML-CL		7	48	29	5	4	5	2	27	20	7	-	1.87	16.43	1.61	2.66	DST	0.22	29	-	-	-	-	-	-	-	-	-
SPT-9	26.50	66	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							11-10-2021	to	15-10-2021	28+075 Major Bridge	BH-P1	32.68 m	55.00 m	697330.717 m	3123064.726 m	(+)270.070 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-10	28.00	71	33		ML-CL		6	54	27	3	2	7	1	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	29.50	80	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	92	42		ML-CL		7	52	30	2	3	6	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	32.50	97	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	34.00	90	28		ML-CL		7	50	25	3	5	9	1	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	35.50	77	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	37.00	83	27		ML-CL		8	51	27	3	2	7	2	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	38.50	83	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	92	29		ML-CL		7	51	25	3	3	11	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	41.50	90	28	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	43.00	82	26		ML-CL		7	49	28	5	2	9	0	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	44.50	70	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	46.00	80	26		ML-CL		8	48	26	4	5	8	1	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	47.50	82	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.00	100 (25cm)	-		ML-CL		6	53	26	6	2	7	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	50.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	52.00	100 (20cm)	-		ML-CL		7	46	27	7	3	8	2	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	53.50	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	55.00	100 (18cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						11-10-2021	to	14-10-2021	28+075 Major Bridge	BH-P2	33.20 m	55.00 m	697330.724 m	3123026.726 m	(+)270.499 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS	0.00	-	-	Brown, Loose, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	9	14		ML-CL		6	51	25	13	4	1	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		7	52	29	8	3	1	0	27	20	7	-	1.69	11.63	1.51	2.66	DST	0.20	24	-	-	-	-	-	-	-	-	-
SPT-2	4.00	22	25	Brown, Medium dense to dense, Silty sand with clay & gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		SM-SC		5	41	34	14	3	3	0	26	21	5	-	1.80	12.10	1.61	2.65	DST	0.11	29	-	-	-	-	-	-	-	-	-
SPT-3	7.00	38	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		SM-SC		4	40	41	8	3	4	0	25	20	5	-	1.81	12.36	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	41	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		SM-SC		5	38	38	11	2	4	2	25	20	5	-	1.81	12.89	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	42	30		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	50	19	11	5	5	0	31	21	10	-	1.89	15.11	1.64	2.68	UUT	1.69	5	-	-	-	-	-	-	-	-	-
SPT-6	16.00	51	51		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		12	52	20	7	3	4	2	33	22	11	-	1.92	15.80	1.66	2.67	UUT	1.95	4	-	-	-	-	-	-	-	-	-
SPT-7	19.00	59	59		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		11	52	25	4	2	6	0	32	21	11	-	1.93	16.24	1.66	2.67	CUT Total Effective	0.23 0.20	24 27	-	-	-	-	-	-	-	-	-
SPT-8	22.00	63	63		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		8	45	25	13	3	6	0	28	21	7	-	1.92	16.30	1.65	2.66	DST	0.21	29	-	-	-	-	-	-	-	-	-
SPT-9	25.00	100 (24cm)	-				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	100 (24cm)	-		ML-CL		7	45	26	10	3	9	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						11-10-2021	to	14-10-2021	28+075 Major Bridge	BH-P2	33.20 m	55.00 m	697330.724 m	3123026.726 m	(+)270.499 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-11	28.00	77	35		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	84	39		ML-CL		7	47	24	13	1	8	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	31.00	98	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	32.50	>100	-		ML-CL		6	48	20	17	1	7	1	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	34.00	76	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	35.50	88	28		ML-CL		6	47	24	11	2	10	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	37.00	88	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	38.50	81	26		ML-CL		8	49	30	4	3	6	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	40.00	77	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	41.50	76	25	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	47	27	8	5	4	2	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	43.00	77	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	44.50	-	-		ML-CL		6	49	24	11	3	7	0	26	20	6	-	1.96	18.00	1.66	2.66	DST	0.18	31	-	-	-	-	-	-	-	-	-
SPT-22	46.00	100 (26cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	47.50	100 (22cm)	-		ML-CL		6	47	28	7	2	10	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.00	100 (18cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	50.50	100 (21cm)	-		ML-CL		7	44	30	3	5	9	2	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	52.00	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	53.50	100 (19cm)	-		ML-CL		7	45	20	13	4	11	0	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	55.00	100 (27cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

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		16-10-2021	to	18-10-2021	28+075 Major Bridge	BH-A2	33.21 m	55.00 m	697330.724 m	3123004.726 m	(+)270.616 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		CL		12	59	16	10	2	1	0	34	21	13	-	1.69	12.64	1.50	2.67	UUT	0.44	4	-	-	-	0.780	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.39 8.23 5.96 4.78	2.28 1.85 1.24 0.72	0.159
SPT-1	2.50	12	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		8	46	31	11	2	2	0	28	21	7	-	1.82	12.36	1.62	2.66	DST	0.18	27	-	-	-	-	-	-	-	-
SPT-2	5.50	40	41		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL		10	62	15	7	4	2	0	34	22	12	-	1.80	14.16	1.58	2.68	UUT	0.85	5	-	-	-	-	-	-	-	-
SPT-3	8.50	25	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		12	49	21	4	9	5	0	33	22	11	-	1.84	14.80	1.60	2.67	UUT	1.06	5	-	-	-	-	-	-	-	-
SPT-4	11.50	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		11	58	15	7	5	4	0	32	21	11	-	1.84	15.04	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		11	53	20	6	3	7	0	31	20	11	-	1.84	15.26	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	>100	-	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		ML-CL		7	45	31	8	2	7	0	27	20	7	-	1.86	16.11	1.60	2.66	DST	0.20	28	-	-	-	-	-	-	-	-
SPT-7	20.50	50	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		ML-CL		8	49	29	3	0	9	2	28	21	7	-	1.86	16.30	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	60	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		ML-CL		7	49	19	12	3	10	0	28	21	7	-	1.89	16.74	1.62	2.66	DST	0.22	29	-	-	-	-	-	-	-	-
SPT-9	26.50	100 (29cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	28.00	88	40		ML-CL		6	54	22	6	4	8	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							16-10-2021	to	18-10-2021	28+075 Major Bridge	BH-A2	33.21 m	55.00 m	697330.724 m	3123004.726 m	(+)270.616 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
SPT-11	29.50	75	35	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	100 (19cm)	-		ML-CL		7	48	25	8	2	9	1	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	32.50	79	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	34.00	77	25		ML-CL		6	49	29	4	3	7	2	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	35.50	92	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	37.00	100 (22cm)	-		ML-CL		7	45	24	10	2	12	0	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	38.50	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	82	82	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	50	18	9	5	8	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	41.50	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	43.00	88	88		CL		12	52	16	7	2	11	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	44.50	86	86		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	46.00	83	83		CL		11	55	17	4	1	10	2	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	47.50	92	92		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.00	100 (25cm)	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	45	24	10	1	13	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	50.50	100 (24cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	52.00	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	53.50	100 (23cm)	-		ML-CL		6	48	28	6	2	9	1	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	55.00	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						13-10-2021	to	14-10-2021	28+360 Major Bridge	BH-A1	34.78 m	40.00 m	697053.722 m	3123109.166 m	(+)268.602 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Loose, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	5	8		SM		0	32	62	5	1	0	0	-	Nil	NP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		SM		0	25	68	6	1	0	0	-	Nil	NP	-	1.62	10.36	1.47	2.62	DST	0.00	28	-	-	-	-	-	-	-	-	-
SPT-2	4.00	10	11		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Medium dense, Silty sand with clay	SM-SC		4	36	53	4	1	2	0	25	20	5	-	1.73	11.20	1.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	29	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		SM-SC		5	29	55	6	2	3	0	25	20	5	-	1.75	11.49	1.57	2.63	DST	0.10	27	-	-	-	-	-	-	-	-	-
SPT-4	10.00	27	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-	Brown, Dense, Silty sand with gravel	SM		0	21	60	11	3	5	0	-	Nil	NP	-	1.80	12.40	1.60	2.62	DST	0.00	31	-	-	-	-	-	-	-	-	-
SPT-5	13.00	42	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		SM		0	32	55	6	1	6	0	-	Nil	NP	-	1.80	12.77	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	16.00	43	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	46	28	11	2	6	0	27	20	7	-	1.84	14.16	1.61	2.66	DST	0.18	28	-	-	-	-	-	-	-	-	-
SPT-7	19.00	60	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		ML-CL		6	47	24	10	6	5	2	26	20	6	-	1.86	14.80	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	78	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		ML-CL		7	46	22	13	4	7	1	28	21	7	-	1.92	15.64	1.66	2.66	DST	0.19	30	-	-	-	-	-	-	-	-	-
SPT-9	25.00	100 (28cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	101 (24cm)	-		ML-CL		7	51	25	7	1	9	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		13-10-2021	to	14-10-2021	28+360 Major Bridge	BH-A1	34.78 m	40.00 m	697053.722 m	3123109.166 m	(+)268.602 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-11	28.00	100 (21cm)	-	Brown, Very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	100 (23cm)	-		ML-CL		8	47	26	6	2	11	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	31.00	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	32.50	100 (23cm)	-		ML-CL		7	44	25	13	1	10	0	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	34.00	100 (21cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	35.50	100 (22cm)	-		ML-CL		6	52	27	5	2	8	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	37.00	100 (20cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	38.50	100 (23cm)	-		ML-CL		7	47	26	7	2	11	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	40.00	100 (28cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							13-10-2021	to	15-10-2021	28+360 Major Bridge	BH-P1	34.10 m	50.00 m	697050.915 m	3123091.386 m	(+)267.861 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium dense, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM-SC		5	30	44	14	7	0	0	25	20	5	-	1.69	11.03	1.52	2.63	DST	0.11	26	-	-	-	-	-	-	-	-	-
SPT-1	2.50	12	15		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		6	53	28	4	4	5	0	27	21	6	-	1.82	12.74	1.61	2.66	DST	0.21	26	-	-	-	-	-	-	-	-	-
SPT-2	5.50	34	34		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		ML-CL		7	56	26	3	2	6	0	27	20	7	-	1.83	13.10	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	45	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-	Brown, Very stiff, Silty clay of low plasticity with gravel	CL		11	50	18	10	7	4	0	32	21	11	-	1.84	14.79	1.60	2.67	UUT	2.93	5	-	-	-	-	-	-	-	-	-
SPT-4	11.50	29	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		6	49	26	12	3	4	0	26	20	6	-	1.83	14.60	1.60	2.66	DST	0.20	27	-	-	-	-	-	-	-	-	-
SPT-5	14.50	44	30		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		ML-CL		7	46	25	13	3	5	1	27	20	7	-	1.84	15.03	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	53	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		ML-CL		7	44	27	11	4	7	0	28	21	7	-	1.87	15.41	1.62	2.66	DST	0.22	28	-	-	-	-	-	-	-	-	-
SPT-7	20.50	69	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		9	57	19	6	5	4	0	30	20	10	-	1.89	16.74	1.62	2.68	CUT Total Effective	0.21 0.18	24 26	-	-	-	-	-	-	-	-	-
SPT-8	23.50	39	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	25.00	-	-				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							13-10-2021	to	15-10-2021	28+360 Major Bridge	BH-P1	34.10 m	50.00 m	697050.915 m	3123091.386 m	(+)267.861 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-9	25.50	93	45		ML-CL		7	49	26	7	3	8	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	26.50	98	46		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	28.00	54	25		ML-CL		8	46	21	12	7	6	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	63	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	31.00	-	-		ML-CL		7	46	28	9	4	5	1	26	19	7	-	1.88	17.68	1.60	2.66	DST	0.18	29	-	-	-	-	-	-	-	-	-
SPT-13	32.50	62	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	34.00	-	-		ML-CL		6	48	25	7	8	6	0	27	21	6	-	1.95	18.10	1.65	2.65	DST	0.19	31	-	-	-	-	-	-	-	-	-
SPT-14	35.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	37.00	100 (20cm)	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		8	51	23	4	3	10	1	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	38.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	40.00	100 (21cm)	-		ML-CL		7	46	27	7	5	8	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	41.50	100 (20cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	43.00	100 (20cm)	-		ML-CL		6	50	25	6	2	9	2	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	44.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	46.00	100 (22cm)	-		ML-CL		7	45	30	4	5	7	2	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	47.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	49.00	100 (21cm)	-		ML-CL		8	44	27	7	3	10	1	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	49.25	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							12-10-2021	to	14-10-2021	28+360 Major Bridge	BH-P2	33.85 m	50.00 m	697046.700 m	3123064.680 m	(+)267.285 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS	0.00	-	-	Brown, Loose, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	10	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		7	48	34	7	3	1	0	28	21	7	-	1.70	11.67	1.52	2.66	DST	0.20	23	-	-	-	-	-	-	-	-	-
SPT-2	4.00	20	23	Brown, Medium dense, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		SM-SC		5	34	43	12	4	2	0	25	20	5	-	1.74	11.26	1.56	2.65	DST	0.09	27	-	-	-	-	-	-	-	-	-
SPT-3	7.00	34	32	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		7	55	28	2	4	4	0	27	20	7	-	1.81	13.27	1.60	2.66	DST	0.18	27	-	-	-	-	-	-	-	-	-
SPT-4	10.00	40	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		ML-CL		6	53	27	5	3	6	0	26	20	6	-	1.85	14.36	1.62	2.65	DST	0.18	28	-	-	-	-	-	-	-	-	-
SPT-5	13.00	55	40		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		ML-CL		7	49	30	6	2	5	1	27	20	7	-	1.85	14.89	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	16.00	55	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		ML-CL		6	49	30	4	3	8	0	26	20	6	-	1.91	15.74	1.65	2.66	DST	0.19	30	-	-	-	-	-	-	-	-	-
SPT-7	19.00	100 (20cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	20.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	100 (20cm)	-		ML-CL		7	46	30	6	1	10	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	23.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	100 (19cm)	-		ML-CL		8	50	26	7	2	7	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	26.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		12-10-2021	to	14-10-2021	28+360 Major Bridge	BH-P2	33.85 m	50.00 m	697046.700 m	3123064.680 m	(+)267.285 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-10	28.00	100	46		ML-CL		8	47	28	7	2	8	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	29.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	31.00	100 (19cm)	-		ML-CL		7	50	24	6	3	10	0	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	32.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	34.00	100 (21cm)	-		ML-CL		6	52	29	5	1	7	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	35.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	37.00	100 (20cm)	-		ML-CL		7	50	22	8	4	9	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	38.50	100 (23cm)	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	40.00	100 (20cm)	-		ML-CL		8	48	24	10	2	8	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	41.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	43.00	100 (24cm)	-		ML-CL		7	47	26	11	1	7	1	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	44.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	46.00	>100	-		ML-CL		7	45	25	9	4	9	1	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	47.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	49.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	49.23	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		12-10-2021	to	13-10-2021	28+360 Major Bridge	BH-A2	34.20 m	40.00 m	697043.901 m	3123046.953 m	(+)267.528 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Loose, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM		0	32	56	11	1	0	0	-	Nil	NP	-	1.66	10.43	1.50	2.62	DST	0.00	28	-	-	-	-	-	-	-	-
SPT-1	2.50	9	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		7	50	30	5	4	4	0	27	20	7	-	1.83	12.40	1.63	2.66	DST	0.20	27	-	-	-	-	-	-	-	-
SPT-2	5.50	44	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		ML-CL		6	46	31	8	3	6	0	27	21	6	-	1.84	13.04	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	50	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		ML-CL		7	48	28	6	4	5	2	26	19	7	-	1.85	13.78	1.63	2.66	DST	0.18	28	-	-	-	-	-	-	-	-
SPT-4	11.50	59	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		ML-CL		6	47	23	11	5	8	0	26	20	6	-	1.89	14.76	1.65	2.65	DST	0.18	30	-	-	-	-	-	-	-	-
SPT-5	14.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	16.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	17.50	76	47		ML-CL		7	50	22	9	6	6	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	19.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	20.50	>100	-		ML-CL		8	49	28	4	3	7	1	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	22.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	100 (21cm)	-		ML-CL		7	46	26	9	5	5	2	27	21	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	25.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	26.50	100 (20cm)	-		ML-CL		8	44	16	14	8	10	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		12-10-2021	to	13-10-2021	28+360 Major Bridge	BH-A2	34.20 m	40.00 m	697043.901 m	3123046.953 m	(+)267.528 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction ($\varphi°$)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
UDS*	28.00	-	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	29.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	31.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	32.50	100 (19cm)	-		ML-CL		7	47	20	10	7	9	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	34.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	35.50	100 (25cm)	-		ML-CL		6	47	19	13	4	8	3	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	37.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	38.50	100 (18cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	40.00	100 (25cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		18-10-2021	to	21-10-2021	28+900 Major Bridge	BH-A1	36.90 m	40.00 m	696531.197 m	3123223.834 m	(+)262.678 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium dense to dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	27	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		6	48	32	10	2	2	0	26	20	6	-	1.76	12.10	1.57	2.66	DST	0.21	26	-	-	-	-	-	-	-	-	-
SPT-2	4.00	20	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		ML-CL		7	44	27	14	5	3	0	27	20	7	-	1.78	12.78	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	29	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		7	45	30	9	4	5	0	26	19	7	-	1.79	13.04	1.58	2.66	DST	0.18	27	-	-	-	-	-	-	-	-	-
SPT-4	10.00	32	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		6	50	28	5	3	8	0	27	21	6	-	1.88	13.90	1.65	2.66	DST	0.20	29	-	-	-	-	-	-	-	-	-
SPT-5	13.00	100 (30cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	14.50	64	64	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	55	19	6	6	4	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	16.00	68	68		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	17.50	-	-		CL		12	60	15	4	3	6	0	33	22	11	-	1.96	15.47	1.70	2.68	UUT	3.16	5	-	-	-	-	-	-	-	-	-
SPT-8	19.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	20.50	100 (21cm)	100 (21cm)		CL		11	56	16	3	2	11	1	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	22.00	100 (24cm)	100 (24cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	23.50	102 (21cm)	102 (21cm)		CL		12	49	19	7	3	8	2	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	25.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	26.50	100 (25cm)	100 (25cm)		CL		10	53	20	3	2	12	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	28.00	100 (21cm)	100 (21cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEGTH
CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							18-10-2021	to	21-10-2021	28+900 Major Bridge	BH-A1	36.90 m	40.00 m	696531.197 m	3123223.834 m	(+)262.678 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-15	29.50	100 (22cm)	100 (22cm)	Brown, Hard, Silty clay of low plasticity with gravel	CL		13	52	17	5	3	9	1	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	31.00	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	32.50	100 (23cm)	100 (23cm)		CL		11	56	14	7	1	11	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	34.00	100 (30cm)	100 (30cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	35.50	100 (23cm)	100 (23cm)		CL		10	48	20	6	4	9	3	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	37.00	100 (20cm)	100 (20cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	38.50	>100	-		CL		10	53	19	4	1	13	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	40.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		19-10-2021	to	22-10-2021	28+900 Major Bridge	BH-P1	38.10 m	50.00 m	696528.146 m	3123214.311 m	(+)263.022 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium dense, Sandy silt of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		ML-CL		7	54	26	6	3	4	0	28	21	7	-	1.77	12.10	1.58	2.66	DST	0.20	26	-	-	-	-	-	-	-	-	-
SPT-1	2.50	22	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		12	55	20	4	3	5	1	33	22	11	-	1.87	14.10	1.64	2.67	UUT	1.75	5	-	-	-	-	-	-	-	-	-
SPT-2	5.50	53	53		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		CL		11	55	17	8	2	7	0	32	21	11	-	1.87	14.85	1.63	2.68	UUT	1.52	5	-	-	-	-	-	-	-	-	-
SPT-3	8.50	46	46		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		11	50	23	4	3	9	0	31	20	11	-	1.93	15.04	1.68	2.68	UUT	2.43	4	-	-	-	-	-	-	-	-	-
SPT-4	11.50	76	76		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	46	27	8	2	10	0	27	20	7	-	1.90	14.87	1.65	2.66	DST	0.19	30	-	-	-	-	-	-	-	-	-
SPT-5	13.50	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	14.50	82	55		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		ML-CL		8	45	28	3	4	12	0	28	21	7	-	1.91	15.11	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	17.50	100 (23cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	19.00	100 (21cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	20.50	100 (22cm)	-		ML-CL		7	47	30	2	3	9	2	26	19	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	22.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	23.50	100 (25cm)	100 (25cm)	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	49	20	6	3	9	2	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	25.00	100 (27cm)	100 (27cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	26.50	100 (25cm)	100 (25cm)		CL		12	48	18	9	1	12	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		19-10-2021	to	22-10-2021	28+900 Major Bridge	BH-P1	38.10 m	50.00 m	696528.146 m	3123214.311 m	(+)263.022 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-14	28.00	100 (22cm)	100 (22cm)	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	29.50	100 (23cm)	100 (23cm)		CL		13	48	21	3	4	11	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	31.00	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	32.50	100 (22cm)	100 (22cm)		CL		12	51	18	5	3	7	4	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	34.00	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	35.50	100 (23cm)	100 (23cm)		CL		11	46	22	4	5	12	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	37.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	38.50	>100	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	48	30	2	1	12	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	40.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	41.50	>100	-		ML-CL		6	48	29	4	2	10	1	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	43.00	100 (24cm)	100 (24cm)	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	54	22	5	1	7	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	44.50	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	46.00	>100	-		CL		11	55	17	4	3	9	1	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-27	47.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-28	49.00	>100	-		CL		12	48	15	8	4	13	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	49.22	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
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CEGTH
CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		15-10-2021	to	18-10-2021	28+900 Major Bridge	BH-P2	34.55 m	50.00 m	696520.214 m	3123189.550 m	(+)263.955 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Loose to medium dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	9	14		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		6	46	34	13	1	0	0	26	20	6	-	1.70	12.10	1.52	2.66	DST	0.20	25	-	-	-	-	-	-	-	-	-
SPT-2	4.00	18	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		7	48	28	10	2	5	0	27	20	7	-	1.79	12.76	1.59	2.66	DST	0.19	26	-	-	-	-	-	-	-	-	-
SPT-3	7.00	31	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		8	47	30	6	2	4	3	28	21	7	-	1.80	13.02	1.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	34	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		ML-CL		7	53	26	3	5	6	0	27	20	7	-	1.83	13.46	1.61	2.66	DST	0.20	27	-	-	-	-	-	-	-	-	-
SPT-5	13.00	47	34		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		ML-CL		6	46	30	6	4	7	1	27	21	6	-	1.86	14.28	1.63	2.66	DST	0.19	28	-	-	-	-	-	-	-	-	-
SPT-6	16.00	70	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		12	57	13	10	1	7	0	33	22	11	-	1.92	16.34	1.65	2.68	UUT	1.82	5	-	-	-	-	-	-	-	-	-
SPT-7	19.00	55	55		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		13	53	16	5	1	12	0	34	23	11	-	1.99	17.20	1.70	2.67	UUT	3.14	5	-	-	-	0.575	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.58 8.53 7.59 6.17	1.15 0.84 0.52 0.36	0.073
SPT-8	22.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	23.50	>100	-		CL		10	51	18	8	2	10	1	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	25.00	100 (23cm)	100 (23cm)				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	26.50	100 (17cm)	100 (17cm)		CL		11	41	21	11	5	11	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
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Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-12	28.00	100 (25cm)	100 (25cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	29.50	>100	-		CL		12	50	23	2	1	9	3	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	31.00	100 (22cm)	100 (22cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	32.50	100 (26cm)	100 (26cm)		CL		13	50	20	3	2	10	2	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	34.00	100 (17cm)	100 (17cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	35.50	100 (22cm)	100 (22cm)		CL		11	53	17	2	3	14	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	37.00	100 (23cm)	100 (23cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	38.50	>100	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		12	50	16	7	4	11	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	40.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-21	41.50	>100	-		CL		10	51	20	3	5	9	2	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-22	43.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-23	44.50	>100	-		CL		11	47	19	10	3	7	3	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-24	46.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-25	47.50	>100	-		CL		12	47	22	4	3	10	2	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-26	49.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	49.08	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

SOIL CHARACTERISTICS

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Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Very stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		CL		10	58	16	11	2	3	0	31	21	10	-	1.77	13.16	1.56	2.67	UUT	0.75	4	-	-	-	-	-	-	-	-	-
SPT-1	2.50	22	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		7	51	28	6	3	5	0	27	20	7	-	1.81	12.48	1.61	2.66	DST	0.20	26	-	-	-	-	-	-	-	-	-
SPT-2	5.50	37	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		11	57	21	4	3	4	0	32	21	11	-	1.84	14.19	1.61	2.67	UUT	1.23	5	-	-	-	-	-	-	-	-	-
SPT-3	8.50	36	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		12	58	20	2	2	5	1	33	22	11	-	1.87	15.26	1.62	2.68	UUT	1.35	5	-	-	-	-	-	-	-	-	-
SPT-4	11.50	40	40		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		13	58	17	3	1	8	0	34	23	11	-	1.90	15.90	1.64	2.67	UUT	1.66	5	-	-	-	0.630	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	10.07 8.47 6.84 5.82	1.48 1.06 0.63 0.45	0.093
SPT-5	14.50	77	77		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		12	53	20	6	4	5	0	32	21	11	-	1.91	16.34	1.64	2.67	CUT Total Effective	0.30 0.23	24 27	-	-	-	-	-	-	-	-	-
SPT-6	17.50	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-	Brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	46	24	10	1	12	0	28	21	7	-	1.93	17.00	1.65	2.66	DST	0.18	30	-	-	-	-	-	-	-	-	-
SPT-7	20.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	>100	-		ML-CL		6	46	29	6	2	9	2	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	23.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	25.00	>100	-	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	57	20	4	1	8	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	26.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

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									Fine	Medium	Coarse	Fine	Coarse																				
SPT-12	28.00	100 (19cm)	100 (19cm)	Brown, Hard, Silty clay of low plasticity with gravel	CL		13	54	19	2	1	11	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	29.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	31.00	100 (22cm)	100 (22cm)		CL		12	50	20	3	2	13	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	32.50	100 (19cm)	100 (19cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	34.00	100 (21cm)	100 (21cm)		CL		11	49	19	7	3	11	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	35.50	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	37.00	100 (23cm)	100 (23cm)		CL		12	49	17	3	5	10	4	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-19	38.50	100 (21cm)	100 (21cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-20	40.00	>100	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE

RESULT OF CHEMICAL ANALYSIS OF SOIL SAMPLES

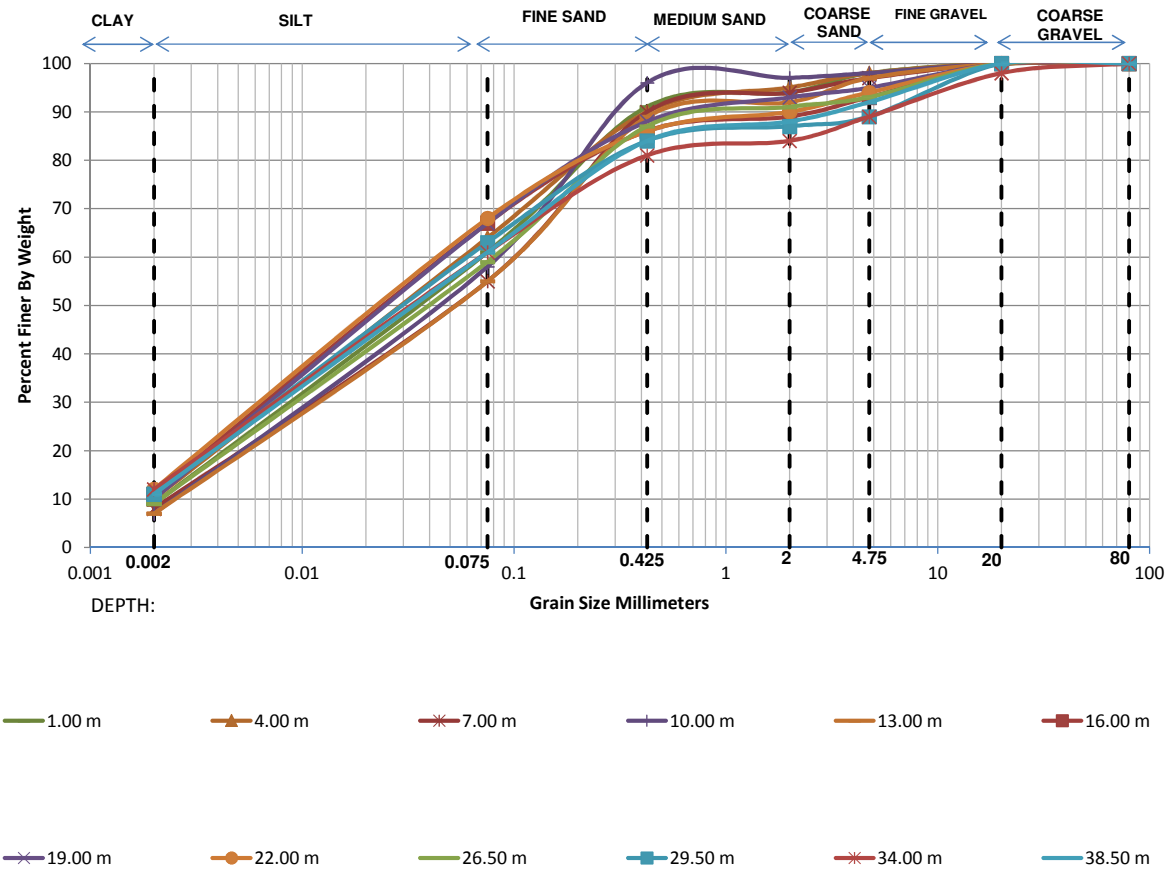
Sr. No	Chainage Old (km)	Chainage New (km)	BH No.	Depth of collected sample (m)	pH	Chlorides (Cl^-)		Sulphate (SO_3^{2-})	
						(mg/kg)	(%)	(mg/kg)	(%)
1.	27+620	28+287	BH-A1	19.00	7.93	78.34	0.0078	30.71	0.0031
2.			BH-P1	2.50	7.40	48.78	0.0049	25.81	0.0026
3.	28+075	28+743	BH-A1	2.50	7.00	57.13	0.0057	30.91	0.0031
4.			BH-P1	25.00	8.01	61.08	0.0061	21.95	0.0022
5.	28+360	29+028	BH-A1	1.00	6.85	47.45	0.0047	28.27	0.0028
6.			BH-P1	34.00	8.61	57.04	0.0057	34.12	0.0034
7.	28+900	27+567	BH-A1	17.5	7.95	63.25	0.0063	34.74	0.0035
8.			BH-P2	14.5	8.11	52.26	0.0052	31.04	0.0031

RESULT OF CHEMICAL ANALYSIS OF WATER SAMPLE

Sr. No	Chainage Old (km)	Chainage New (km)	BH No.	pH	Chlorides (Cl^-) (mg/l)	Sulphate (SO_3^{2-}) (mg/l)
1.	27+620	28+287	BH-A1	7.86	696.25	412.17
2.	28+075	28+743	BH-A1	7.94	526.14	346.28
3.	28+360	29+028	BH-P1	7.86	491.25	274.26
4.	28+900	29+567	BH-A1	7.63	484.16	304.18

GRAIN SIZE DISTRIBUTION CURVES

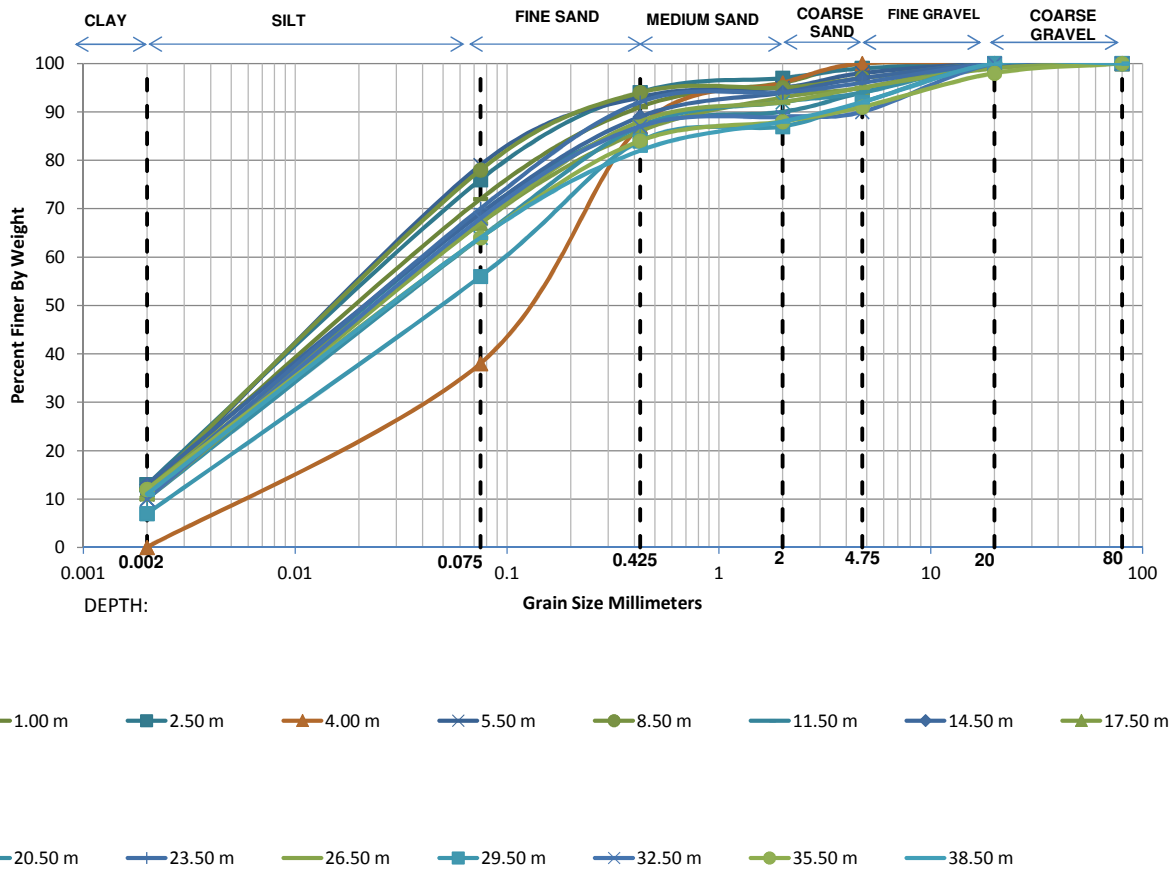
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	9.00	52.00	30.00	3.00	4.00	2.00	0.00	0.0024	0.0183	0.0725	30.19	1.92
4.00 m	10.00	54.00	26.00	5.00	3.00	2.00	0.00	0.0020	0.0159	0.0655	32.76	1.94
7.00 m	8.00	47.00	35.00	4.00	3.00	3.00	0.00	0.0030	0.0230	0.0923	31.23	1.93
10.00 m	7.00	51.00	38.00	1.00	1.00	2.00	0.00	0.0036	0.0223	0.0804	22.45	1.73
13.00 m	7.00	48.00	34.00	3.00	5.00	3.00	0.00	0.0036	0.0240	0.0925	25.52	1.72
16.00 m	11.00	56.00	19.00	3.00	4.00	7.00	0.00	-	0.0138	0.0591	-	-
19.00 m	10.00	57.00	21.00	5.00	2.00	5.00	0.00	0.0020	0.0147	0.0594	29.71	1.83
22.00 m	12.00	56.00	18.00	4.00	4.00	6.00	0.00	-	0.0126	0.0569	-	-
26.50 m	9.00	50.00	28.00	4.00	2.00	7.00	0.00	0.0024	0.0192	0.0779	32.38	1.96
29.50 m	11.00	52.00	21.00	3.00	2.00	11.00	0.00	-	0.0152	0.0675	-	-
34.00 m	12.00	49.00	20.00	3.00	5.00	9.00	2.00	-	0.0150	0.0723	-	-
38.50 m	11.00	50.00	23.00	4.00	4.00	8.00	0.00	-	0.0160	0.0724	-	-

GRAIN SIZE DISTRIBUTION CURVES

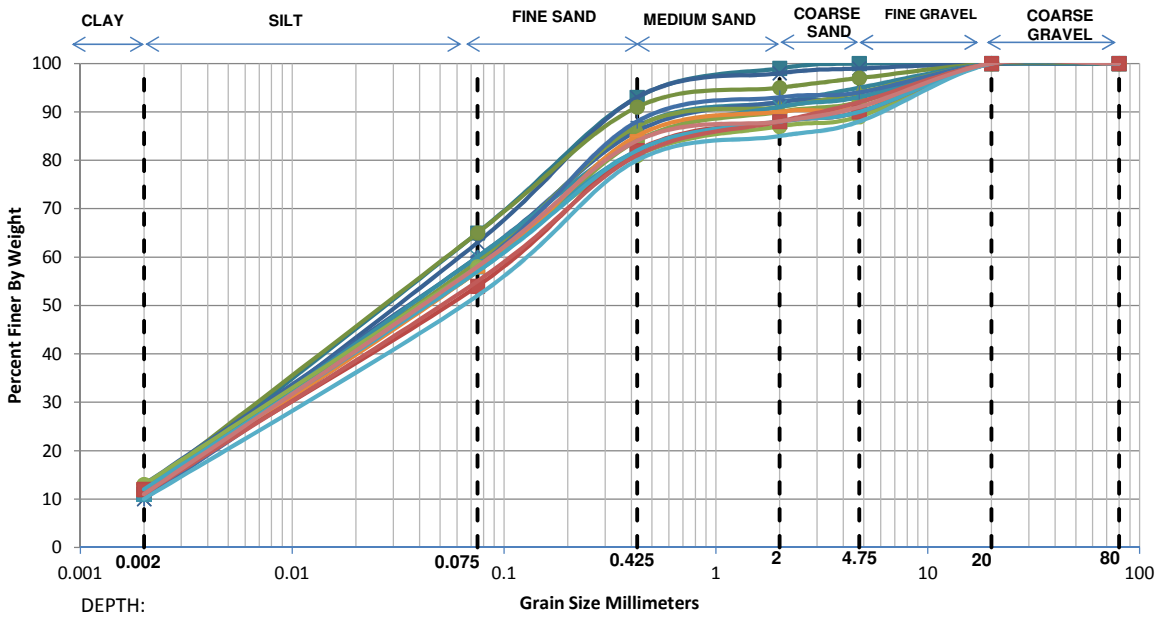
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	12.00	60.00	19.00	5.00	4.00	0.00	0.00	-	0.0117	0.0504	-	-
2.50 m	13.00	63.00	18.00	3.00	2.00	1.00	0.00	-	0.0102	0.0446	-	-
4.00 m	0.00	38.00	49.00	9.00	4.00	0.00	0.00	0.0086	0.0516	0.1688	19.55	1.82
5.50 m	11.00	68.00	14.00	2.00	3.00	2.00	0.00	-	0.0111	0.0420	-	-
8.50 m	12.00	66.00	16.00	1.00	2.00	3.00	0.00	-	0.0106	0.0427	-	-
11.50 m	11.00	58.00	18.00	3.00	4.00	6.00	0.00	-	0.0132	0.0555	-	-
14.50 m	13.00	56.00	20.00	5.00	3.00	3.00	0.00	-	0.0116	0.0549	-	-
17.50 m	12.00	55.00	19.00	7.00	2.00	5.00	0.00	-	0.0129	0.0588	-	-
20.50 m	10.00	54.00	23.00	5.00	2.00	6.00	0.00	0.0020	0.0158	0.0654	32.72	1.91
23.50 m	11.00	59.00	22.00	2.00	2.00	4.00	0.00	-	0.0131	0.0540	-	-
26.50 m	10.00	57.00	21.00	4.00	3.00	4.00	1.00	0.0020	0.0147	0.0594	29.71	1.83
29.50 m	7.00	49.00	28.00	3.00	5.00	8.00	0.00	0.0036	0.0230	0.0903	25.10	1.63
32.50 m	10.00	58.00	19.00	2.00	1.00	10.00	0.00	0.0020	0.0144	0.0575	28.77	1.79
35.50 m	12.00	52.00	20.00	4.00	3.00	7.00	2.00	-	0.0139	0.0650	-	-
38.50 m	11.00	53.00	18.00	6.00	4.00	8.00	0.00	-	0.0147	0.0651	-	-

GRAIN SIZE DISTRIBUTION CURVES

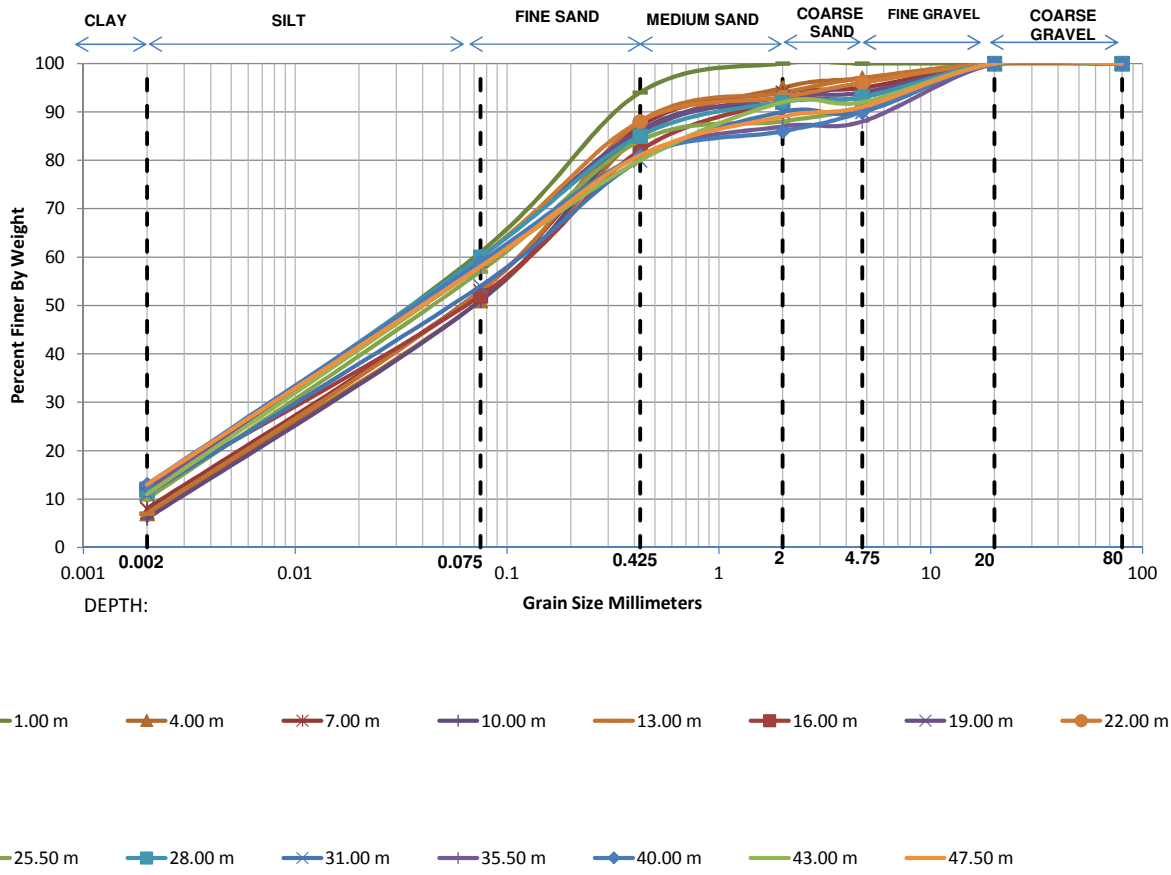
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-P3



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	11.00	54.00	28.00	6.00	1.00	0.00	0.00	-	0.0147	0.0633	-	-
5.50 m	10.00	53.00	30.00	5.00	1.00	1.00	0.00	0.0020	0.0165	0.0678	33.90	2.00
8.50 m	12.00	53.00	26.00	4.00	2.00	3.00	0.00	-	0.0138	0.0631	-	-
11.50 m	11.00	48.00	28.00	5.00	3.00	5.00	0.00	-	0.0172	0.0780	-	-
14.50 m	13.00	47.00	26.00	6.00	1.00	7.00	0.00	-	0.0148	0.0750	-	-
17.50 m	12.00	47.00	28.00	4.00	3.00	6.00	0.00	-	0.0162	0.0780	-	-
20.50 m	11.00	49.00	24.00	7.00	2.00	7.00	0.00	-	0.0165	0.0750	-	-
23.50 m	10.00	48.00	30.00	5.00	1.00	6.00	0.00	0.0020	0.0188	0.0813	40.67	2.17
26.50 m	12.00	45.00	27.00	6.00	2.00	8.00	0.00	-	0.0172	0.0865	-	-
29.50 m	11.00	47.00	24.00	6.00	2.00	10.00	0.00	-	0.0175	0.0824	-	-
34.00 m	13.00	45.00	23.00	6.00	2.00	11.00	0.00	-	0.0155	0.0828	-	-
38.50 m	11.00	46.00	28.00	5.00	1.00	9.00	0.00	-	0.0182	0.0860	-	-
41.50 m	12.00	42.00	28.00	6.00	2.00	10.00	0.00	-	0.0191	0.1035	-	-
46.00 m	12.00	45.00	25.00	6.00	2.00	10.00	0.00	-	0.0171	0.0872	-	-
50.50 m	11.00	44.00	26.00	7.00	4.00	8.00	0.00	-	0.0193	0.0988	-	-
55.00 m	10.00	42.00	28.00	5.00	3.00	12.00	0.00	0.0020	0.0226	0.1176	58.79	2.18
59.50 m	11.00	47.00	26.00	4.00	3.00	9.00	0.00	-	0.0176	0.0819	-	-

GRAIN SIZE DISTRIBUTION CURVES

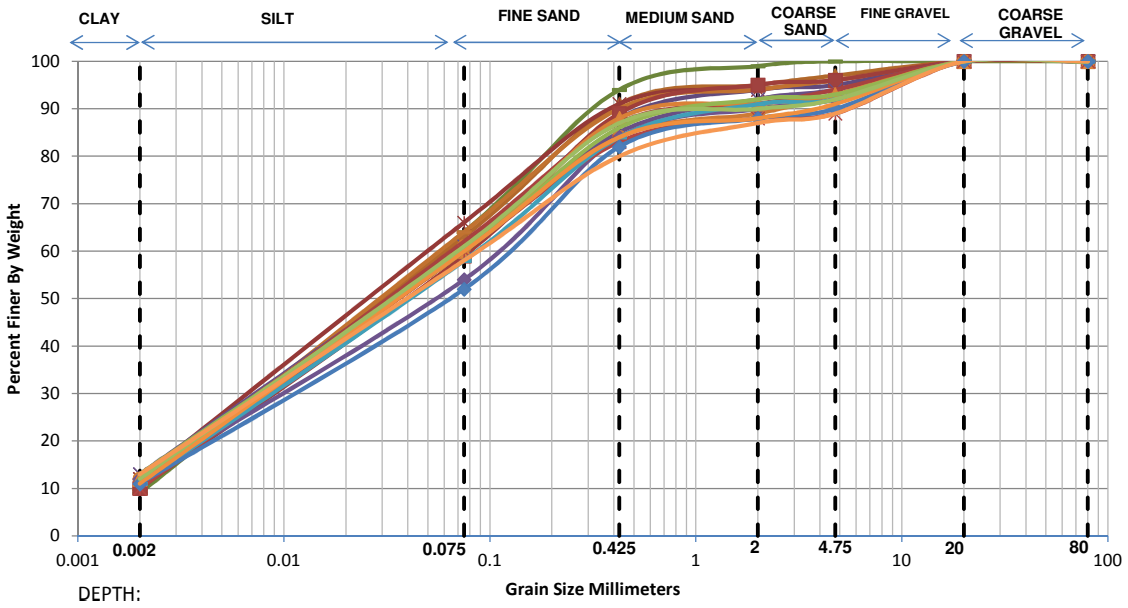
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-P4



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	11.00	50.00	33.00	6.00	0.00	0.00	0.00	-	0.0165	0.0725	-	-
4.00 m	7.00	44.00	34.00	10.00	2.00	3.00	0.00	0.0037	0.0271	0.1156	31.28	1.72
7.00 m	8.00	45.00	34.00	7.00	1.00	5.00	0.00	0.0030	0.0244	0.1032	34.73	1.93
10.00 m	6.00	45.00	35.00	6.00	4.00	4.00	0.00	0.0046	0.0284	0.1133	24.84	1.56
13.00 m	7.00	46.00	35.00	6.00	3.00	3.00	0.00	0.0037	0.0255	0.1021	27.90	1.75
16.00 m	12.00	40.00	30.00	10.00	1.00	7.00	0.00	-	0.0206	0.1160	-	-
19.00 m	11.00	49.00	26.00	7.00	1.00	6.00	0.00	-	0.0166	0.0750	-	-
22.00 m	11.00	49.00	28.00	5.00	3.00	4.00	0.00	-	0.0167	0.0750	-	-
25.50 m	10.00	47.00	27.00	4.00	3.00	9.00	0.00	0.0020	0.0192	0.0861	43.07	2.14
28.00 m	12.00	48.00	25.00	7.00	1.00	7.00	0.00	-	0.0156	0.0750	-	-
31.00 m	11.00	43.00	26.00	10.00	0.00	10.00	0.00	-	0.0200	0.1066	-	-
35.50 m	12.00	46.00	23.00	6.00	1.00	12.00	0.00	-	0.0165	0.0827	-	-
40.00 m	13.00	46.00	22.00	5.00	4.00	10.00	0.00	-	0.0150	0.0784	-	-
43.00 m	11.00	47.00	22.00	12.00	0.00	8.00	0.00	-	0.0174	0.0831	-	-
47.50 m	13.00	45.00	23.00	8.00	2.00	9.00	0.00	-	0.0155	0.0829	-	-

GRAIN SIZE DISTRIBUTION CURVES

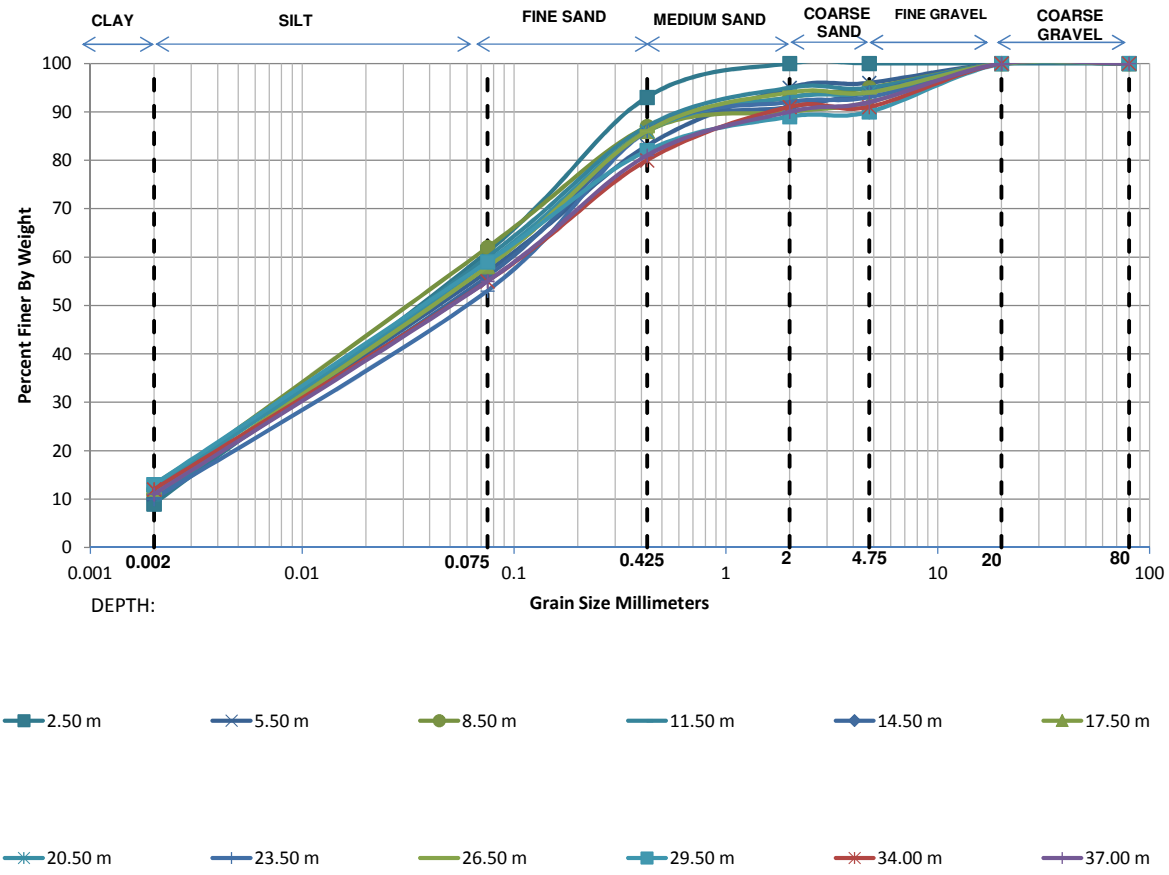
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-P2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	9.00	55.00	30.00	5.00	1.00	0.00	0.00	0.0024	0.0170	0.0658	27.46	1.84
4.00 m	11.00	52.00	28.00	4.00	2.00	3.00	0.00	-	0.0155	0.0676	-	-
7.00 m	12.00	54.00	25.00	3.00	2.00	4.00	0.00	-	0.0134	0.0610	-	-
10.00 m	11.00	50.00	27.00	6.00	1.00	5.00	0.00	-	0.0162	0.0724	-	-
13.00 m	10.00	54.00	26.00	4.00	2.00	4.00	0.00	0.0020	0.0159	0.0655	32.76	1.94
16.00 m	10.00	49.00	30.00	6.00	1.00	4.00	0.00	0.0020	0.0183	0.0779	38.94	2.14
19.00 m	13.00	48.00	24.00	7.00	2.00	6.00	0.00	-	0.0143	0.0723	-	-
22.00 m	12.00	49.00	23.00	5.00	4.00	7.00	0.00	-	0.0151	0.0723	-	-
25.00 m	11.00	51.00	25.00	4.00	3.00	6.00	0.00	-	0.0157	0.0699	-	-
28.00 m	12.00	42.00	30.00	6.00	2.00	8.00	0.00	-	0.0192	0.1016	-	-
31.00 m	12.00	48.00	28.00	3.00	2.00	7.00	0.00	-	0.0158	0.0750	-	-
34.00 m	10.00	50.00	23.00	5.00	1.00	11.00	0.00	0.0020	0.0174	0.0750	37.50	2.03
37.00 m	11.00	47.00	26.00	7.00	1.00	8.00	0.00	-	0.0176	0.0820	-	-
40.00 m	11.00	41.00	30.00	6.00	2.00	10.00	0.00	-	0.0217	0.1147	-	-
43.00 m	13.00	47.00	26.00	6.00	1.00	7.00	0.00	-	0.0148	0.0750	-	-
47.50 m	11.00	49.00	24.00	4.00	3.00	9.00	0.00	-	0.0165	0.0750	-	-
52.00 m	12.00	49.00	26.00	3.00	2.00	8.00	0.00	-	0.0153	0.0723	-	-
56.50 m	13.00	45.00	22.00	7.00	2.00	11.00	0.00	-	0.0155	0.0831	-	-

GRAIN SIZE DISTRIBUTION CURVES

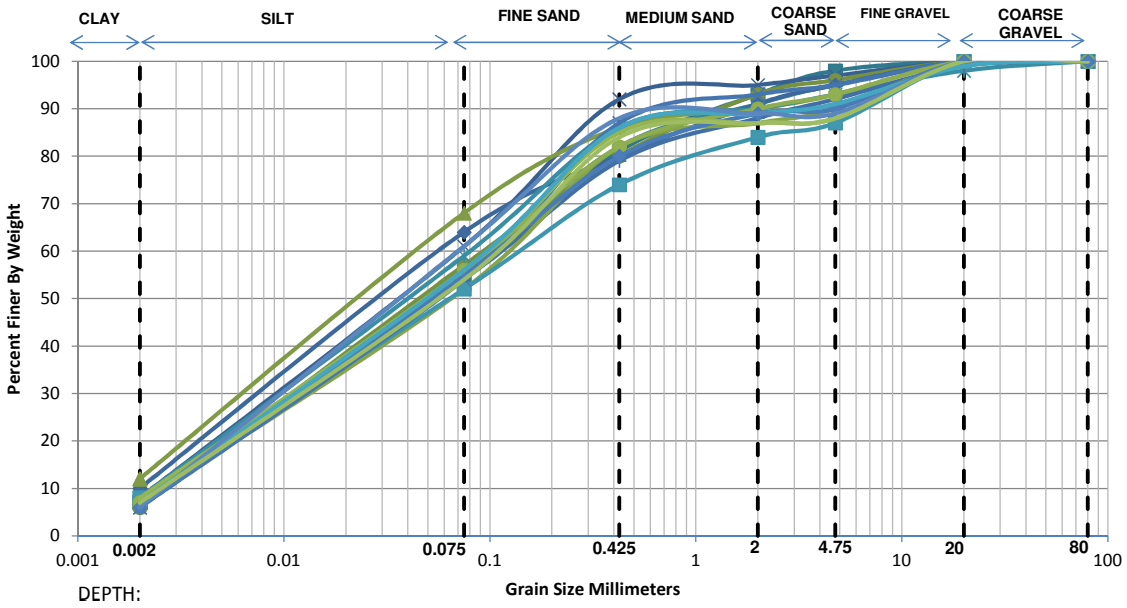
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	27+620 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	9.00	52.00	32.00	7.00	0.00	0.00	0.00	0.0024	0.0184	0.0725	30.20	1.94
5.50 m	11.00	46.00	26.00	12.00	1.00	4.00	0.00	-	0.0181	0.0871	-	-
8.50 m	12.00	50.00	25.00	6.00	2.00	5.00	0.00	-	0.0148	0.0698	-	-
11.50 m	10.00	50.00	27.00	8.00	0.00	5.00	0.00	0.0020	0.0176	0.0750	37.50	2.07
14.50 m	11.00	45.00	30.00	5.00	3.00	6.00	0.00	-	0.0189	0.0902	-	-
17.50 m	13.00	45.00	28.00	4.00	2.00	8.00	0.00	-	0.0158	0.0818	-	-
20.50 m	12.00	47.00	27.00	7.00	1.00	6.00	0.00	-	0.0162	0.0781	-	-
23.50 m	10.00	43.00	33.00	6.00	1.00	7.00	0.00	0.0020	0.0222	0.1044	52.22	2.35
26.50 m	11.00	47.00	28.00	8.00	0.00	6.00	0.00	-	0.0177	0.0817	-	-
29.50 m	13.00	46.00	23.00	7.00	1.00	10.00	0.00	-	0.0151	0.0784	-	-
34.00 m	12.00	43.00	25.00	11.00	0.00	9.00	0.00	-	0.0182	0.1007	-	-
37.00 m	11.00	44.00	26.00	9.00	2.00	8.00	0.00	-	0.0193	0.0991	-	-

GRAIN SIZE DISTRIBUTION CURVES

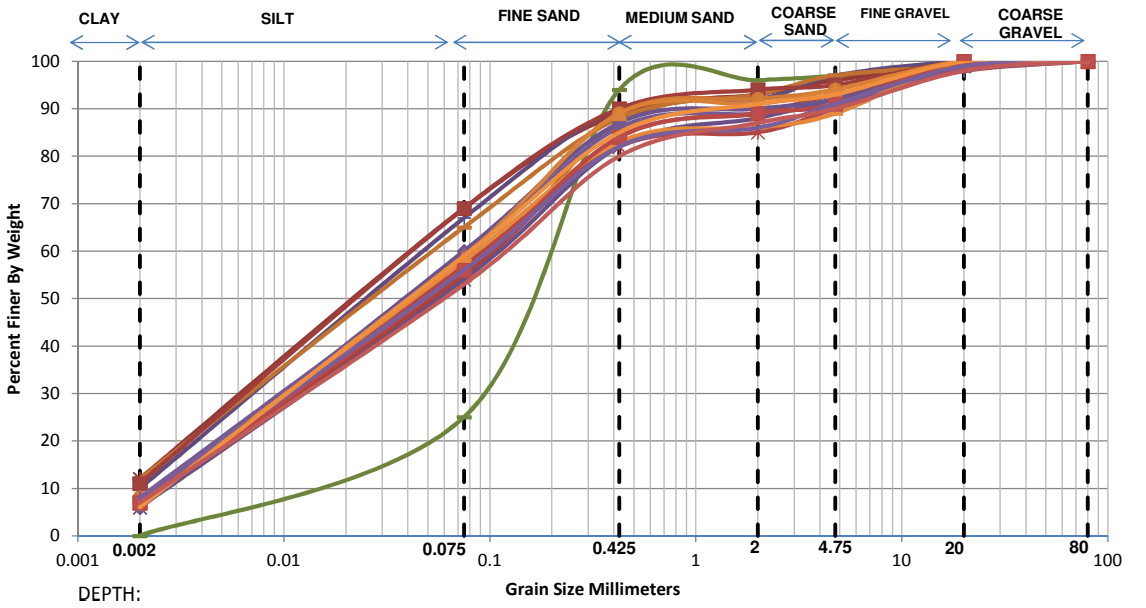
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+075 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	7.00	48.00	26.00	12.00	5.00	2.00	0.00	0.0036	0.0235	0.0988	27.39	1.55
5.50 m	8.00	53.00	31.00	3.00	2.00	3.00	0.00	0.0029	0.0194	0.0726	24.94	1.78
8.50 m	6.00	51.00	23.00	13.00	3.00	4.00	0.00	0.0044	0.0233	0.0880	20.21	1.41
11.50 m	7.00	49.00	26.00	9.00	4.00	5.00	0.00	0.0036	0.0229	0.0920	25.60	1.59
14.50 m	10.00	54.00	16.00	11.00	4.00	5.00	0.00	0.0020	0.0155	0.0652	32.61	1.84
17.50 m	12.00	56.00	18.00	4.00	3.00	7.00	0.00	-	0.0126	0.0569	-	-
20.50 m	8.00	51.00	27.00	4.00	3.00	5.00	2.00	0.0029	0.0201	0.0779	26.68	1.78
23.50 m	6.00	48.00	25.00	9.00	4.00	7.00	1.00	0.0044	0.0253	0.1069	24.11	1.35
26.50 m	7.00	45.00	30.00	5.00	3.00	10.00	0.00	0.0037	0.0260	0.1134	30.93	1.63
29.50 m	8.00	44.00	22.00	10.00	3.00	13.00	0.00	0.0030	0.0244	0.1364	45.93	1.47
32.50 m	6.00	48.00	33.00	6.00	2.00	5.00	0.00	0.0045	0.0258	0.0980	21.96	1.52
35.50 m	7.00	49.00	26.00	8.00	3.00	7.00	0.00	0.0036	0.0229	0.0919	25.57	1.59
38.50 m	7.00	49.00	30.00	3.00	2.00	8.00	1.00	0.0036	0.0231	0.0894	24.84	1.66
41.50 m	6.00	49.00	25.00	9.00	1.00	10.00	0.00	0.0044	0.0246	0.0993	22.51	1.39
44.50 m	8.00	48.00	29.00	2.00	1.00	12.00	0.00	0.0029	0.0220	0.0899	30.54	1.82
47.50 m	7.00	49.00	30.00	3.00	2.00	8.00	1.00	0.0036	0.0231	0.0894	24.84	1.66
50.50 m	6.00	55.00	27.00	1.00	0.00	11.00	0.00	0.0043	0.0214	0.0726	16.95	1.47
53.50 m	7.00	47.00	30.00	3.00	1.00	12.00	0.00	0.0036	0.0245	0.1000	27.54	1.65

GRAIN SIZE DISTRIBUTION CURVES

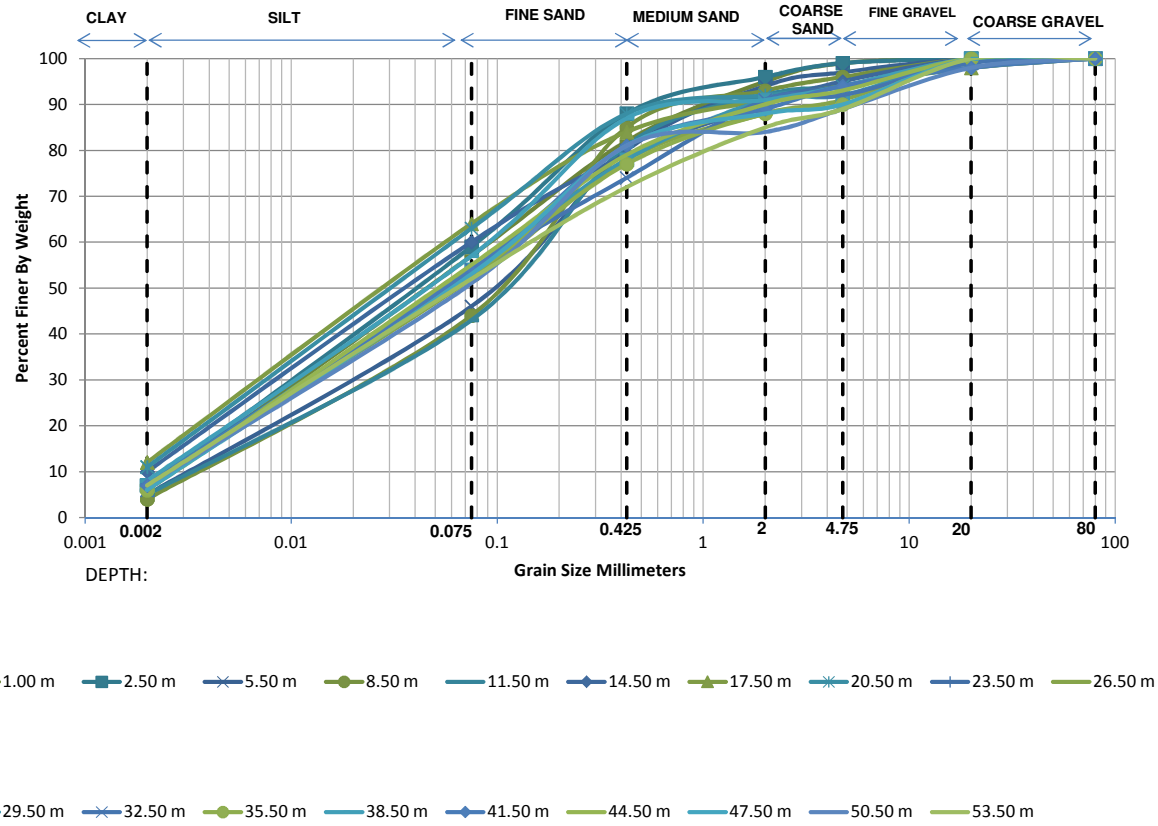
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+075 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	0.00	25.00	69.00	2.00	1.00	3.00	0.00	0.0188	0.0928	0.1971	10.48	2.32
4.00 m	7.00	48.00	32.00	6.00	3.00	4.00	0.00	0.0036	0.0239	0.0936	25.87	1.68
7.00 m	12.00	57.00	20.00	4.00	3.00	3.00	1.00	-	0.0124	0.0552	-	-
10.00 m	10.00	57.00	23.00	2.00	5.00	3.00	0.00	0.0020	0.0148	0.0595	29.75	1.84
13.00 m	12.00	53.00	23.00	5.00	4.00	2.00	1.00	-	0.0137	0.0629	-	-
16.00 m	11.00	58.00	21.00	4.00	1.00	5.00	0.00	-	0.0133	0.0556	-	-
19.00 m	6.00	48.00	28.00	6.00	4.00	7.00	1.00	0.0044	0.0255	0.1023	23.00	1.43
22.00 m	8.00	51.00	30.00	3.00	2.00	6.00	0.00	0.0029	0.0203	0.0778	26.62	1.81
25.00 m	7.00	48.00	29.00	5.00	4.00	5.00	2.00	0.0036	0.0237	0.0953	26.37	1.63
28.00 m	6.00	54.00	27.00	3.00	2.00	7.00	1.00	0.0043	0.0219	0.0750	17.42	1.48
31.00 m	7.00	52.00	30.00	2.00	3.00	6.00	0.00	0.0036	0.0214	0.0777	21.86	1.65
34.00 m	7.00	50.00	25.00	3.00	5.00	9.00	1.00	0.0036	0.0222	0.0864	24.16	1.60
37.00 m	8.00	51.00	27.00	3.00	2.00	7.00	2.00	0.0029	0.0201	0.0779	26.68	1.79
40.00 m	7.00	51.00	25.00	3.00	3.00	11.00	0.00	0.0036	0.0217	0.0817	22.95	1.61
43.00 m	7.00	49.00	28.00	5.00	2.00	9.00	0.00	0.0036	0.0230	0.0904	25.15	1.63
46.00 m	8.00	48.00	26.00	4.00	5.00	8.00	1.00	0.0029	0.0218	0.0916	31.15	1.76
49.00 m	6.00	53.00	26.00	6.00	2.00	7.00	0.00	0.0043	0.0223	0.0779	18.02	1.48
52.00 m	7.00	46.00	27.00	7.00	3.00	8.00	2.00	0.0036	0.0250	0.1113	30.55	1.54

GRAIN SIZE DISTRIBUTION CURVES

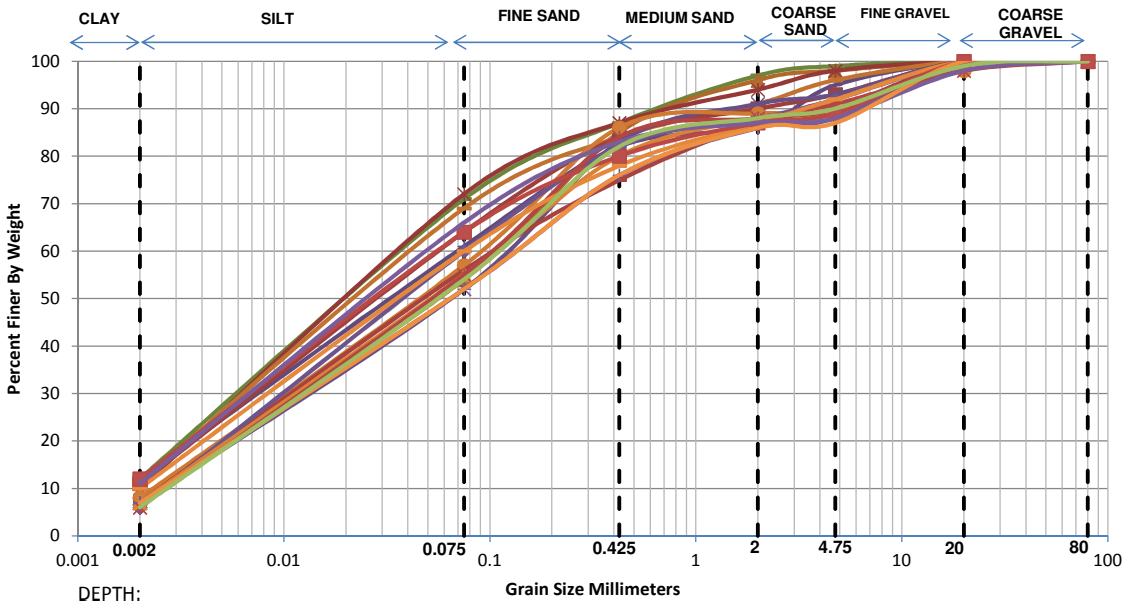
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+075 Major Bridge
B.H. No.	BH-P2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	6.00	51.00	25.00	13.00	4.00	1.00	0.00	0.0044	0.0234	0.0870	19.94	1.44
2.50 m	7.00	52.00	29.00	8.00	3.00	1.00	0.00	0.0036	0.0213	0.0778	21.88	1.65
5.50 m	5.00	41.00	34.00	14.00	3.00	3.00	0.00	0.0059	0.0348	0.1549	26.32	1.32
8.50 m	4.00	40.00	41.00	8.00	3.00	4.00	0.00	0.0075	0.0391	0.1489	19.75	1.37
11.50 m	5.00	38.00	38.00	11.00	2.00	4.00	2.00	0.0061	0.0393	0.1662	27.08	1.51
14.50 m	10.00	50.00	19.00	11.00	5.00	5.00	0.00	0.0020	0.0172	0.0750	37.50	1.98
17.50 m	12.00	52.00	20.00	7.00	3.00	4.00	2.00	-	0.0139	0.0650	-	-
20.50 m	11.00	52.00	25.00	4.00	2.00	6.00	0.00	-	0.0153	0.0676	-	-
23.50 m	8.00	45.00	25.00	13.00	3.00	6.00	0.00	0.0030	0.0238	0.1171	39.50	1.63
26.50 m	7.00	45.00	26.00	10.00	3.00	9.00	0.00	0.0037	0.0257	0.1229	33.57	1.47
29.50 m	7.00	47.00	24.00	13.00	1.00	8.00	0.00	0.0036	0.0241	0.1099	30.35	1.46
32.50 m	6.00	48.00	20.00	17.00	1.00	7.00	1.00	0.0044	0.0250	0.1217	27.55	1.16
35.50 m	6.00	47.00	24.00	11.00	2.00	10.00	0.00	0.0045	0.0260	0.1185	26.58	1.28
38.50 m	8.00	49.00	30.00	4.00	3.00	6.00	0.00	0.0029	0.0214	0.0851	28.99	1.83
41.50 m	7.00	47.00	27.00	8.00	5.00	4.00	2.00	0.0036	0.0243	0.1040	28.69	1.56
44.50 m	6.00	49.00	24.00	11.00	3.00	7.00	0.00	0.0044	0.0246	0.1009	22.89	1.36
47.50 m	6.00	47.00	28.00	7.00	2.00	10.00	0.00	0.0045	0.0262	0.1095	24.47	1.41
50.50 m	7.00	44.00	30.00	3.00	5.00	9.00	2.00	0.0037	0.0269	0.1203	32.61	1.63
53.50 m	7.00	45.00	20.00	13.00	4.00	11.00	0.00	0.0036	0.0253	0.1480	40.61	1.19

GRAIN SIZE DISTRIBUTION CURVES

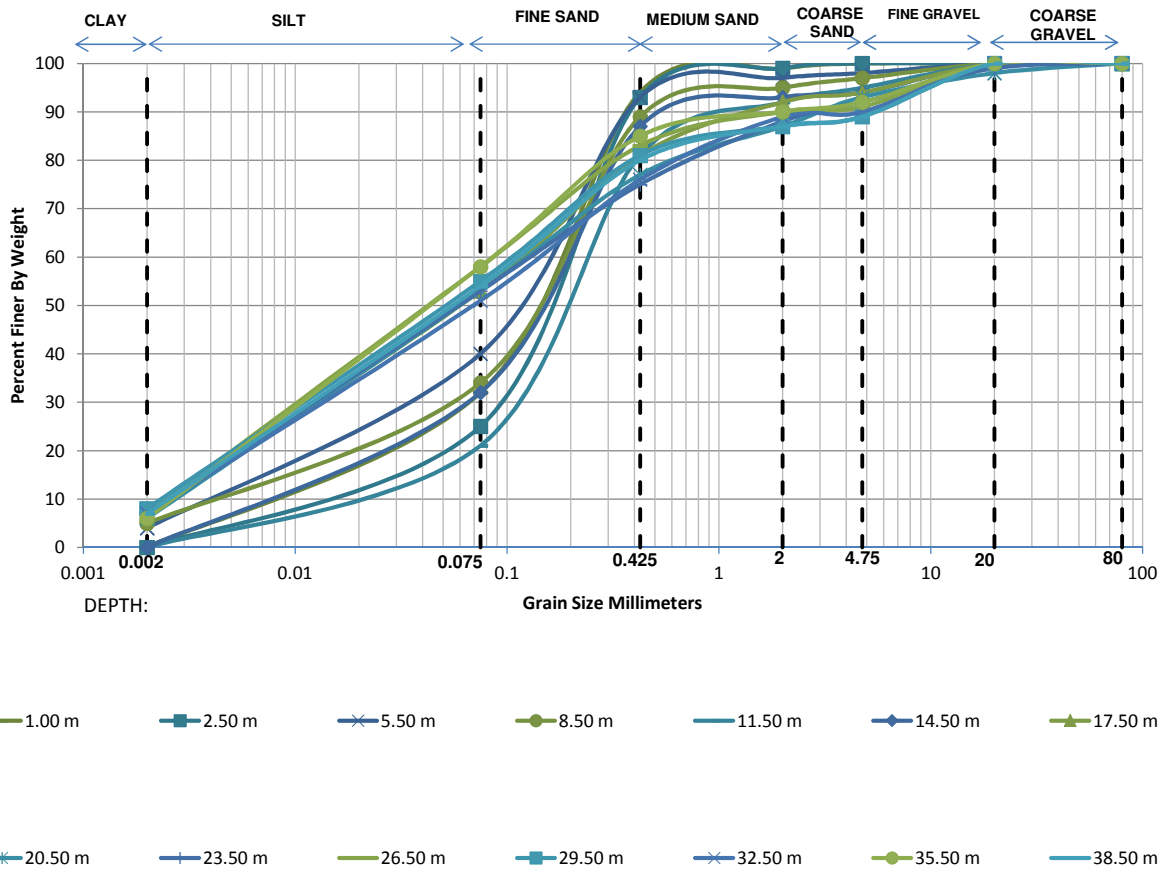
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+075 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	12.00	59.00	16.00	10.00	2.00	1.00	0.00	-	0.0119	0.0518	-	-
4.00 m	8.00	46.00	31.00	11.00	2.00	2.00	0.00	0.0030	0.0234	0.1005	33.95	1.84
7.00 m	10.00	62.00	15.00	7.00	4.00	2.00	0.00	0.0020	0.0132	0.0510	25.50	1.72
10.00 m	12.00	49.00	21.00	4.00	9.00	5.00	0.00	-	0.0150	0.0723	-	-
13.00 m	11.00	58.00	15.00	7.00	5.00	4.00	0.00	-	0.0131	0.0553	-	-
16.00 m	11.00	53.00	20.00	6.00	3.00	7.00	0.00	-	0.0148	0.0652	-	-
19.00 m	7.00	45.00	31.00	8.00	2.00	7.00	0.00	0.0037	0.0261	0.1127	30.70	1.65
22.00 m	8.00	49.00	29.00	3.00	0.00	9.00	2.00	0.0029	0.0214	0.0853	29.06	1.82
25.00 m	7.00	49.00	19.00	12.00	3.00	10.00	0.00	0.0036	0.0225	0.1004	28.05	1.40
28.00 m	6.00	54.00	22.00	6.00	4.00	8.00	0.00	0.0043	0.0216	0.0750	17.47	1.45
31.00 m	7.00	48.00	25.00	8.00	2.00	9.00	1.00	0.0036	0.0235	0.0993	27.53	1.54
34.00 m	6.00	49.00	29.00	4.00	3.00	7.00	2.00	0.0044	0.0249	0.0950	21.48	1.47
37.00 m	7.00	45.00	24.00	10.00	2.00	12.00	0.00	0.0037	0.0256	0.1287	35.20	1.39
40.00 m	10.00	50.00	18.00	9.00	5.00	8.00	0.00	0.0020	0.0172	0.0750	37.50	1.97
43.00 m	12.00	52.00	16.00	7.00	2.00	11.00	0.00	-	0.0137	0.0649	-	-
46.00 m	11.00	55.00	17.00	4.00	1.00	10.00	2.00	-	0.0140	0.0609	-	-
49.00 m	7.00	45.00	24.00	10.00	1.00	13.00	0.00	0.0037	0.0256	0.1287	35.20	1.39
53.50 m	6.00	48.00	28.00	6.00	2.00	9.00	1.00	0.0044	0.0255	0.1023	23.00	1.43

GRAIN SIZE DISTRIBUTION CURVES

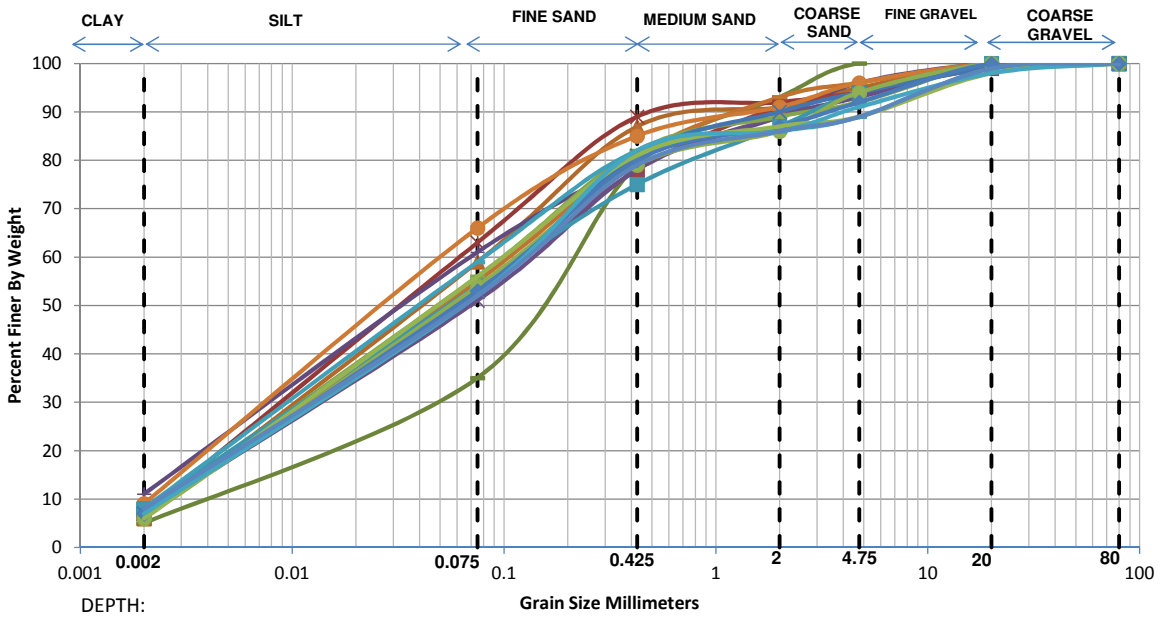
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+360 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	0.00	32.00	62.00	5.00	1.00	0.00	0.00	0.0120	0.0685	0.1751	14.65	2.24
2.50 m	0.00	25.00	68.00	6.00	1.00	0.00	0.00	0.0188	0.0930	0.2002	10.67	2.30
5.50 m	4.00	36.00	53.00	4.00	1.00	2.00	0.00	0.0082	0.0467	0.1499	18.36	1.78
8.50 m	5.00	29.00	55.00	6.00	2.00	3.00	0.00	0.0076	0.0608	0.1812	24.00	2.70
11.50 m	0.00	21.00	60.00	11.00	3.00	5.00	0.00	0.0250	0.1117	0.2477	9.90	2.01
14.50 m	0.00	32.00	55.00	6.00	1.00	6.00	0.00	0.0117	0.0683	0.1905	16.26	2.09
17.50 m	7.00	46.00	28.00	11.00	2.00	6.00	0.00	0.0036	0.0251	0.1106	30.34	1.56
20.50 m	6.00	47.00	24.00	10.00	6.00	5.00	2.00	0.0045	0.0260	0.1182	26.51	1.28
23.50 m	7.00	46.00	22.00	13.00	4.00	7.00	1.00	0.0036	0.0247	0.1254	34.53	1.34
26.50 m	7.00	51.00	25.00	7.00	1.00	9.00	0.00	0.0036	0.0217	0.0819	22.98	1.61
29.50 m	8.00	47.00	26.00	6.00	2.00	11.00	0.00	0.0029	0.0224	0.0980	33.26	1.74
32.50 m	7.00	44.00	25.00	13.00	1.00	10.00	0.00	0.0037	0.0265	0.1373	37.35	1.39
35.50 m	6.00	52.00	27.00	5.00	2.00	8.00	0.00	0.0043	0.0229	0.0814	18.73	1.49
38.50 m	7.00	47.00	26.00	7.00	2.00	11.00	0.00	0.0036	0.0242	0.1051	29.01	1.54

GRAIN SIZE DISTRIBUTION CURVES

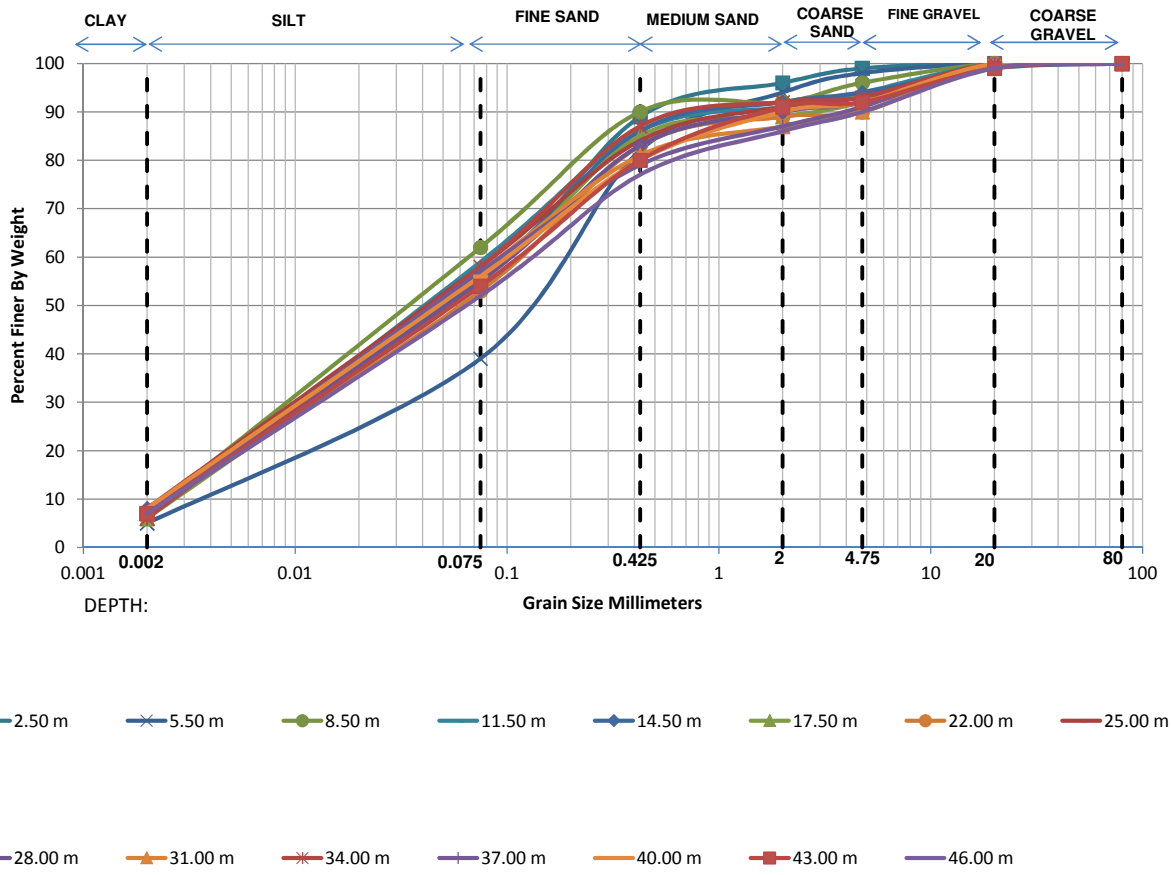
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+360 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	5.00	30.00	44.00	14.00	7.00	0.00	0.00	0.0072	0.0571	0.2118	29.40	2.14
4.00 m	6.00	53.00	28.00	4.00	4.00	5.00	0.00	0.0043	0.0225	0.0778	17.97	1.50
7.00 m	7.00	56.00	26.00	3.00	2.00	6.00	0.00	0.0035	0.0193	0.0681	19.43	1.57
10.00 m	11.00	50.00	18.00	10.00	7.00	4.00	0.00	-	0.0158	0.0723	-	-
13.00 m	6.00	49.00	26.00	12.00	3.00	4.00	0.00	0.0044	0.0247	0.0986	22.35	1.40
16.00 m	7.00	46.00	25.00	13.00	3.00	5.00	1.00	0.0036	0.0249	0.1169	32.12	1.46
19.00 m	7.00	44.00	27.00	11.00	4.00	7.00	0.00	0.0037	0.0267	0.1300	35.31	1.49
22.00 m	9.00	57.00	19.00	6.00	5.00	4.00	0.00	0.0024	0.0159	0.0615	25.70	1.72
25.50 m	7.00	49.00	26.00	7.00	3.00	8.00	0.00	0.0036	0.0229	0.0918	25.54	1.59
28.00 m	8.00	46.00	21.00	12.00	7.00	6.00	0.00	0.0030	0.0228	0.1170	39.66	1.50
31.00 m	7.00	46.00	28.00	9.00	4.00	5.00	1.00	0.0036	0.0251	0.1102	30.22	1.57
34.00 m	6.00	48.00	25.00	7.00	8.00	6.00	0.00	0.0044	0.0253	0.1065	24.00	1.36
37.00 m	8.00	51.00	23.00	4.00	3.00	10.00	1.00	0.0029	0.0199	0.0781	26.78	1.75
40.00 m	7.00	46.00	27.00	7.00	5.00	8.00	0.00	0.0036	0.0250	0.1113	30.55	1.54
43.00 m	6.00	50.00	25.00	6.00	2.00	9.00	2.00	0.0044	0.0240	0.0922	21.02	1.42
46.00 m	7.00	45.00	30.00	4.00	5.00	7.00	2.00	0.0037	0.0260	0.1132	30.86	1.63
49.00 m	8.00	44.00	27.00	7.00	3.00	10.00	1.00	0.0030	0.0247	0.1197	40.24	1.71

GRAIN SIZE DISTRIBUTION CURVES

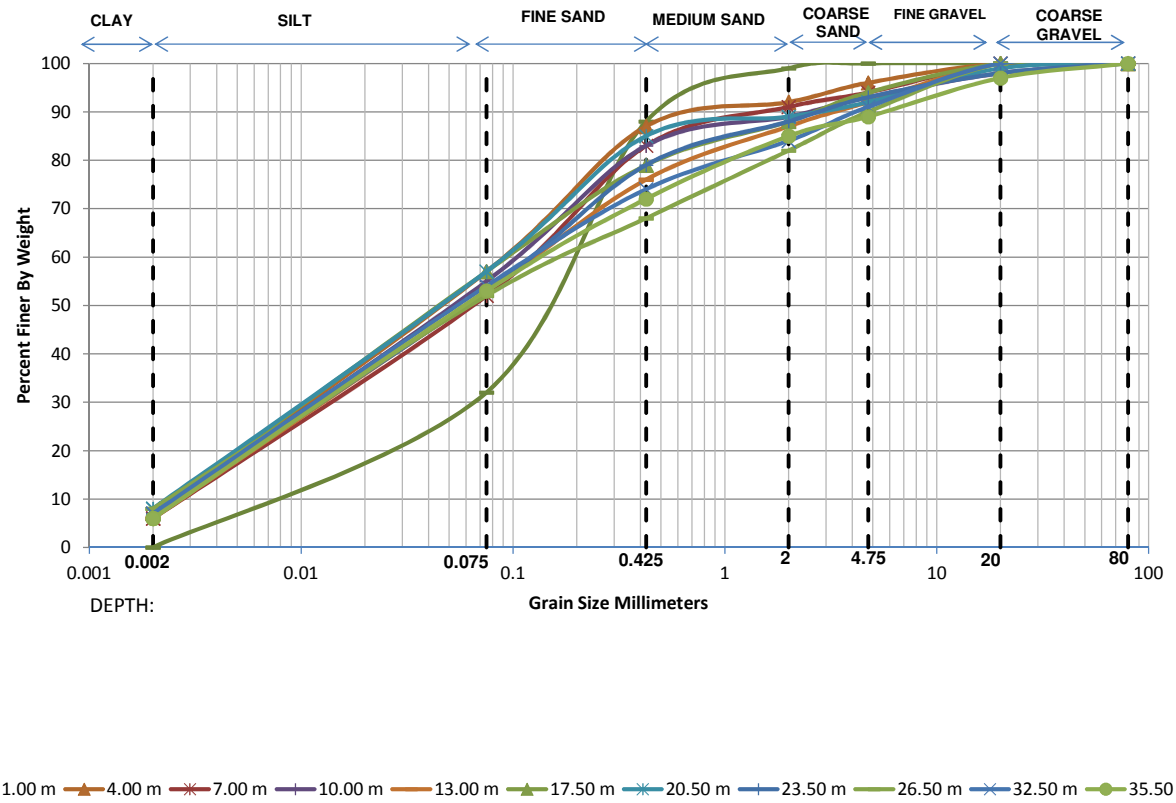
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+360 Major Bridge
B.H. No.	BH-P2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	7.00	48.00	34.00	7.00	3.00	1.00	0.00	0.0036	0.0240	0.0928	25.61	1.72
5.50 m	5.00	34.00	43.00	12.00	4.00	2.00	0.00	0.0066	0.0470	0.1821	27.62	1.84
8.50 m	7.00	55.00	28.00	2.00	4.00	4.00	0.00	0.0035	0.0199	0.0703	19.98	1.59
11.50 m	6.00	53.00	27.00	5.00	3.00	6.00	0.00	0.0043	0.0224	0.0778	17.99	1.49
14.50 m	7.00	49.00	30.00	6.00	2.00	5.00	1.00	0.0036	0.0231	0.0896	24.90	1.66
17.50 m	6.00	49.00	30.00	4.00	3.00	8.00	0.00	0.0044	0.0249	0.0944	21.32	1.49
22.00 m	7.00	46.00	30.00	6.00	1.00	10.00	0.00	0.0036	0.0252	0.1068	29.26	1.63
25.00 m	8.00	50.00	26.00	7.00	2.00	7.00	0.00	0.0029	0.0206	0.0818	27.95	1.78
28.00 m	8.00	47.00	28.00	7.00	2.00	8.00	0.00	0.0029	0.0226	0.0964	32.70	1.79
31.00 m	7.00	50.00	24.00	6.00	3.00	10.00	0.00	0.0036	0.0222	0.0871	24.36	1.58
34.00 m	6.00	52.00	29.00	5.00	1.00	7.00	0.00	0.0044	0.0230	0.0811	18.65	1.50
37.00 m	7.00	50.00	22.00	8.00	4.00	9.00	0.00	0.0036	0.0221	0.0883	24.74	1.54
40.00 m	8.00	48.00	24.00	10.00	2.00	8.00	0.00	0.0029	0.0217	0.0937	31.90	1.71
43.00 m	7.00	47.00	26.00	11.00	1.00	7.00	1.00	0.0036	0.0242	0.1060	29.25	1.53
46.00 m	7.00	45.00	25.00	9.00	4.00	9.00	1.00	0.0037	0.0257	0.1252	34.24	1.44

GRAIN SIZE DISTRIBUTION CURVES

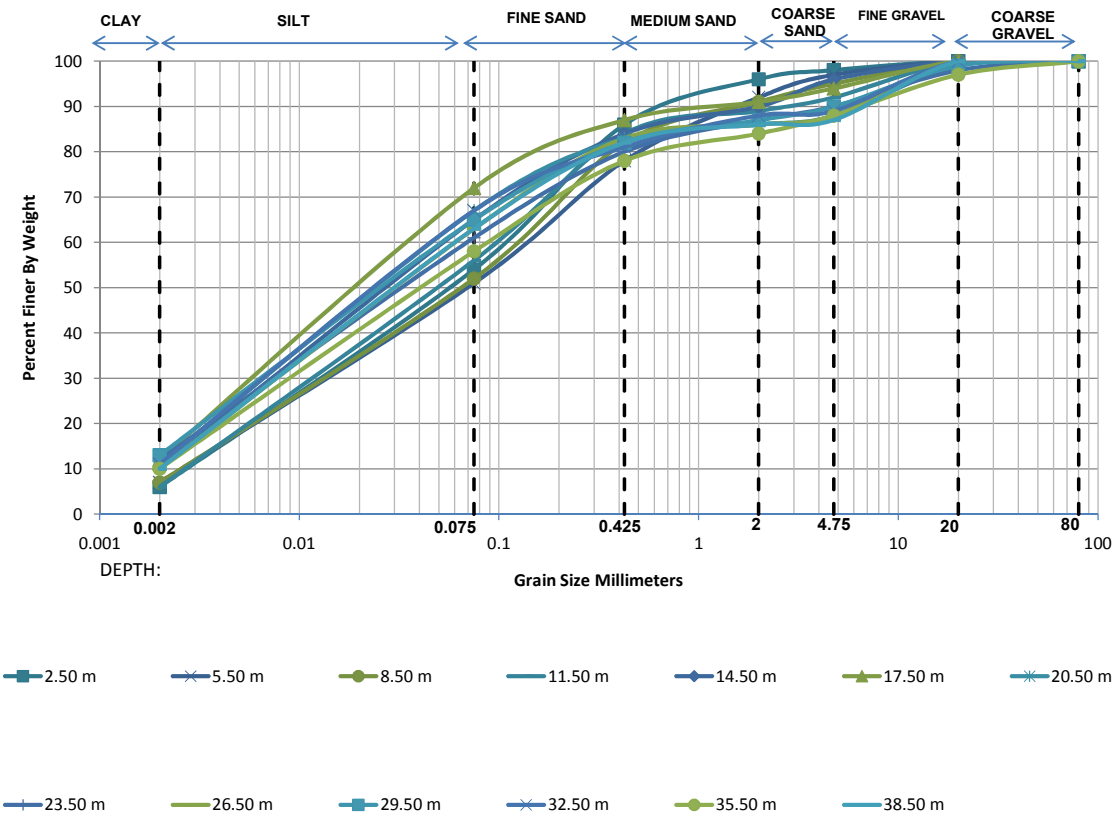
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+360 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	0.00	32.00	56.00	11.00	1.00	0.00	0.00	0.0118	0.0683	0.1896	16.13	2.09
4.00 m	7.00	50.00	30.00	5.00	4.00	4.00	0.00	0.0036	0.0225	0.0850	23.72	1.66
7.00 m	6.00	46.00	31.00	8.00	3.00	6.00	0.00	0.0045	0.0272	0.1124	24.91	1.46
10.00 m	7.00	48.00	28.00	6.00	4.00	5.00	2.00	0.0036	0.0237	0.0961	26.62	1.61
13.00 m	6.00	47.00	23.00	11.00	5.00	8.00	0.00	0.0045	0.0259	0.1213	27.22	1.24
17.50 m	7.00	50.00	22.00	9.00	6.00	6.00	0.00	0.0036	0.0221	0.0884	24.76	1.54
20.50 m	8.00	49.00	28.00	4.00	3.00	7.00	1.00	0.0029	0.0213	0.0856	29.17	1.81
23.50 m	7.00	46.00	26.00	9.00	5.00	5.00	2.00	0.0036	0.0250	0.1136	31.21	1.51
26.50 m	8.00	44.00	16.00	14.00	8.00	10.00	0.00	0.0030	0.0239	0.1829	61.73	1.06
32.50 m	7.00	47.00	20.00	10.00	7.00	9.00	0.00	0.0036	0.0238	0.1193	33.03	1.32
35.50 m	6.00	47.00	19.00	13.00	4.00	8.00	3.00	0.0044	0.0256	0.1384	31.17	1.07

GRAIN SIZE DISTRIBUTION CURVES

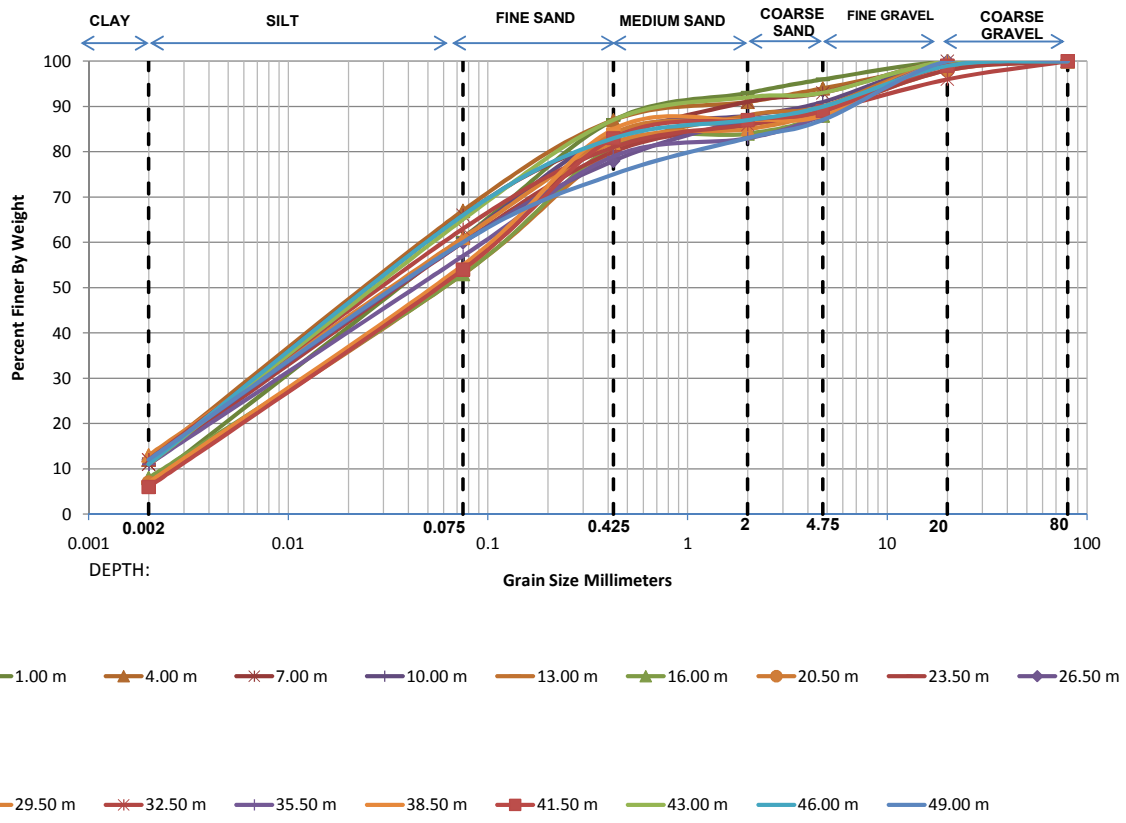
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+900 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	6.00	48.00	32.00	10.00	2.00	2.00	0.00	0.0045	0.0258	0.0992	22.25	1.50
5.50 m	7.00	44.00	27.00	14.00	5.00	3.00	0.00	0.0037	0.0267	0.1310	35.59	1.47
8.50 m	7.00	45.00	30.00	9.00	4.00	5.00	0.00	0.0037	0.0260	0.1144	31.19	1.61
11.50 m	6.00	50.00	28.00	5.00	3.00	8.00	0.00	0.0044	0.0242	0.0903	20.55	1.47
14.50 m	10.00	55.00	19.00	6.00	6.00	4.00	0.00	0.0020	0.0153	0.0632	31.61	1.85
17.50 m	12.00	60.00	15.00	4.00	3.00	6.00	0.00	-	0.0116	0.0502	-	-
20.50 m	11.00	56.00	16.00	3.00	2.00	11.00	1.00	-	0.0137	0.0589	-	-
23.50 m	12.00	49.00	19.00	7.00	3.00	8.00	2.00	-	0.0149	0.0723	-	-
26.50 m	10.00	53.00	20.00	3.00	2.00	12.00	0.00	0.0020	0.0160	0.0676	33.78	1.91
29.50 m	13.00	52.00	17.00	5.00	3.00	9.00	1.00	-	0.0126	0.0625	-	-
32.50 m	11.00	56.00	14.00	7.00	1.00	11.00	0.00	-	0.0136	0.0588	-	-
35.50 m	10.00	48.00	20.00	6.00	4.00	9.00	3.00	0.0020	0.0183	0.0834	41.71	2.00
38.50 m	10.00	53.00	19.00	4.00	1.00	13.00	0.00	0.0020	0.0160	0.0675	33.77	1.90

GRAIN SIZE DISTRIBUTION CURVES

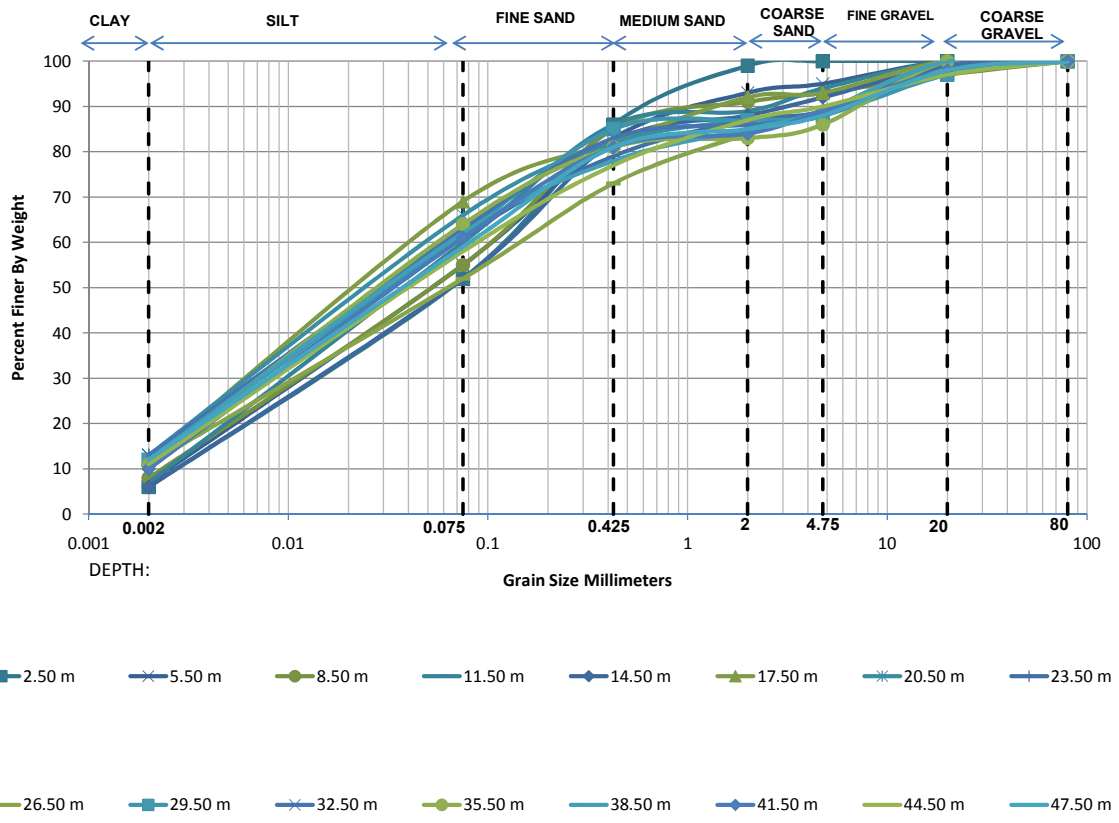
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+900 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	7.00	54.00	26.00	6.00	3.00	4.00	0.00	0.0035	0.0202	0.0726	20.58	1.60
4.00 m	12.00	55.00	20.00	4.00	3.00	5.00	1.00	-	0.0130	0.0588	-	-
7.00 m	11.00	55.00	17.00	8.00	2.00	7.00	0.00	-	0.0140	0.0609	-	-
10.00 m	11.00	50.00	23.00	4.00	3.00	9.00	0.00	-	0.0160	0.0724	-	-
13.00 m	7.00	46.00	27.00	8.00	2.00	10.00	0.00	0.0036	0.0250	0.1115	30.62	1.54
16.00 m	8.00	45.00	28.00	3.00	4.00	12.00	0.00	0.0030	0.0240	0.1089	36.72	1.78
20.50 m	7.00	47.00	30.00	2.00	3.00	9.00	2.00	0.0036	0.0245	0.0999	27.49	1.65
23.50 m	11.00	49.00	20.00	6.00	3.00	9.00	2.00	-	0.0163	0.0750	-	-
26.50 m	12.00	48.00	18.00	9.00	1.00	12.00	0.00	-	0.0153	0.0750	-	-
29.50 m	13.00	48.00	21.00	3.00	4.00	11.00	0.00	-	0.0141	0.0722	-	-
32.50 m	12.00	51.00	18.00	5.00	3.00	7.00	4.00	-	0.0142	0.0672	-	-
35.50 m	11.00	46.00	22.00	4.00	5.00	12.00	0.00	-	0.0179	0.0884	-	-
38.50 m	7.00	48.00	30.00	2.00	1.00	12.00	0.00	0.0036	0.0238	0.0943	26.08	1.66
41.50 m	6.00	48.00	29.00	4.00	2.00	10.00	1.00	0.0044	0.0256	0.1009	22.68	1.46
43.00 m	11.00	54.00	22.00	5.00	1.00	7.00	0.00	-	0.0145	0.0631	-	-
46.00 m	11.00	55.00	17.00	4.00	3.00	9.00	1.00	-	0.0140	0.0609	-	-
49.00 m	12.00	48.00	15.00	8.00	4.00	13.00	0.00	-	0.0152	0.0750	-	-

GRAIN SIZE DISTRIBUTION CURVES

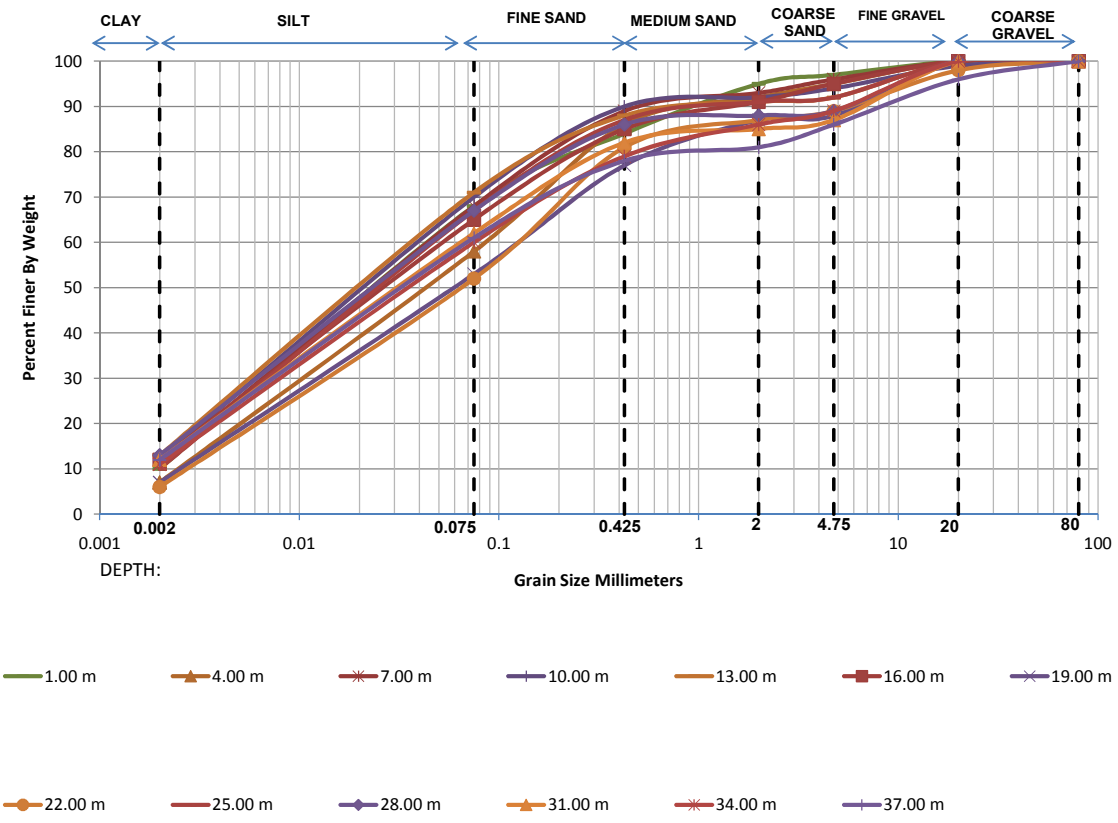
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+900 Major Bridge
B.H. No.	BH-P2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	6.00	46.00	34.00	13.00	1.00	0.00	0.00	0.0045	0.0274	0.1096	24.22	1.52
5.50 m	7.00	48.00	28.00	10.00	2.00	5.00	0.00	0.0036	0.0237	0.0967	26.76	1.60
8.50 m	8.00	47.00	30.00	6.00	2.00	4.00	3.00	0.0030	0.0227	0.0949	32.16	1.83
11.50 m	7.00	53.00	26.00	3.00	5.00	6.00	0.00	0.0035	0.0207	0.0750	21.20	1.61
14.50 m	6.00	46.00	30.00	6.00	4.00	7.00	1.00	0.0045	0.0272	0.1135	25.16	1.44
17.50 m	12.00	57.00	13.00	10.00	1.00	7.00	0.00	-	0.0122	0.0549	-	-
20.50 m	13.00	53.00	16.00	5.00	1.00	12.00	0.00	-	0.0123	0.0603	-	-
23.50 m	10.00	51.00	18.00	8.00	2.00	10.00	1.00	0.0020	0.0168	0.0724	36.18	1.94
26.50 m	11.00	41.00	21.00	11.00	5.00	11.00	0.00	-	0.0211	0.1422	-	-
29.50 m	12.00	50.00	23.00	2.00	1.00	9.00	3.00	-	0.0147	0.0698	-	-
32.50 m	13.00	50.00	20.00	3.00	2.00	10.00	2.00	-	0.0134	0.0671	-	-
35.50 m	11.00	53.00	17.00	2.00	3.00	14.00	0.00	-	0.0146	0.0651	-	-
38.50 m	12.00	50.00	16.00	7.00	4.00	11.00	0.00	-	0.0144	0.0696	-	-
41.50 m	10.00	51.00	20.00	3.00	5.00	9.00	2.00	0.0020	0.0169	0.0724	36.19	1.96
44.50 m	11.00	47.00	19.00	10.00	3.00	7.00	3.00	-	0.0172	0.0842	-	-
47.50 m	12.00	47.00	22.00	4.00	3.00	10.00	2.00	-	0.0159	0.0784	-	-

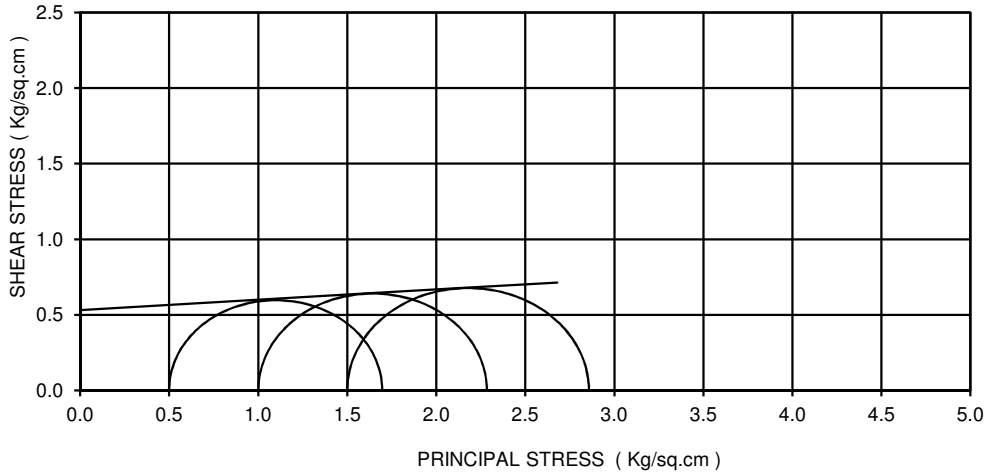
GRAIN SIZE DISTRIBUTION CURVES

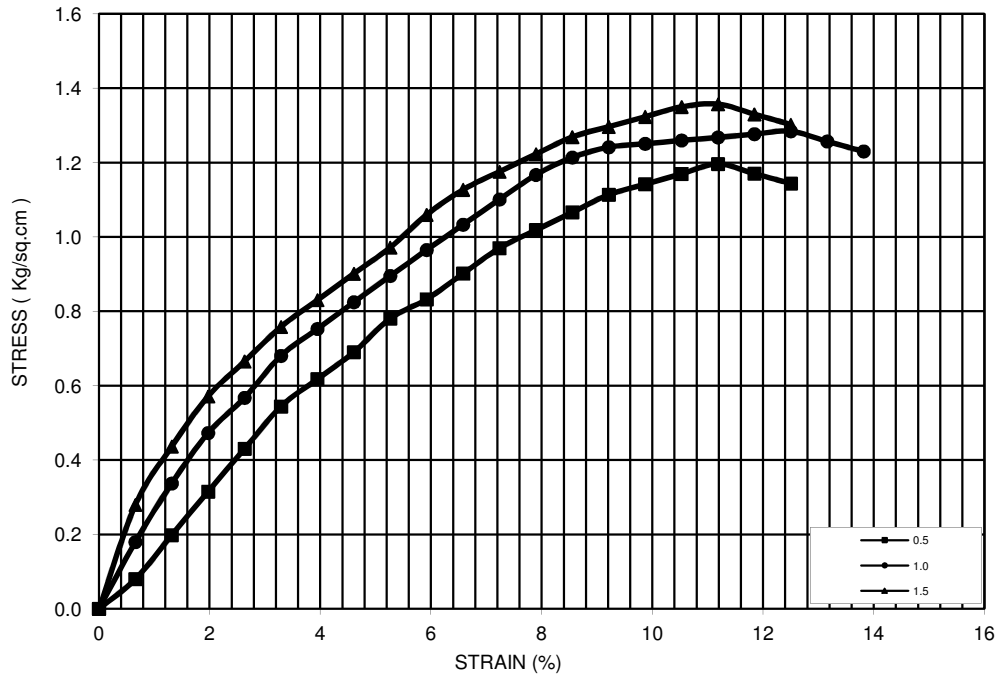
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	28+900 Major Bridge
B.H. No.	BH-A2



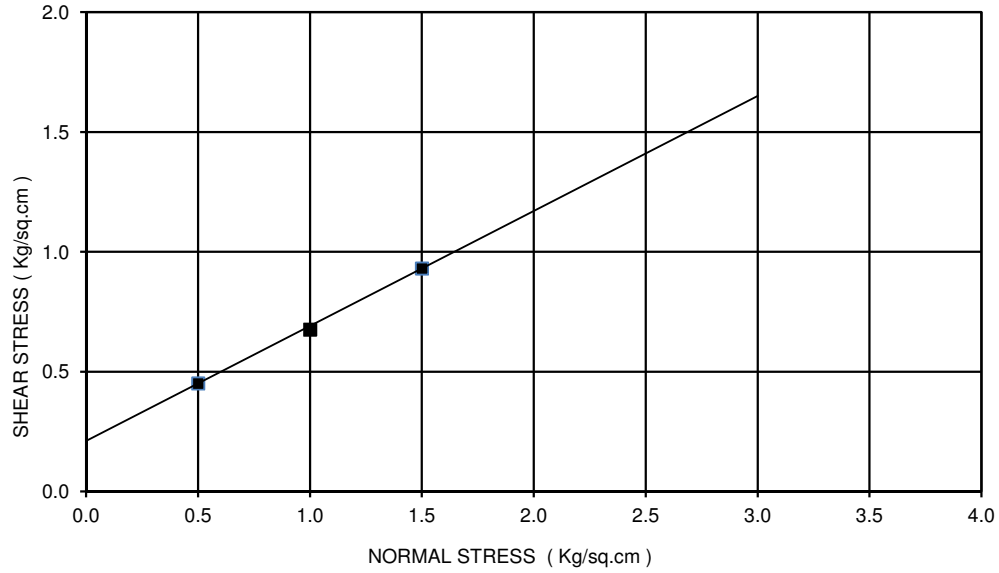
Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	10.00	58.00	16.00	11.00	2.00	3.00	0.00	0.0020	0.0143	0.0574	28.70	1.77
4.00 m	7.00	51.00	28.00	6.00	3.00	5.00	0.00	0.0036	0.0218	0.0814	22.81	1.64
7.00 m	11.00	57.00	21.00	4.00	3.00	4.00	0.00	-	0.0136	0.0573	-	-
10.00 m	12.00	58.00	20.00	2.00	2.00	5.00	1.00	-	0.0122	0.0536	-	-
13.00 m	13.00	58.00	17.00	3.00	1.00	8.00	0.00	-	0.0111	0.0514	-	-
16.00 m	12.00	53.00	20.00	6.00	4.00	5.00	0.00	-	0.0136	0.0628	-	-
19.00 m	7.00	46.00	24.00	10.00	1.00	12.00	0.00	0.0036	0.0248	0.1184	32.56	1.43
22.00 m	6.00	46.00	29.00	6.00	2.00	9.00	2.00	0.0045	0.0271	0.1151	25.54	1.42
25.00 m	10.00	57.00	20.00	4.00	1.00	8.00	0.00	0.0020	0.0147	0.0594	29.69	1.82
28.00 m	13.00	54.00	19.00	2.00	1.00	11.00	0.00	-	0.0121	0.0585	-	-
31.00 m	12.00	50.00	20.00	3.00	2.00	13.00	0.00	-	0.0146	0.0697	-	-
34.00 m	11.00	49.00	19.00	7.00	3.00	11.00	0.00	-	0.0163	0.0750	-	-
37.00 m	12.00	49.00	17.00	3.00	5.00	10.00	4.00	-	0.0149	0.0722	-	-

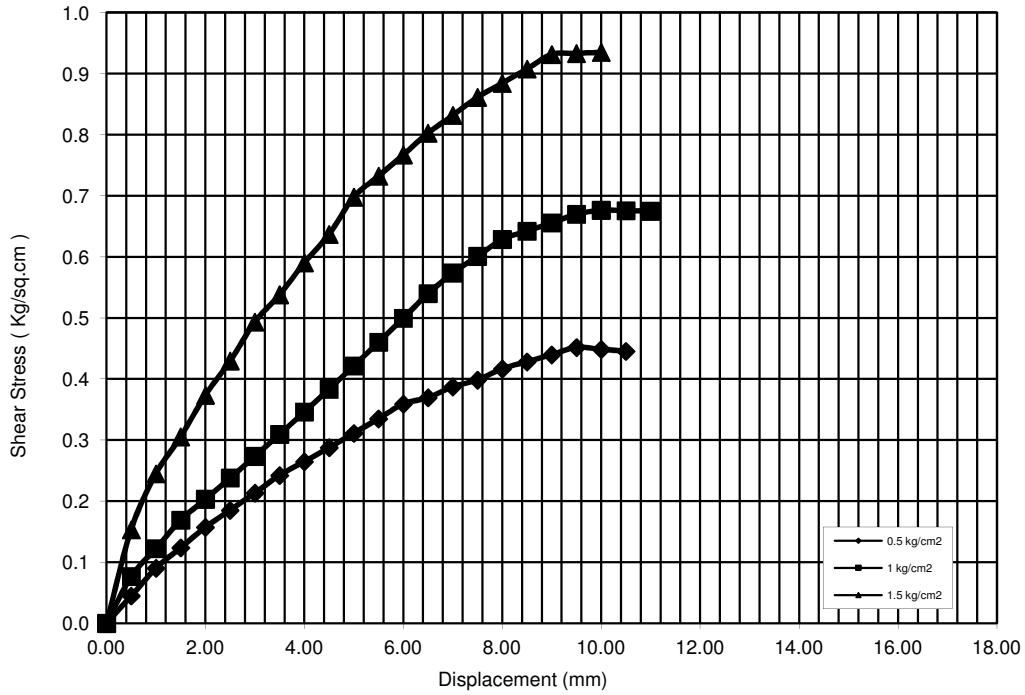
BORE HOLE NO: BH-A-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.53 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



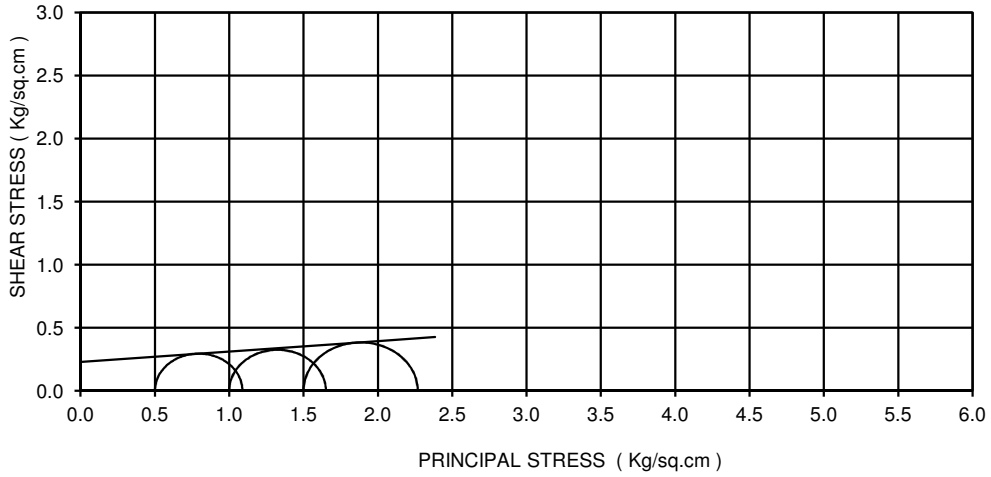


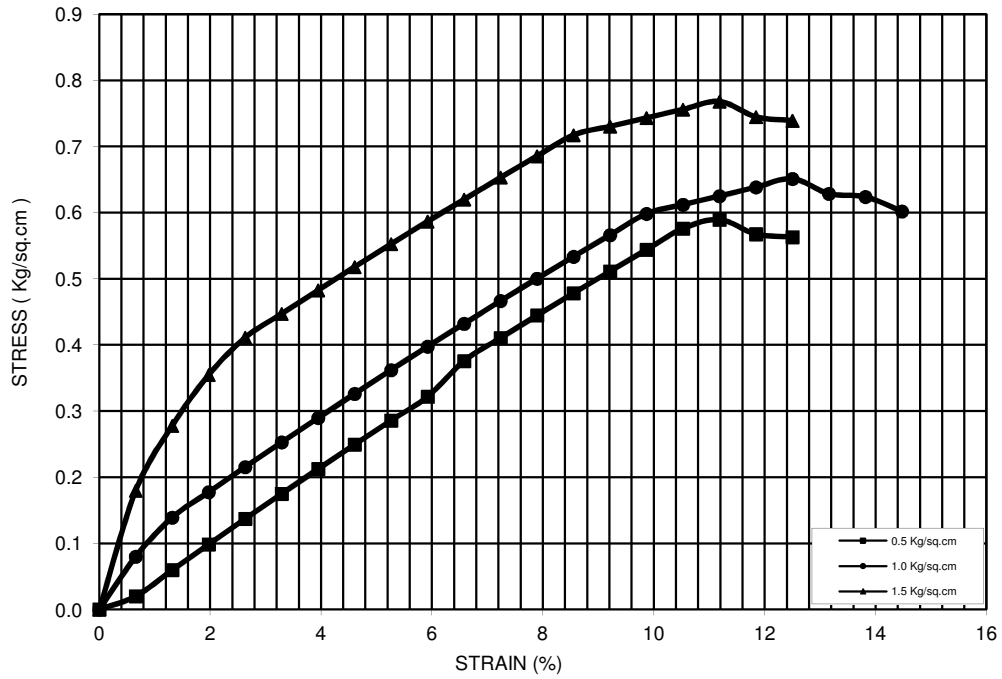
BORE HOLE NO: BH-A-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-3
DEPTH: 7.00 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



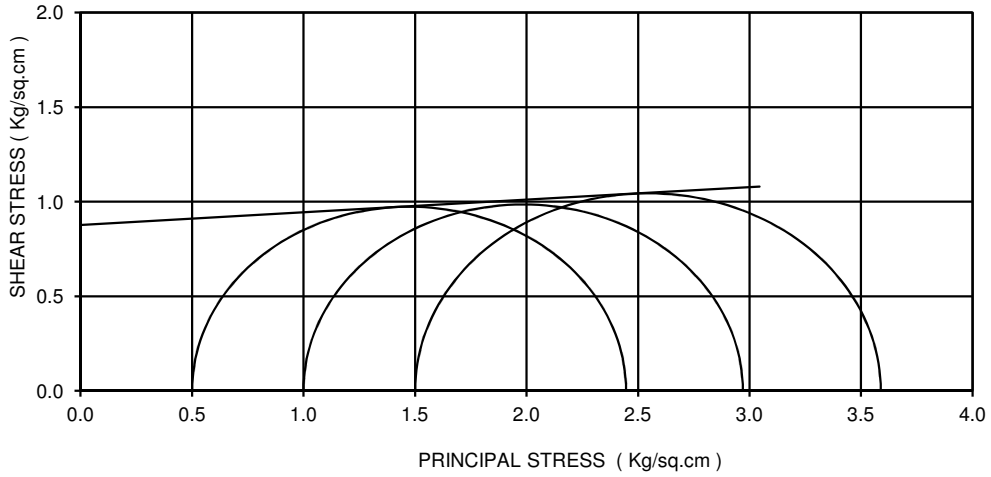


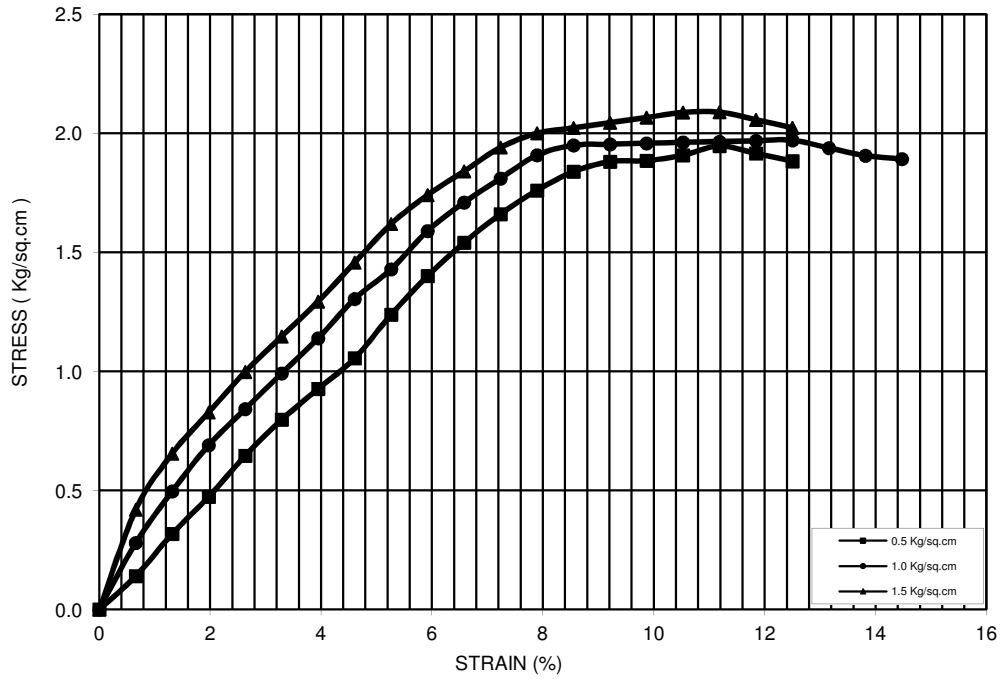
BORE HOLE NO: BH-P-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.23 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



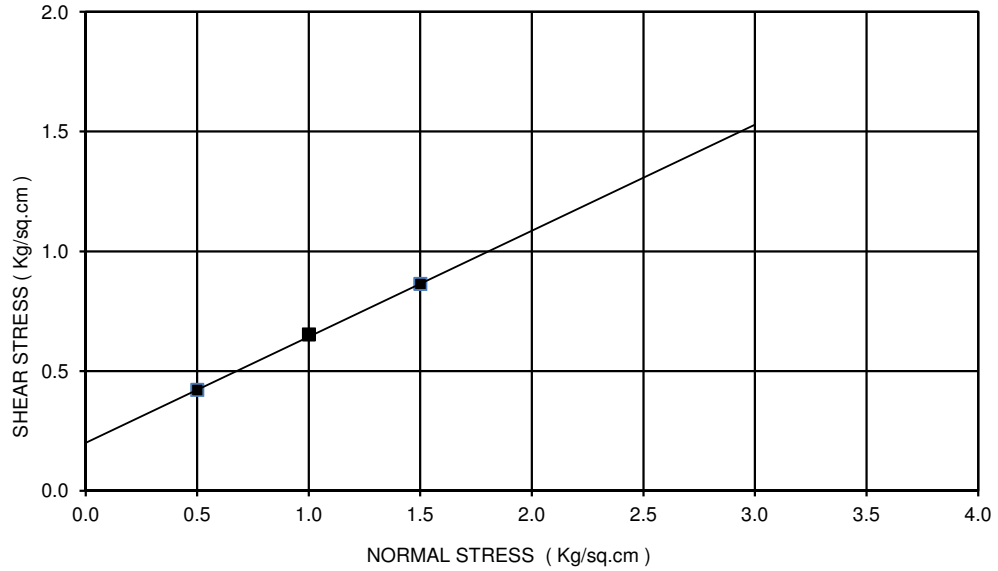


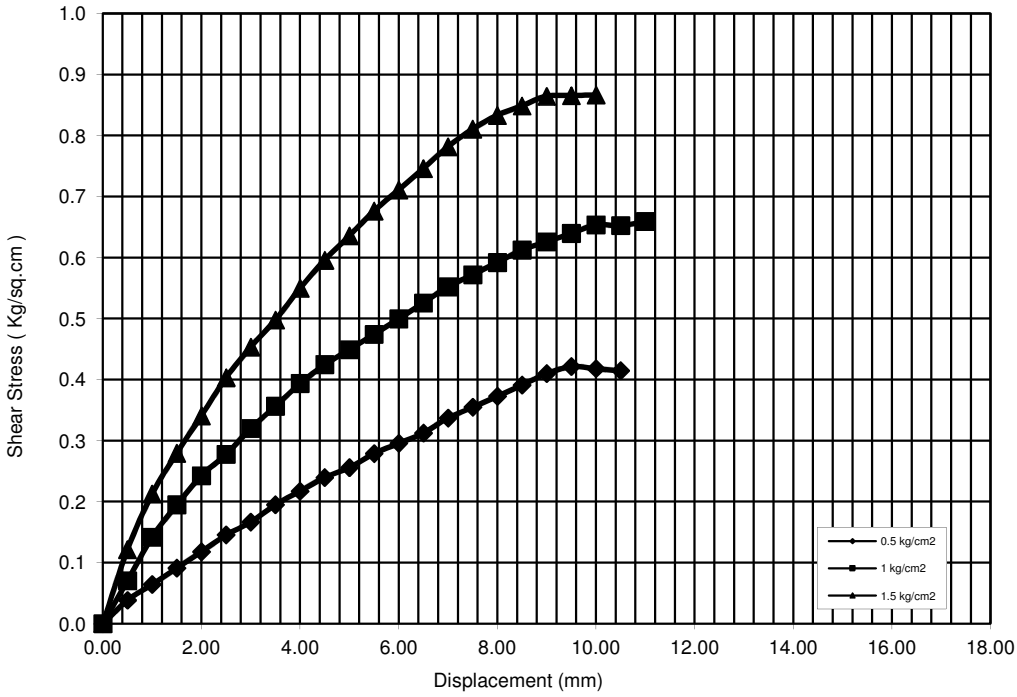
BORE HOLE NO: BH-P-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.88 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



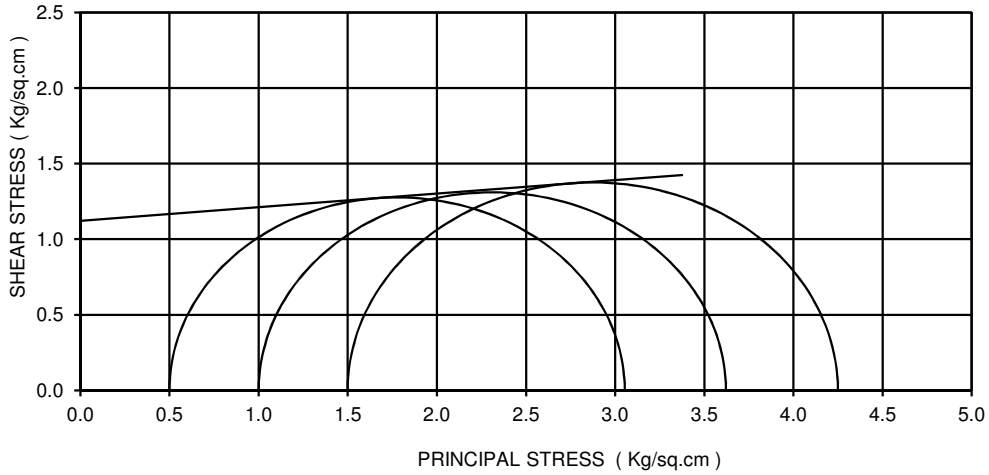


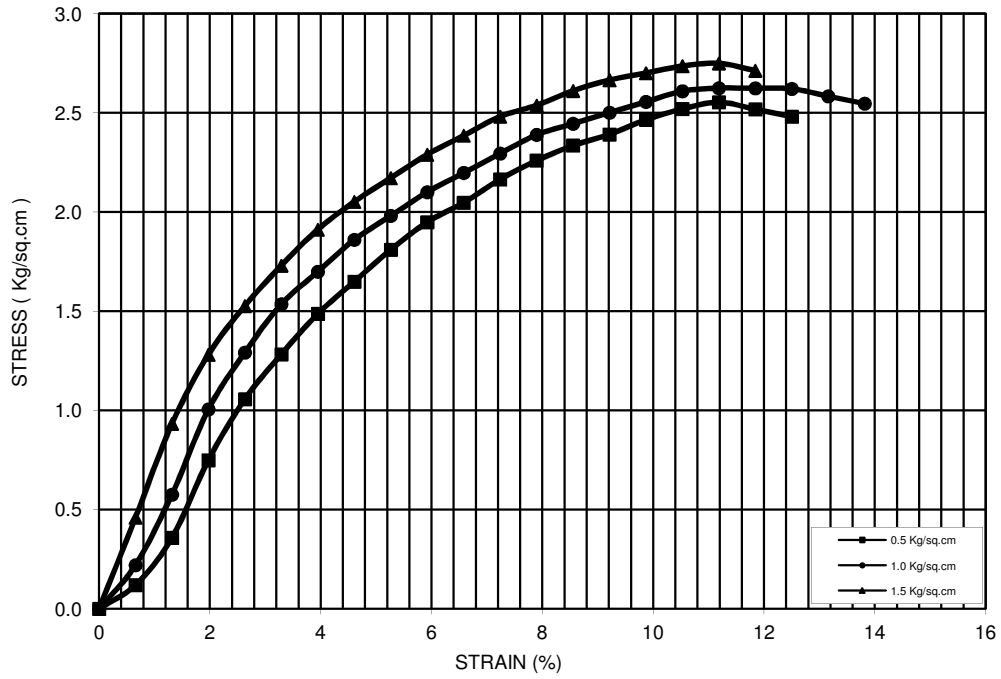
BORE HOLE NO: BH-P-2
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



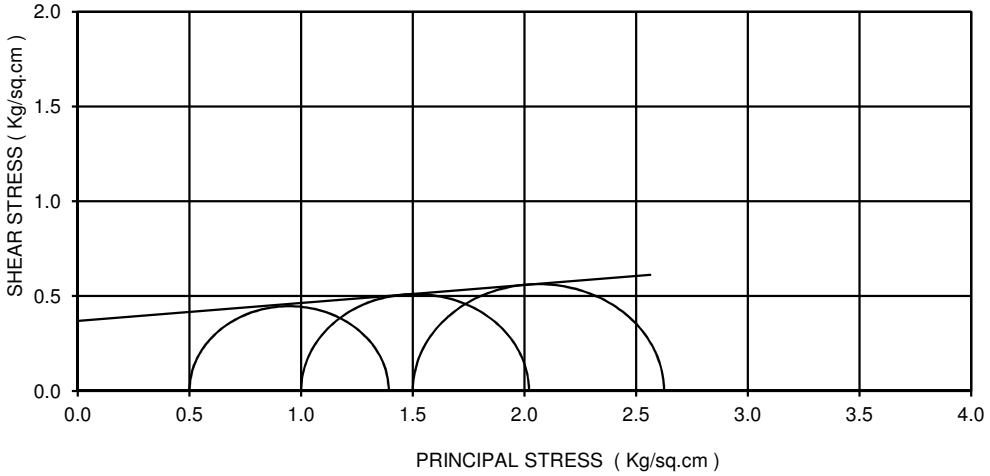


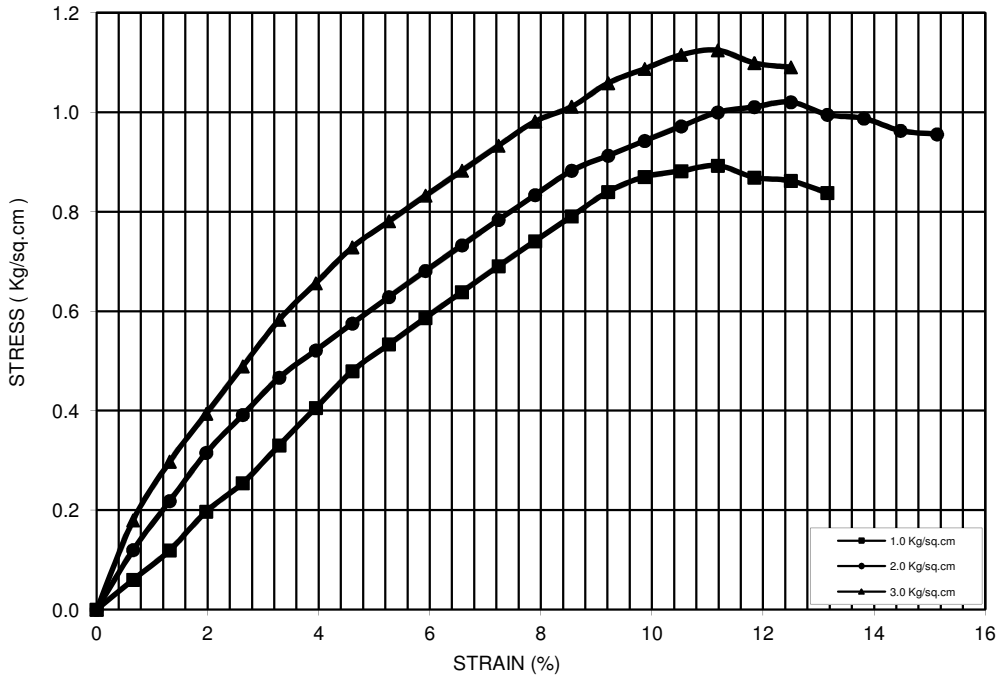
BORE HOLE NO: BH-P-2
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 4.00m
COHESION(C)= 1.12 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



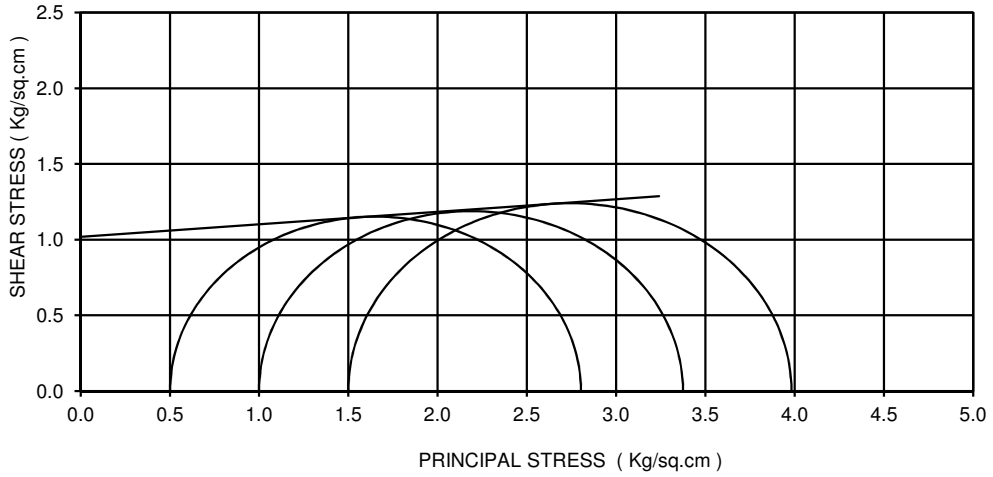


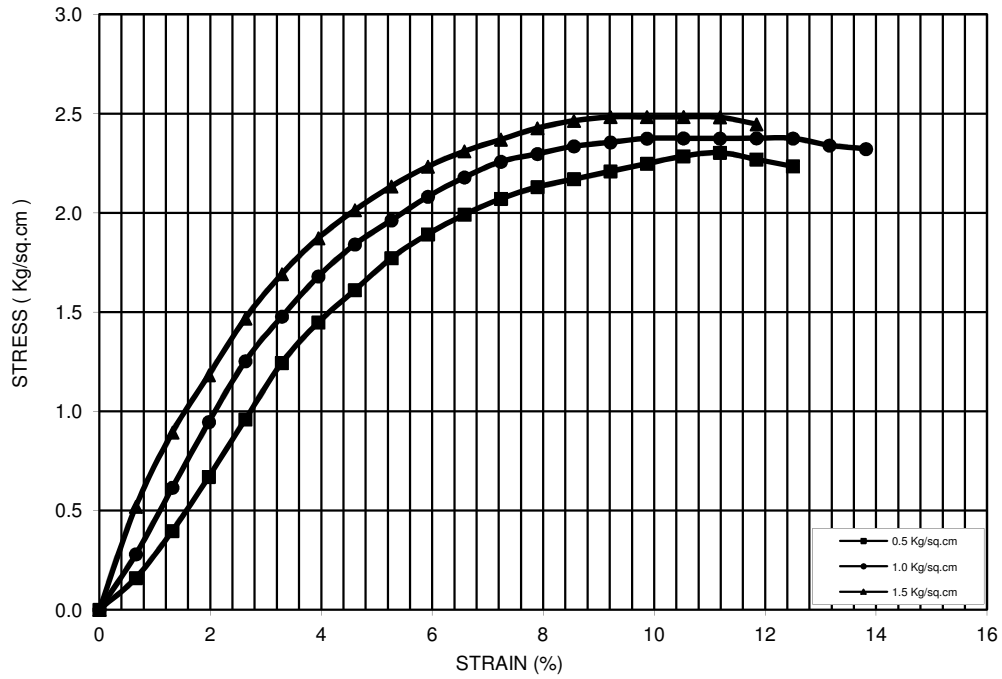
BORE HOLE NO: BH-P-3
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.37 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



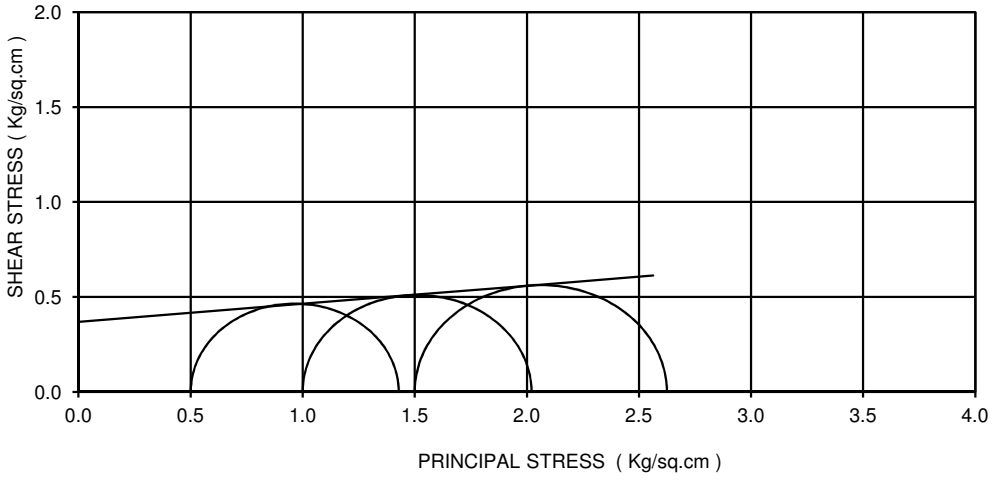


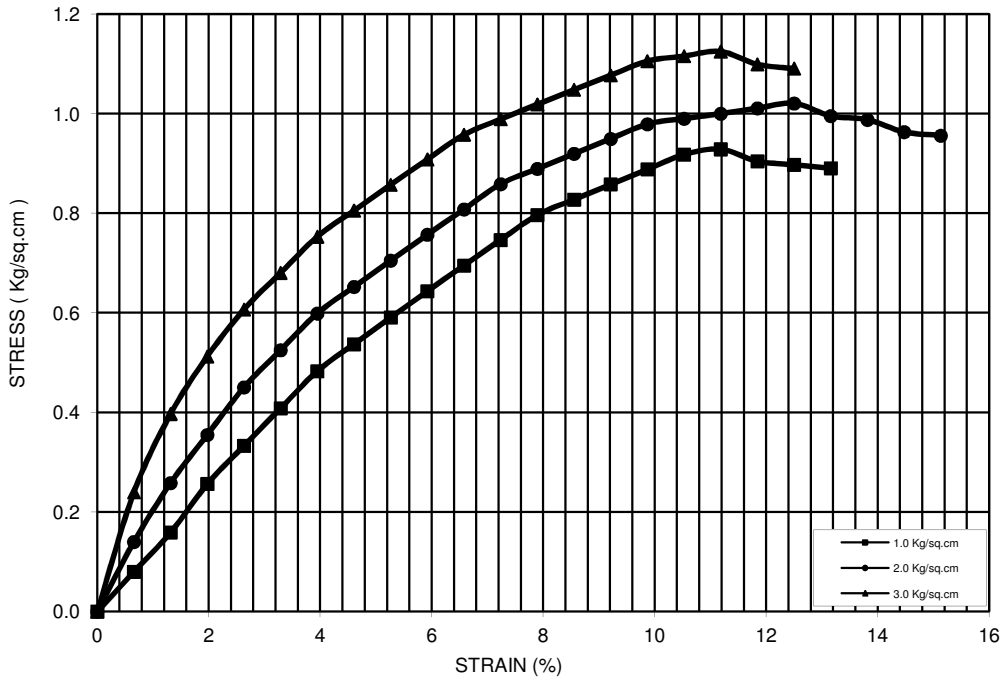
BORE HOLE NO: BH-P-3
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 1.02 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



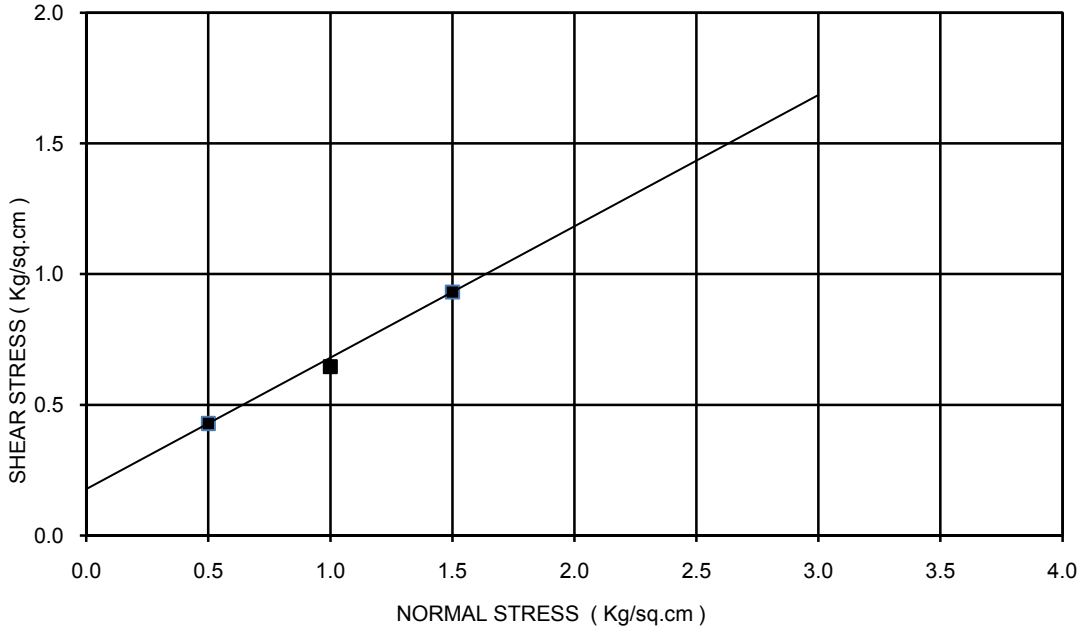


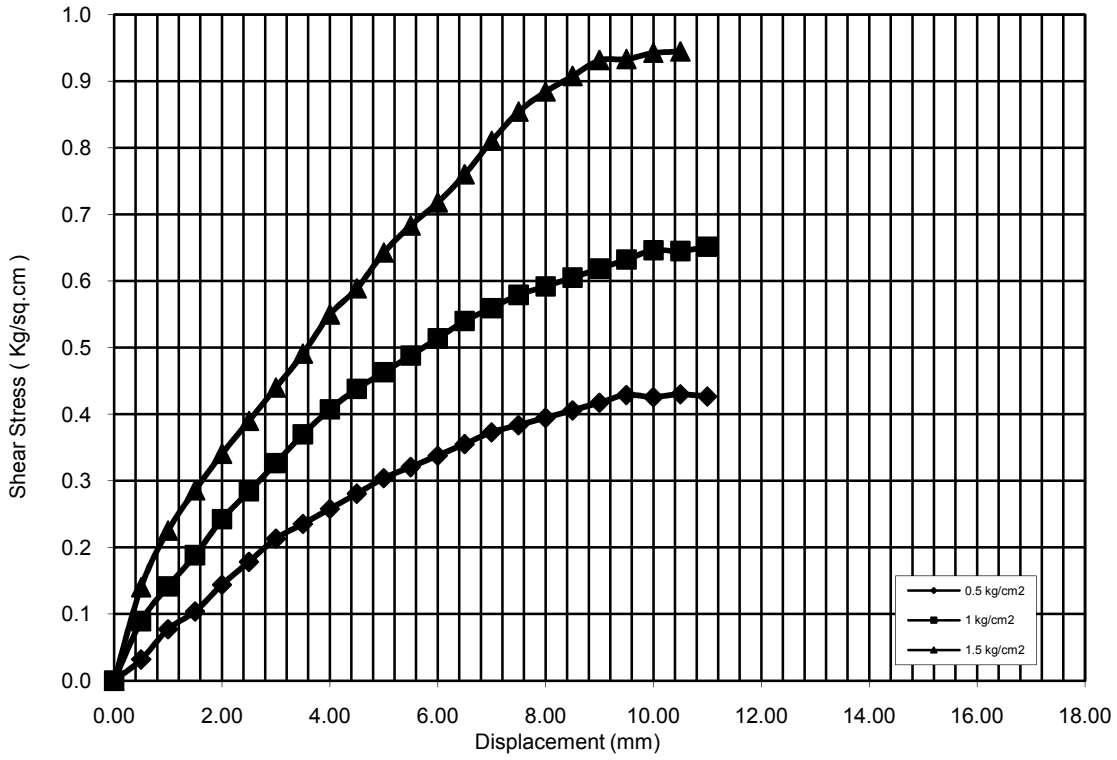
BORE HOLE NO: BH-P-4
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.37 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



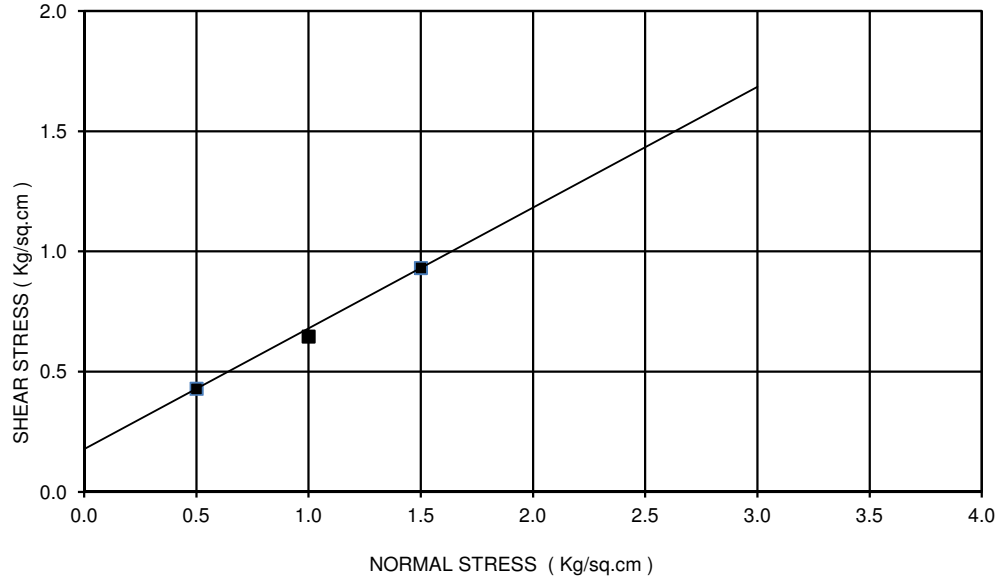


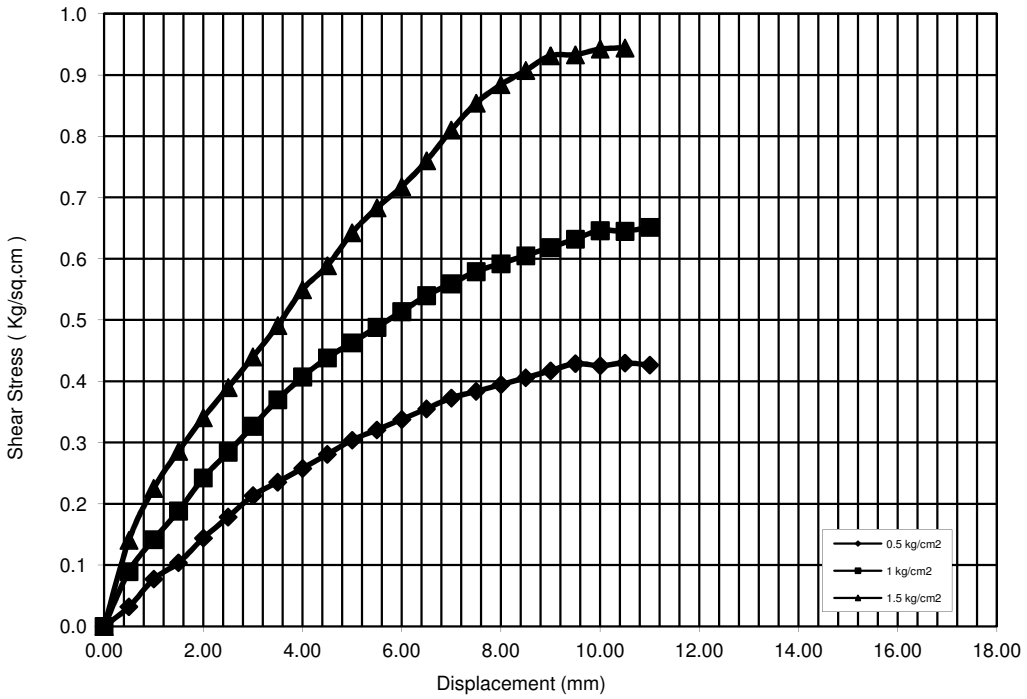
BORE HOLE NO: BH-P4
Chainage:- 27+620
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



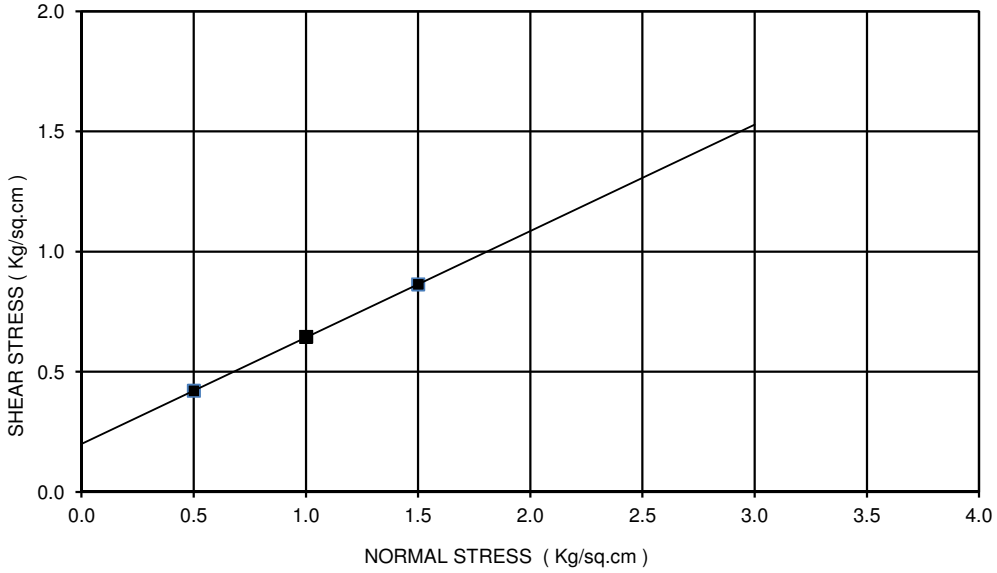


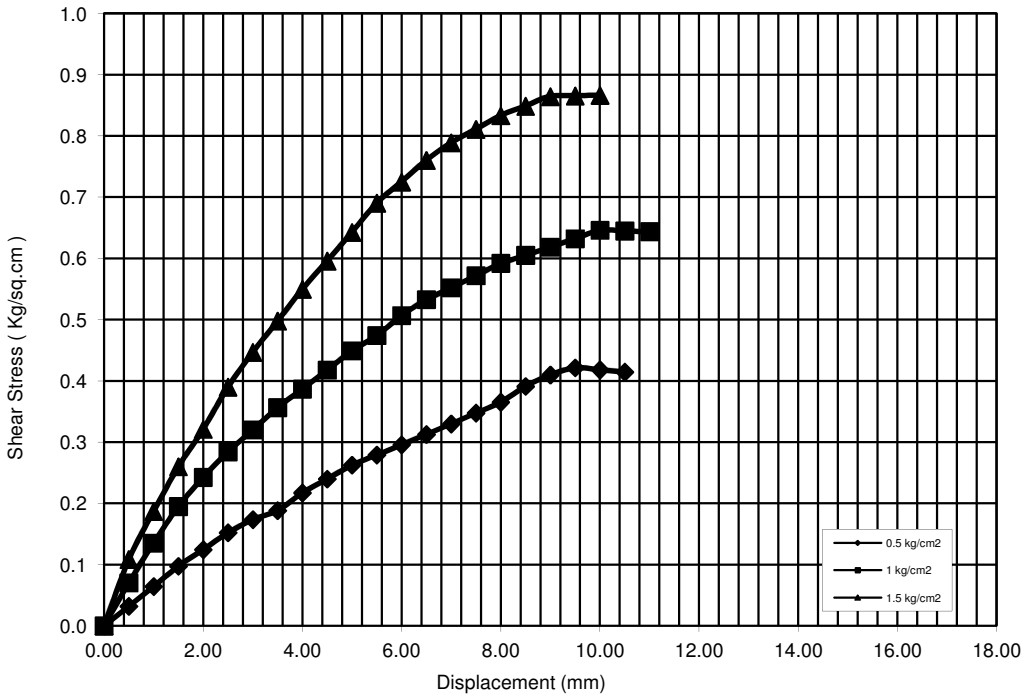
BORE HOLE NO: BH-A2
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



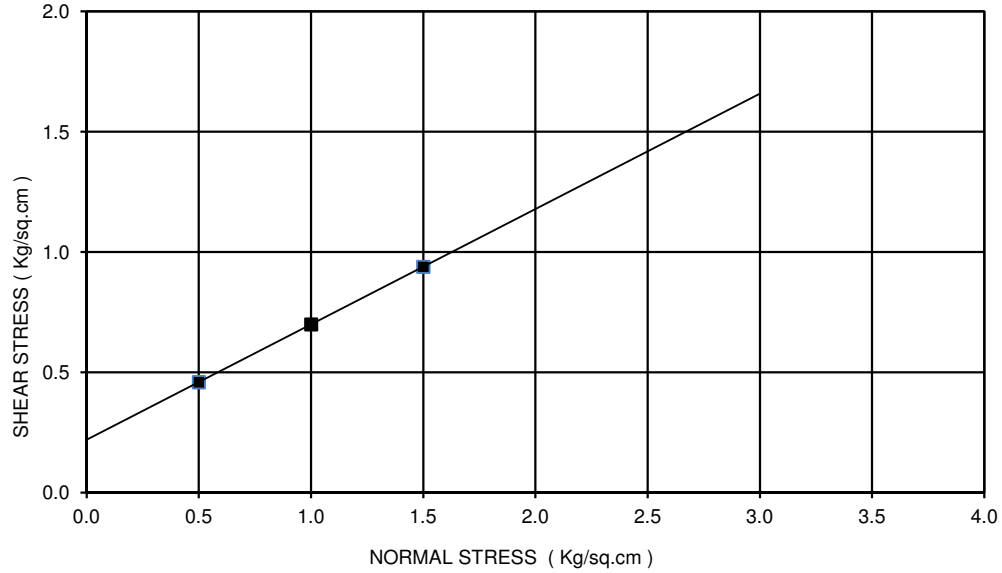


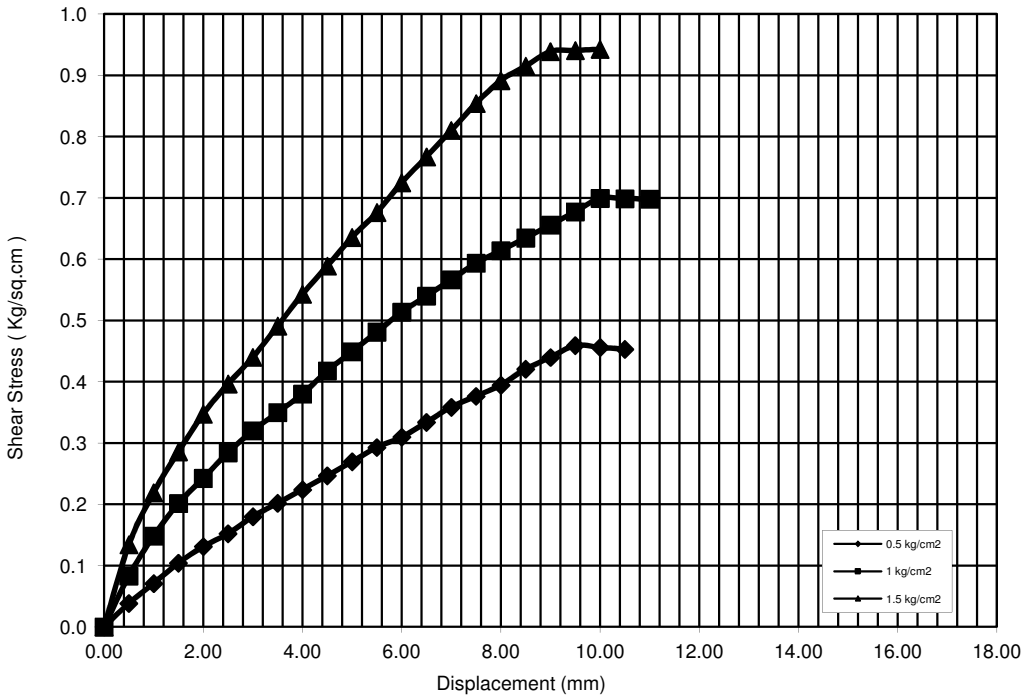
BORE HOLE NO: BH-A2
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



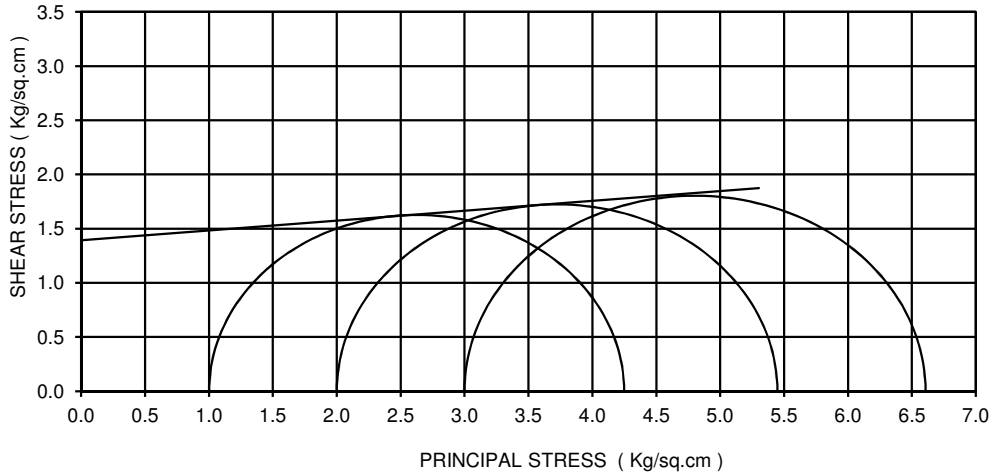


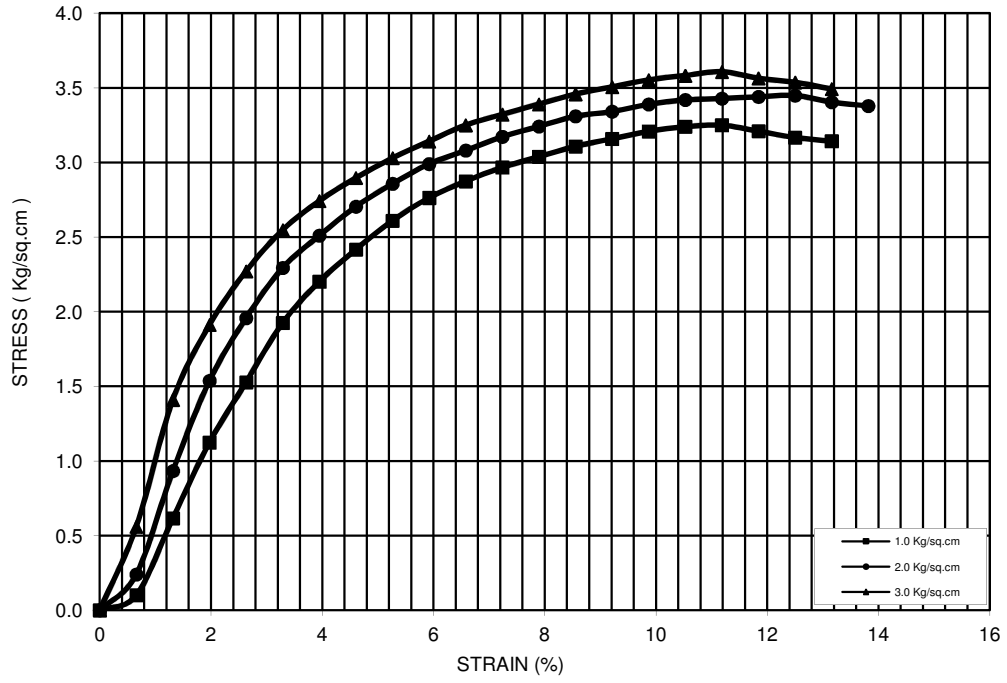
BORE HOLE NO: BH-A1
Chainage:- 28+075 km
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.22 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



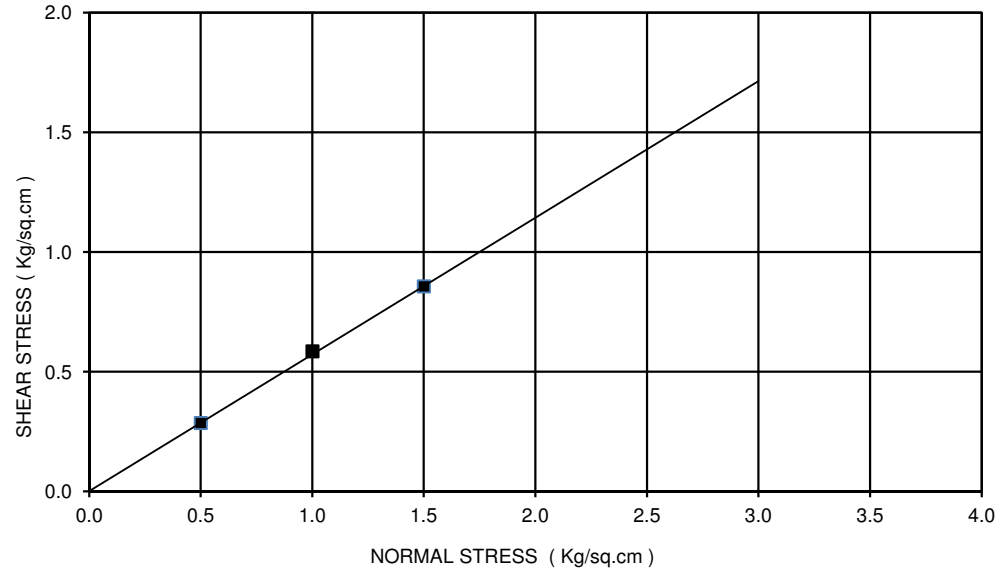


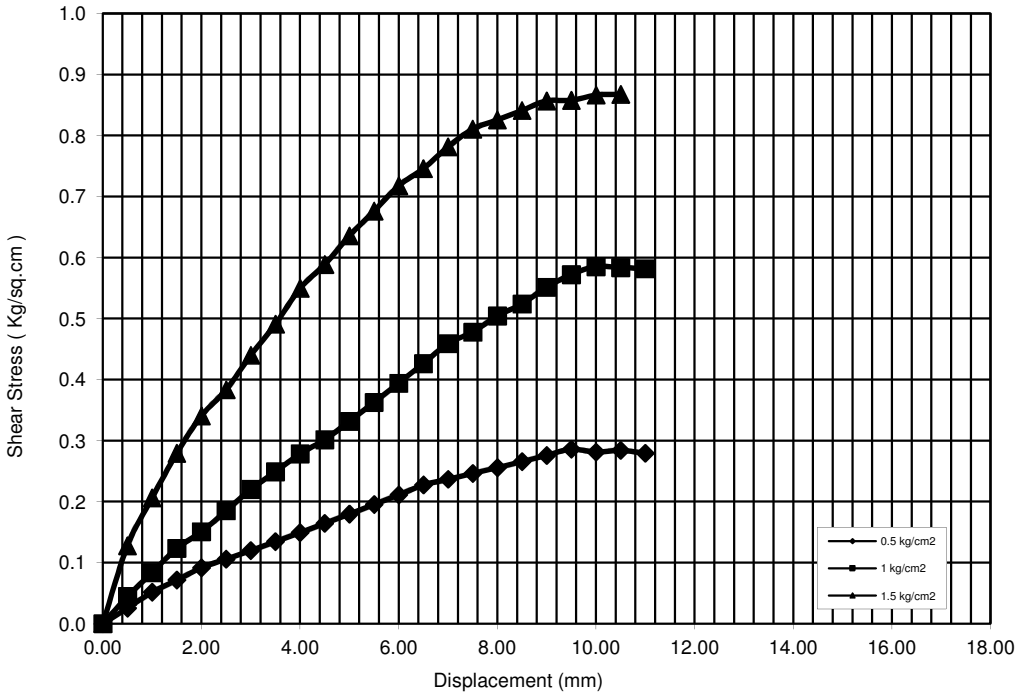
BORE HOLE NO: BH-A1
Chainage:- 28+075 km
SAMPLE NO.: UDS-5
DEPTH: 14.50m
COHESION(C)= 1.39 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



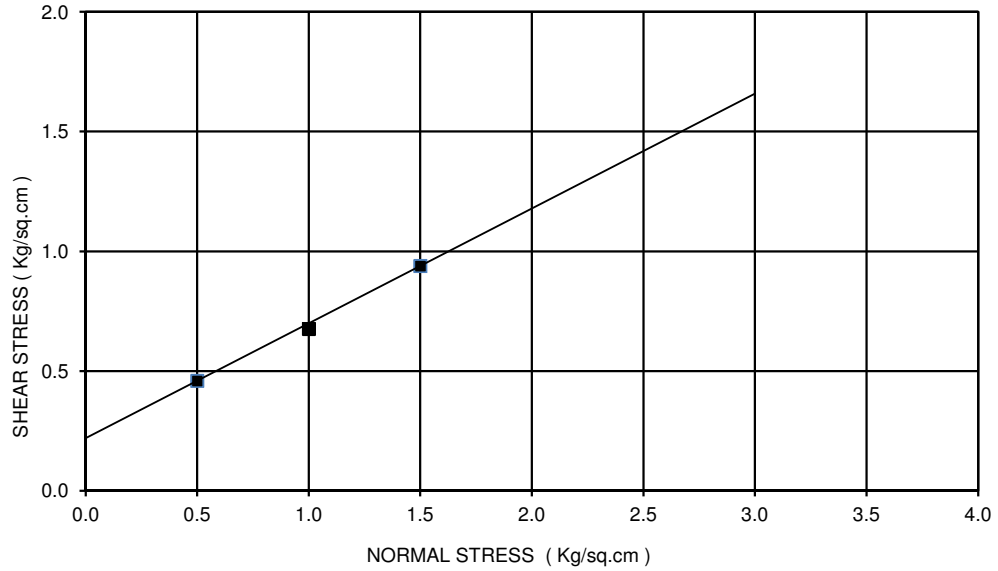


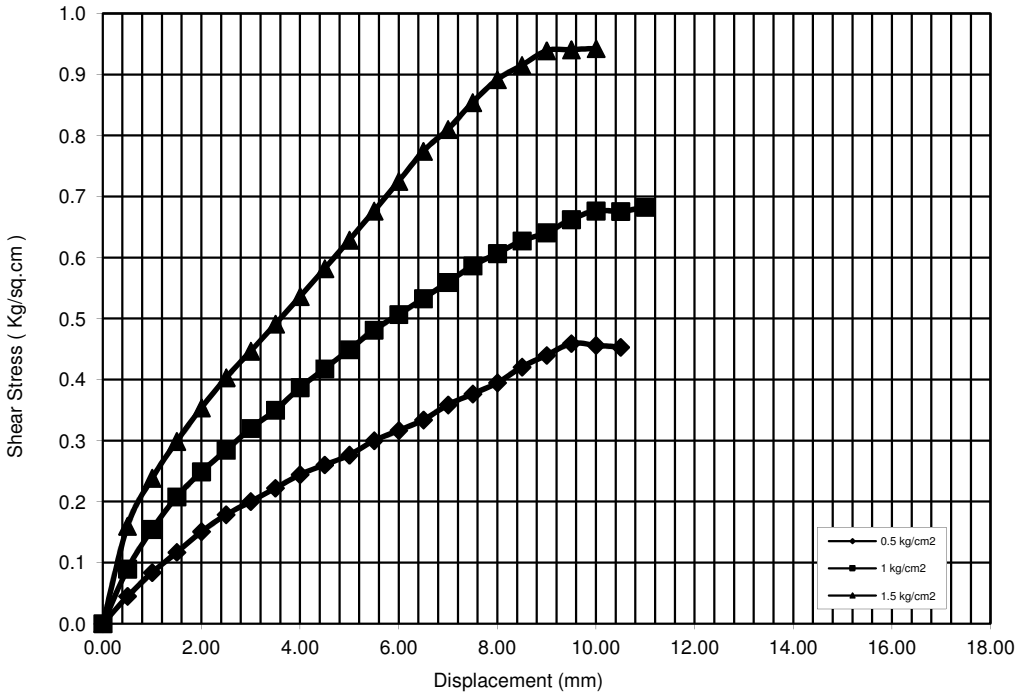
BORE HOLE NO: BH-P1
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.00 kg/sq.cm
ANGLE OF FRICTION(Phi): 30 deg
TYPE OF THE TEST: DST



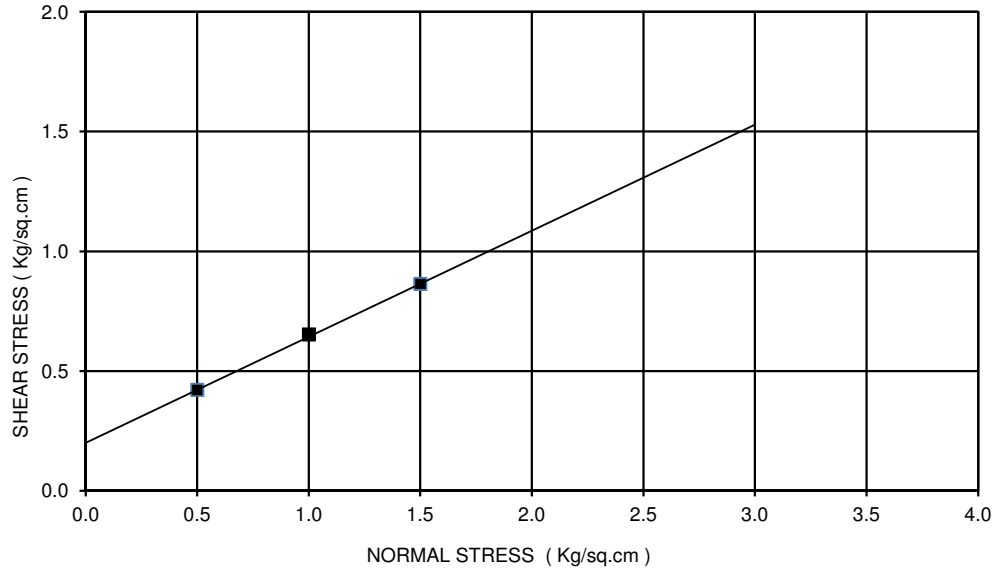


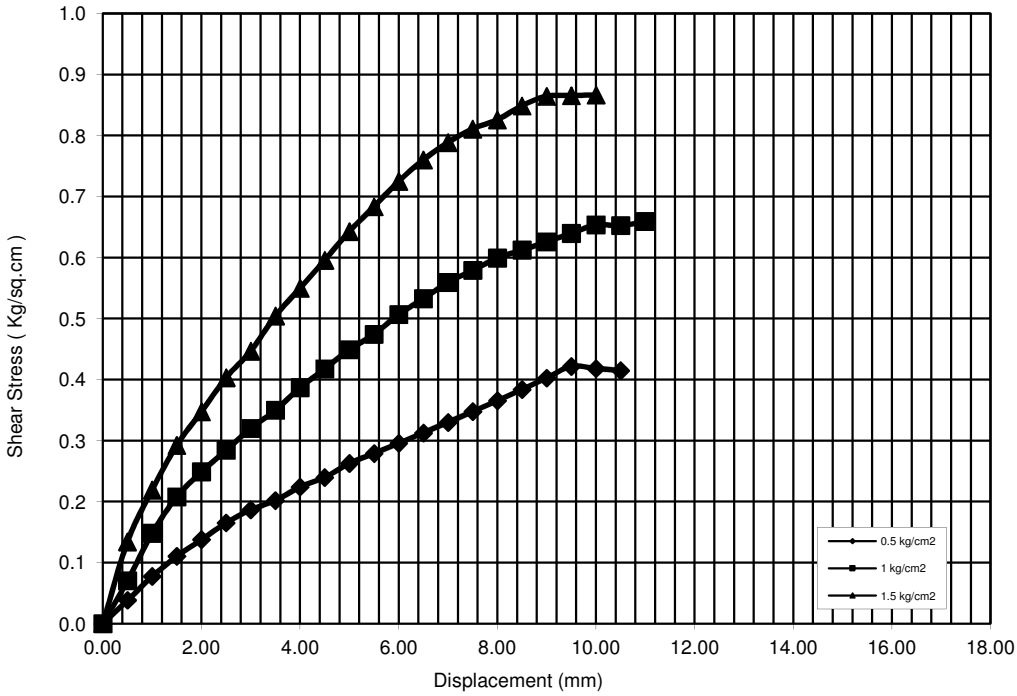
BORE HOLE NO: BH-P1
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.22 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



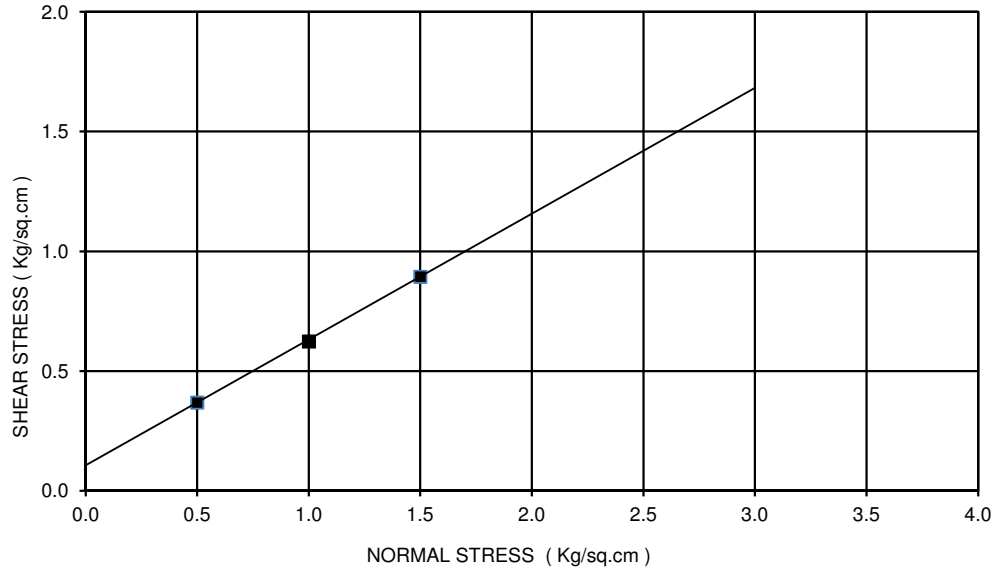


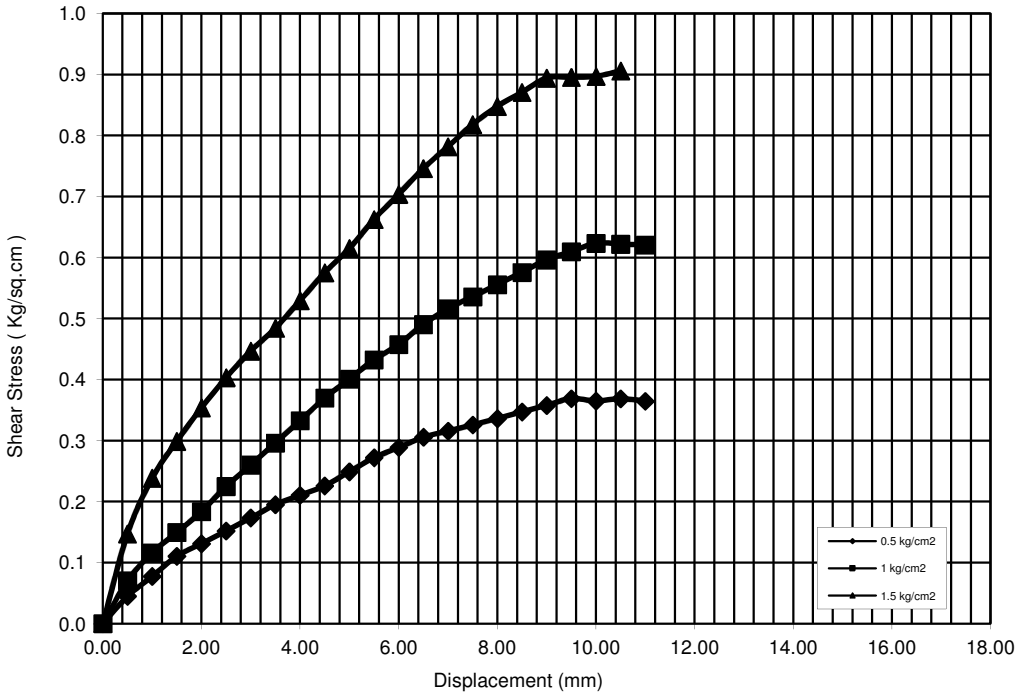
BORE HOLE NO: BH-P2
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



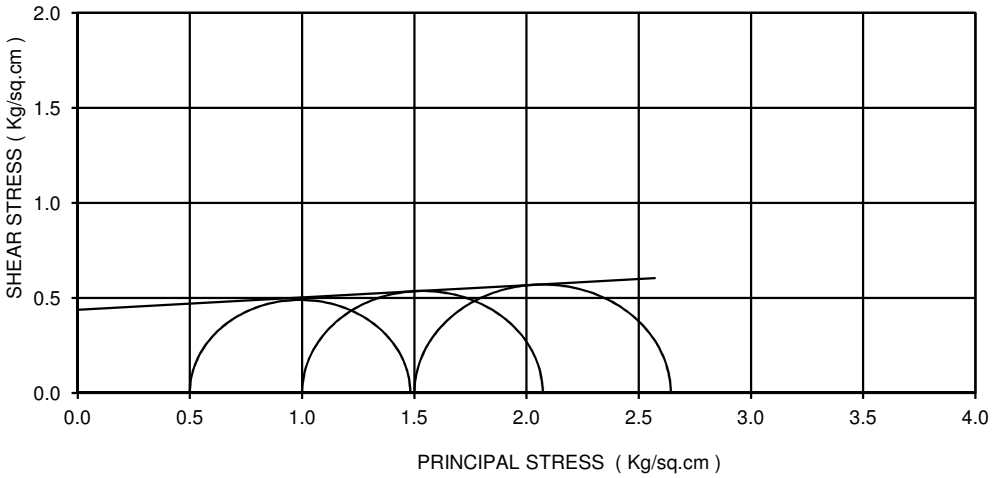


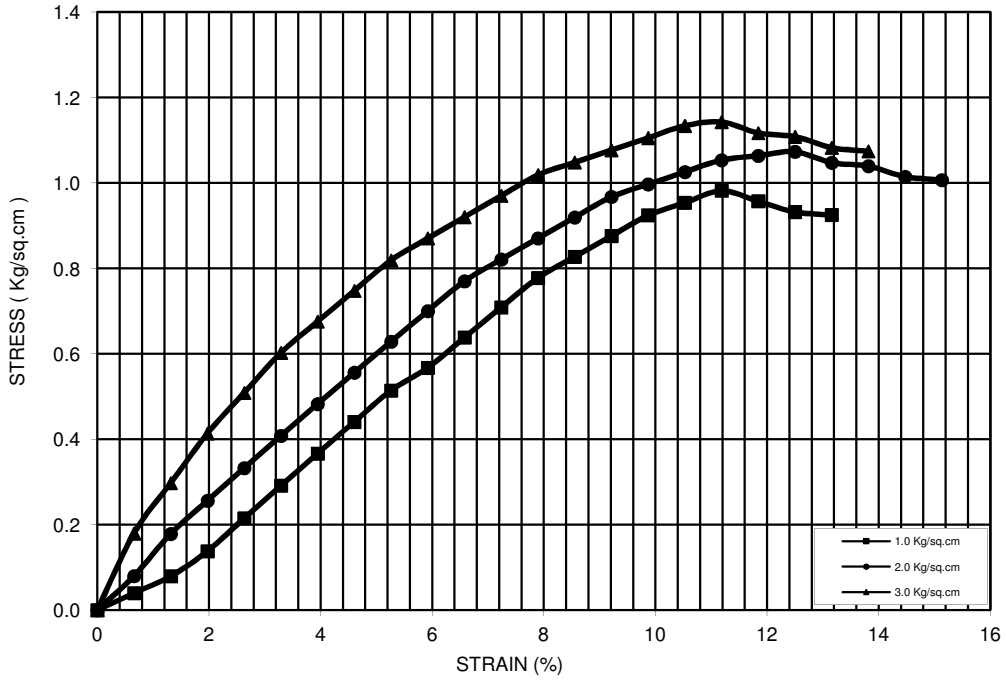
BORE HOLE NO: BH-P2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.11 kg/sq.cm
ANGLE OF FRICTION(Phi): 28 deg
TYPE OF THE TEST: DST



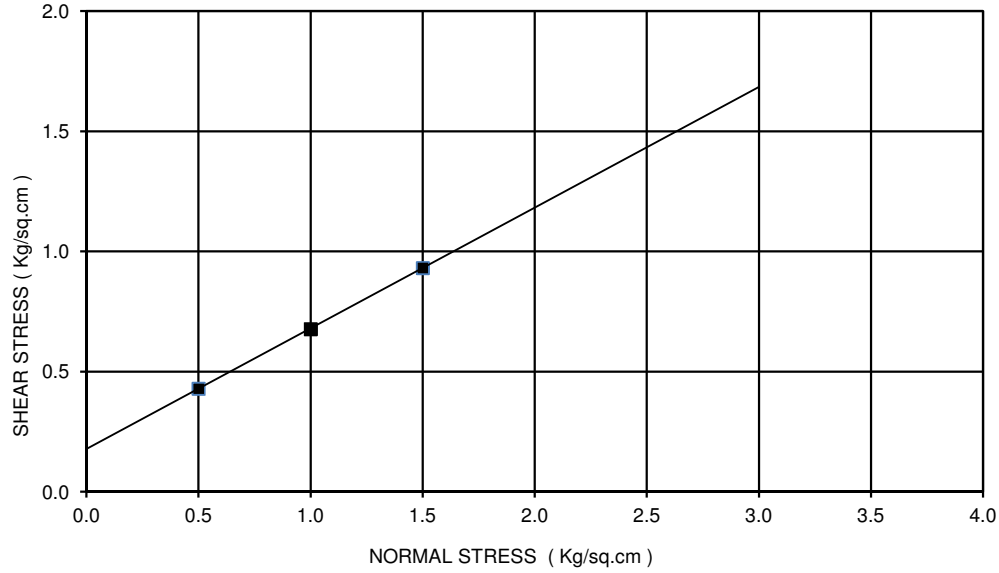


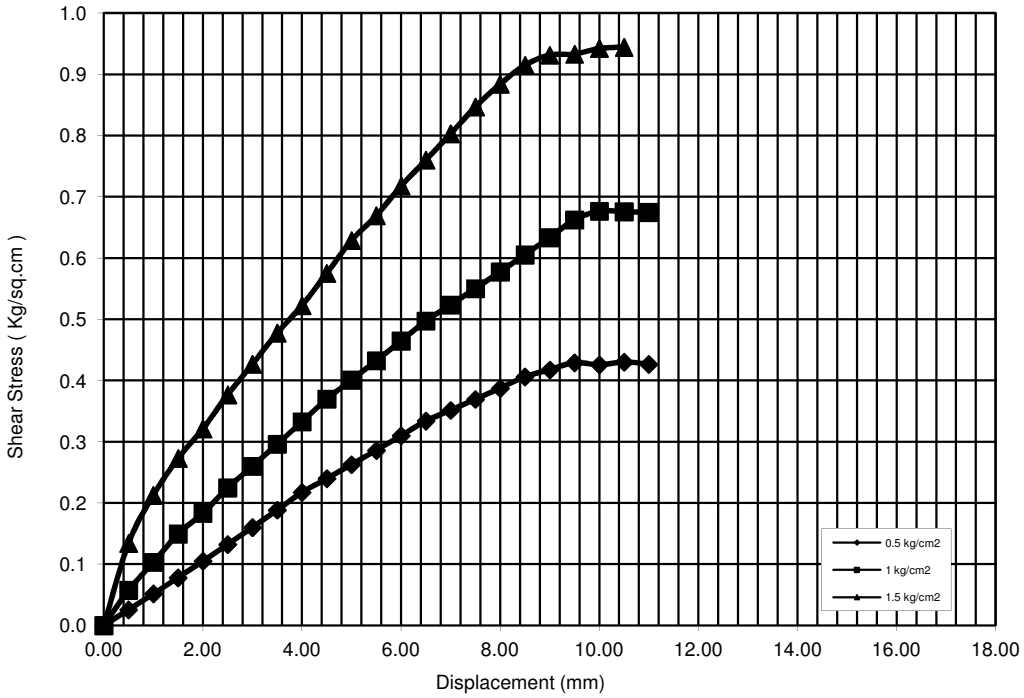
BORE HOLE NO: BH-A2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.44 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



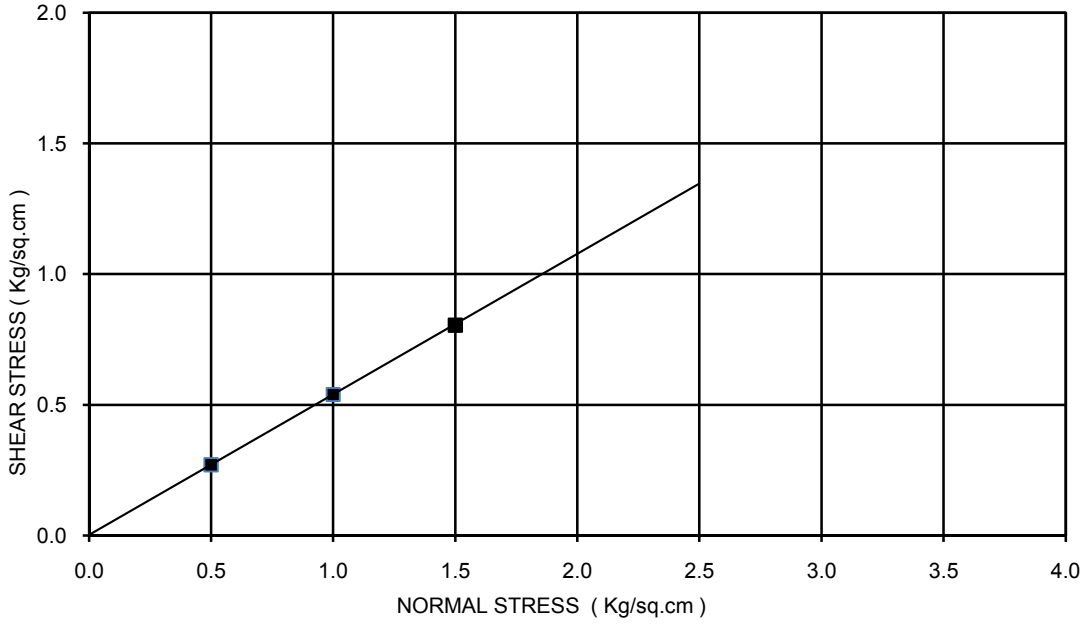


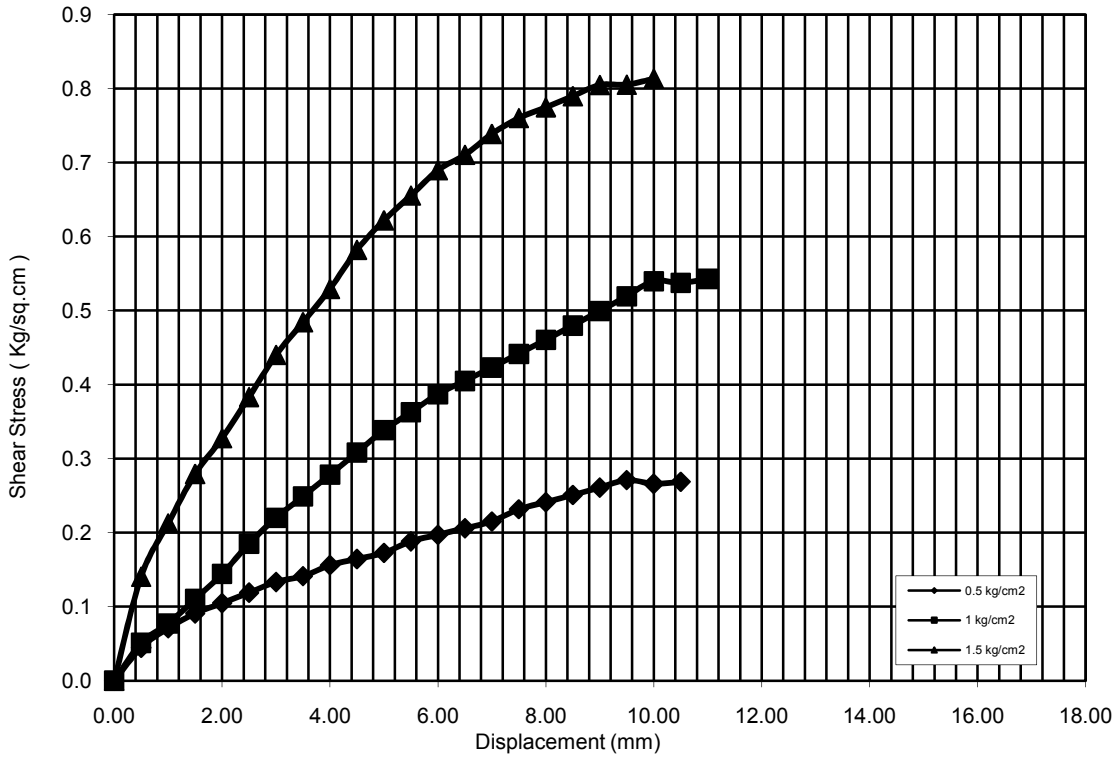
BORE HOLE NO: BH-A2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.18 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



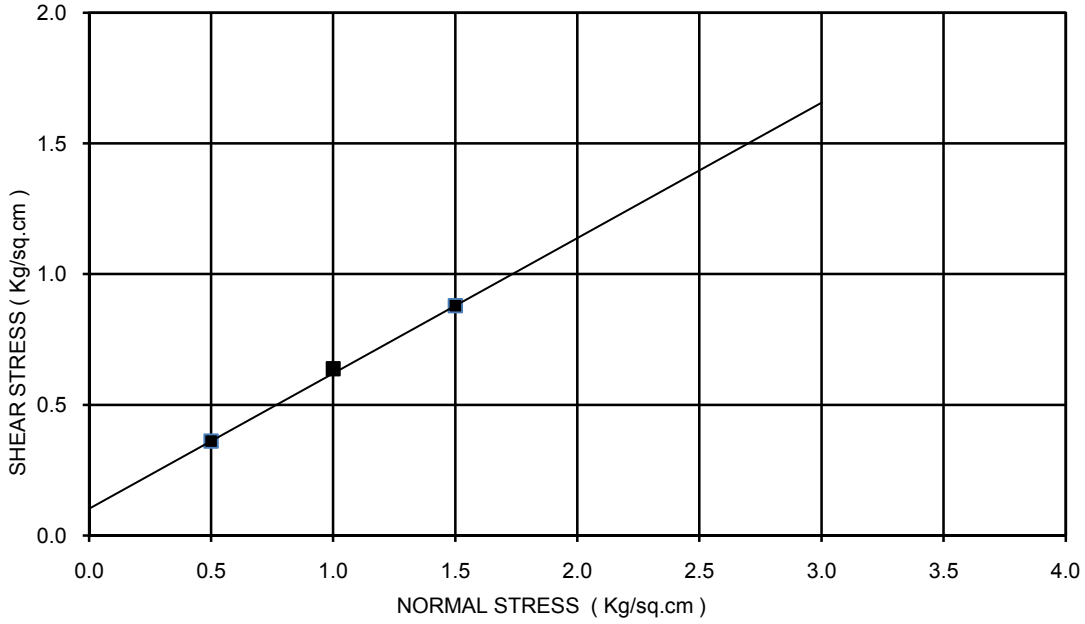


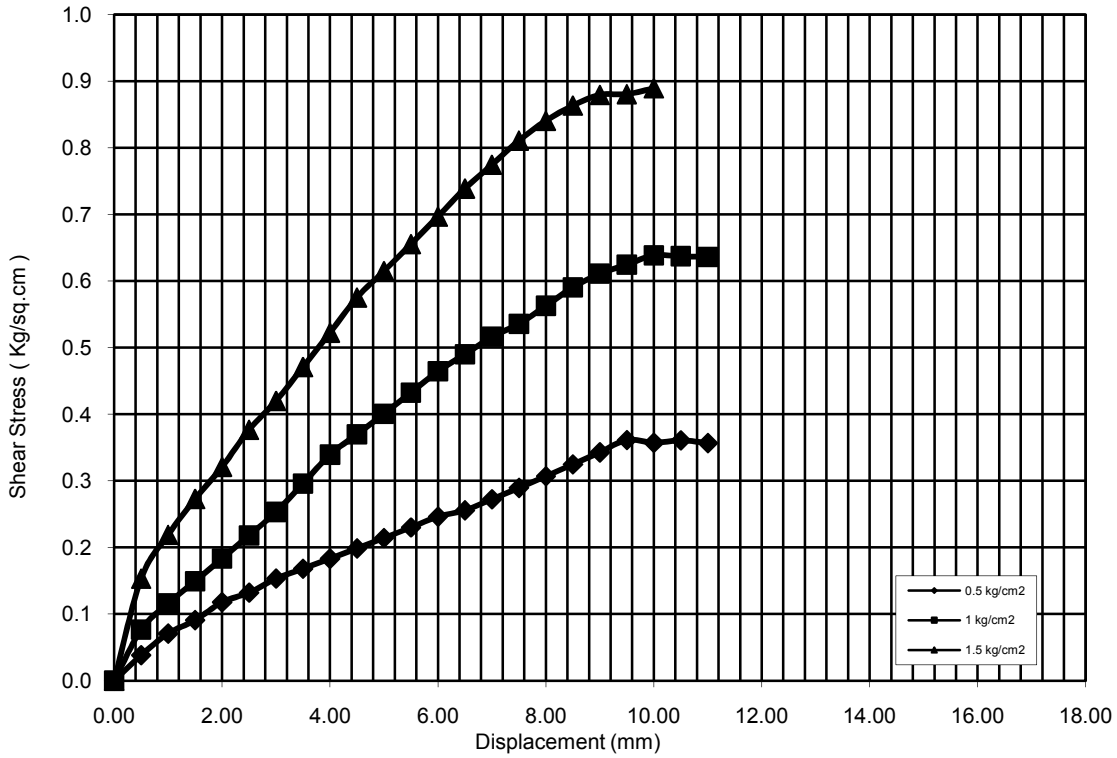
BORE HOLE NO: BH-A1
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 2.5 m
COHESION(C)= 0.00 kg/sq.cm
ANGLE OF FRICTION(Phi): 28 deg
TYPE OF THE TEST: DST



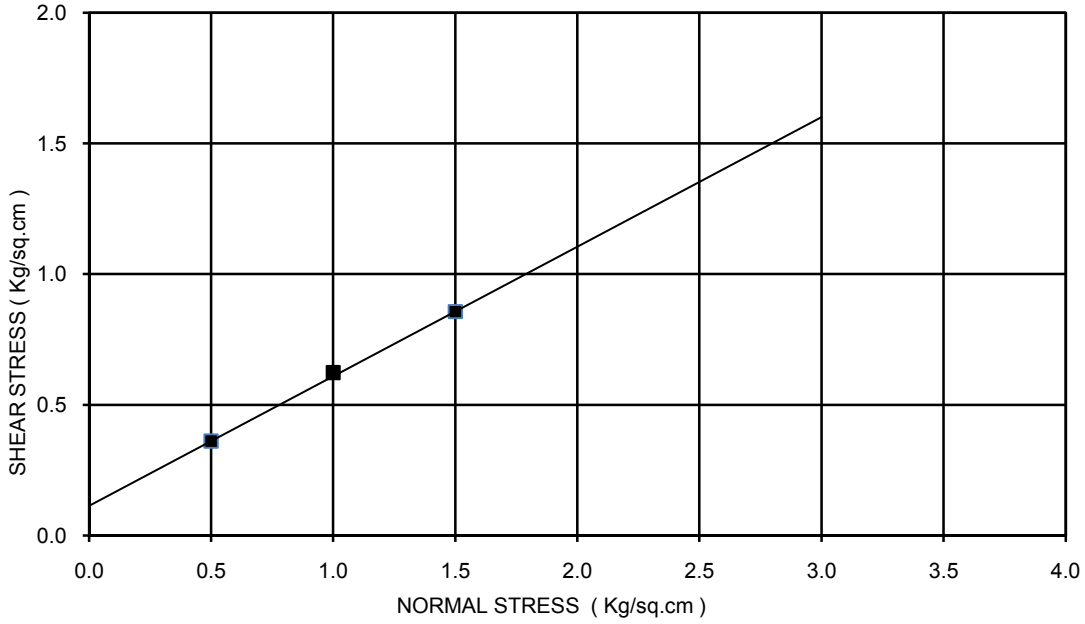


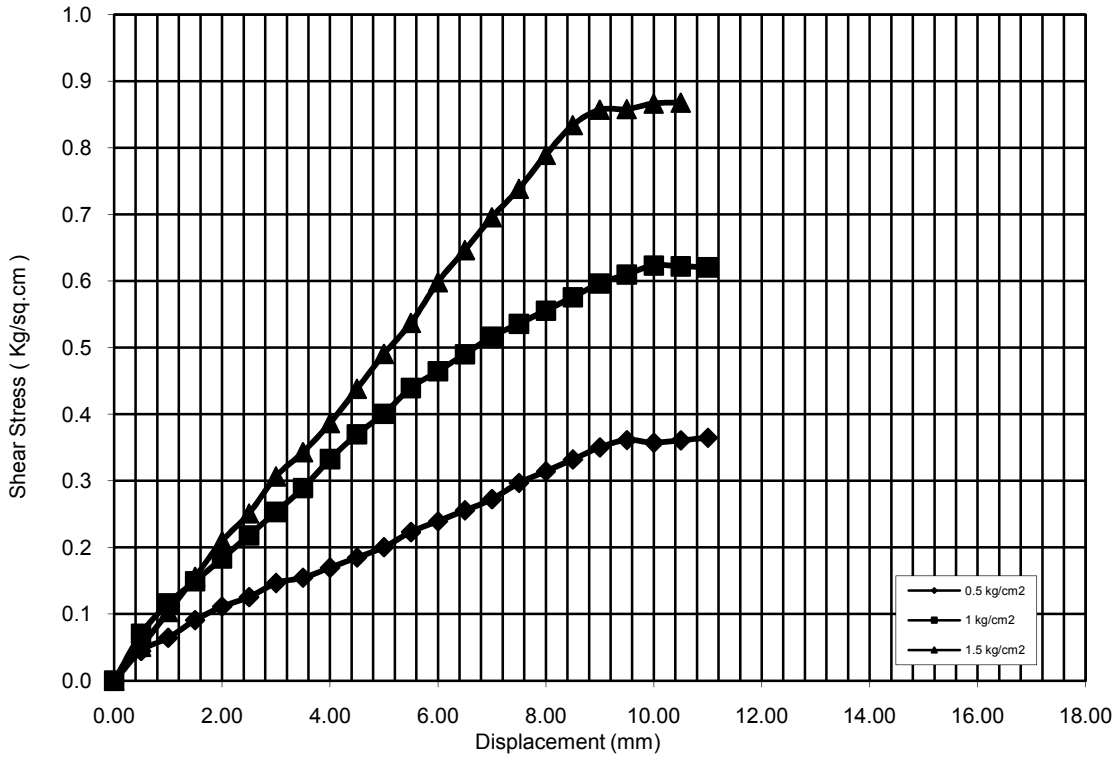
BORE HOLE NO: BH-A1
Chainage:- 28+360
SAMPLE NO.: UDS-3
DEPTH: 8.50 m
COHESION(C)= 0.10 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



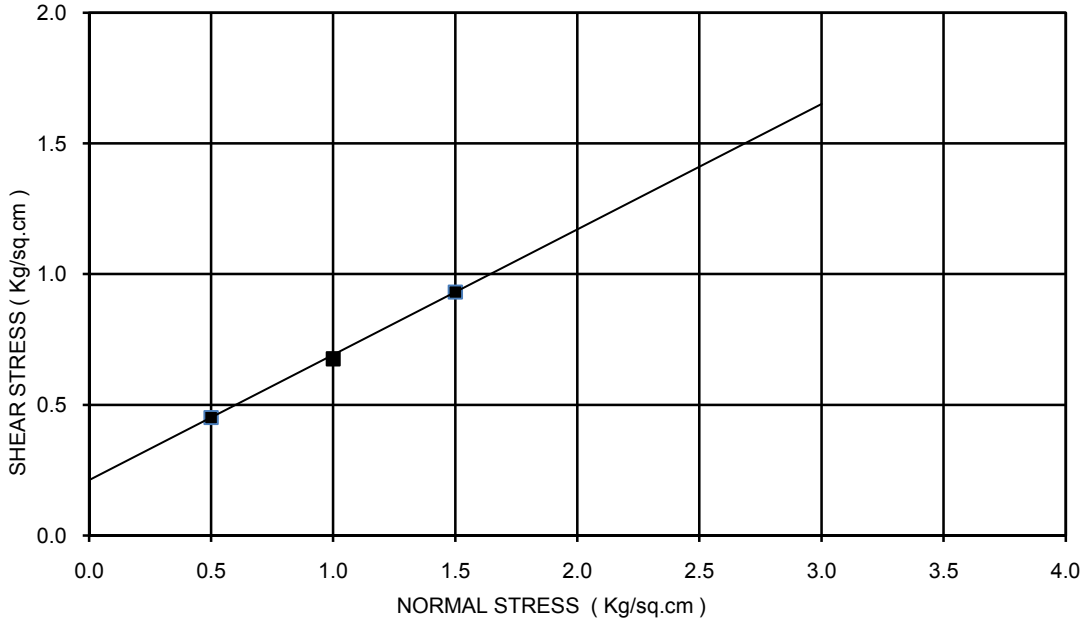


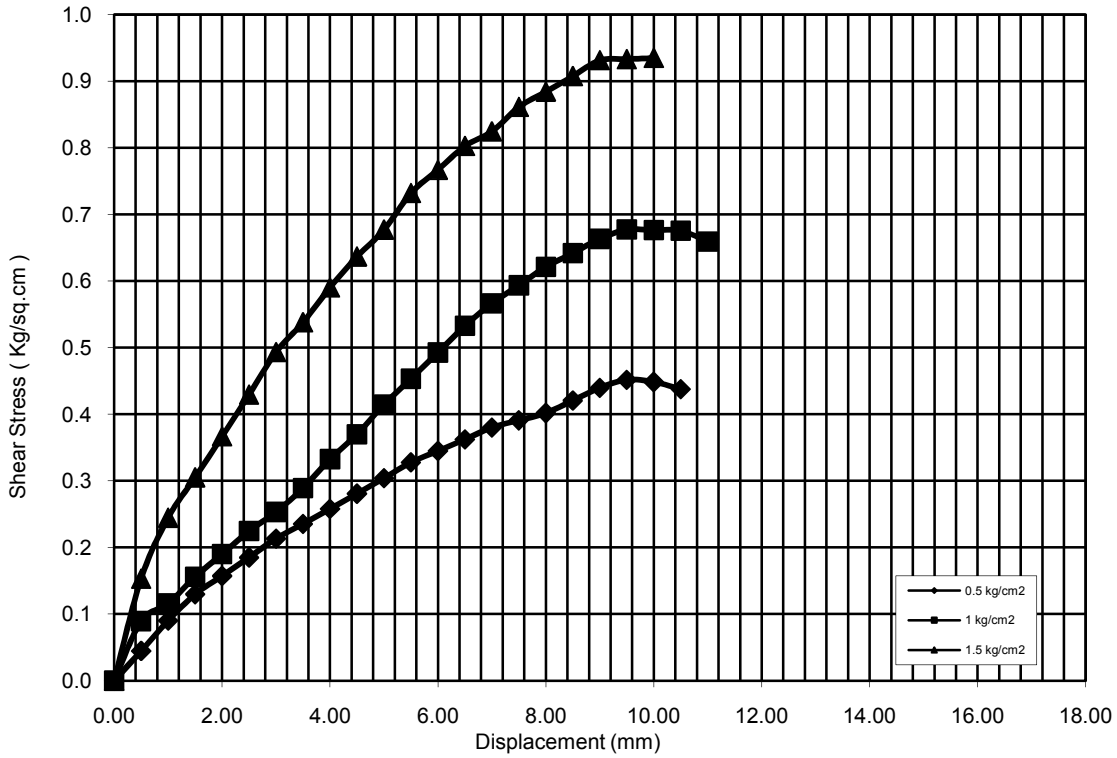
BORE HOLE NO: BH-P1
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.11 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



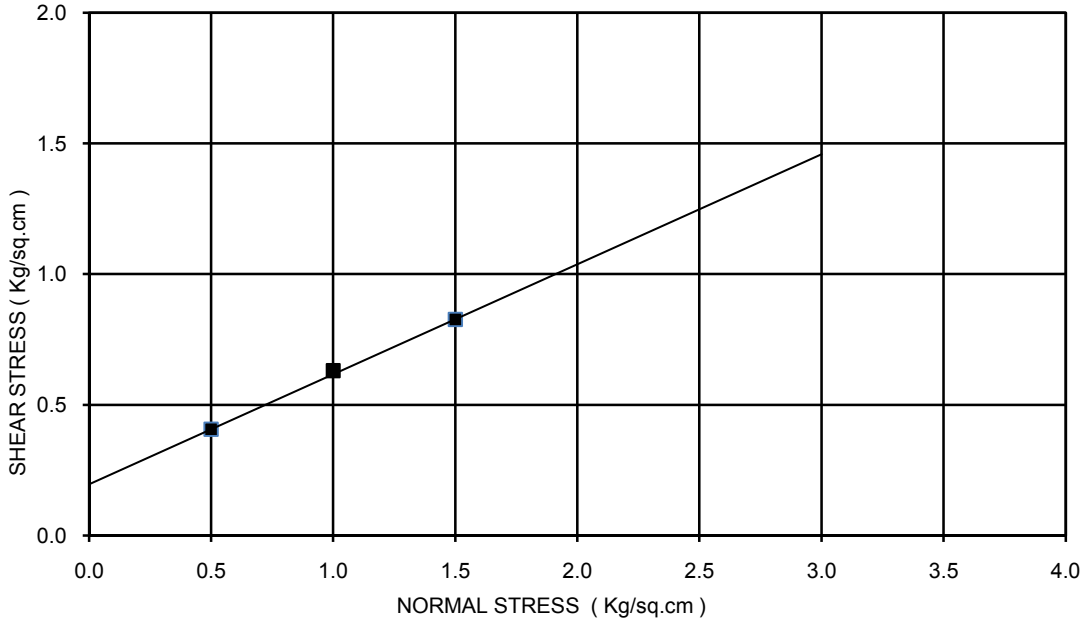


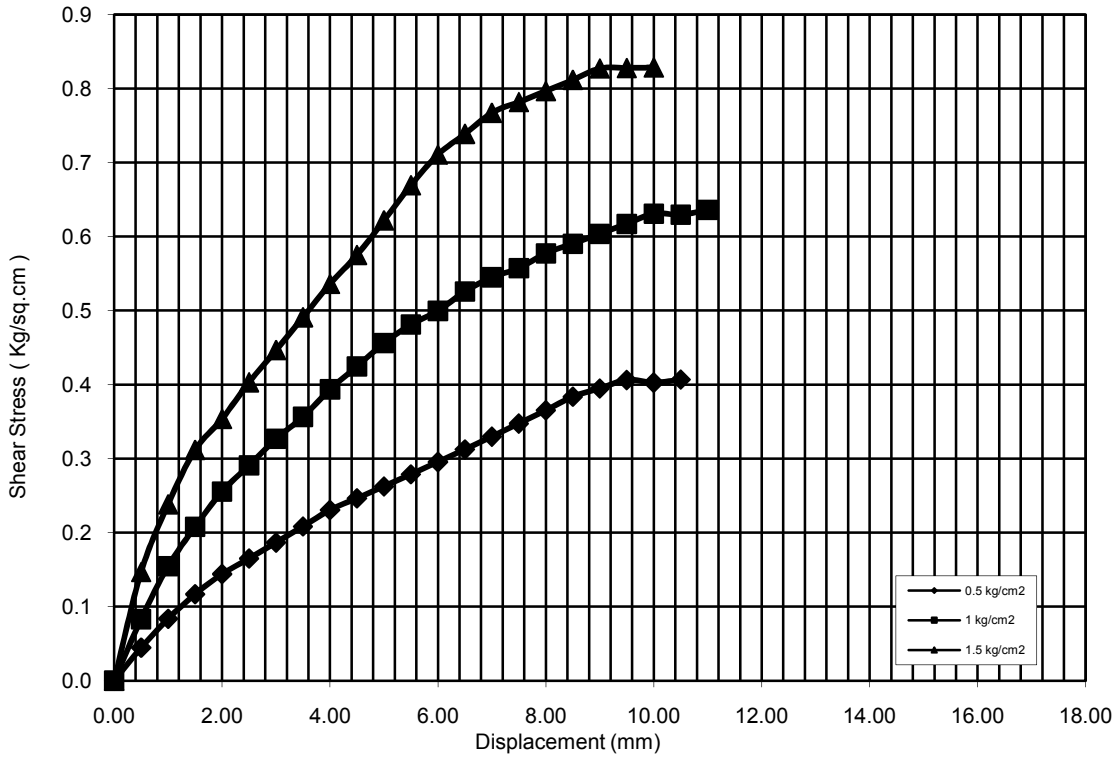
BORE HOLE NO: BH-P1
Chainage:- 28+360
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



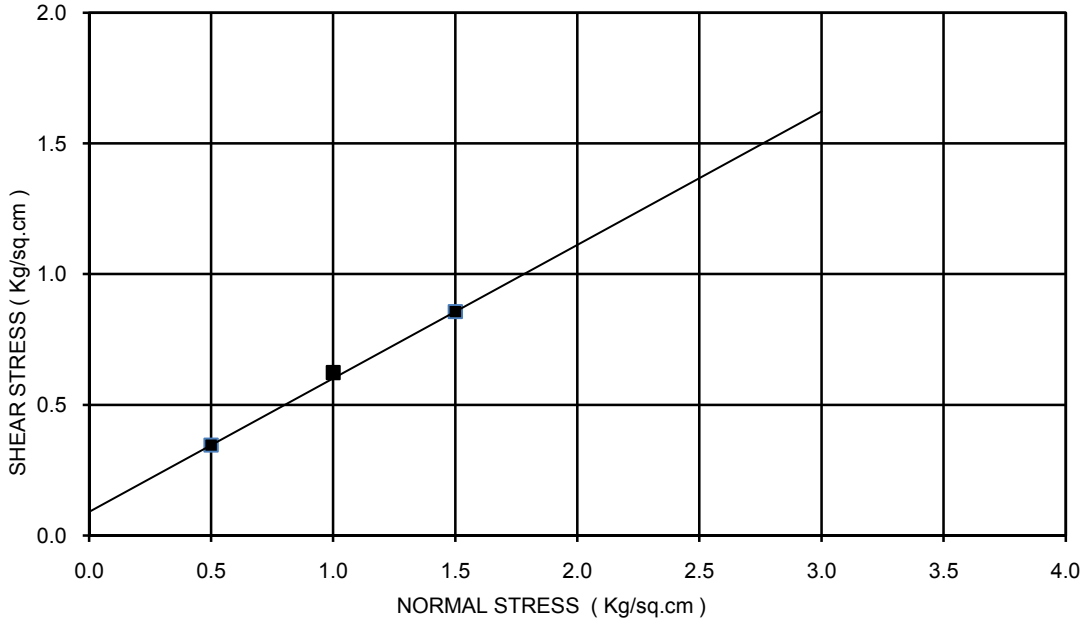


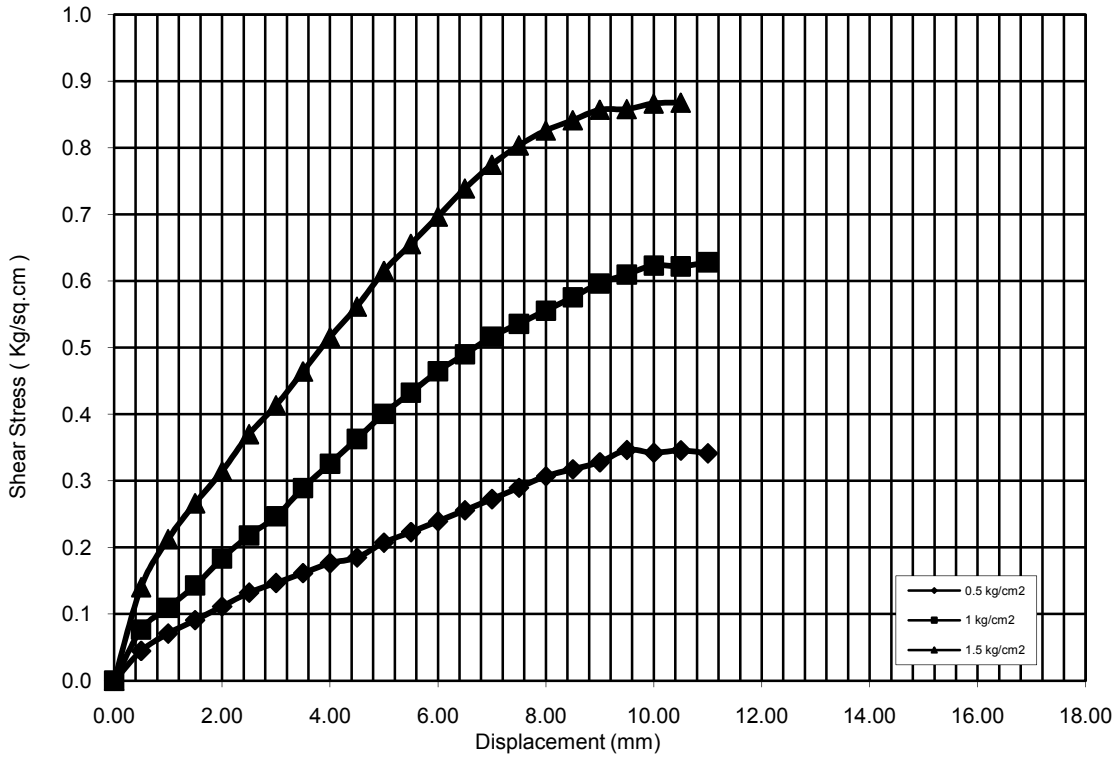
BORE HOLE NO: BH-P2
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 23 deg
TYPE OF THE TEST: DST



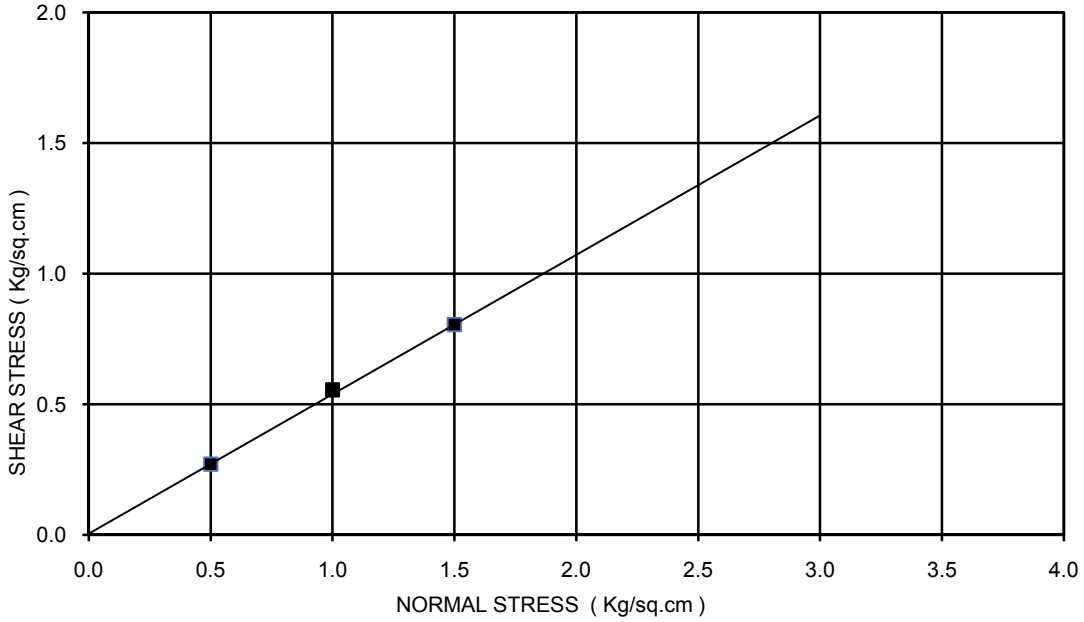


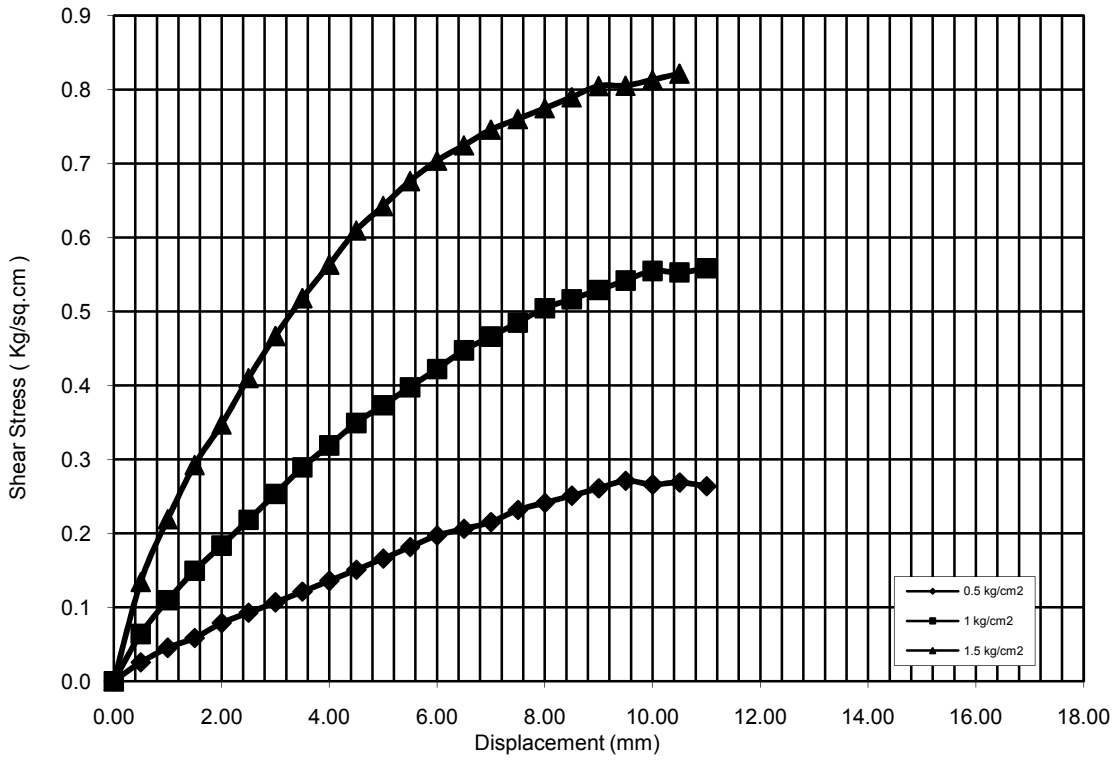
BORE HOLE NO: BH-P2
Chainage:- 28+360
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



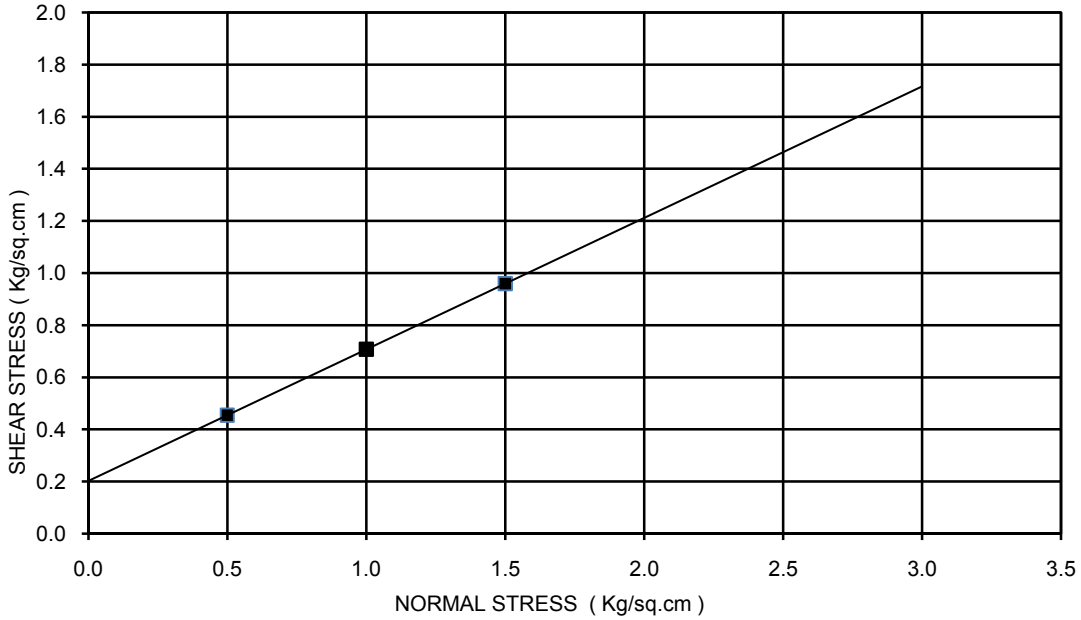


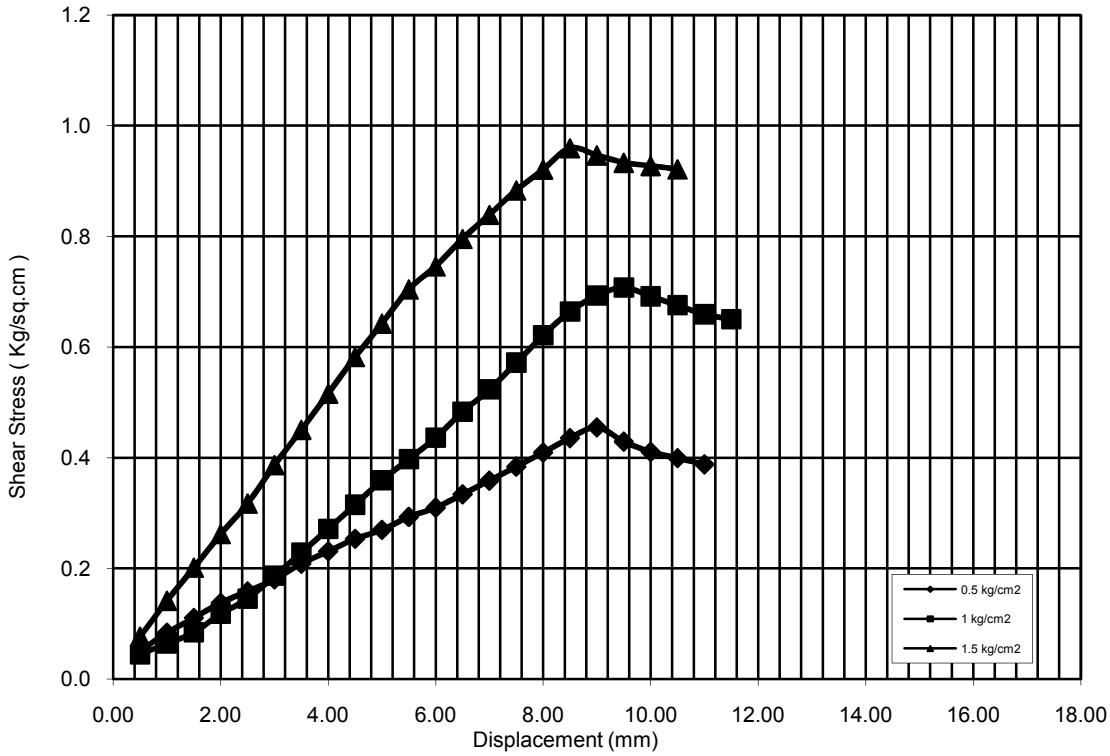
BORE HOLE NO: BH-A2
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.00 kg/sq.cm
ANGLE OF FRICTION(Phi): 28 deg
TYPE OF THE TEST: DST



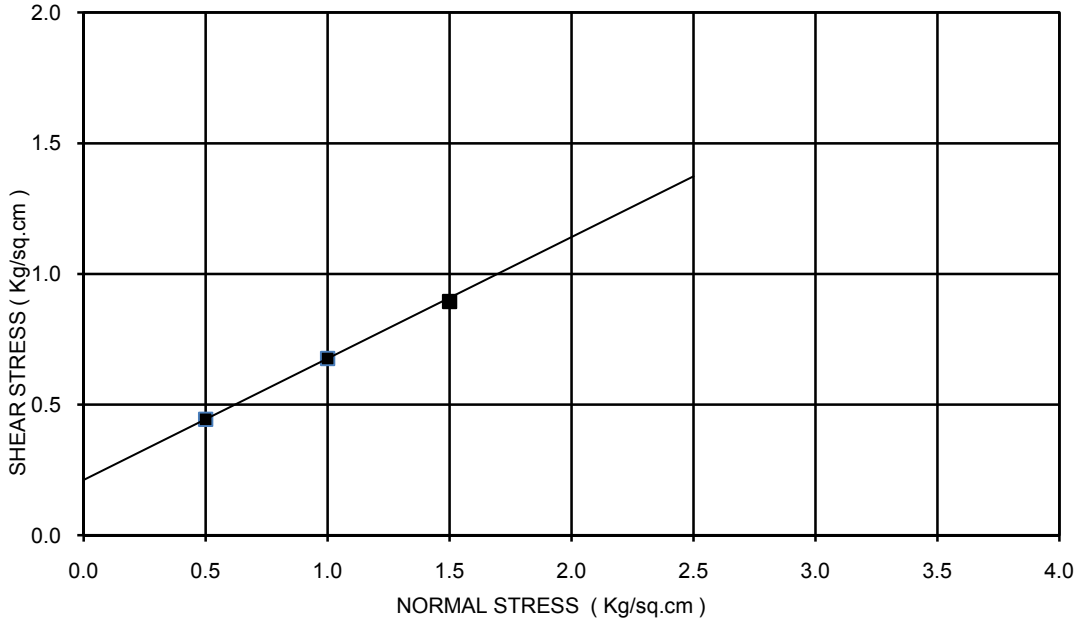


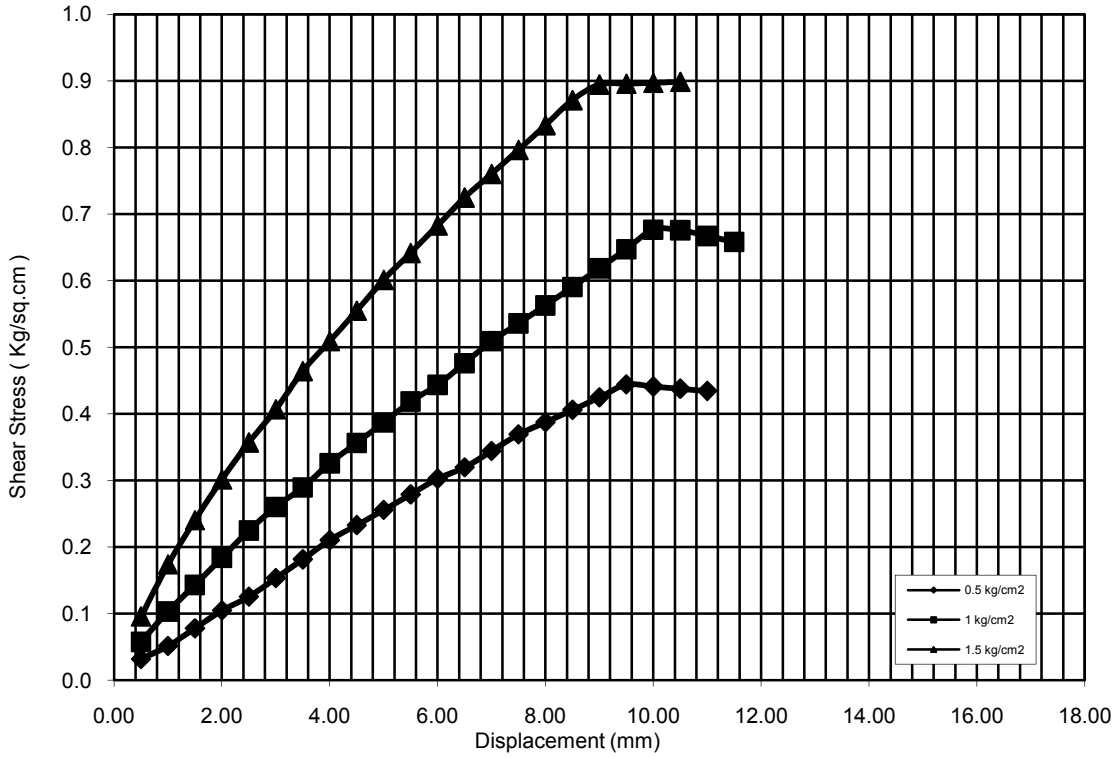
BORE HOLE NO: BH-A2
CHAINAGE : - 28+360
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.2 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



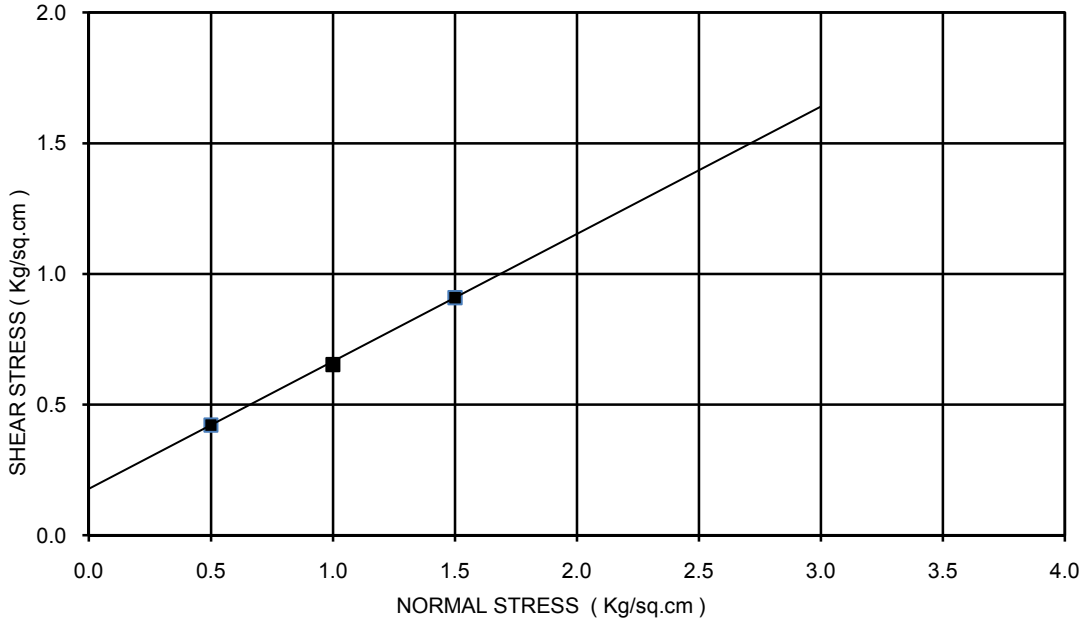


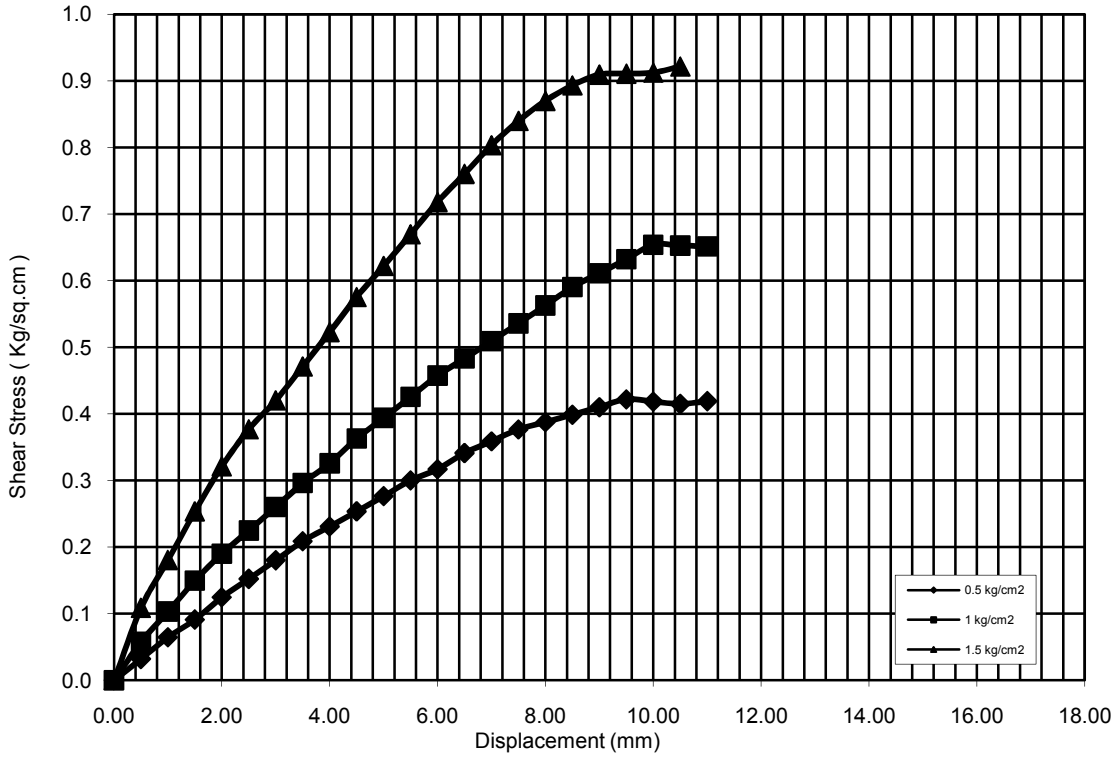
BORE HOLE NO: BH-A1
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST



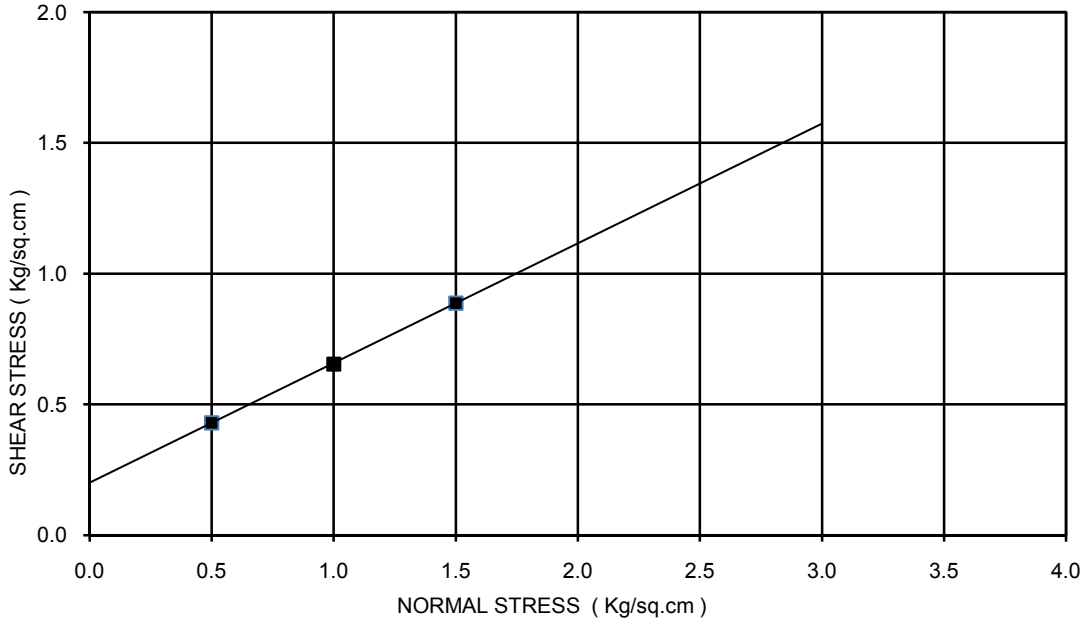


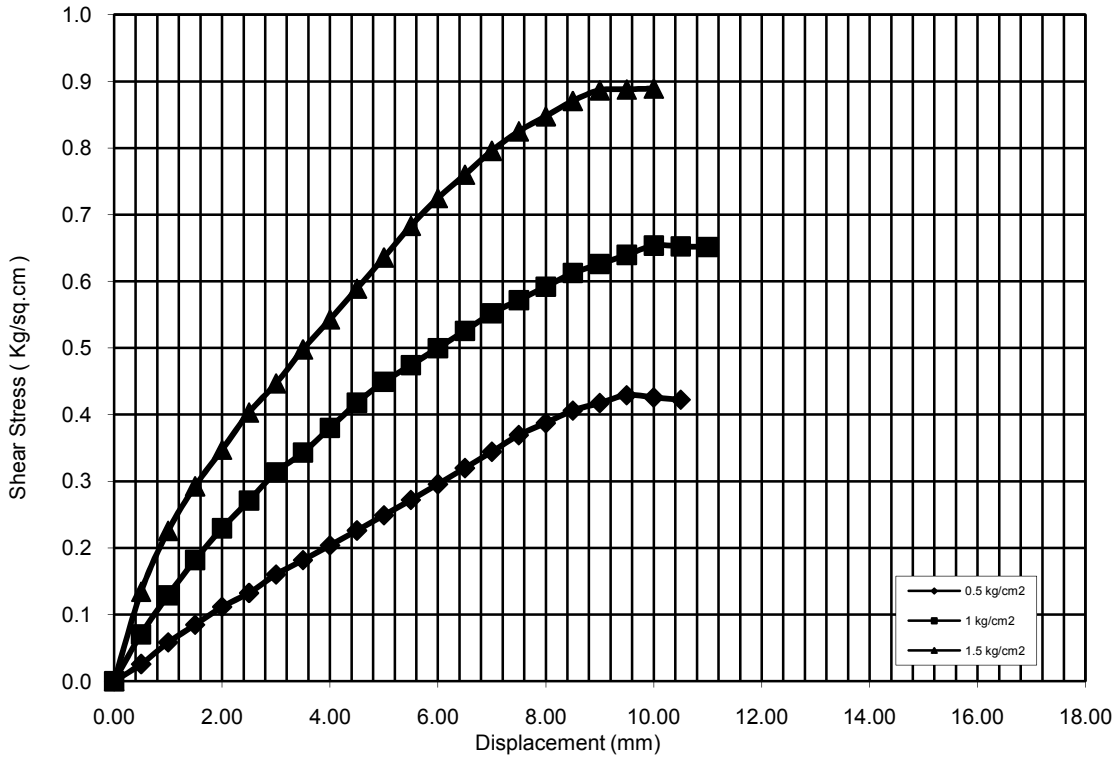
BORE HOLE NO: BH-A1
Chainage: 28+900
SAMPLE NO.: UDS-3
DEPTH: 8.50 m
COHESION(C)= 0.18 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



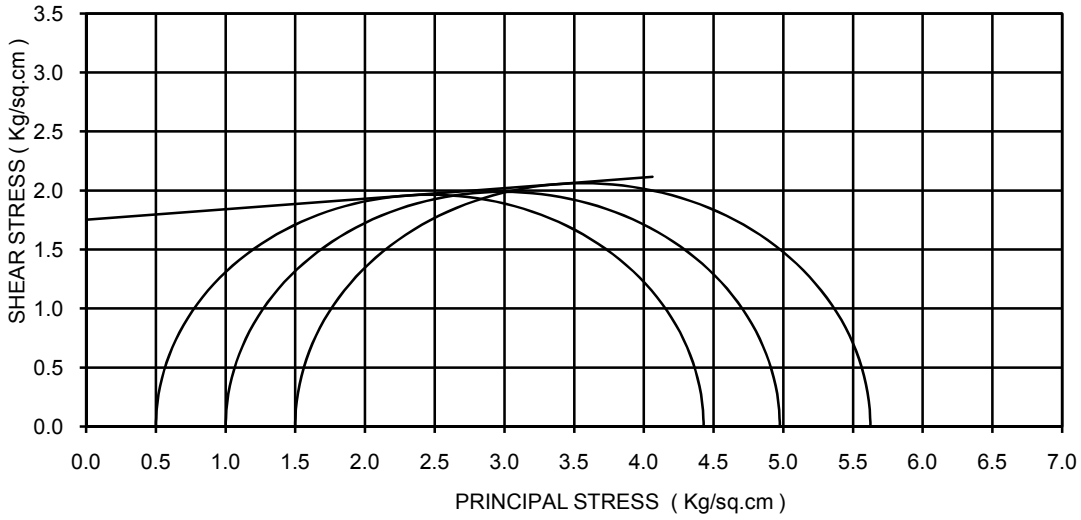


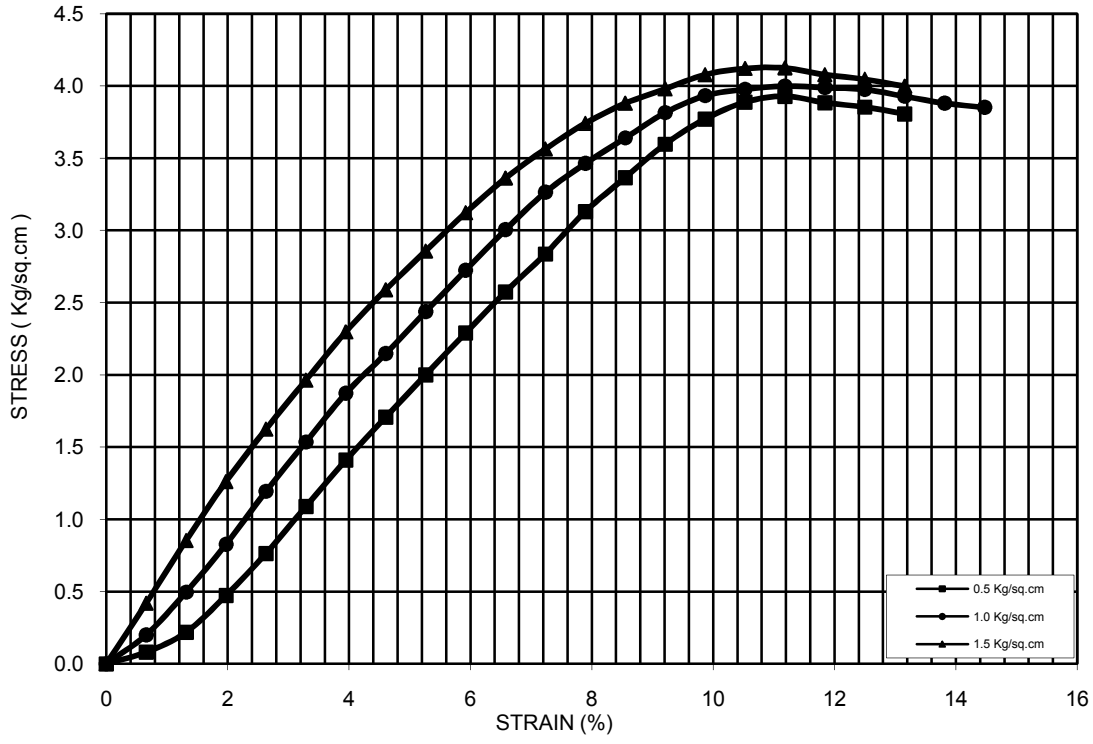
BORE HOLE NO: BH-P1
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST



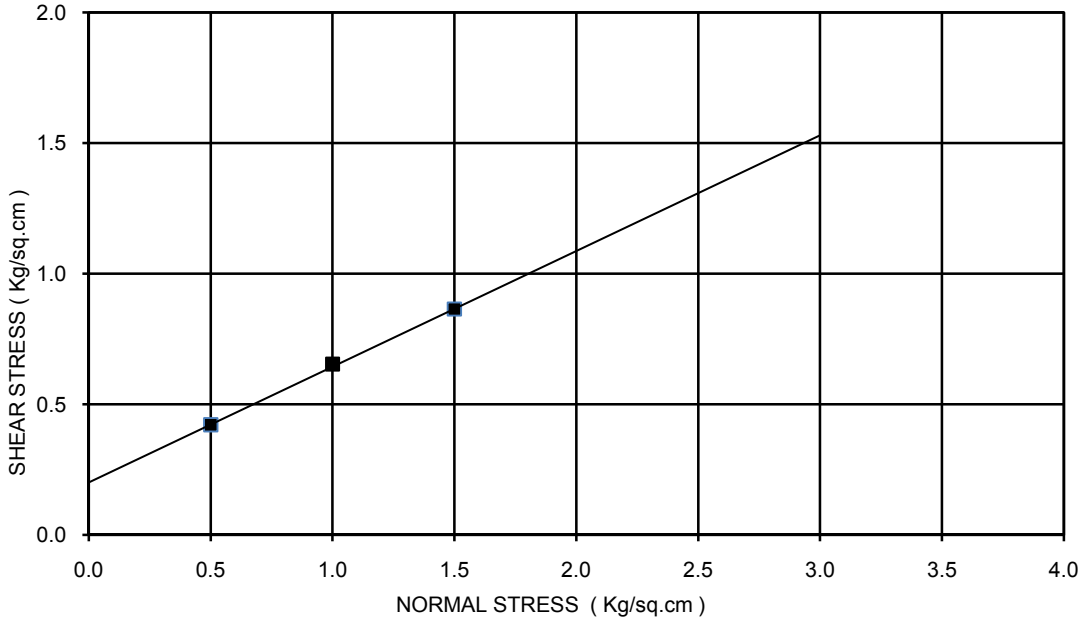


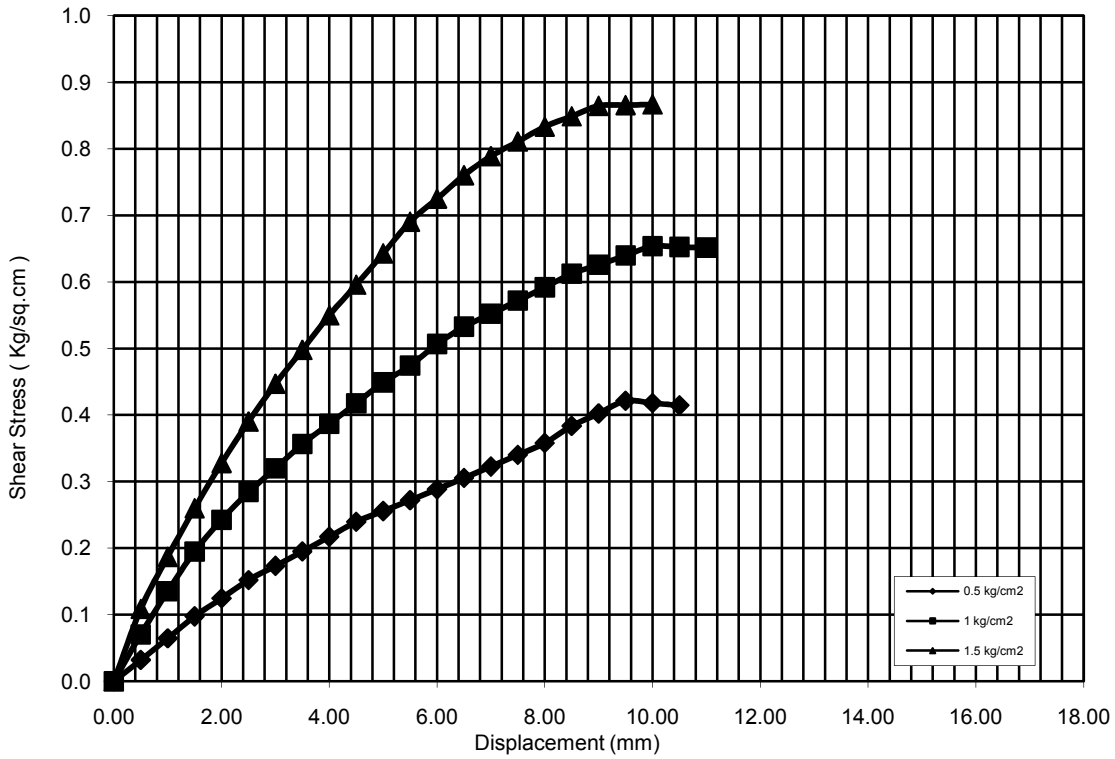
BORE HOLE NO: BH-P1
Chainage: 28+900
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 1.75 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



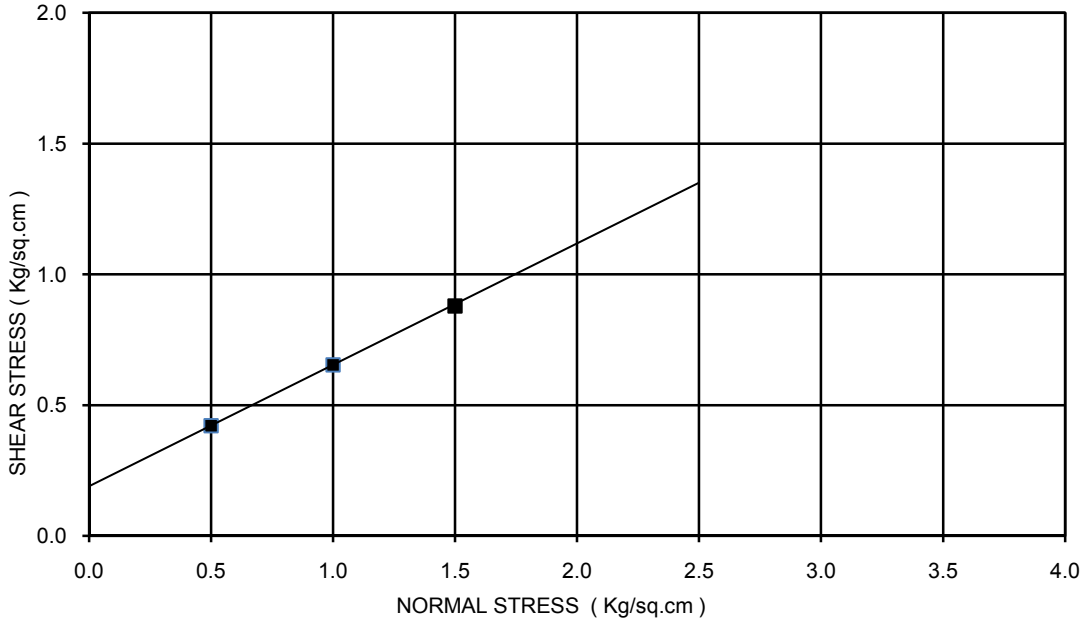


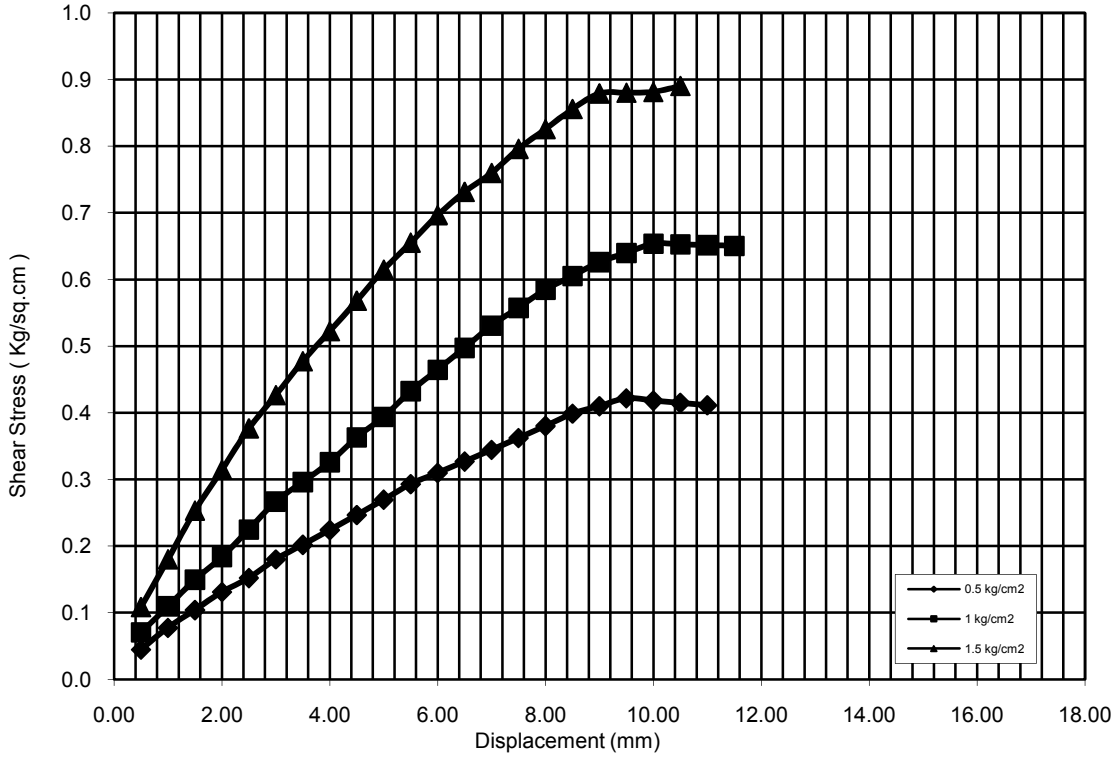
BORE HOLE NO: BH-P2
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



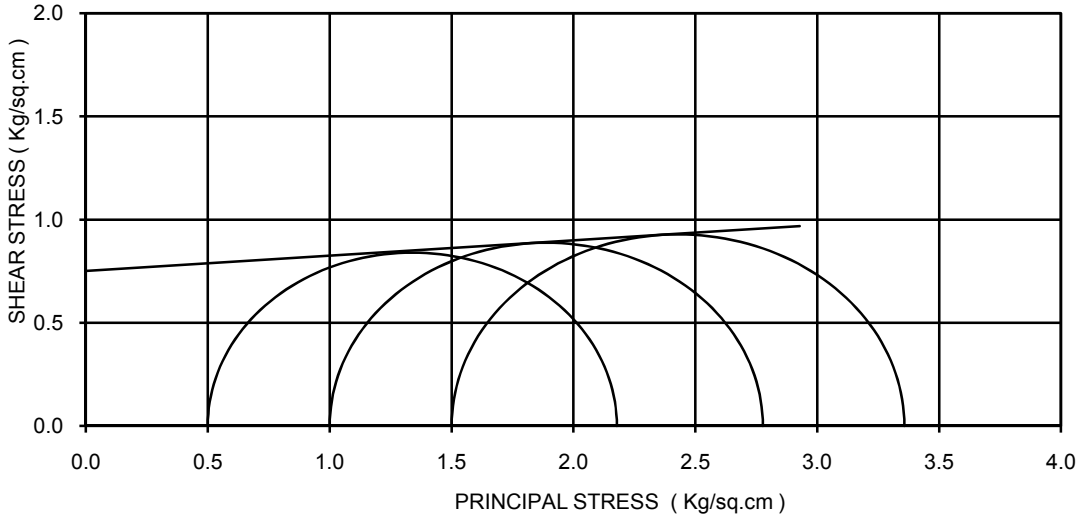


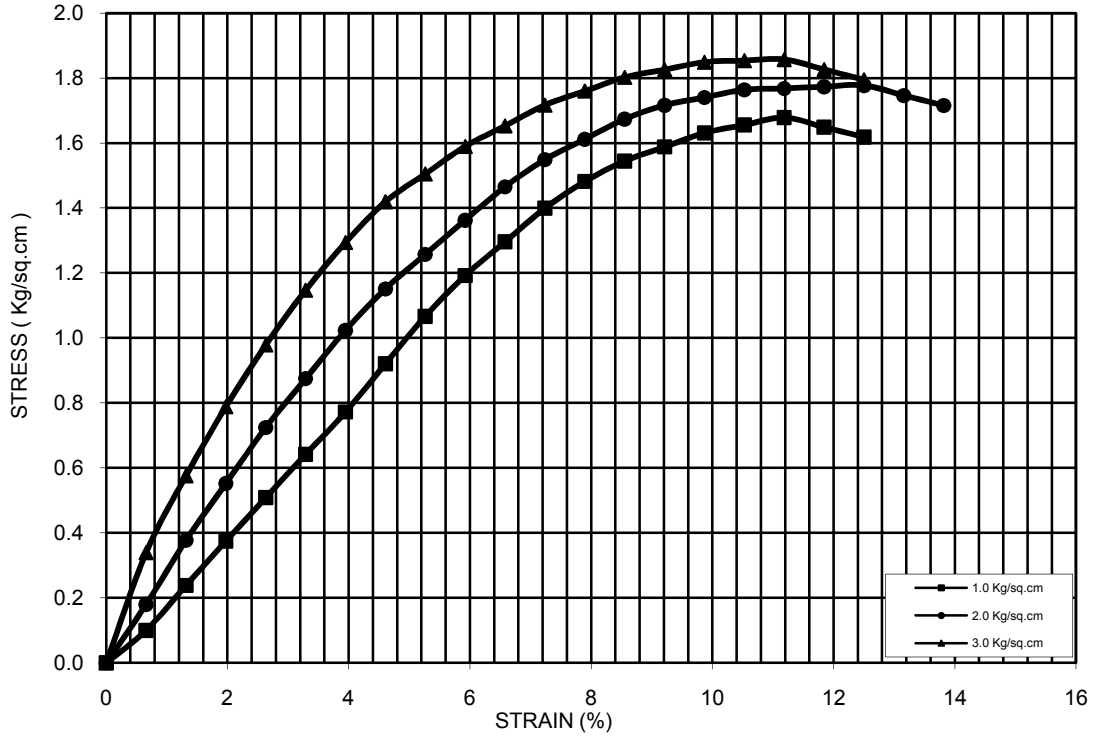
BORE HOLE NO: BH-P2
Chainage: 28+900
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.19 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST



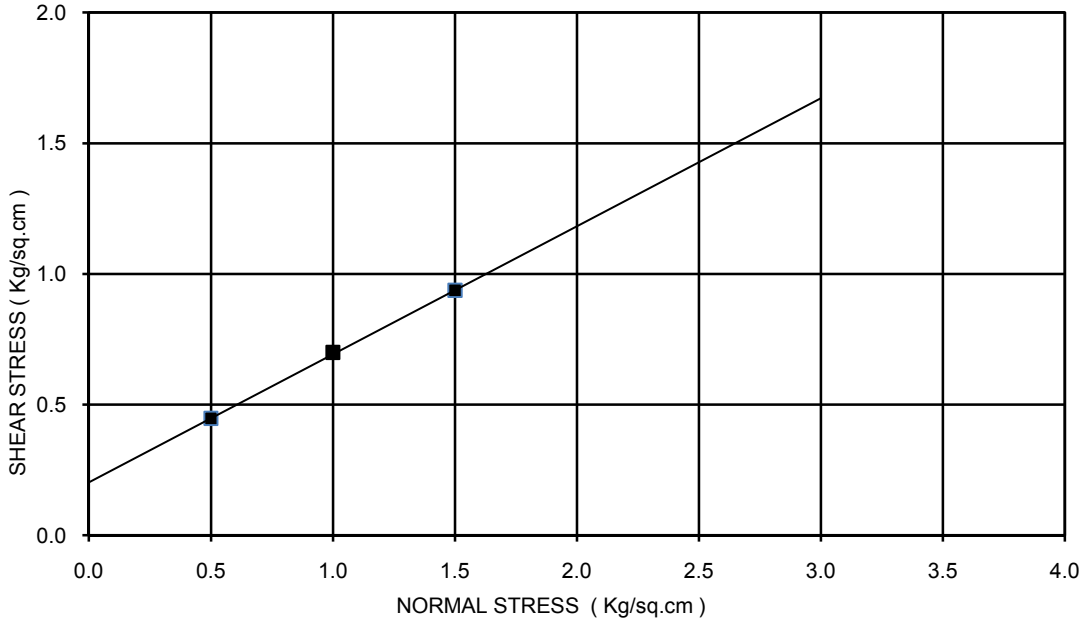


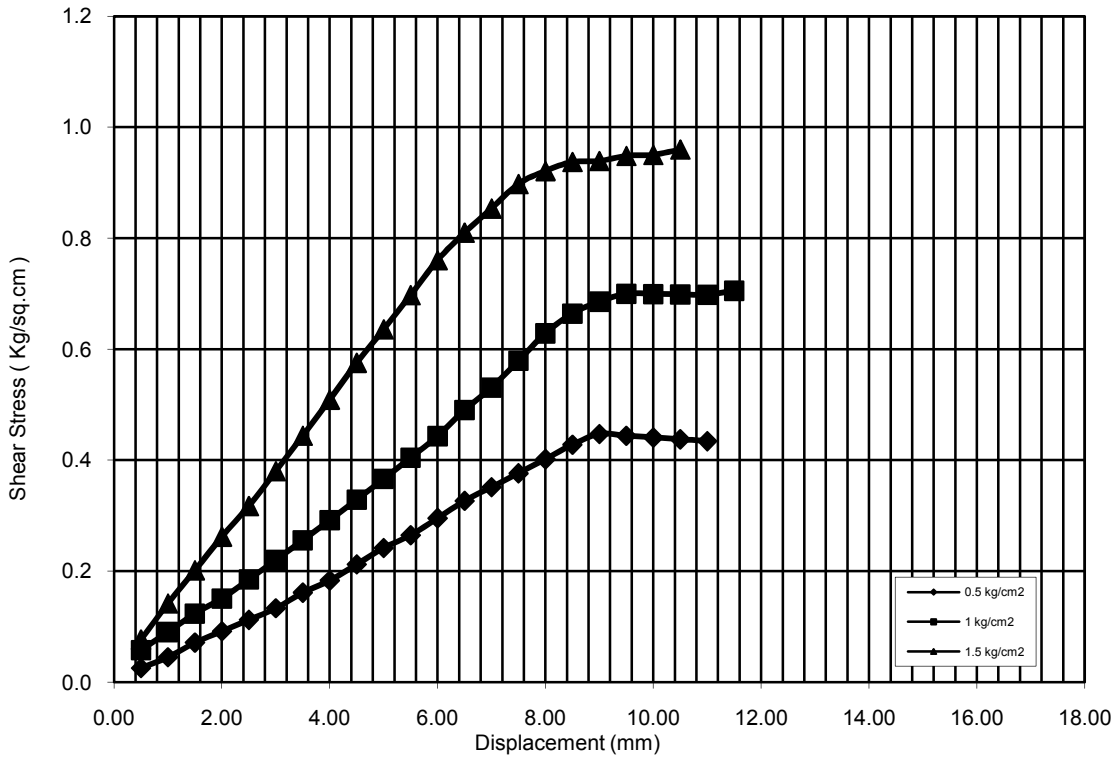
BORE HOLE NO: BH-A2
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.75 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT

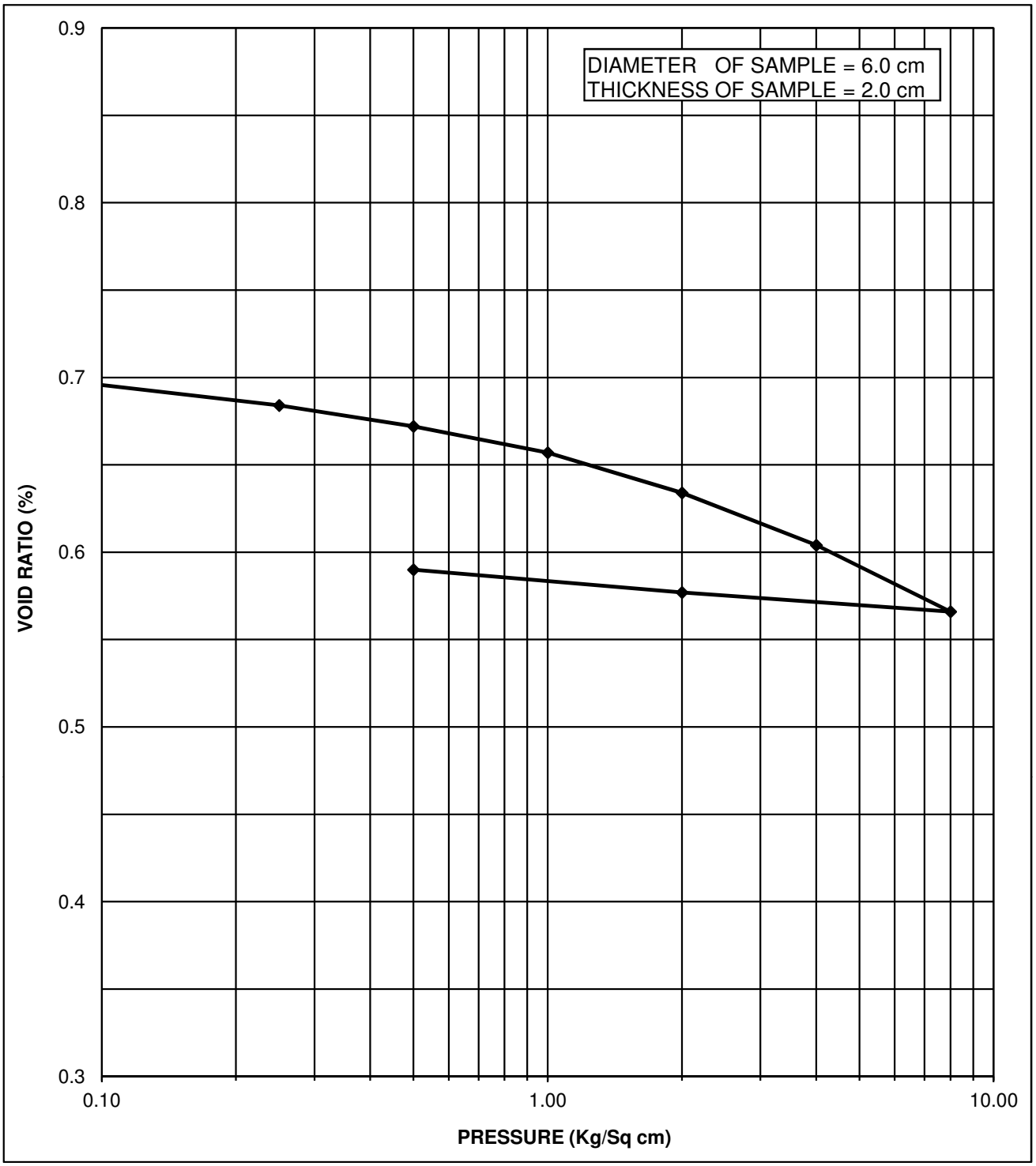




BORE HOLE NO: BH-A2
Chainage: 28+900
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST







CHAINAGE : 27+620

BORE HOLE NO. = BH-P1

SAMPLE NO. = UDS-2

DEPTH = 5.50 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 13.46 %

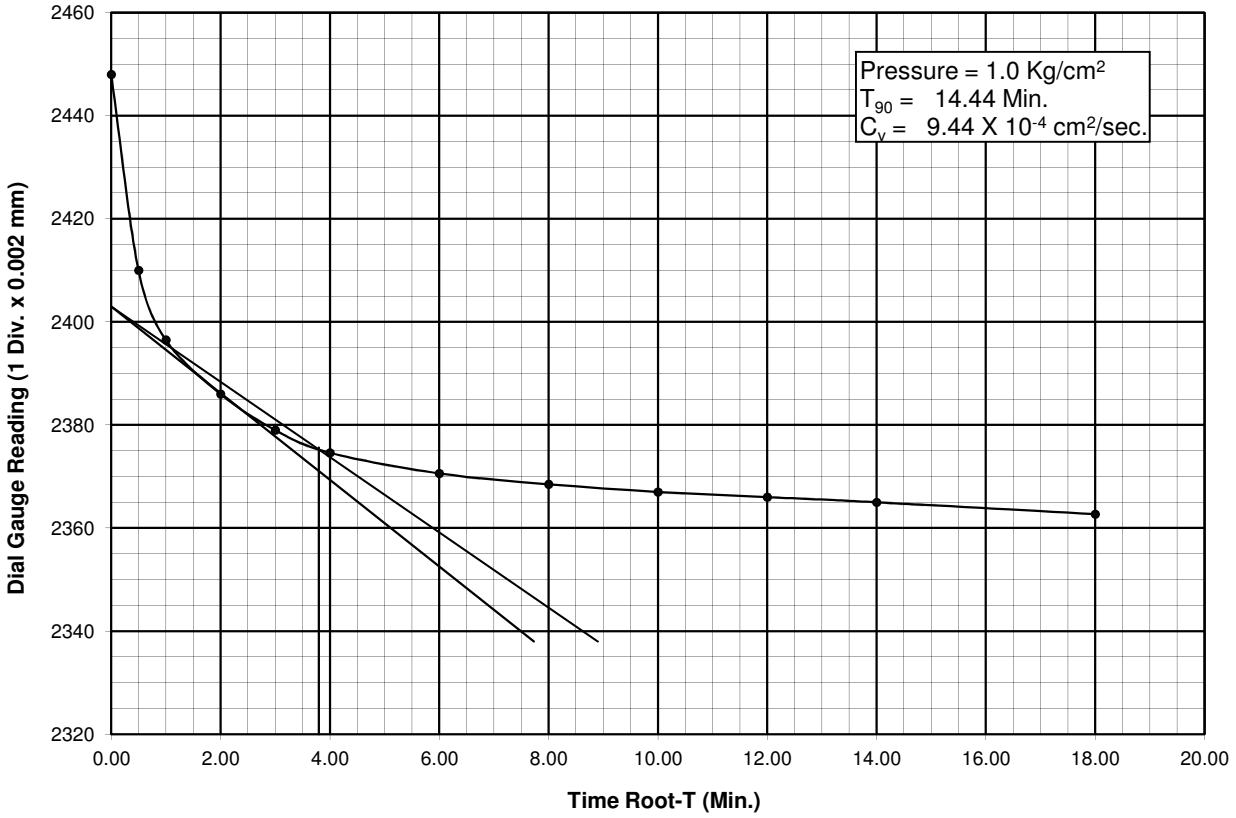
DRY DENSITY = 1.58 gm/cm^3

VOID RATIO (e_o) = 0.695

COMPRESSION INDEX (C_c) = 0.126

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

CHAINAGE: = 27+620
BORE HOLE NO. = BH-P1
SAMPLE NO. = UDS-3
DEPTH = 7.50 M



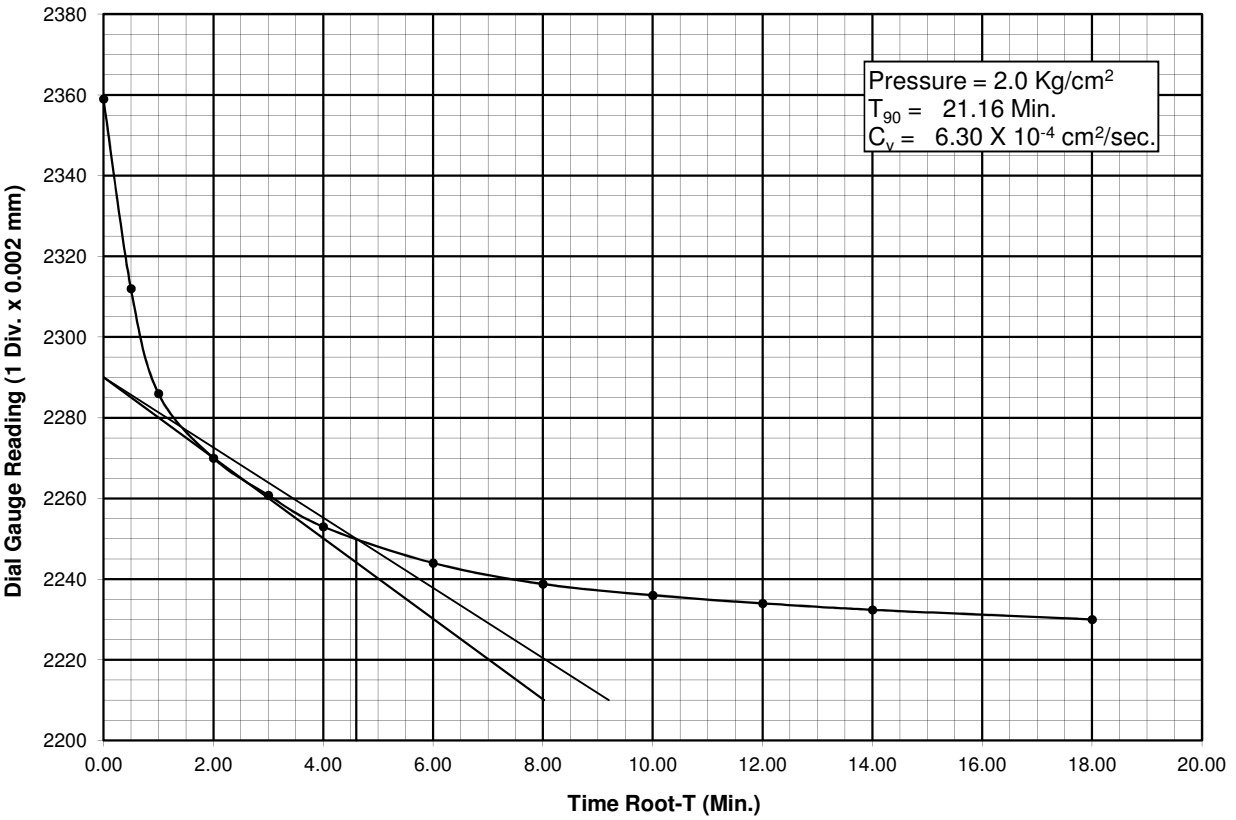
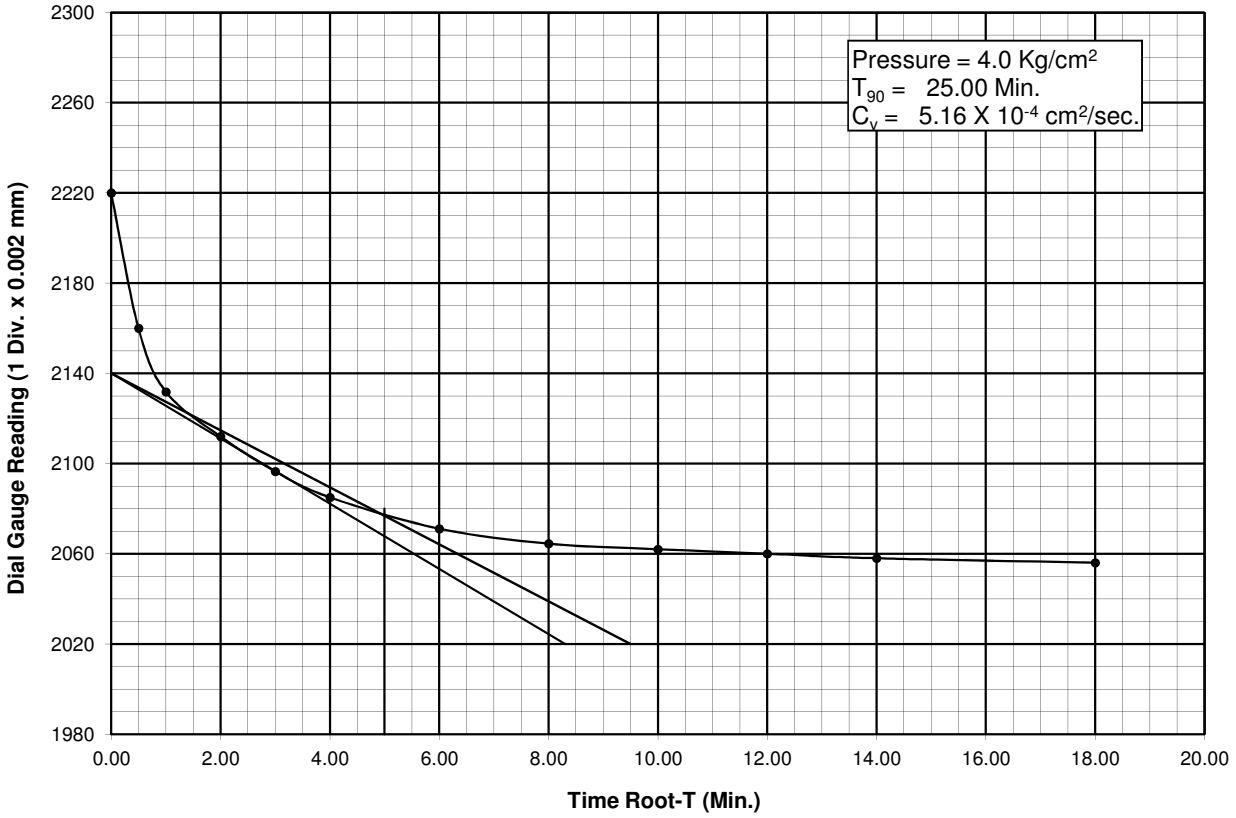


Figure No. -

CHAINAGE: = 27+620
BORE HOLE NO. = BH-P1
SAMPLE NO. = UDS-3
DEPTH = 7.50 M



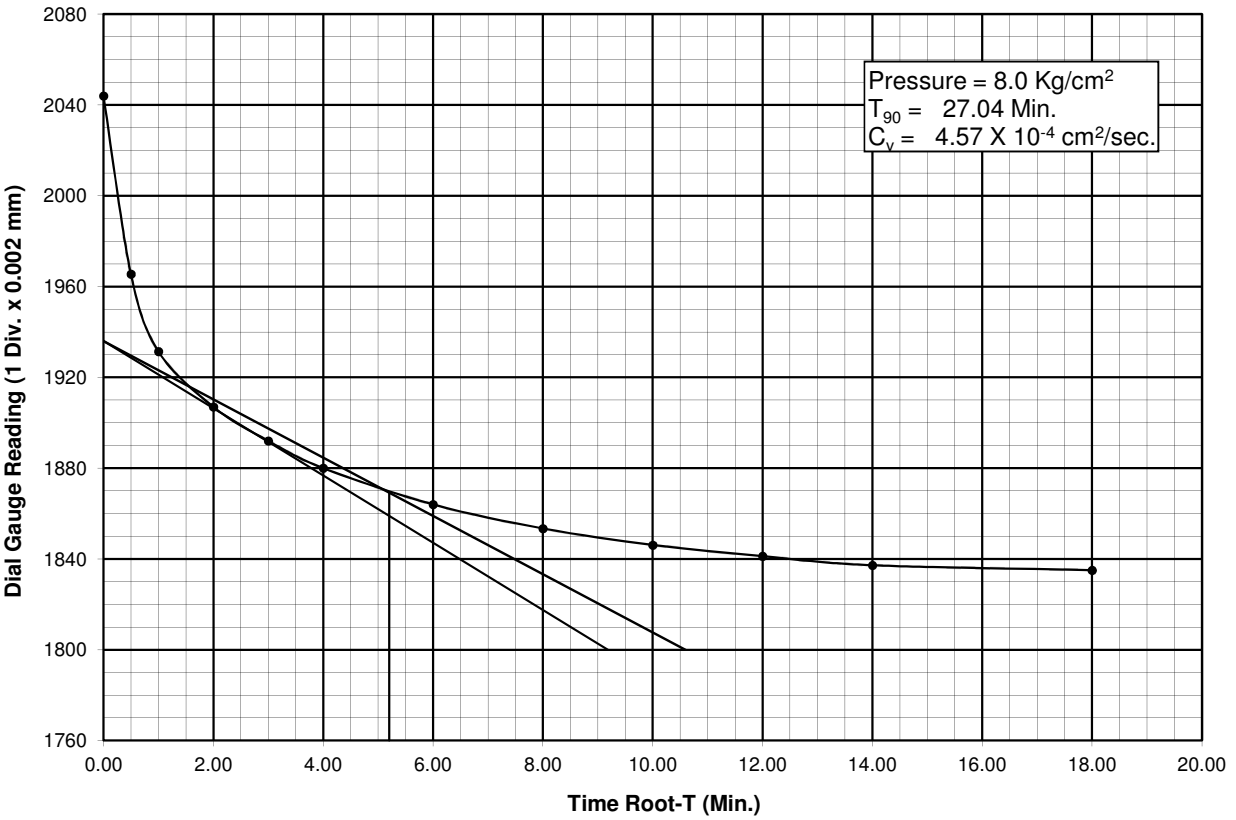
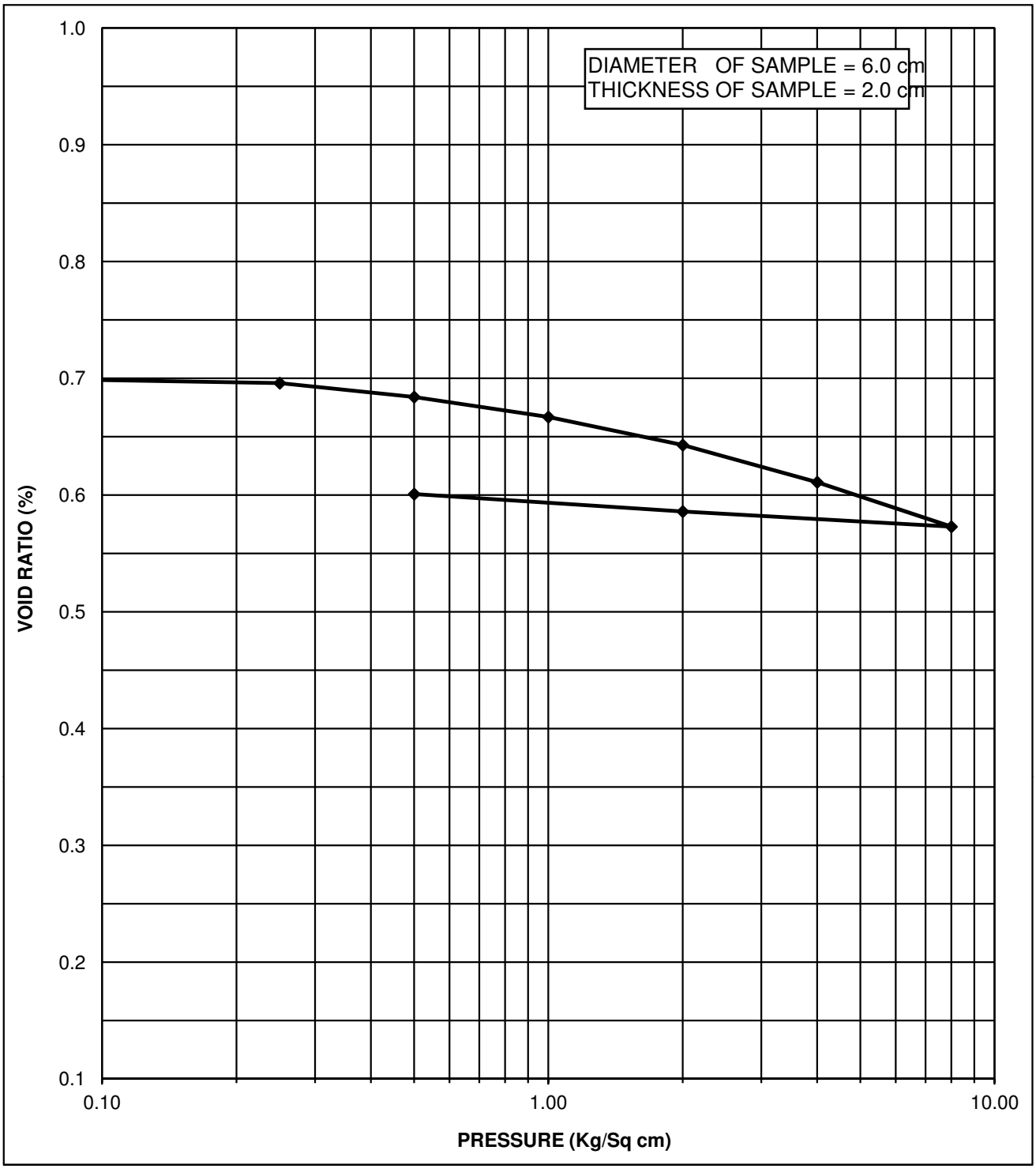


Figure No. -



CHAINAGE = 28+075

BORE HOLE NO. = BH-P1

SAMPLE NO. = UDS-3

DEPTH = 7.00 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 14.30 %

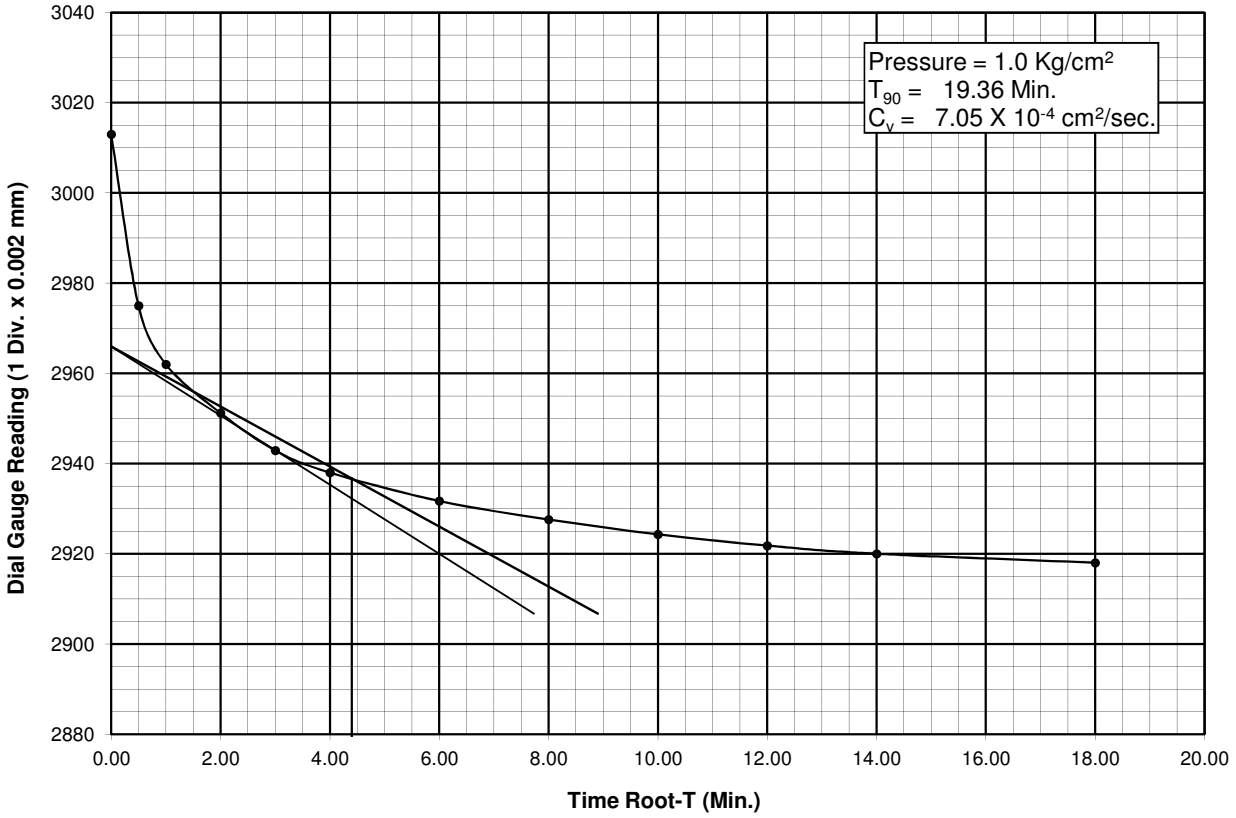
DRY DENSITY = 1.57 gm/cm^3

VOID RATIO (e_o) = 0.705

COMPRESSION INDEX (C_c) = 0.126

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

CHAINAGE	=	28+075
BORE HOLE NO.	=	BH-P1
SAMPLE NO.	=	UDS-3
DEPTH	=	7.00 M



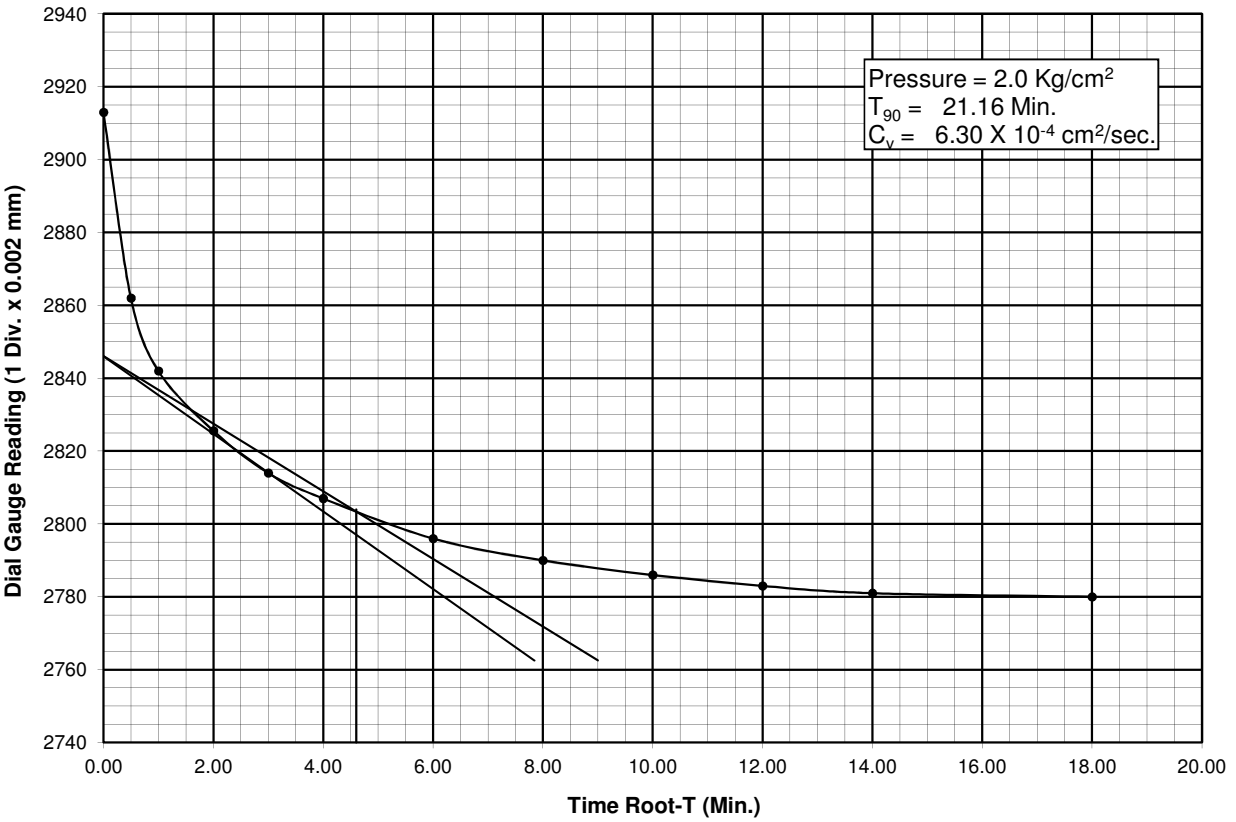
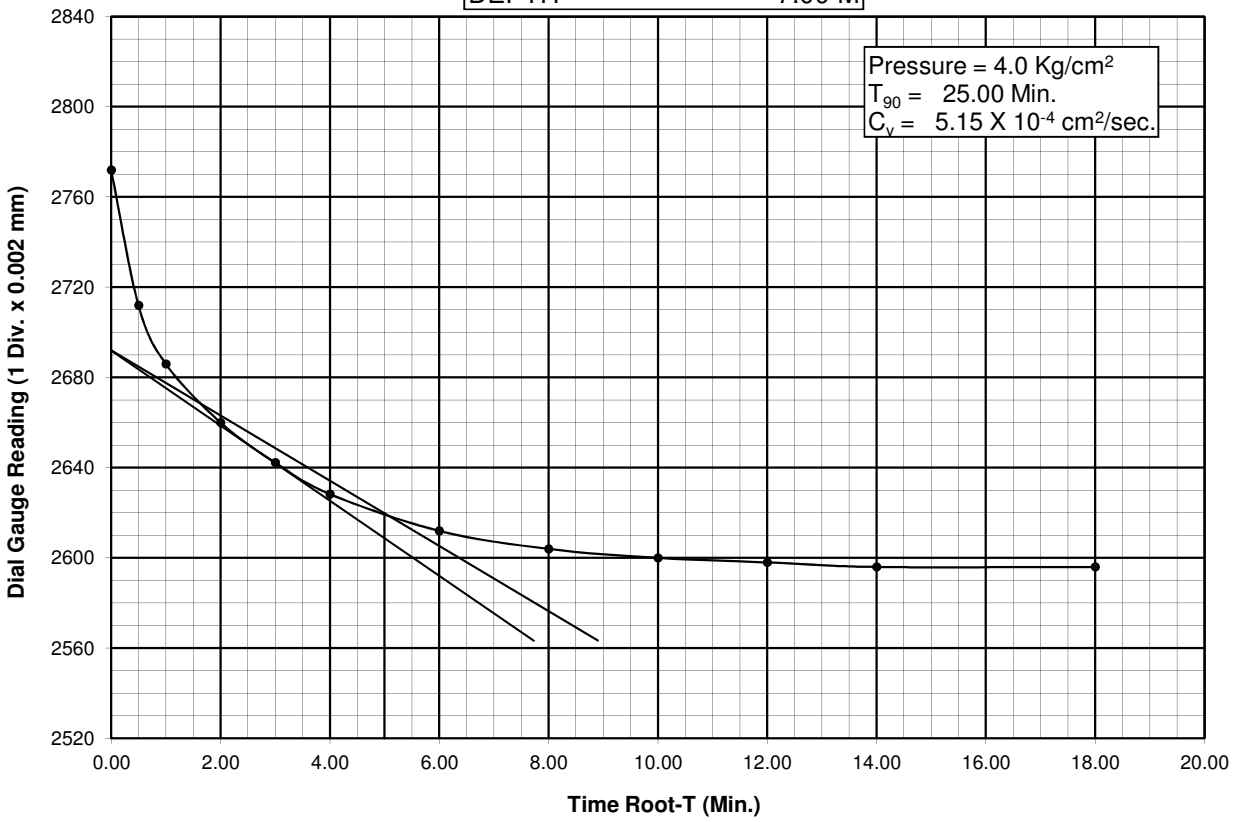
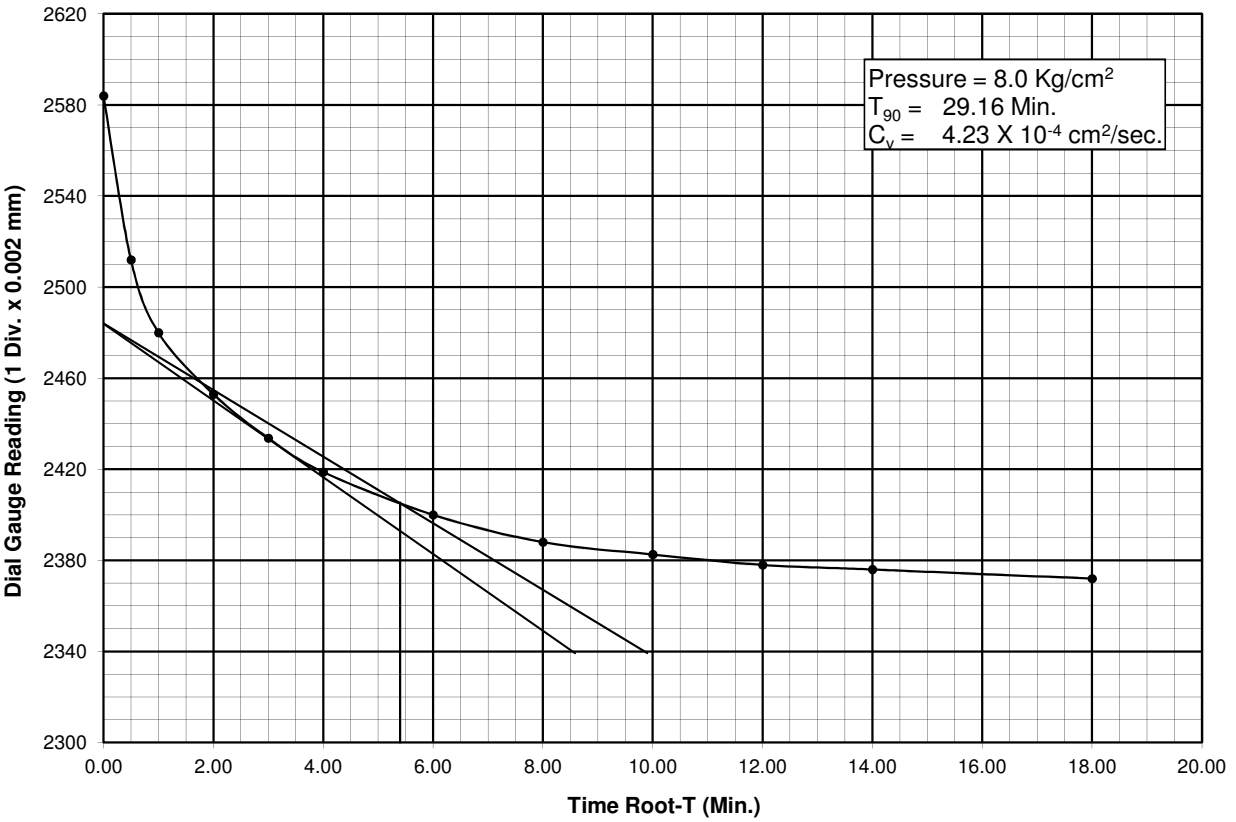


Figure No. -

CHAINAGE	=	28+075
BORE HOLE NO.	=	BH-P1
SAMPLE NO.	=	UDS-3
DEPTH	=	7.00 M





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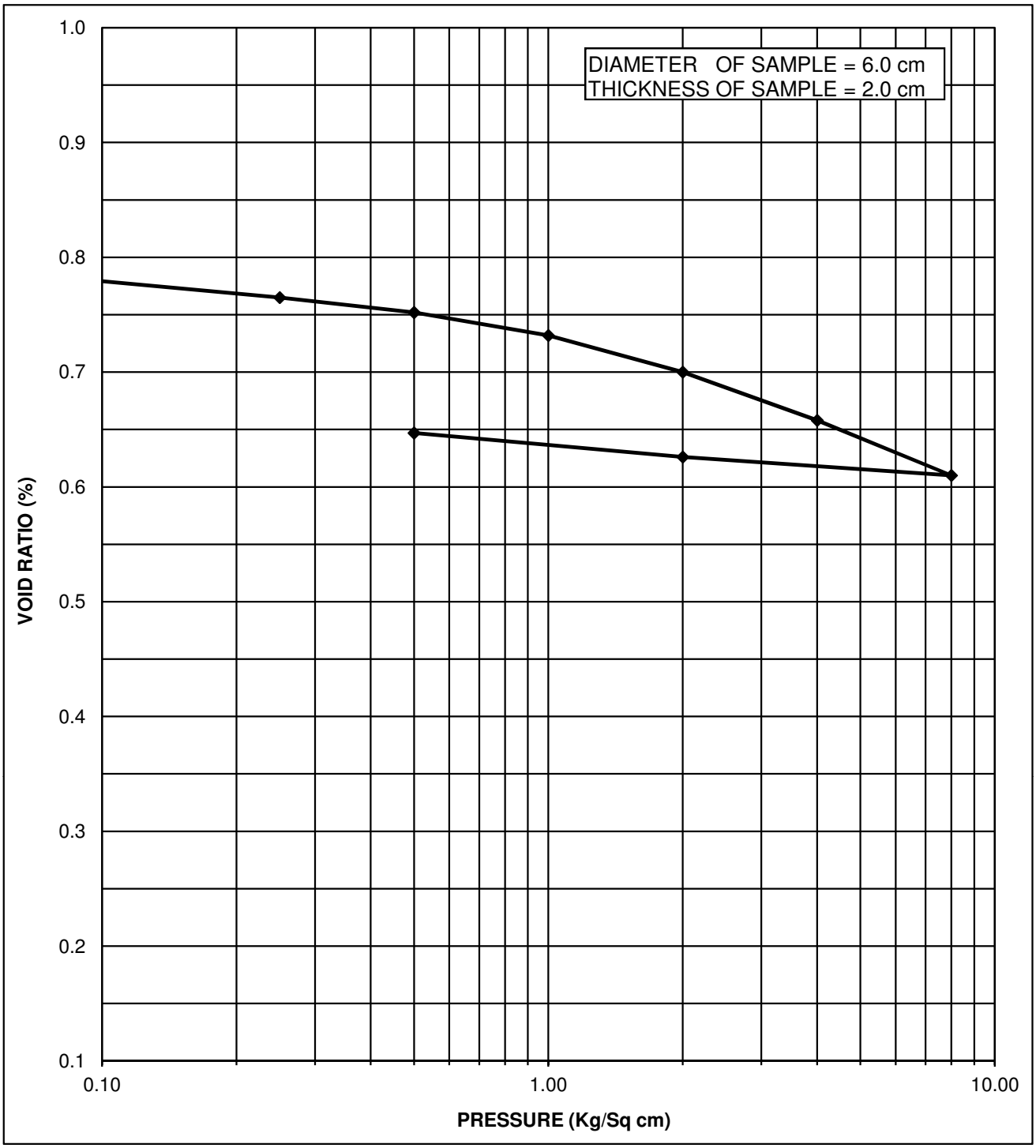


CHAINAGE = 28+075

BORE HOLE NO. = BH-A2

SAMPLE NO. = UDS-1

DEPTH = 1.00 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 12.64 %

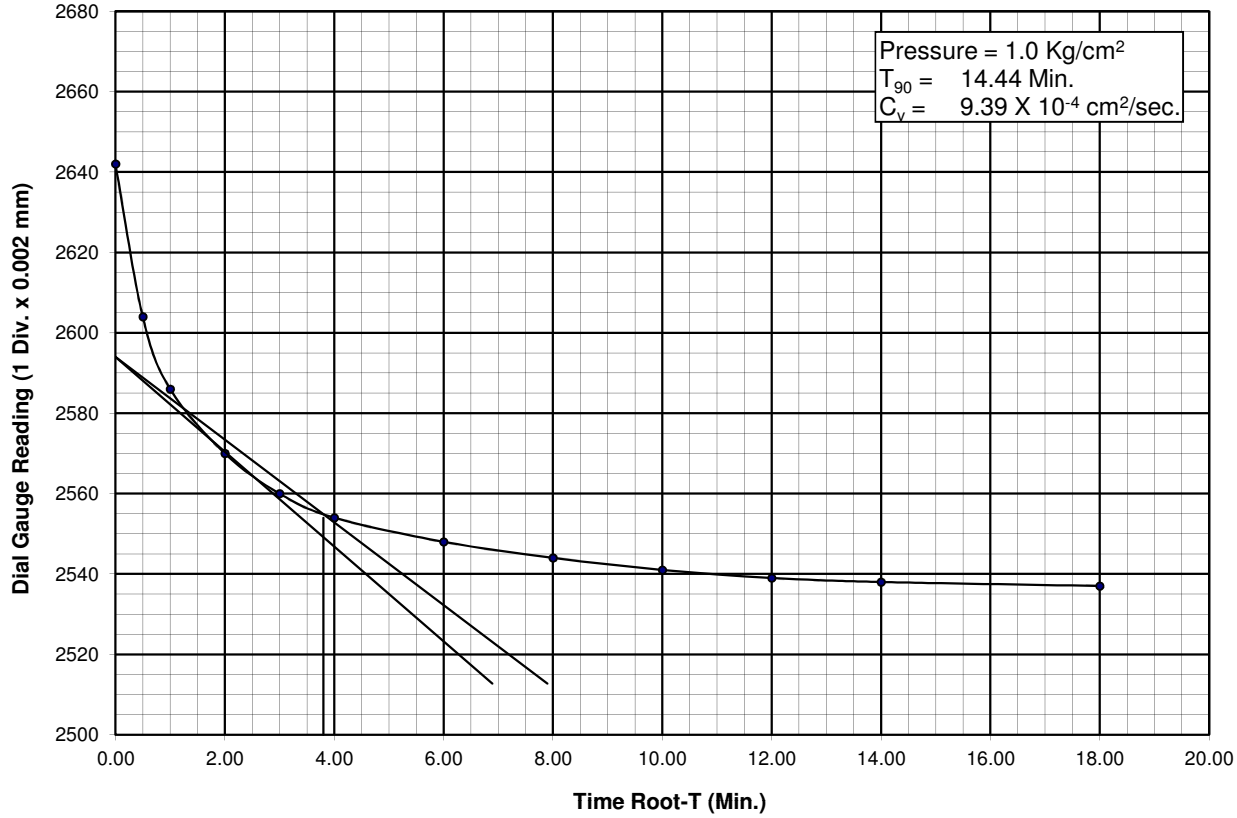
DRY DENSITY = 1.50 gm/cm^3

VOID RATIO (e_o) = 0.780

COMPRESSION INDEX (C_c) = 0.159

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

CHAINAGE	=	28+075
BORE HOLE NO.	=	BH-A2
SAMPLE NO.	=	UDS-2
DEPTH	=	4.50 M



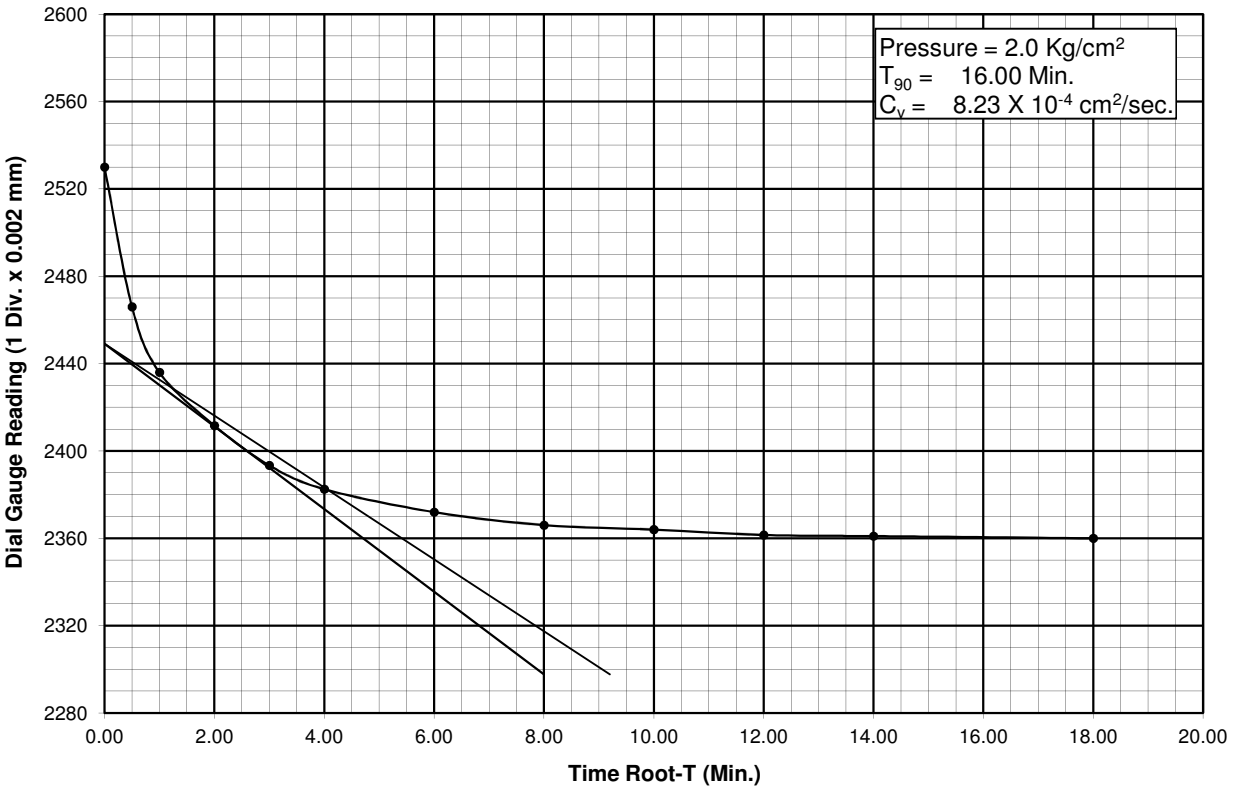
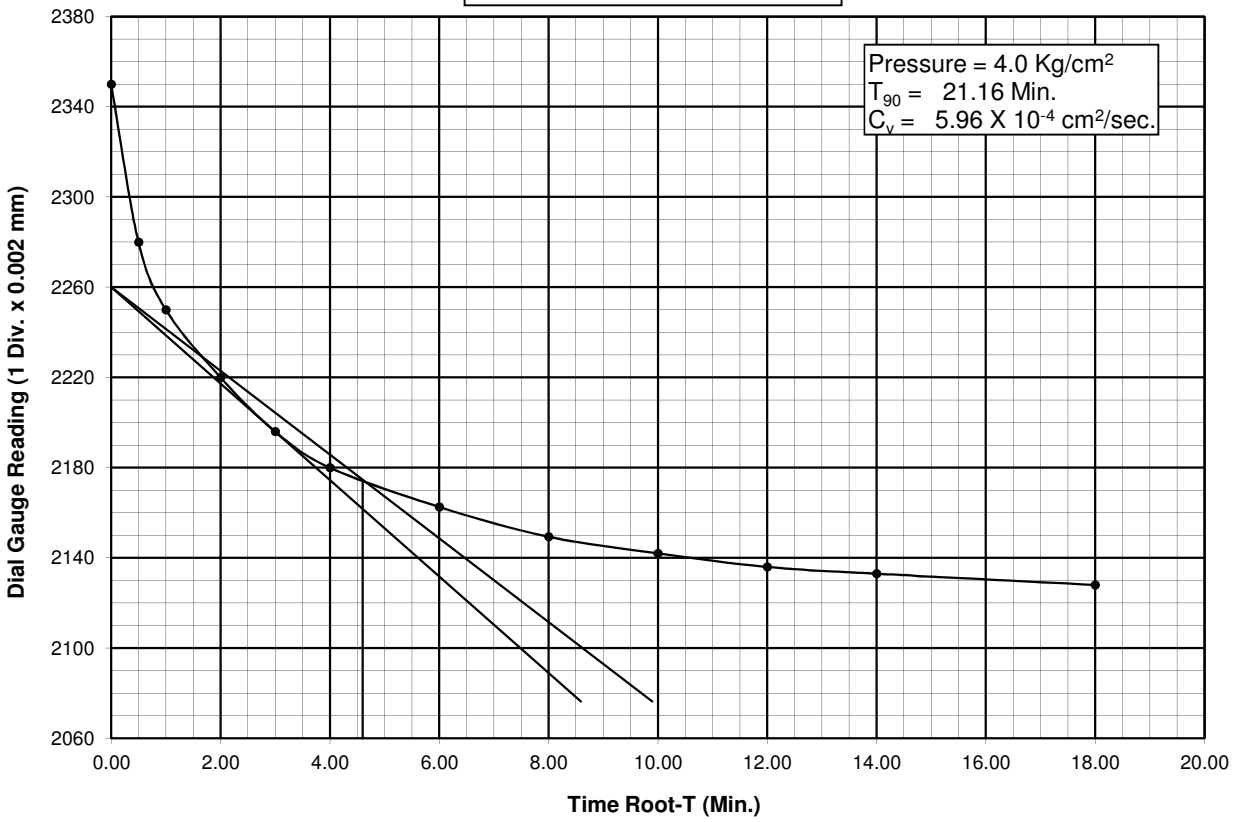
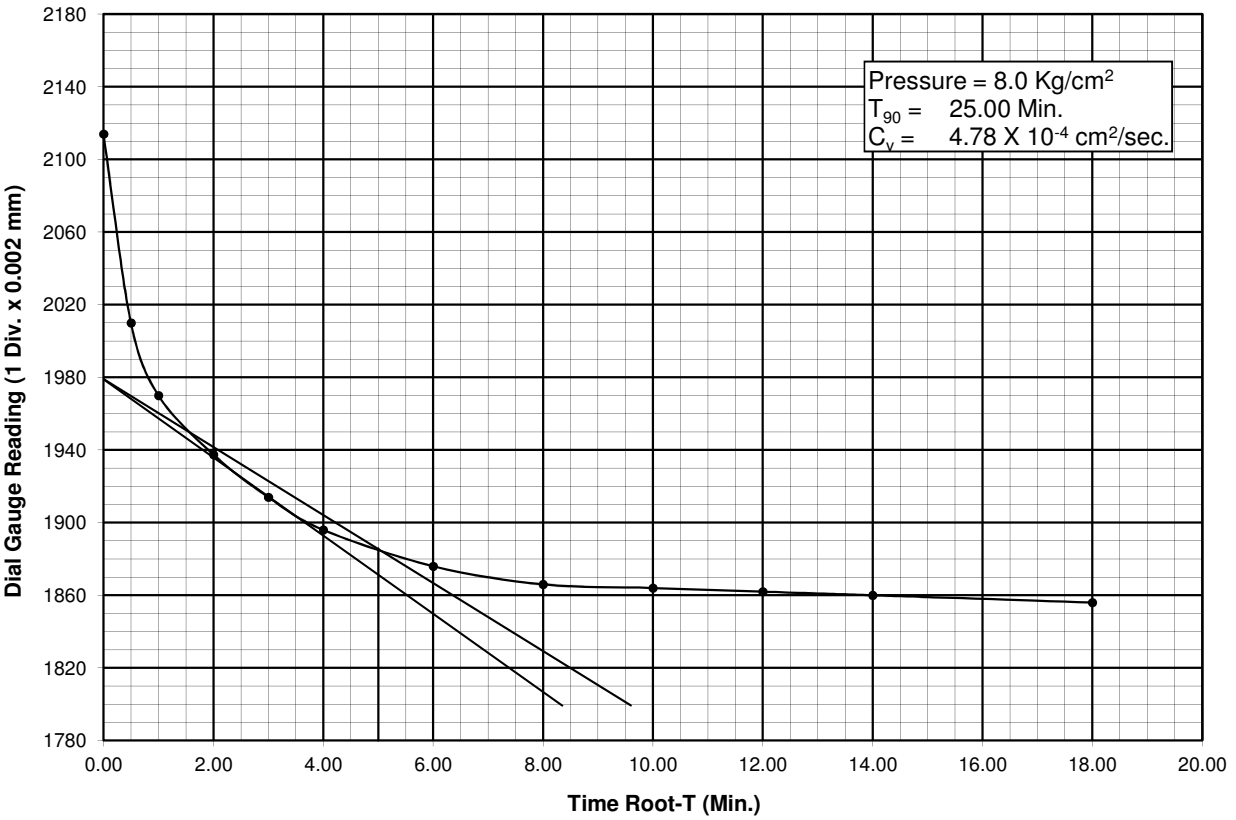


Figure No. -

CHAINAGE = 28+075
BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-2
DEPTH = 4.50 M





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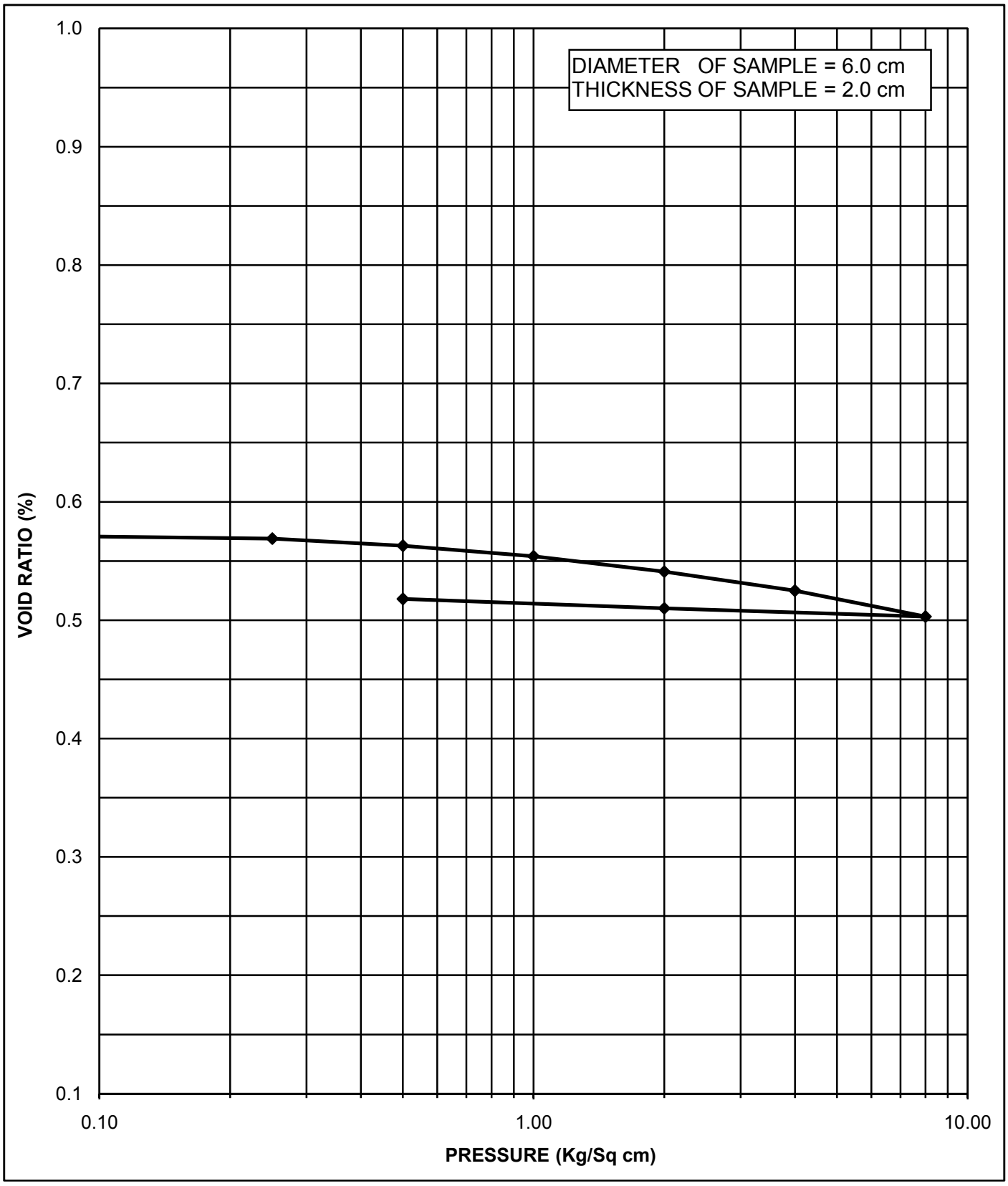


BORE HOLE NO. = BH-P2

SAMPLE NO. = UDS-7

DEPTH = 20.50 M

TYPY OF SOIL = CL

INITIAL WATER CONTENT = 17.20 %

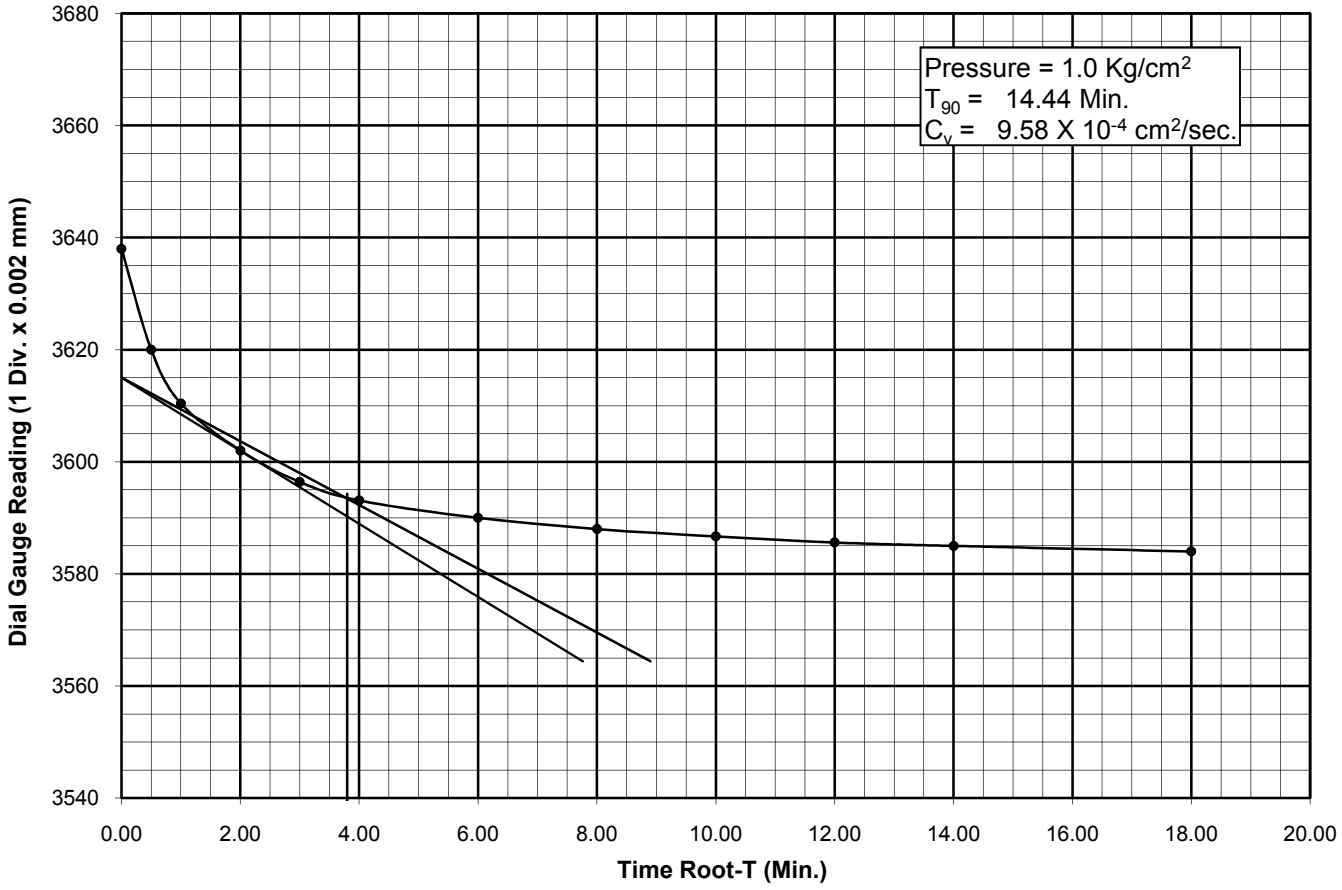
DRY DENSITY = 1.70 gm/cm^3

VOID RATIO (e_o) = 0.575

COMPRESIVE INDEX (C_c) = 0.073

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

BORE HOLE NO. = BH-P2
SAMPLE NO. = UDS-7
DEPTH = 20.50 M



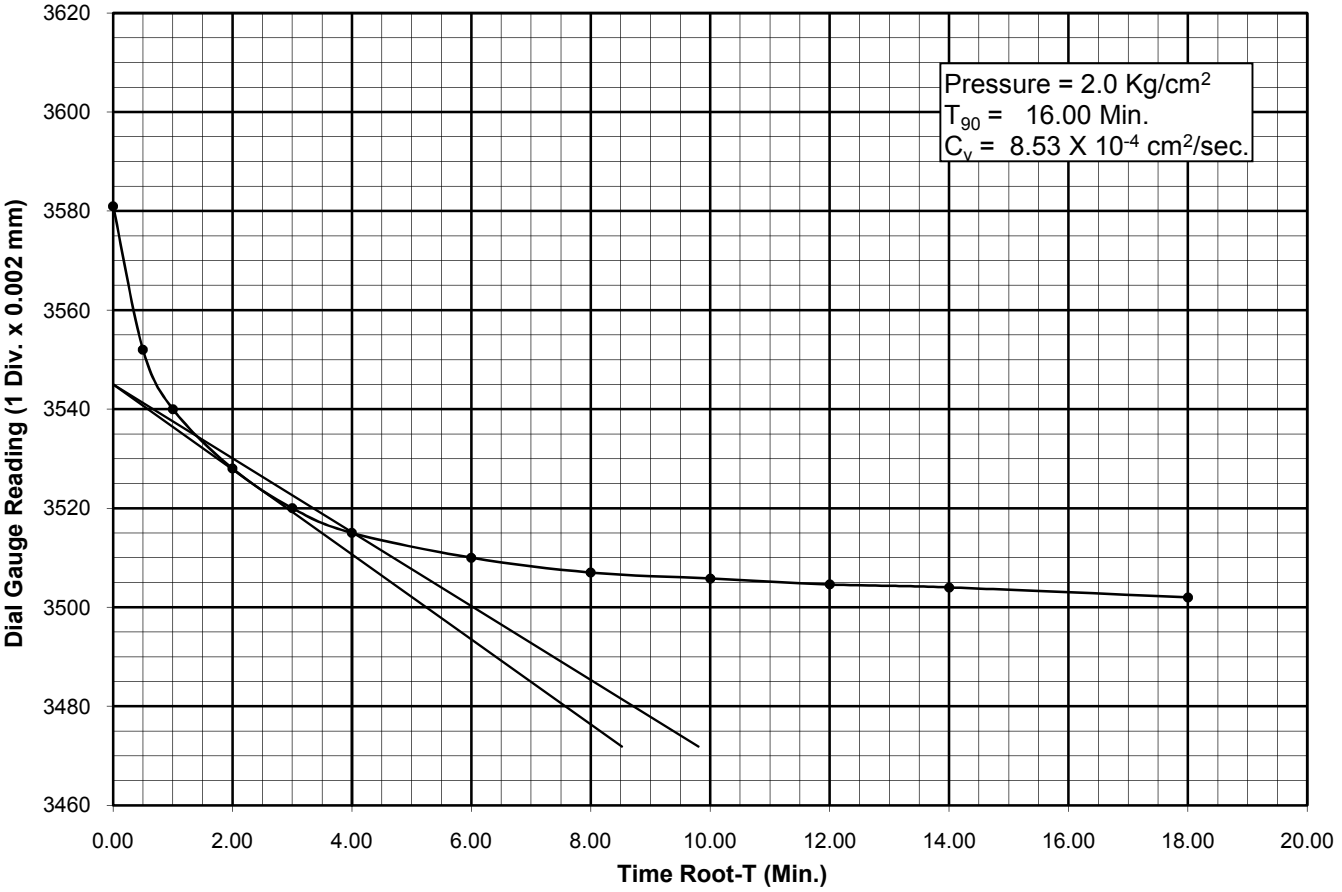
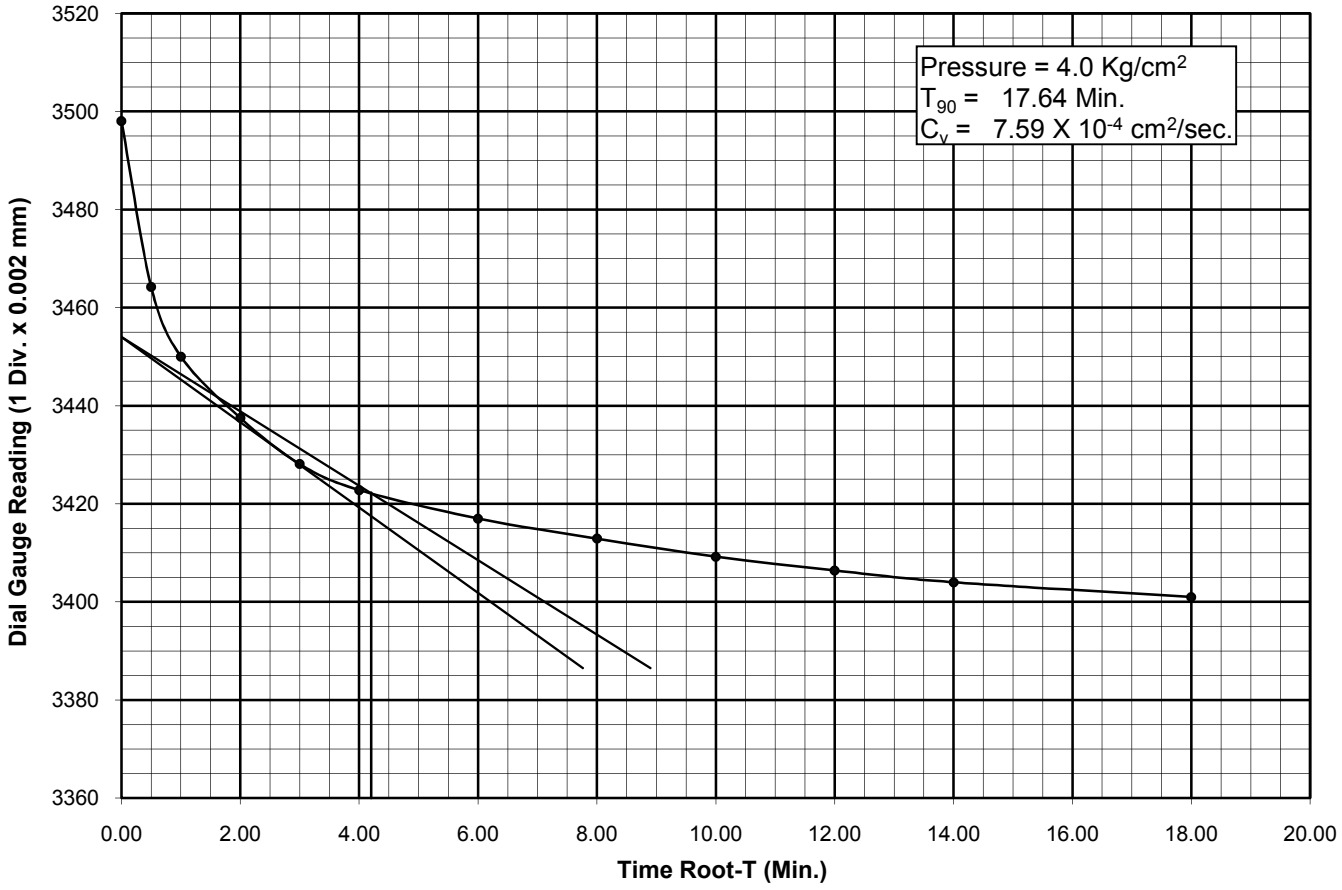
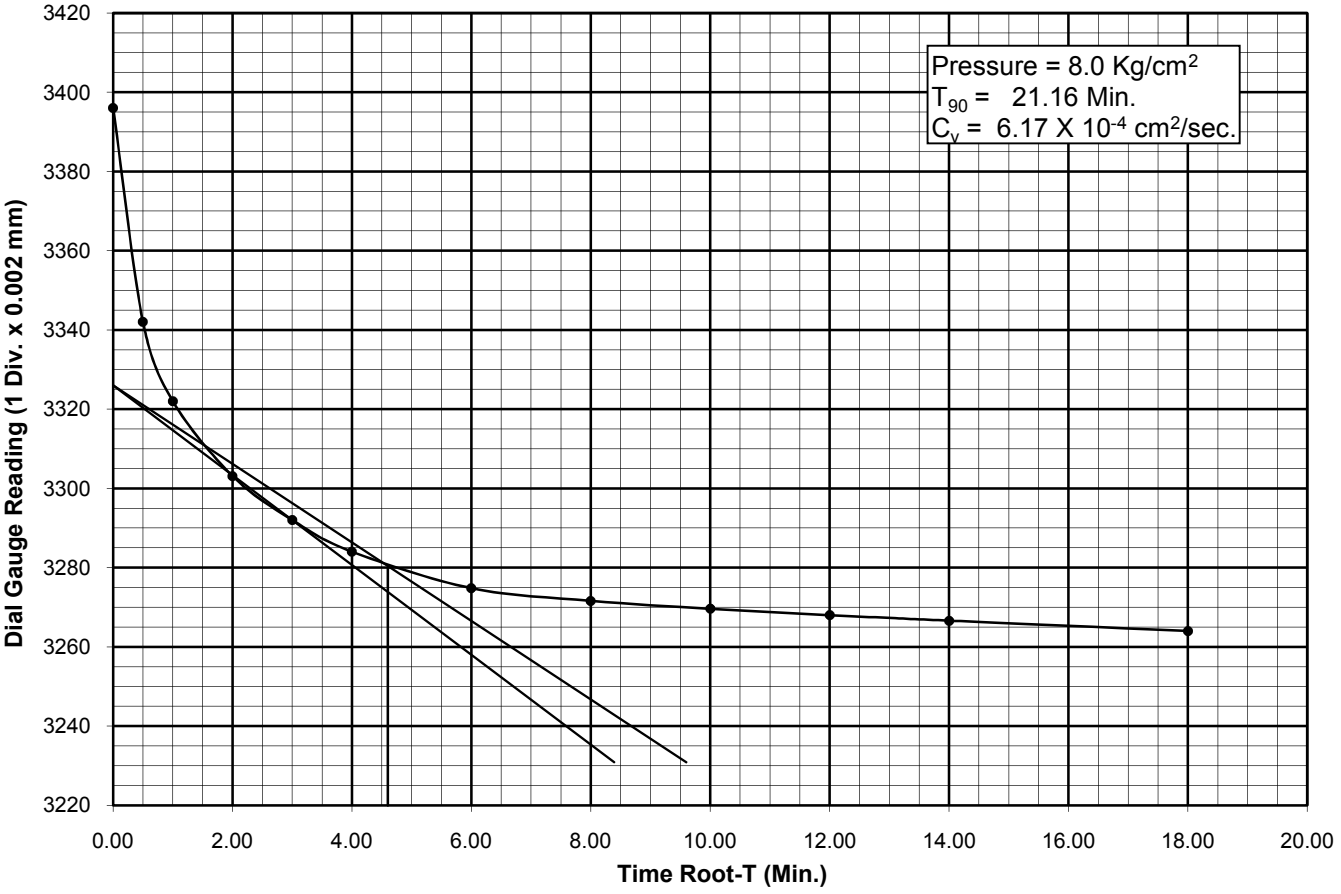


Figure No. -

BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-7
DEPTH = 20.50 M





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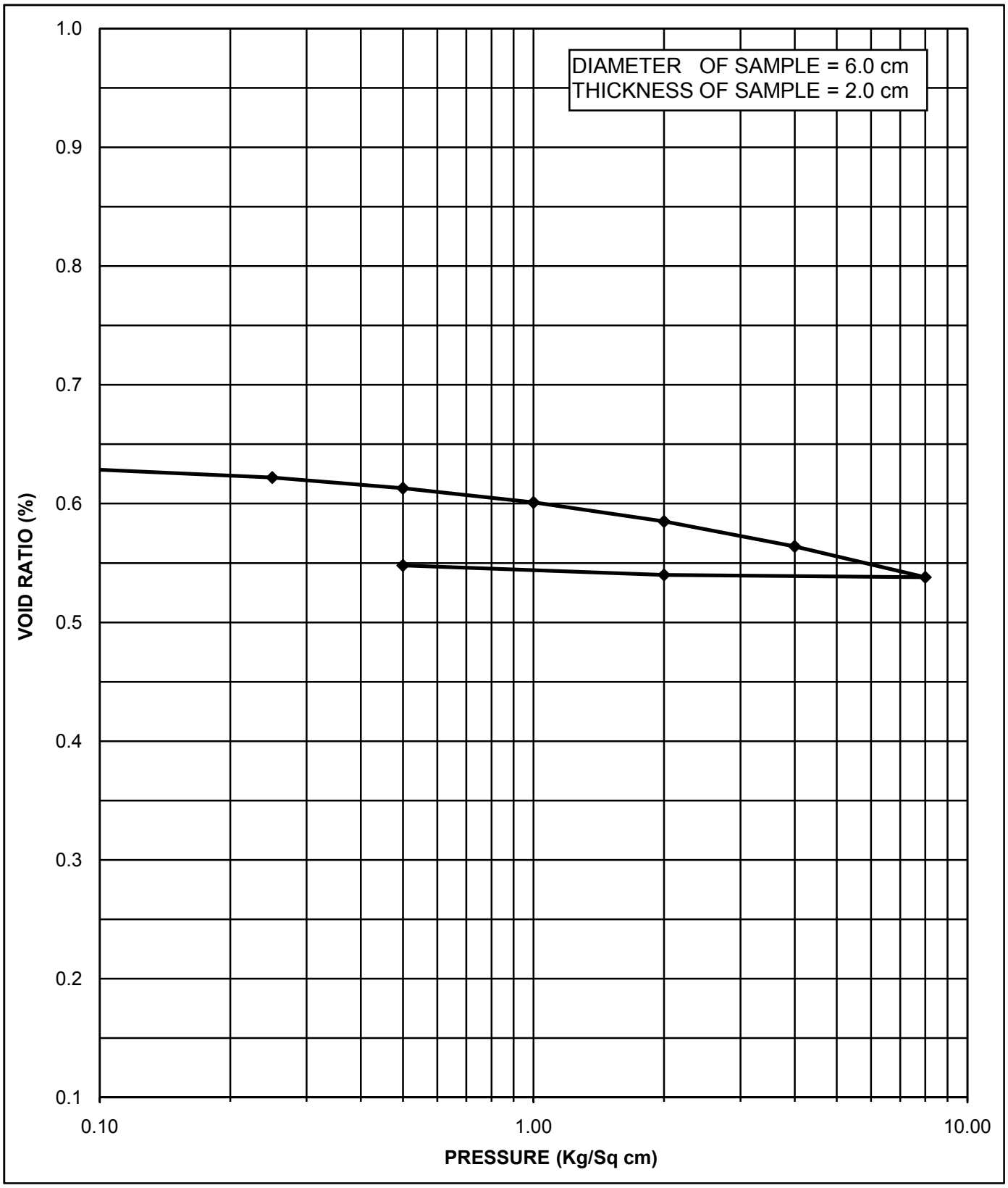


BORE HOLE NO. = BH-A2

SAMPLE NO. = UDS-5

DEPTH = 13.00 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 15.90 %

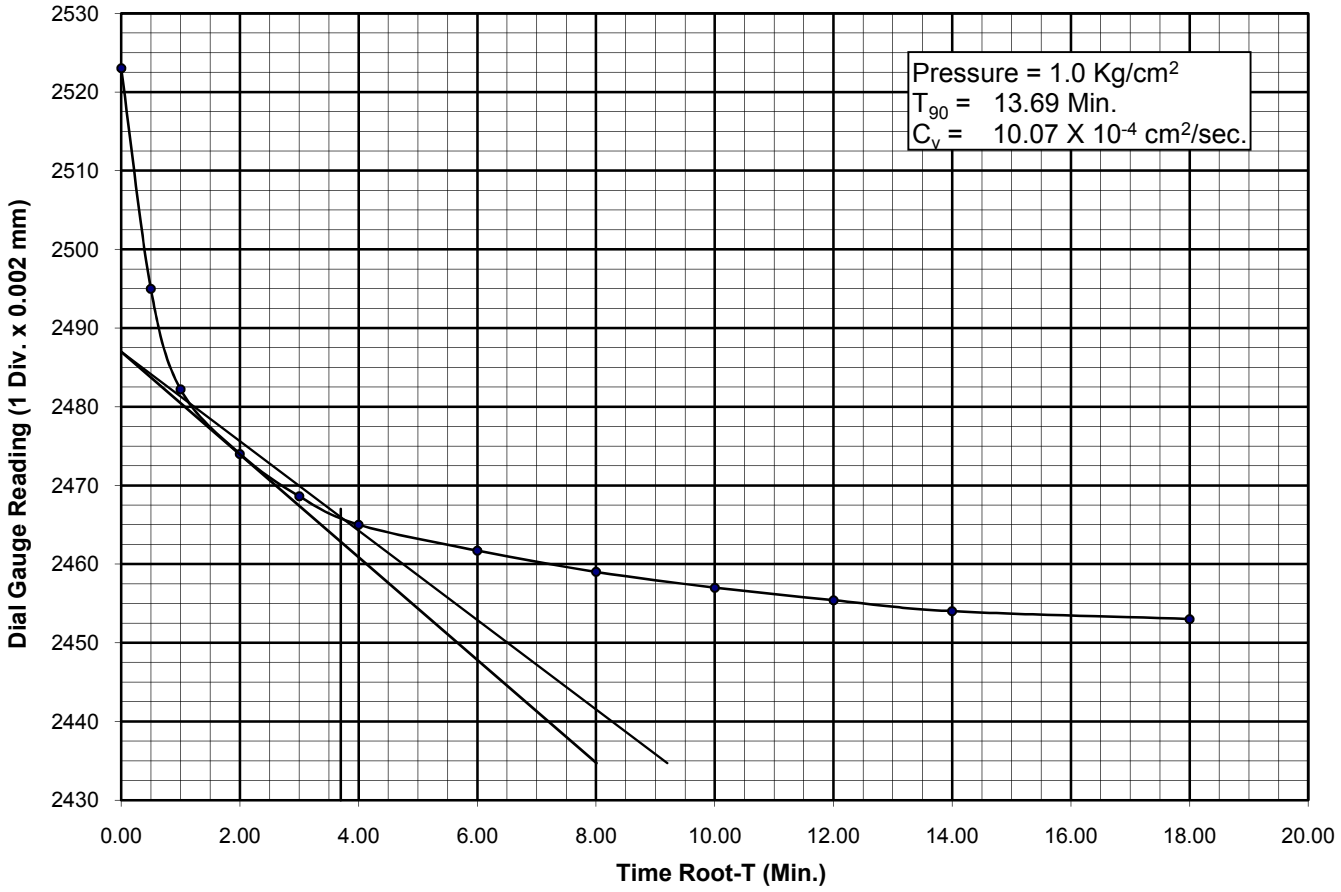
DRY DENSITY = 1.64 gm/cm^3

VOID RATIO (e_o) = 0.630

COMPRESSION INDEX (C_c) = 0.093

FIGURE NO. PRESSURE Vs VOID RATIO CURVE (e-log p)

BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-5
DEPTH = 13.00 M



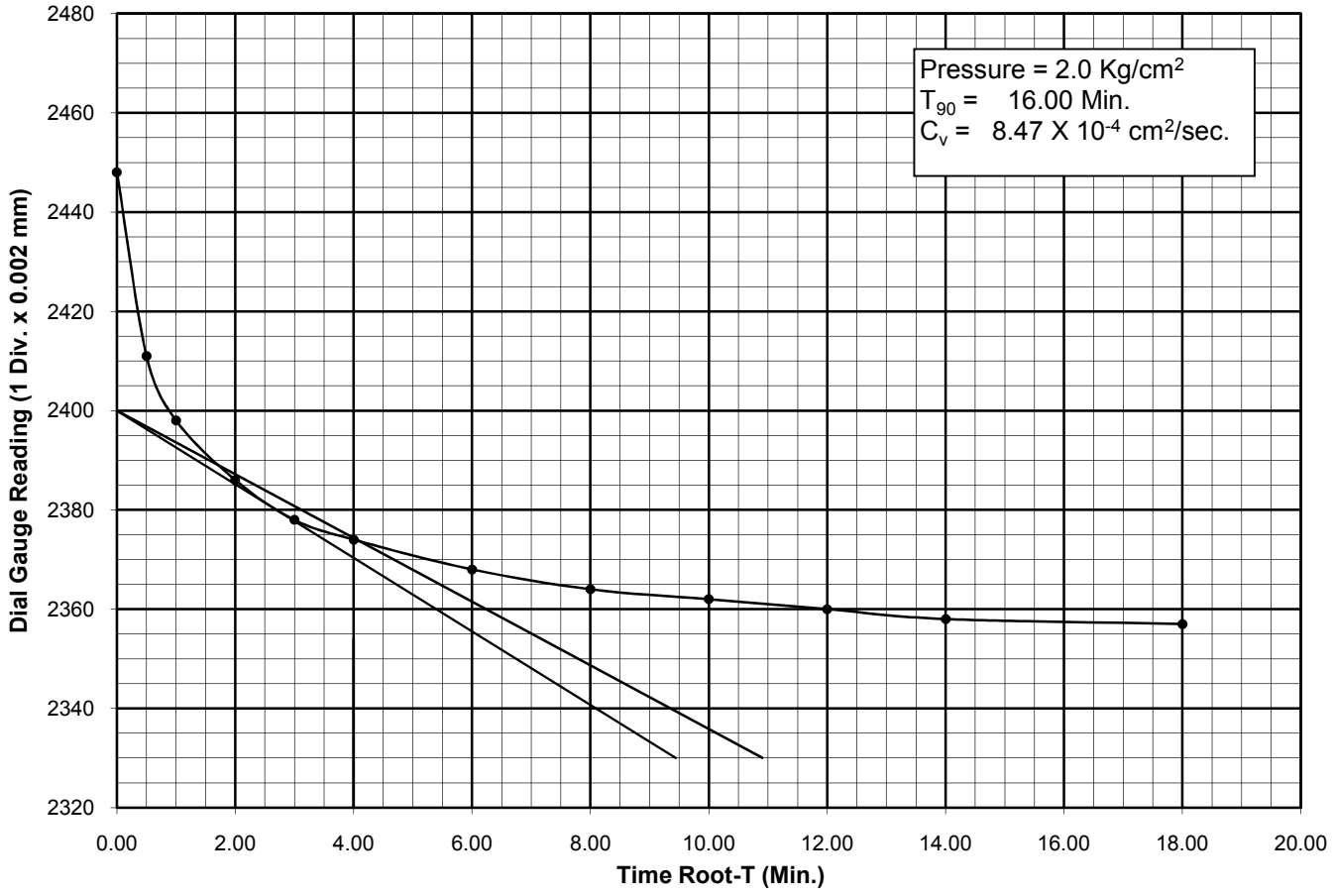
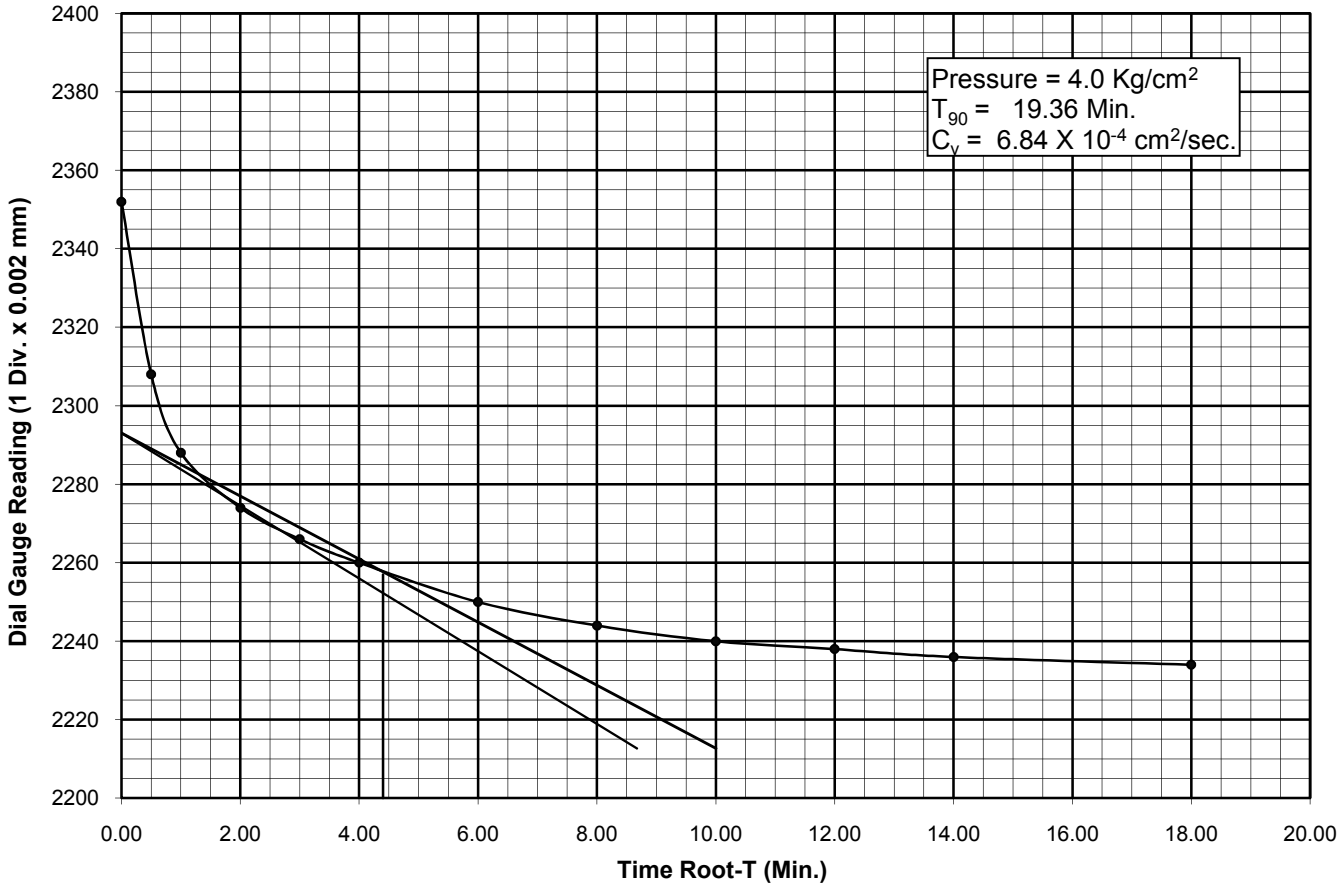


Figure No. -

BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-5
DEPTH = 13.00 M



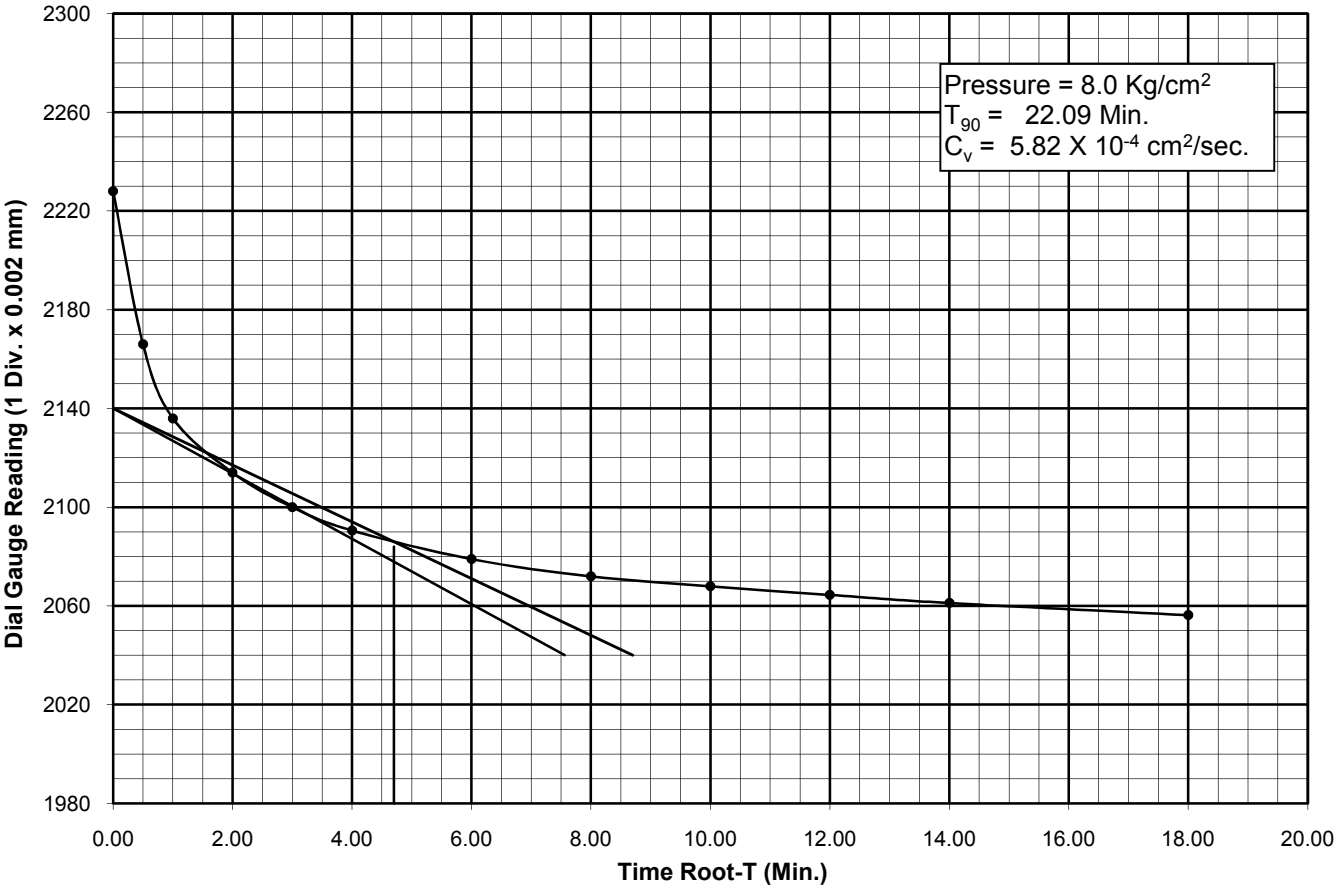


Figure No. -

Contents

Geotechnical Investigation Report

Old Ch. 11+523 to Old Ch. 16+815 (New CH: 12+208 to 17+500)

SR NO. : 544_21-22

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA

CLIENT

M/S. HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD. (HRIDCL)

PROGRAMME

AUGUST - 2022

SR. No.	Report No.	Revision No.	Date
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/1030_(21 BHs)	02	31.10.2022
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/740_(21 BHs)	01	19.08.2022
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/717_(21 BHs)	00	10.08.2022

CEGTH
CEG TEST HOUSE
AND RESEARCH CENTRE PVT LTD

B-11(G), Malviya Industrial Area, Jaipur-302017
Tel. : 91-141-4046599, Fax : 91-141-2751806
E-mail : info@cegtesthouse.com., www.cegtesthouse.com

CEGTH/HRIDCL/SR-544/2022-23/1030 Date:- 31.10.2022

To,

Haryana Rail Infrastructure Development Corporation Ltd. (HRIDCL)
SCO No.-17-19, 3rd & 4th Floor,
Sector - 17-A,
Chandigarh - 160017
Tele:- 0172-2715644
Email: hridc2017@gmail.com

Subject :- Geotechnical investigation work for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana.

Dear Sir,

We are pleased to submit this report of the subject work based on 21 borehole carried out at Old Ch. 11+523 to Old Ch. 16+815 (New CH 12+208 to 17+500) for the proposed project site.

The accompanying report presents results of various field tests and laboratory tests conducted on selected soil samples and their interpretation.

Should there be any clarifications regarding the contents please contact us at your most convenient time.

We value the opportunity to participate in this project and look forward a pleasant association on future projects.

Very truly yours,
CEG Test House & Research Centre Pvt. Ltd.

Nehal Jain
General Manager - Geotechnical
Authorized Signatory

Prepared By:-

Ankur Mudgal
Sr. Manager

SR. No.	Report Ref. No.	Revision No.	Date
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/1030_(21 BHs)	02	31.10.2022
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/740_(21 BHs)	01	19.08.2022
544_21-22	CEGTH/HRIDCL/SR-544/2022-23/717_(21 BHs)	00	10.08.2022

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CHAPTER 1 GENERAL

1.0 INTRODUCTION:

The work of conducting "**Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana"** was awarded to "**CEG Test House & Research Centre Pvt. Ltd., Jaipur" by M/S.** "**Haryana Rail Infrastructure Development Corporation Ltd. (HRIDCL)"** as per work order no. HRIDC/ HORC/ GT/ CEG/ 237/ 2021/ 577-M dated 29th July 2021.

Field work including drilling of boreholes, conducting field tests such as Electrical Resistivity Test, & Plate Load Test and sample collection was carried out in the presence of representative of Client. Laboratory tests were conducted on selected soil samples to determine the design parameters, confirming to relevant IS specifications and the guidelines received from time to time from representative of Client.

This report includes the details of Methodology of Investigation, collection of samples of soil, field test results, laboratory test results, analysis of results and recommendations for proposed structure carried out at Old Ch. 11+523 to Old Ch. 16+815 (New CH 12+208 to 17+500) based on soil sample collected from the locations of 21 boreholes.

2.0 SITE LOCATION & GENERAL GEOLOGICAL HISTORY:

The details of the site & test locations for the proposed project are shown in location plan attached vide **Appendix A-1**. The site of proposed project is located from Palwal to Harsana Kalan (Sonipat) in the State of Haryana falls in seismic zone – IV (Zone factor=0.24) of India.

Soil of the Haryana Sub-Region have been classified and described under the following major soil types as shown below:-

- Typic Ustochrepts : Soil of old alluvial plains
- Typic Ustipsamments : Soil of Aravali plains
- Typic Ustifluvents : Soil of recent alluvial plains and flood plains
- Typic Torripsamments : Soil of Aeofluvial plains
- Rocky Outcrops : Aravali rocky hills

The district wise details of soil characteristics are described below:-

Panipat: The soils are well drained, Sandy loam to clay loam/silty clay loam in plains and loam to clay loam/ silty/ loose clay loam in relic channels/depressions/basins.

Sonipat: The district comprises of recent flood plains, young meander plains, old meander plains and old alluvial plains. Recent flood plains occur along the Yamuna River and clearly show fluvial features. The soils are loamy sand to sandy loam on the surface and sandy loam to clay loam in the sub surface.

Rohtak: The district mainly comprises of old alluvial plains. The soils are loamy sand to sandy loam on the surface and sandy loam to clay loam in the sub surface. Old meander plains are almost flat with loamy sand to silty clay loam soils. Oldest among all the land forms are old alluvial plains, which cover major areas in the district. These soils are sand to loamy sand/sandy loam (surface) to silt loam/silty clay loam (sub-surface).

Jhajjar: The district mainly comprises of old alluvial plains and some parts of the district also have soil belonging to Aravali plains.

Rewari: The soils of the district fall under Entisols and Inceptisols orders. The surface soil texture varies from sand to fine loamy sand.

Gurgaon: The district comprises of sand dunes, sandy plains, alluvial plains, salt affected areas,

low lands, lakes, hills and pediments. The soil varies from sand to loamy sand in sand dunes and sandy plain areas, sandy loam to clay loam / silty clay loam in alluvial plains, calcareous, loamy sand to loam in salt affected plains, silty loam to loam in low lands and calcareous, loamy sand to loam in hills.

Mewat: The soils of the area are generally sandy loam to loam. In parts of the low-lying areas, they are clayey and saline. The upper hills are mostly barren.

Faridabad and Palwal: The district comprises of recent Yamuna flood plains, low lying plains, depressions, sand dunes and hills. The texture of the soil is sand to loamy sand in recent Yamuna flood plains, sandy loam in plains, sandy loam to clay loam in alluvial plains, sandy loam to loam

(surface), clay loam/silty clay (sub-surface) in low lying plains and depressions.

3.0 SCOPE OF WORK:

The stipulated scope of work involved carrying out the following operations:-

a) Mobilisation of necessary plant equipment, men and materials for the complete Geotechnical investigation work as per specifications, drawings and instructions of the Engineer and to complete the same within the stipulated time schedule and demobilisation after completion of field work.

b) Shifting of Equipments from one structure location to another including Ereaction, installation of rigs at site and dismantling of the same after completion of field work. Shifting of setup for each borehole location and associated preparation for borehole under water

c) Making 150 mm nominal diameter boreholes at various locations in all types of soils except hard rock and large boulders using suitable approved method of boring including chiselling, cleaning, providing casing pipe as required; performing Standard Penetration Test at every 3.0m interval and at change of strata; collection of water samples and disturbed soil samples, observation such as ground water, etc., collection of undisturbed soil samples at every 3.0 m interval and at change of strata; transportation of all the collected samples to the laboratory and back filling of boreholes on completion of the same, complete as per specification and instructions of the Engineer, for depths below natural ground level.

d) Conducting Electrical resistivity tests at various locations all complete as per specification and directions of the Engineer.

e) Conducting plate load test at various locations, all complete as per specification and directions of the Engineer.

f) Drilling of Nx size boreholes (75mm dia.) in all types of hard rock, collection of core samples, maintaining continuous record of core recovery/ RQD, keeping the cores in wooden core boxes, transporting to laboratory, backfilling on completion of the same, all complete as per specification and instructions of the EIC.

g) Conducting various laboratory tests on soil samples at an approved laboratory including preparation of soil samples to determine the following properties of soil, all complete as per specification.

<u>On soil Samples</u>

- Dry density test
- Bulk Density and Moisture Content.
- Sieve Analysis
- Hydrometer Analysis
- Liquid Limit and Plastic Limit
- Specific gravity
- Shrinkage Limit

- Free Swell Index
- Direct Shear Test
- Triaxial Shear Test
- One Dimensional consolidation test
- Chemical Analysis of soil samples (pH, chloride, Sulphate)

h) Conducting laboratory tests on rock samples including preparation of the samples to determine the following properties, all complete as per specification

<u>On Rock Samples</u>

- Moisture content, porosity & Density
- Specific gravity
- Hardness
- Unconfined compression test
- Point load strength index
- Modulus of Elasticity and Poission's Ratio
- Abrasion Test

i) Conducting chemical tests on water samples to determine the Sulphate, chloride and pH value all complete as per specification.

j) Submitting draft report in soft copy including all field records and laboratory test results, graphs, etc., all complete as per specifications.

k) Submitting final report in three hard copies in after the approval of the draft report including all field records and laboratory test results, graphs, etc., all complete as per specifications.

4. FIELD INVESTIGATION IN SOIL STRATA:

The investigation was planned to obtain the subsurface stratification in the proposed project site and collect soil / rock core samples for laboratory testing to determine the engineering properties such as shear strength, along with basic engineering classification of the subsurface stratum.

For geotechnical investigation work, required equipements along with rotary drilling rigs and manpower were mobilized at site to carry out various field activities as per the scope of work. These were shifted from one test location to another location during execution of field work and were demobilized on satisfactory completion of field work.

For conducting the field investigations the following practices were followed at site:

- The locations of 21 boreholes carried out at Old Ch. 11+523 to Old Ch. 16+815 **(**New CH 12+208 to 17+500) were marked at site at specified locations. These locations are shown in **Appendix A-1** attached subsequently.

The details of various boreholes along with their coordinates are provided herein below:

Table 1.1: Details of Borehole Locations

S. No.	Chainage Old (km)	Chainage New (km)	Structure	BH.No.	Depth of Water Table below EGL (m)	Depth of Borehole below EGL (m)	Co-ordinates (m)		(+) R.L. (m)
							E	N	
1.	11+523	12+208	MNB	BH-CL	4.22	10.00	709040.651	3123968.349	195.402
2.	11+614	12+299		BH-CL	4.60	10.00	708954.798	3123947.903	195.557
3.	11+657	12+342		BH-CL	4.70	10.00	708910.733	3123935.677	195.027
4.	12+125	12+808		BH-CL	1.56	10.00	708479.897	3123758.290	194.849
5.	12+431	13+115		BH-CL	1.50	10.00	708224.151	3123592.675	195.631
6.	13+218	13+903		BH-CL	3.10	10.00	707594.763	3123118.176	195.027
7.	13+787	14+472	MJB	BH-A1	2.53	40.00	707152.851	3122785.015	194.731
8.				BH-P1	2.55	40.00	707140.474	3122775.684	194.755
9.				BH-A2	2.50	40.00	707128.097	3122766.353	194.784
10.	13+917	14+601	MNB	BH-CL	2.90	10.00	707035.822	3122696.787	194.850
11.	14+072	14+756		BH-CL	3.10	10.00	706910.449	3122602.267	194.471
12.	14+415	15+100		BH-CL	3.00	10.00	706638.160	3122396.987	194.541
13.	15+259	15+944		BH-CL	2.90	10.00	705971.993	3121873.019	193.786
14.	15+416	16+101		BH-CL	3.20	10.00	705861.877	3121764.321	194.416
15.	15+441	16+127	MJB	BH-A1	3.00	30.00	705851.853	3121753.862	194.160
16.				BH-A2	3.10	30.00	705838.108	3121739.334	193.216
17.	16+042	16+727		BH-A1	3.65	30.00	705482.626	3121279.064	194.075
18.				BH-A2	3.68	30.00	705472.020	3121262.045	194.105
19.	16+231	16+917		BH-A1	3.13	30.00	705386.344	3121114.308	192.968
20.				BH-A2	3.10	30.00	705376.865	3121096.697	193.065
21.	16+815	17+500	MNB	BH-CL	4.10	10.00	705153.768	3120569.349	194.981

***Not Encountered:-NE**

- In soil, boreholes of 150mm dia. were drilled as per the standard procedure laid in IS: 1892.
- Borehole was properly cleaned before taking any sample in soil.
- Casing was used as per the prevailing soil conditions, to stabilize the borehole.
- Standard Penetration Tests were conducted in bore holes at regular intervals or at every change of strata as per Technical specification.
- Undisturbed were collected wherevery feasible as per the requirements and at specified depths. The same has been discussed in detail in soil characteristics sheets attached with the report.

- The Ground Water Table was met at depths of from 1.5m to 4.7m below EGL in the boreholes. The detailed procedure adopted for conducting various field tests is given here in below:

(i) Standard Penetration Test:

The Standard Penetration Test was conducted in boreholes as per IS 2131. The test was carried out using the standard split spoon sampler to measure the number of blows 'N'.

Standard split spoon sampler was attached to an 'A' rod. It was driven from borehole bottom to a distance of 45 cm using a standard hammer of 63.5 kg falling freely from a height of 75 cm to the required depth. While driving, the number of blows required to penetrate every 15 cm are recorded. The total number of blows required for the last 30 cm is taken as 'N' value at that particular depth of the borehole. Wherever the total penetration was less than 45cm, the no. of blows & the depth penetrated is recorded in the respective borelog.

SPT 'N' values were correlated with relative density of non-cohesive stratum and with consistency of cohesive stratum as given below:-

Table 1.2: Soil compactness as per SPT N values (cl. 9.7, table 9.3 & 9.4, page 330_text book of V.N.S. Murthy)

Correlation for Clay / Plastic silt		Correlation for Sand / Non-Plastic silt	
Consistency	**SPT "N" Value**	**Compactness**	**SPT "N" Value**
Very Soft	0 - 2	Very Loose	0 - 4
Soft	2 - 4	Loose	4 - 10
Medium	4 - 8	Medium	10 - 30
Stiff	8 - 15	Dense	30 - 50
Very Stiff	15 - 30	Very Dense	> 50
Hard	> 30		

The field SPT N values obtained were further corrected as per the guidelines given in IS: 2131 as follows:

(a) For overburden: - The N value for cohesionless soil is corrected with the help of fig. 1 given in IS-2131.

(b) Due to dilatancy :- Wherever N values observed below water table in fine sand, silty sand or silt was greater than 15, then corrected N values were corrected as under:

$$N' = 15 + \tfrac{1}{2}(N-15)$$

(ii) Undisturbed Sampling (Soil) in boreholes:

Undisturbed samples were collected using MS tubes of suitable diameter and length with Area ratio as per clause 4.1.1 (c) of IS: 1892 (latest) fitted to an adopter with ball and socket arrangement. Before taking any sample, sampling tube was properly greased. Immediately after taking

on undisturbed sample in a tube, the adopter head was removed along with the disturbed material. The visible ends of the sample were trimmed off any wet disturbed soil. The ends were coated alternately with four layers of just molten wax. More molten wax was added to give a total thickness of min. 25 mm. The samples were carefully labeled and transported to the laboratory for testing. Undisturbed samples wherever slipped during lifting were duly marked in the field logs as well as in the soil profile.

5.0 LABORATORY TESTS ON SOIL SAMPLES:

The following laboratory tests were conducted on selected soil samples:

Table 1.3: Description of Tests

Description of Test	Reference	Undisturbed (UDS) Soil Samples	Disturbed (DS/SPT) Soil Samples
Grain Size Analysis / Hydrometer	IS: 2720 (Part - 4)	√	-
Natural Moisture Content / Bulk / Dry density	IS : 2720 (Part – 2)	√	-
Atterberg Limits • Liquid Limit • Plastic Limit	 IS: 2720 (Part - 5) IS: 2720 (Part - 5)	 √ √	 √ √
Specific Gravity	IS : 2720 (Part – 3)	√	-
Direct Shear Test	IS : 2720 (Part – 13)	√	-
Triaxial compressive shear test	IS : 2720 (Part – 11 & 12)	√	-
Chemical Analysis of Soil Samples	IS : 2720 (Part – 26, 27)	√	-

Note:- The detailed procedure adopted for conducting various laboratory tests is described in the following paragraphs:

5.1.1 Dry density and Bulk density

For determination of bulk density and dry density, a sample of known volume 'V' was extracted from the undisturbed sampling tube and it's bulk weight 'W' was noted down.Moisture content 'Wn' was determined by oven drying method.

The bulk density and dry density were determined by following equation-

Bulk density (γ_b) = W/V

Dry density (γ_d) = γ_b/ (1+Wn)

5.1.2 Natural water content

For this test, the soil sample of known quantity (Wm) was taken in a container.The container with soil sample was placed into an oven for drying at 105-110°c temperature for 16-24 hours. After drying, the dry sample was again weighted to determine the dry weight of sample (Wd).

The natural water content was computed by the following equation-

Wn = (Wm-Wd)*100/Wd

5.1.3 Grain Size Analysis (IS: 2720- Part-4)

Wet sieve analysis:

For determination of particle sizes finer than 75 micron, wet sieve analysis test was conducted. For this test, oven dried sample of known quantity was taken in a container and soaked with dispersing agent. The soaked soil sample was washed thoroughly over 75 micron IS sieve until the water passing sieve was substantially clean.

Fraction retained on 75 micron IS sieve was carefully collected in a container without any loss in material and placed into oven for drying.

Dry sieve analysis:

For this test, the oven dried soil sample after wet sieving was sieved through the set of IS sieves 20 mm, 10 mm, 4.75 mm, 2.0 mm, 1.0 m , 425 micron , 300 micron, 150 micron and 75micron. The amounts of soil retained on each sieve were noted down. The % retained, cumulative % retained and % passing were computed accordingly. Wherever the soil sample % passing 75 micron sieve was significant, Hydrometer method was used to find the percentage of silt and clay fraction.

Grain size analysis for the fraction passing 75 micron IS Sieve (Hydrometer method)

Calibration of Hydrometer

Hydrometer was calibrated to determine a relationship (an equation) between the effective depth H_R and corresponding hydrometer reading R_h (obtained during test).

50 to 100 gm of soil sample passing through 75 micron IS Sieve was taken. It was mixed with 100 ml of sodium hexametaphesphate solution and the mixture was warmed for about 10 minutes. It was then transferred to the cup of the mechanical mixer and the soil suspension was stirred for 15 minutes. The soil suspension was transferred into 1000 ml measuring cylinder and distilled water was added to make 1000ml solution. This solution was mixed vigorously. The measuring cylinder was then allowed to stand and the stopwatch was started. Hydrometer was immersed in the solution and reading were taken after half, one, two and four minutes. The hydrometer was then removed slowly and kept in distilled water at the same temperature as the soil suspension. Readings were taken after the periods of 8, 15 and 30 minutes, and one, two and four hours. Hydrometer was removed, rinsed and placed in the distilled water after each reading. After 4 hours reading was taken once or twice within 24 hours. Finally a reading was taken at the end of 24 hours. The temperature of the suspension was observed and recorded.

Calculations

Diameter of the particles (D):

$$D = \sqrt{\frac{30\mu}{980(G-1)}} \times \sqrt{\frac{H_R}{t}} = M\sqrt{\frac{H_R}{t}}$$

Where,

D = diameter of particle in suspension, in mm;

μ = co-efficient of viscosity of water at the temperature of the suspension at the time of taking the hydrometer reading, in poise;

G = specific gravity of the soil fraction used in the sedimentations analysis;

H_R = effective depth corresponding to R_n, in cm.

t = time elapsed between the beginning of sedimentation and taking of hydrometer reading in minutes

$M = \sqrt{\frac{30\mu}{980(G-1)}}$ = a constant factor for given values of μ and G at the temperature of the suspension.

Percentage finer than diameter D:

The percentage by mass (w) of particles smaller than corresponding equivalent particle diameters (D) was calculated from the formula:

$$w = \frac{100G_s}{W_b(G_s-1)} \times R_h$$

Where

w = percentage finer

G_s = specific gravity of soil particle

W_b = weight of soil

R_h = Hydrometer reading

5.1.4 Specific Gravity (IS: 2720-Part-3 Sec-1)

The specific gravity of soil sample was determined by density bottle method. For this test 5-10g oven dried and cooled soil sample was taken in 50ml capacity density bottle and its weight was noted down as W_2 .The soil was covered with distilled water and left for sufficient period for suitable soaking. The entrapped air was removed by vacuum. The bottle with soil was filled fully

with water and its weight was noted down (W_3). The mass of empty bottle and bottle filled with distilled water were noted down as W_1 and W_4 respectively.

The Specific Gravity was determined by using following equation :

$G=W_2-W_1/[(W_2-W_1)-(W_3-W_4)]$

5.1.5 Liquid Limit (IS: 2720- Part-5)

By Cone Penetrometer Method

The 'Cone Penetrometer Apparatus' is a variant of the fall-cone and consists of a cone with a smooth polished surface and angle of 30° ± 1/2°. The weight of the cone, together with its associated shaft is 80g ± 0.5g. A support assembly with an automatic cone release mechanism and cone height adjustment mechanism used to hold the cone vertically. The angle and weight of the cone were calibrated at regular intervals, and the sharpness of the cone tip was checked daily.

Distilled water was added and thoroughly mixed with the soil sample to produce a homogeneous paste. The paste was then placed in a cup with a diameter of at least 55mm and a depth of at least 40mm. The surface of the soil was smoothed off level and parallel to the base. The support assembly was used to position the tip of the cone so that it was just touching the top surface of the soil, and the automatic tripping mechanism was released. The cone was allowed to penetrate into the soil for a period of 5 (± 1) s, then the cone was locked off to stop further movement and the penetration was recorded. The cup was refilled and the test was repeated. The two recorded penetrations need to be within 0.5mm of each other, otherwise a third test is performed. when the three test vary by more than 1mm the test was repeated.

Further tests were conducted, at varying water contents, in order to produce a series of cone penetrations (usually 4) in the range 15mm to 25mm. The resulting cone penetrations were plotted verses the water content of the test specimens. The Liquid Limit (W_L) was read off the graph, being the water content at which the line of best fit through the test points crosses 20mm penetration.

5.1.6 Plastic Limit (IS: 2720-Part-5)

For this test, soil sample was prepared in the same way as for liquid limit test. A ball of soil sample weighed about 5 gm was formed. The ball was rolled between the fingers of one hand and the glass plate with pressure sufficient to reduce the mass into a thread of about 3 mm in 5 to 10 complete forward and back movements. When a diameter of 3 mm was reached, soil was again remolded into a ball. The process of rolling and remolding was repeated until the thread started just crumbing at a diameter of 3 mm. The crumbled thread was immediately transferred to an airtight container for determination of its moisture content by oven drying method.

This water content has been termed as plastic limit. (W_P)

5.1.7 Plasticity Index (IS: 2720-Part-5)

The plasticity index Ip was given by

$I_p = W_L - W_P$ (in percent)

5.1.8 Direct Shear Test (IS:2720-Part-13):

For this test shear box test apparatus was used. The prepared specimen from remolded/undisturbed sample was placed carefully in the box. The plain grid was kept on top of the specimen with its directions at right angles to the direction of shear. The upper porous stone was placed on the grid and loading pad on the stone. The box with specimen was gently placed in the container (water jacket). The specimen was submerged with water. The container was mounted with the shear box and the specimen inside, on the shearing machine. The upper part of the box was so adjusted that it touchéd the proving ring. The jack was brought forward to bear up against the box container. The proving ring dial gauge was set to read zero.

The steel ball was placed in the recess of the loading pad. The loading yoke was set in contact with the steel ball on the loading pad. Vertical displacement dial gauge to read zero in contact with the top of the yoke. The normal load was applied and any change in thickness of specimen was recorded. Shear displacement dial gauge was also set to read zero. The locking screw was now removed and two parts of the shear box were separated by advancing the spacing screws.

The specimen was sheared at constant rate of strain. The readings of the proving ring dial gauge were noted down every 15 seconds for the first one-minute and then every 30 seconds thereafter. The reading of change in the thickness dial gauge and shear displacement dial gauge were also recorded at the same time interval. The test was continued until the specimen fails. The specimen was assumed to fail when the proving ring dial gauge started receding or at shear displacement of approximately 15% of the length took place.

The soil was removed from the box and test was repeated on the identical specimen under increased normal load.

The rate of strain for conducting Direct Shear Test is kept as 0.25 mm/min as per codal/literature provision based on strata.

5.1.9 Triaxial Shear Test_UUT (IS: 2720-Part-11)

For this test, Triaxial Shear Test apparatus was used. The plain disc was placed on the pedestal of the triaxial cell. The specimen was placed centrally on the disc. A correct size rubber membrane was fitted inside the stretcher with ends of membrane folded over those of the stretcher. Vacuum was applied to stretch the membrane to the inside surface of the stretcher which was carefully slipped around the specimen kept on the pedestal. The vacuum on the membrane was released. Its bottom part was rolled down into the pedestal. plain disc was placed on the top of the specimen

and then loading pad was placed. The top part of membrane was rolled on to the loading pad. Then the stretcher was removed and ends were sealed with 'O' rings. With the properly sealed specimen placed centrally on the pedestal, the cell was assembled, keeping the loading piston initially clear of the loading pad of the specimen, the assembly was placed in the loading frame.

For unconsolidated undrained test, the bottom drainage value (BDV) and top drainage value (TDV) of cell, was closed and air release valve (ARV) was opened. The cell was filled with water through the cell water value CWV. ARV was closed when water begins to escape through it. The cell pressure was raised to the desired value and kept constant till the end of the test.

When the cell pressure was applied, the load piston rises upward, the loading machine was operated at the anticipated rate to bring the load piston slightly above the loading pad of the specimen and the load measuring dial gauge on proving ring was set to zero.

The piston was brought just in contact with loading pad by hand operation of the machine. The axial compression dial gauge was mounted and set to read zero.

The axial loading was started at 1.25 mm/min rate of strain. Simultaneous readings on the load and compression dial gauges were noted down. The test was continued until a recession of the axial load is observed or 20% of strain.

After failure, the specimen was unloaded by reversing the loading machine, cell pressure was reduced and cell water was drained out through BRV. The cell was dismantled and the specimen was taken out, rubber membrane was removed and weight of the failed sample and its water content was determined. The test was repeated on two more identical specimens with increasing cell pressure.

The rate of strain for conducting UUT is kept as 1.25 mm/min as per codal/literature provision based on strata.

5.1.10 Chemical Testing

Chemical Testing was generally performed in accordance with IS: 2720, but the different parts of method as described below:

a) Total Sulphate Content Of Soil

Samples were tested according to IS 2720 (Part 27). The dried soil was extracted with a 10% solution of hydrochloric acid. The extract was adjusted to slightly alkaline pH with ammonia, and then barium chloride solution was added to precipitate the sulphate. The barium sulphate precipitate was collected by filtration, and it was washed, dried and weighed. The mass of barium sulphate recovered was used to calculate the sulphate content of the original soil.

b) pH Value

Samples were tested according to IS: 2720 (Part 26). The soil sample (30 ± 0.1g) was extracted with 75 ml of distilled water and the pH of the resulting suspension was measured with a calibrated (by means of Standard buffer solution) pH meter.

c) Chloride Content

For the water soluble content, soil samples were extracted with a volume of water equal to twice the mass of the soil. The extract was filtered and acidified with a small amount of nitric acid. Standardized silver nitrate solution was then added to precipitate the chloride as its silver salt. The amount of precipitated silver remaining in solution was then determined by titration.

An acid-soluble version of the test was also available, with the initial extraction being with nitric acid instead of water.

CHAPTER 2 ANALYSIS OF TEST RESULTS AND INTERPRETATION

6.0 STRATIFICATION

From the study of the borehole carried out at Old Ch. 11+523 to Old Ch. 16+815 (New CH 12+208 to 17+500) it is revealed that the strata consisit of Coarse grained soil i.e. Silty Sand (SM), Silty Sand with Clay (SM-SC), Clayey Silt with low Plasticity (MLCL), Fine grained Soil i.e. Silty Clay of low Plasticity (CL), Silty Clay of Medium Plasticity (CI).

6.1 GROUND WATER TABLE DEPTH

The Ground Water Table was met at depths of from 1.50 m to 4.6 m below EGL in 21 boreholes and not encountered in the remaining boreholes as given in Table 2.1, it may rise up during heavy rains / rainy season. Therefore, for the analysis of various foundations, the water table has been considered to rise by about 2 to 3.0m at the locations of boreholes.

6.2 RESULTS OF CHEMICAL ANALYSIS

Results of chemical analysis of soil samples (as per **Appendix – B2**) indicates that the soil sample falls under Class I for sulphates and chlorides concentration (As per IS 456-2000 and CIRIA Sp. Publication No. 31). The results are summarized here in below :-

Summary of chemical analysis of soil samples

Chemical Property	Findings (Min. to Max.)	Remarks (Required limits as per IS 456-2000)
pH	7.41 to 8.91	> 6.0
Sulphite as SO_3^{2-} (%)	0.0021 (%) to 0.0036 (%)	< 0.2% (Class I)
Chlorides as Cl^- (%)	0.0065 (%) to 0.0077 (%)	No limit specified in IS 456. However, a limit of 0.10% specified for class I in CIRIA Sp. Publication No. 31)

Note :- All the chemical contents are within permissible limit hence no special precautions are required.

6.3 COMPUTATION OF LIQUEFACTION POTENTIAL

The site falls under seismic zone- IV. Further as per the provisions of IS: 1893 in soil deposits consisting of submerged loose sands & soils falling under classification of SP with standard penetration N value less than 15, the shaking caused by earthquake ground motion may cause liquefaction or excessive total and differential settlements.

For the cohesionless strata encountered in the boreholes at site, the IS: 1893 (Part-1)-2016 should be referred for the analysis of Liquefaction Potential and for the cohesive strata, RDSO BS-118 should be referred.

As per the RDSO guidelines:

a)Cohesive soils should be considered liquefiable if wl≤ 37 %, Ip≤ 12 % and wn>0.80 wl, where Ip is the Plasticity Index.

b)Liquefaction susceptibility of soils should be considered marginal if wl ≤ 47 %, Ip≤ 20 % and wn≥ 0.85 wl, where Ip is the Plasticity Index.

c)Cohesive soils should be considered non-liquefiable if wl>47 % or Ip>20 % or wn<0.85 wl, where Ip is the Plasticity Index.

For the analysis of liquefaction potential, following constant parameters are considered:

EQ Zone	IV
Earthquake Magnitude (Mw)	7.0
Peak Horizontal Ground Acceleration (amax /g)	0.24

The Ground Water Table was met at depths of from 1.50 m to 4.70m below EGL in the boreholes. For the analysis of liquefaction potential, the water table is generally considered to rise all boreholes. However, a sample analysis sheet is provided for reference.

The strata in the boreholes are not likely to liquefy as mentioned above and the same is tabulated below:-

Table 2.1: Liquefaction Analysis

S. No.	Chainage Old	Chainage New	Structure	BH.No.	Water Table depth considered for analysis (m)	Liquefiable upto(m)
1.	11+523	12+208	MNB	BH-CL	0.00	3.00
2.	11+614	12+299		BH-CL	0.00	3.00
3.	11+657	12+342		BH-CL	0.00	3.00
4.	12+125	12+808		BH-CL	0.00	Non-Liquefiable
5.	12+431	13+115		BH-CL	0.00	Non-Liquefiable
6.	13+218	13+903		BH-CL	0.00	3.00
7.	13+787	14+472	MJB	BH-A1	0.00	Non-Liquefiable
8.				BH-P1	0.00	11.50
9.				BH-A2	0.00	7.00
10.	13+917	14+601	MNB	BH-CL	0.00	1.50
11.	14+072	14+756		BH-CL	0.00	1.50
12.	14+415	15+100		BH-CL	0.00	3.00
13.	15+259	15+944	MNB	BH-CL	0.00	6.00
14.	15+416	16+101		BH-CL	0.00	6.00

S. No.	Chainage Old	Chainage New	Structure	BH.No.	Water Table depth considered for analysis (m)	Liquefiable upto(m)
15.	15+441	16+127	MJB	BH-A1	0.00	5.50
16.				BH-A2	0.00	Non-Liquefiable
17.	16+042	16+727		BH-A1	0.00	4.00
18.				BH-A2	0.00	Non-Liquefiable
19.	16+231	16+917		BH-A1	0.00	Non-Liquefiable
20.				BH-A2	0.00	4.00
21.	16+815	17+500	MNB	BH-CL	0.00	Non-Liquefiable

6.4 INTERPRETATION OF LAB TEST RESULTS

Grain Size Analysis

- **Clay content:** It generally varies from 3 to 12%.
- **Silt content:** It generally varies from 22 to 64%.
- **Sand content:** It generally varies from 23 to 88%.
- **Gravel content:** It generally varies from 1 to 12%.

Atterberg's Limit

- **Liquid limit:** The test results of liquid limit of the soil samples reveal that it generally varies from 25 to 27% in ML-CL type of soil, 32 to 36% in CL type of soil.
- **Plastic Limit*:*** The plastic limit of the soil sample varies from 20 to 23% in ML-CL type of soil, 20 to 24% in CL type of soil. However ML-CL type of soil is considered as non-plastic.
- **Plasticity index*:*** The plasticity index of the soil samples generally varies from 6 to 7% in ML-CL type of soil, 09 to 12% in CL type of soil whereas ML-CL and SM/ SM-SC/ SC type of soil are non-plastic.

Natural moisture content & Bulk density

The bulk density of soil samples generally varies from 1.64 gm/cc to 1.98gm/cc whereas natural moisture content varies from 9.51% to 25.3%.

Direct shear tests:

Direct shear test under drained condition have been conducted in sandy silty (ML-CL) / sandy stratum (SM/ SM-SC/ SC) type of soil.

For Sandy strata (SM/ SM-SC/ SC), the value of angle of internal friction varies from 25^{o} to 31^{o}, whereas cohesion varies from 0.00 kg/cm^2 to 0.11 kg/cm^2.

For Silty strata (ML-CL), the value of angle of internal friction varies from 22^{o} to 27^{o}, whereas cohesion varies from 0.19 kg/cm^2 to 0.22 kg/cm^2.

Triaxial shear tests:

Triaxial shear test under undrained condition have been conducted in silty clay (CL) type of soil.

For silty clay (CL) strata, the value of angle of internal friction varies from 4^o to 5^o, whereas cohesion varies from 1.42kg/cm^2 to 2.24kg/cm^2.

CHAPTER 3 TYPE AND DEPTH OF FOUNDATION WITH ANALYSIS

7.0 TYPE & DEPTH OF FOUNDATION:

Based on the nature & strength characteristics of the substrata and requirement of the project, the following type of foundation have been analyzed as given below:

Table 3.1 : Shallow Foundation

Type of foundation	Depth of Foundation below E.G.L. (m)	Size of Foundation (m x m)
Shallow Foundation	1.0, 1.5, 2.0	2.7 x 27
	1.0, 1.5, 2.0	5.5 x 5.5
	1.0, 1.5, 2.0	2.5 x 2.5
	1.0, 1.5, 2.0	3.7 x 3.7
	1.0, 1.5, 2.0	6 x 6
	2.0, 3.0, 4.0	7.2 x 7.2

Table 3.2 : Pile Foundation

Type of foundation	Length of Pile below E.G.L. (m)	Dia. of Pile (m)
Normal Bored Cast in-situ RCC Pile	20.0, 22.0, 24.0, 26.0, 28.0, 30.0	1.0 & 1.2

The details of foundation analysis are given in the subsequent paragraph.

7.1 ANALYSIS OF SHALLOW FOUNDATION

7.1.1 From Shear Failure Criteria

Net Safe Bearing capacity from Shear Failure consideration has been computed in accordance with IS: 6403-1981, which is based on, modified Terzaghi's classical approach. The weighted average of shear strength parameters for various strata upto depth equal to 0.5*B*Tan (45+Ø/2) (where B = Width of the Foundation, Ø = Angle of internal friction) is used in the analysis. A factor of safety of 2.5 to estimate the net safe bearing capacity from ultimate net bearing capacity.

For soils, containing both coarse grained (gravels & sands) and fine grained (clays), c and Φ are used to determine the soil strength. In case of predominantly fine grained soils, c and Φ are determined by the Triaxial Compression test as per IS: 2720 pt XI. For predominantly coarse grained soils, c and Φ are determined by Direct Shear test as per IS: 2720 pt XIII. These c and Φ values were used for determining the SBC of soil as per shear failure criteria.

The ultimate net bearing capacity in case of general shear failure is given by following expression,

$q_d = c\ N_c\ s_c\ d_c\ i_c + q\ (N_q\text{-}1)\ s_q\ d_q\ i_q + (1/2)\ B\ \gamma\ N_\gamma\ s_\gamma\ d_\gamma\ i_\gamma\ W'$

The ultimate net bearing capacity in case of local shear failure is given by following expression,

$q'_d = (2/3)\ c\ N'_c\ s_c\ d_c\ i_c + q\ (N'_q\text{-}1)\ s_q\ d_q\ i_q + (1/2)\ B\ \gamma\ N'_\gamma\ s_\gamma\ d_\gamma\ i_\gamma\ W'$

Where,

$d_c = 1 + 0.2\ (D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^o$

$d_q = d_\gamma = 1 + 0.1\ (D_f/B)*SQRT(N_\phi)$ for $\phi > 10^o$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' for local shear failure $= \tan^{-1}(0.67 \tan\phi)$

7.1.2 From Settlement Failure Criteria

Allowable Bearing Pressure from Settlement Failure consideration has been computed in accordance with IS: 8009 (Part-I). The magnitude of settlement, when foundation loads are applied, depends upon the compressibility of the underlying strata and rigidity of the substructure.

The total permissible settlement in cohesion-less soil is estimated using SPT value as per IS: 8009 (Part-I). While using this approach, the N value was corrected, wherever applicable, below the footing base to at least 1.5B below the base to account for the effects of energy ratio, adopted bearing pressure, dilation for submerged silty fine sands / fine sands as well as that due to the overburden pressure.

Further for settlement Calculation in cohesive soil the following equation has been used.

$S_t = \Delta P\ M_v\ H$

Where,

M_v = Coefficient of volume compressibility, cm^2/kg

ΔP = Pressure increment, kg/cm^2

H = Thickness of layers

Note: - Value of Coefficient of volume compressibility (Mv) has been calculated by using the following co-relation [Ref. Stroud and Butler, 1975] :-

Coefficient of Volume Compressibility derived from SPT N-Value (after Stroud and Butler, 1975)

Plasticity Index (%)	Conversion Factor (f_2)	m_v (10^{-3} kPa^{-1}) based on N-Value: $m_v = 1/(f_2 N)$				
		N=10	N=20	N=30	N=40	N=50
10	800	0.12	0.06	0.04	0.03	0.02
20	525	0.19	0.09	0.06	0.05	0.04
30	475	0.21	0.10	0.07	0.05	0.04
40	450	0.22	0.11	0.07	0.06	0.04

$Mv = 1/(f_2 N_{corr.})$

Where f_2 = factor based on $N_{corr.}$ Value & plasticity index of soil

$N_{corr.}$ = corrected SPT 'N' value

For analysis of shallow foundation the total permissible settlement has been considered as 25mm, & 50mm as per IS 1904.

Zone of influence below foundation has been considered up to 1.5 times the width of the foundation.

For the determination of the SBC from settlement criteria, the corrected SPT N values within the influence zone are given in the table below.

NOTE:-

- Lower of the two values obtained from settlement and shear criteria is used in arriving at allowable bearing capacity of the soil.
- Structural foundations are designed based on the minimum of Safe Bearing Capacity obtained from Shear Failure Criteria and Allowable Bearing Pressure corresponding to the permissible settlement. The permissible Settlement that can be allowed for the foundation depends on the strata at the location and type of foundation (whether Isolated or Raft).

  Settlement occurs with the application of loads on foundations. It has two components, Immediate Settlement and Long Term Settlement. The immediate settlement takes place immediately as the loading is imposed on the structure and long term settlement arises due to the consolidation of the sub-soil with time under the load. Hence, the total settlement allowed for a foundation is the sum of the immediate and consolidation settlement that is expected to occur. The cohesionless strata (predominantly sandy) is primarily subjected to immediate settlement and cohesive strata (clayey) undergoes settlement in long time with the compression of the strata due to consolidation. Settlement of the foundation is determined from the relation provided in Indian standards (IS: 8009 (part-1) &/or various literatures (Bowles, BM Das, etc.).

  From the Geotechnical investigation conducted on our site along with subsequent laboratory tests on soil samples, it is observed that predominantly the strata is silty with sand (SM/SC/SM-SC/ML-CL i.e. predominantly cohesionless) with the presence of small patches of silty clay of low plasticity (CL). Since the Settlement that takes place in cohesionless strata is mostly immediate, it takes place immediately after the imposing of load, initially during construction with the application of Dead Load and further during Live Load. The live load usually is many times lesser than the dead load, and correspondingly the post construction settlement is very less for live loads. As an example, if dead load is three times that of live load, then the settlement corresponding to

live load (i.e. the post construction settlement) will be one-third of the settlement due to dead load which is comparatively lesser than 25mm for permissible settlement of 50mm.

According to the IS 1904, the permissible settlement for concrete structure having raft foundation is allowed upto 75mm, and the permissible settlement is 25mm post construction as per IRS code (Code of Practice for The Design of Sub-Structures and Foundations of Bridges). As discussed above, the settlement post construction is directly proportional to the allowable settlement. Therefore, given the importance of structure to be constructed and considering mostly cohesionless strata encountered at site, it is recommended that the maximum permissible settlement shall be restricted to 50mm for the design purpose on conservative side so that the post construction settlement can be constraint to lesser than 25mm.

As per IS- 8009 part 1 clause 9.2.2.1, If the clay layer is sandwitched between cohesionless soil layers, the immediate settlement is zero. Hence, even though the immediate settlement has been calculated during analysis, however it is ignored in the calculation of total settlement.

The sample calculations for computation of allowable bearing capacity of sub-strata for shallow foundation vide **Appendix – C-1.**

7.2 ANALYSIS OF PILE FOUNDATION

(A) DEEP FOUNDATION

The safe Load Carrying Capacity of normal bored cast in-situ RCC pile is determined in compression, uplift and lateral as per IS: 2911 (Part-1/sec-2) – 2010. The axial capacity of a pile depends upon the soil skin friction along the shaft and end bearing at it's tip.

Thus Axial load = Skin Friction + End-bearing

a) For piles in granular soils (using the static formula)

$$\mathbf{Q_u = (0.5*D*\gamma*N_\gamma + P_D*N_q)*A_p + (\Sigma K_i*P_{Di}*\tan\delta_i)*A_{si}}$$

Where,

Q_u = Ultimate load capacity of pile in KN

D = dia. of pile shaft in m

γ = effective unit weight of the soil at pile tip in kN/m^3

N_γ & N_q = bearing capacity factors depending upon the angle of internal friction Φ at pile tip (N_γ from IS 6403 for general shear failure case & N_q from Fig. 1, IS 2911)

P_D = effective overburden pressure at pile tip in kN/m^2 limited to 15-17 times diameter of pile (as per the Phi value at end bearing)

Σ = Summation for layers (1 to n) in which pile is installed and which contribute to (+ve) skin friction

K_i = coefficient of earth pressure applicable for the i^{th} layer

P_{Di} = effective overburden pressure for the i^{th} layer in kN/m^2 limited to 15-17 times diameter of pile (as per the Phi value at end bearing)

δ_i = angle of wall friction between pile and soil for i^{th} layer, and

A_{si} = surface area of pile shaft in the i^{th} layer in m^2

b) For piles in cohesive soils (using the static formula)

$$\mathbf{Q_u = cp*Nc*A_p + \Sigma\alpha_i*c_i*A_{si}}$$

Where,

Q_u = Ultimate load capacity of pile in KN

A_p = cross-sectional area of pile tip in m^2

N_c = bearing capacity factor (= 9)

Σ = Summation for layers (1 to n) in which pile is installed and which contribute to (+ve) skin friction

α_i = adhesion factor for the i^{th} layer depending on the consistency of soil

c_i = average cohesion for i^{th} layer in kN/m^2

A_{si} = surface area for pile shaft in the i^{th} layer in m^2

c) For computation of safe load carrying capacity of pile in lateral, the following equation has been used:

i. <u>Fixed Head Condition</u>

$$\mathbf{Q = (12 * E * I * Y) / (L_1 + L_f)^3}$$

ii. <u>Free Head Condition</u>

$$\mathbf{Q = (3 * E * I * Y) / (L_1 + L_f)^3}$$

Where,

Q = Lateral Load (in kg)

Y = Permissible lateral deflection taken as 5mm

E = Modulus of Elasticity of concrete

I = Moment of Inertia of the pile cross-section

L_1 = Length of pile above cut-off level

L_f = Length of fixity

The effective length of the pile has been considered below the cut-off level taken as 2.0m below the EGL. Normal Bored cast in-situ RCC piles having stem diameter equal to 100cm & 120cm and of effective length varying from 16.0m to 28.0m were selected.

For the analysis of the pile foundations the soil parameters used for computation of safe load carrying capacity of pile is tabulated below:-

Table 3.3 : Design Soil Parameter

Chainage Old	Chainage New	BH.No.	Layer depth below EGL (m)		Thickness of strata (m)	Strata description	SPT 'N'		Bulk Density (gm/cc)	Cohesion (C) (kg/cm2)	Angle of internal Friction (Φ) (°)
			From	To			Observed	Corrected			
11+523	12+208	BH-CL	0.00	3.00	3.00	Silty Sand	5	8	1.65	0.00	30
			3.00	8.25	5.25	Silty Sand	18	18	1.78	0.00	31
			8.25	10.00	1.75	Silty Sand	-	-	1.82	0.10	31
11+614	12+299	BH-CL	0.00	2.25	2.25	Sandy Silt	8	13	1.69	0.19	28
			2.25	5.25	3.00	Sandy Silt	17	20	1.78	0.21	28
			5.25	8.25	3.00	Sandy Silt	19	17	1.83	0.21	28
			8.25	10.00	1.75	Sandy Silt	-	-	1.84	0.21	28
11+657	12+342	BH-CL	0.00	5.25	5.25	Sandy Silt	12	16	1.73	0.18	28
			5.25	8.25	3.00	Sandy Silt	22	19	1.83	0.20	29
			8.25	10.00	1.75	Silty Clay	-	-	1.93	0.56	5
12+125	12+808	BH-CL	0.00	5.50	5.50	Silty Sand	16	19	1.76	0.00	31
			5.50	10.00	4.50	Sandy Silt	34	27	1.86	0.21	27
12+431	13+115	BH-CL	0.00	4.00	4.00	Silty Sand	16	19	1.74	0.00	31
			4.00	7.00	3.00	Silty Sand	64	46	1.88	0.00	32
			7.00	10.00	3.00	Silty Sand	-	-	1.84	0.00	31
13+218	13+903	BH-CL	0.00	2.25	2.25	Silty Sand	5	8	1.67	0.00	30
			2.25	5.25	3.00	Silty Clay	15	15	1.83	0.53	5
			5.25	8.25	3.00	Silty Clay	23	23	1.96	0.75	6
			8.25	10.00	1.75	Sandy Silt	-	-	1.84	0.21	30
13+787	14+472	BH-A1	0.00	2.50	2.50	Silty Clay	6	6	1.65	0.23	4
			2.50	8.50	6.00	Silty Clay	15	15	1.93	0.49	4
			8.50	11.50	3.00	Silty Clay	20	20	1.95	0.70	5
			11.50	14.50	3.00	Silty Clay	26	26	1.97	0.88	5
			14.50	20.50	6.00	Silty Clay	33	33	1.98	1.02	6
			20.50	24.00	3.50	Silty Clay	32	32	1.98	1.02	6
13+787	14+472	BH-A1	24.00	29.50	5.50	Silty Clay	40	40	2.01	1.42	5
			29.50	35.50	6.00	Silty Clay	83	83	2.04	2.56	5
			35.50	40.00	4.50	Silty Clay	73	73	2.05	2.56	5
		BH-P1	0.00	7.00	7.00	Silty Sand	6	7	1.69	0.09	29
			7.00	10.00	3.00	Silty Sand	9	10	1.71	0.09	29

Chainage Old	Chainage New	BH.No.	Layer depth below EGL (m)		Thickness of strata (m)	Strata description	SPT 'N'		Bulk Density (gm/cc)	Cohesion (C) (kg/cm2)	Angle of internal Friction (Φ) (°)
			From	To			Observed	Corrected			
			10.00	13.00	3.00	Silty Clay	24	24	1.97	0.82	5
			13.00	16.00	3.00	Silty Clay	29	29	1.98	0.95	6
			16.00	19.00	3.00	Silty Clay	56	56	2.01	1.85	5
			19.00	22.00	3.00	Silty Clay	65	65	2.02	2.03	6
			22.00	25.00	3.00	Silty Clay	43	43	2.00	1.42	5
			25.00	28.00	3.00	Silty Clay	64	64	2.03	2.08	5
			28.00	34.00	6.00	Silty Clay	67	67	2.04	2.50	6
			34.00	37.00	3.00	Silty Clay	75	75	2.03	2.37	6
			37.00	40.00	3.00	Silty Clay	-	-	2.03	2.37	6
		BH-A2	0.00	5.50	5.50	Silty Sand	9	13	1.73	0.11	29
			5.50	7.00	1.50	Silty Sand	-	-	1.75	0.11	29
			7.00	11.50	4.50	Silty Clay	22	22	1.95	0.75	5
			11.50	14.50	3.00	Silty Clay	30	30	1.98	1.02	6
			14.50	20.50	6.00	Silty Clay	34	34	1.98	1.02	6
			20.50	23.50	3.00	Silty Clay	43	43	2.00	1.40	6
			23.50	26.50	3.00	Silty Clay	44	44	2.01	1.40	6
			26.50	29.50	3.00	Silty Clay	63	63	2.03	2.18	5
			29.50	32.50	3.00	Silty Clay	72	72	2.03	2.18	5
			32.50	35.50	3.00	Silty Clay	79	79	2.05	2.56	5
			35.50	40.00	4.50	Silty Clay	81	81	2.04	2.56	5
13+917	14+601	BH-CL	0.00	2.25	2.25	Sandy Silt	7	11	1.69	0.20	28
			2.25	5.25	3.00	Silty Clay	14	14	1.91	0.44	4
			5.25	8.25	3.00	Sandy Silt	32	25	1.89	0.21	29
			8.25	10.00	1.75	Silty Clay	-	-	1.99	1.03	5
14+072	14+756	BH-CL	0.00	2.25	2.25	Silty Sand	8	12	1.69	0.09	29
			2.25	5.25	3.00	Silty Clay	14	14	1.89	0.51	4
			5.25	8.25	3.00	Silty Clay	32	32	1.99	1.02	5
			8.25	10.00	1.75	Silty Clay	-	-	1.99	1.02	5
14+415	15+100	BH-CL	0.00	2.25	2.25	Sandy Silt	7	11	1.67	0.19	28
			2.25	5.25	3.00	Silty Clay	20	20	1.86	0.71	4
			5.25	8.25	3.00	Sandy Silt	22	20	1.86	0.22	29
			8.25	10.00	1.75	Sandy Silt	-	-	1.86	0.22	29
15+259	15+944	BH-CL	0.00	5.25	5.25	Sandy Silt	9	13	1.76	0.19	28

Chainage Old	Chainage New	BH.No.	Layer depth below EGL (m)		Thickness of strata (m)	Strata description	SPT 'N'		Bulk Density (gm/cc)	Cohesion (C) (kg/cm2)	Angle of internal Friction (Φ) (°)
			From	To			Observed	Corrected			
			5.25	8.25	3.00	Silty Clay	31	31	1.99	1.05	5
			8.25	10.00	1.75	Silty Clay	-	-	2.00	1.05	5
15+416	16+101	BH-CL	0.00	2.25	2.25	Sandy Silt	8	12	-	0.21	28
			2.25	5.25	3.00	Sandy Silt	17	19	1.78	0.21	28
			5.25	8.25	3.00	Sandy Silt	19	17	1.83	0.21	28
			8.25	10.00	1.75	Sandy Silt	-	-	1.84	0.21	28
15+441	16+127	BH-A1	0.00	4.00	4.00	Silty Sand	5	6	1.64	0.10	28
			4.00	7.00	3.00	Silty Clay	36	36	1.99	1.13	6
			7.00	10.00	3.00	Silty Clay	39	39	2.00	1.13	6
			10.00	13.00	3.00	Silty Clay	33	33	1.99	1.13	6
			13.00	16.00	3.00	Silty Clay	28	28	1.98	1.13	6
			16.00	19.00	3.00	Silty Clay	42	42	2.00	1.38	6
			19.00	22.00	3.00	Silty Clay	41	41	1.99	1.38	6
			22.00	25.00	3.00	Silty Clay	45	45	2.00	1.38	6
			25.00	30.00	4.95	Silty Clay	75	75	2.03	2.35	6
		BH-A2	0.00	5.50	5.50	Silty Clay	11	11	1.72	0.39	4
			5.50	8.50	3.00	Silty Clay	25	25	1.97	0.85	5
			8.50	11.50	3.00	Silty Clay	35	35	1.99	1.19	4
			11.50	14.50	3.00	Silty Clay	39	39	2.00	1.36	5
			14.50	17.50	3.00	Silty Clay	43	43	2.00	1.36	5
			17.50	20.50	3.00	Silty Clay	42	42	1.99	1.36	5
			20.50	23.50	3.00	Silty Clay	52	52	2.01	1.79	5
			23.50	26.50	3.00	Silty Clay	56	56	2.03	1.79	5
			26.50	30.00	3.50	Silty Clay	55	55	2.03	1.79	5
16+042	16+727	BH-A1	0.00	6.00	6.00	Silty Sand	10	13	1.71	0.10	28
			6.00	10.00	4.00	Silty Sand	19	18	1.77	0.11	30
			10.00	14.50	4.50	Sandy Silt	22	18	1.86	0.20	29
			14.50	17.50	3.00	Silty Clay	31	31	1.98	1.06	5
			17.50	20.50	3.00	Silty Clay	36	36	1.99	1.23	4
16+042	16+727	BH-A1	20.50	23.50	3.00	Silty Clay	42	42	2.00	1.40	4
			23.50	30.00	6.45	Silty Clay	77	77	2.04	2.74	4
		BH-A2	0.00	4.00	4.00	Silty Sand	9	12	1.69	0.11	28
			4.00	7.00	3.00	Silty Sand	16	17	1.75	0.12	29
			7.00	8.50	1.50	Silty Sand	19	18	1.76	0.12	29

Chainage Old	Chainage New	BH.No.	Layer depth below EGL (m)		Thickness of strata (m)	Strata description	SPT 'N'		Bulk Density (gm/cc)	Cohesion (C) (kg/cm2)	Angle of internal Friction (Φ) (°)
			From	To			Observed	Corrected			
			8.50	13.00	4.50	Silty Clay	27	23	1.96	0.85	4
			13.00	16.00	3.00	Silty Clay	27	27	1.96	0.85	4
			16.00	19.00	3.00	Silty Clay	42	42	1.99	1.40	4
			19.00	22.00	3.00	Silty Clay	56	56	2.02	1.83	5
			22.00	25.00	3.00	Silty Clay	62	62	2.02	1.98	4
			25.00	30.00	4.95	Silty Clay	78	78	2.04	2.50	4
16+231	16+917	BH-A1	0.00	4.00	4.00	Silty Sand	11	14	1.71	0.11	28
			4.00	7.00	3.00	Silty Sand	27	23	1.80	0.10	29
			7.00	10.00	3.00	Sandy Silt	48	32	1.88	0.22	29
			10.00	13.00	3.00	Silty Clay	39	39	1.99	1.19	5
			13.00	16.00	3.00	Silty Clay	32	32	1.99	1.19	5
			16.00	19.00	3.00	Silty Clay	45	45	2.00	1.48	6
			19.00	22.50	3.50	Silty Clay	47	47	1.99	1.48	6
			22.50	30.00	7.50	Sandy Silt	85	36	1.95	0.18	29
		BH-A2	0.00	5.50	5.50	Sandy Silt	10	14	1.74	0.20	27
			5.50	8.50	3.00	Sandy Silt	23	20	1.82	0.19	28
			8.50	11.50	3.00	Sandy Silt	33	24	1.87	0.20	28
			11.50	14.50	3.00	Silty Clay	28	28	1.98	0.95	5
			14.50	17.50	3.00	Silty Clay	40	40	1.99	1.31	6
			17.50	20.50	3.00	Silty Clay	39	39	1.99	1.31	6
			20.50	23.50	3.00	Silty Clay	46	46	2.02	1.65	5
			23.50	26.50	3.00	Silty Clay	53	53	2.01	1.65	5
			26.50	30.00	3.50	Sandy Silt	47	23	1.91	0.18	30
16+815	17+500	BH-CL	0.00	5.50	5.50	Sandy Silt	21	26	1.81	0.20	27
			5.50	10.00	4.50	Sandy Silt	19	17	1.88	0.19	28

Design parameter have been obtain from the laboratory test results however various depth where the shear parameter seems on the lower side with respect to SPT 'N' values those shear parameter have been judicially improved based on the SPT 'N' for the analysis purpose.

The sample calculation for computation of safe load carrying capacity of normal bored cast-in-situ RCC pile in compression & uplift are attached vide **Appendix C-2.**

The sample calculation for computation of safe load carrying capacity of normal bored cast-in-situ RCC pile in lateral are attached vide **Appendix C-3.**

CHAPTER 4 FOUNDATION RECOMMENDATIONS

8.0 FOUNDATION RECOMMENDATIONS

- Based on the nature & strength characteristics of the substrata and requirement of the project, shallow foundation and normal bored cast in-situ RCC pile foundation have been analyzed.
- Based on the method of analysis & design parameters given under Para 7.1 above, the recommended net allowable bearing capacity values are given in Table 4.1 to 4.4.

Table 4.1: Recommended Net Allowable Bearing Capacity for shallow foundation for allowable settlement 25mm

Chainage Old	Chainage New	BH. No.	Foundation Size (m x m)	Depth of foundation below EGL (m)	Net Safe Bearing Capacity from Shear Failure (t/m^2)	Net Allowable Bearing Pressure from settlement failure (t/m^2)	Recommended Net Allowable Bearing Capacity (t/m^2)
11+523	12+208	BH-CL	2.7 X 2.7	1.00	8.34	7.46	7.46
			2.7 X 2.7	1.50	10.56	8.02	8.02
			2.7 X 2.7	2.00	12.90	8.55	8.55
11+614	12+299	BH-CL	5.5 X 5.5	1.00	16.83	5.92	5.92
			5.5 X 5.5	1.50	18.12	6.11	6.11
			5.5 X 5.5	2.00	19.43	6.32	6.32
11+657	12+342	BH-CL	2.5 X 2.5	1.00	14.04	8.06	8.06
			2.5 X 2.5	1.50	15.75	8.71	8.71
			2.5 X 2.5	2.00	17.52	9.30	9.30
12+125	12+808	BH-CL	2.7 X 2.7	1.00	8.58	10.08	8.58
			2.7 X 2.7	1.50	10.83	10.84	10.83
			2.7 X 2.7	2.00	13.19	11.56	11.56
12+431	13+115	BH-CL	3.7 X 3.7	1.00	10.01	14.37	10.01
			3.7 X 3.7	1.50	12.13	15.12	12.13
			3.7 X 3.7	2.00	14.34	15.95	14.34
13+218	13+903	BH-CL	3.7 X 3.7	1.00	11.96	3.98	3.98
			3.7 X 3.7	1.50	12.36	5.99	5.99
			3.7 X 3.7	2.00	12.75	12.05	12.05
13+787	14+472	BH-A1	7.2 X 7.2	2.00	10.94	6.40	6.40
			7.2 X 7.2	3.00	11.36	6.75	6.75
			7.2 X 7.2	4.00	11.77	7.13	7.13
		BH-P1	7.2 X 7.2	2.00	14.90	1.77	NR
			7.2 X 7.2	3.00	17.35	1.96	NR
			7.2 X 7.2	4.00	19.89	2.23	NR
		BH-A2	7.2 X 7.2	2.00	16.41	5.18	NR
			7.2 X 7.2	3.00	19.04	5.88	NR
			7.2 X 7.2	4.00	21.75	6.70	NR

Chainage Old	Chainage New	BH. No.	Foundation Size (m x m)	Depth of foundation below EGL (m)	Net Safe Bearing Capacity from Shear Failure (t/m^2)	Net Allowable Bearing Pressure from settlement failure (t/m^2)	Recommended Net Allowable Bearing Capacity (t/m^2)
13+917	14+601	BH-CL	3.7 X 3.7	1.00	9.62	7.15	7.15
			3.7 X 3.7	1.50	9.94	9.49	9.49
			3.7 X 3.7	2.00	10.25	13.82	10.25
14+072	14+756	BH-CL	6 X 6	1.00	10.95	5.33	5.33
			6 X 6	1.50	11.20	5.75	5.75
			6 X 6	2.00	11.44	7.01	7.01
14+415	15+100	BH-CL	2.7 X 2.7	1.00	14.40	7.37	7.37
			2.7 X 2.7	1.50	16.00	10.87	10.87
			2.7 X 2.7	2.00	17.64	19.93	17.64
15+259	15+944	BH-CL	6 X 6	1.00	16.41	5.13	NR
			6 X 6	1.50	17.73	5.53	NR
			6 X 6	2.00	19.08	6.02	NR
15+416	16+101	BH-CL	6 X 6	1.00	14.84	6.30	NR
			6 X 6	1.50	16.05	6.47	NR
			6 X 6	2.00	17.28	6.67	NR
15+441	16+127	BH-A1	7.2 X 7.2	2.00	34.48	4.41	NR
			7.2 X 7.2	3.00	35.72	4.19	NR
			7.2 X 7.2	4.00	36.96	10.82	NR
		BH-A2	7.2 X 7.2	2.00	8.73	8.30	8.30
			7.2 X 7.2	3.00	9.05	8.75	8.75
			7.2 X 7.2	4.00	9.38	9.24	9.24
16+042	16+727	BH-A1	7.2 X 7.2	2.00	21.70	7.05	7.05
			7.2 X 7.2	3.00	25.23	7.43	7.43
			7.2 X 7.2	4.00	28.88	7.74	7.74
		BH-A2	7.2 X 7.2	2.00	22.09	6.89	6.89
			7.2 X 7.2	3.00	25.54	7.67	7.67
			7.2 X 7.2	4.00	29.12	8.71	8.71
16+231	16+917	BH-A1	7.2 X 7.2	2.00	29.28	9.73	9.73
			7.2 X 7.2	3.00	33.19	10.26	10.26
			7.2 X 7.2	4.00	37.22	10.97	10.97
		BH-A2	7.2 X 7.2	2.00	23.30	7.31	7.31
			7.2 X 7.2	3.00	26.45	7.69	7.69
			7.2 X 7.2	4.00	29.70	8.20	8.20
16+815	17+500	BH-CL	7.2 X 7.2	1.00	23.42	10.55	10.55
			7.2 X 7.2	1.50	25.11	10.77	10.77
			7.2 X 7.2	2.00	26.83	11.04	11.04

* The maximum value of recommended net allowable bearing capacity shall be restricted to 30 t/m2.

Table 4.2: Recommended Net Allowable Bearing Capacity for shallow foundation for allowable settlement 50mm

Chainage Old	Chainage New	BH. No.	Foundation Size (m x m)	Depth of foundation below EGL (m)	Net Safe Bearing Capacity from Shear Failure (t/m^2)	Net Allowable Bearing Pressure from settlement failure (t/m^2)	Recommended Net Allowable Bearing Capacity (t/m^2)
11+523	12+208	BH-CL	2.7 X 2.7	1.00	8.34	14.91	8.34
			2.7 X 2.7	1.50	10.56	16.04	10.56
			2.7 X 2.7	2.00	12.90	17.10	12.90
11+614	12+299	BH-CL	5.5 X 5.5	1.00	16.83	11.84	11.84
			5.5 X 5.5	1.50	18.12	12.22	12.22
			5.5 X 5.5	2.00	19.43	12.64	12.64
11+657	12+342	BH-CL	2.5 X 2.5	1.00	14.04	16.12	14.04
			2.5 X 2.5	1.50	15.75	17.41	15.75
			2.5 X 2.5	2.00	17.52	18.60	17.52
12+125	12+808	BH-CL	2.7 X 2.7	1.00	8.58	20.16	8.58
			2.7 X 2.7	1.50	10.83	21.69	10.83
			2.7 X 2.7	2.00	13.19	23.13	13.19
12+431	13+115	BH-CL	3.7 X 3.7	1.00	10.01	28.73	10.01
			3.7 X 3.7	1.50	12.13	30.23	12.13
			3.7 X 3.7	2.00	14.34	31.91	14.34
13+218	13+903	BH-CL	3.7 X 3.7	1.00	11.96	7.96	7.96
			3.7 X 3.7	1.50	12.36	11.97	11.97
			3.7 X 3.7	2.00	12.75	24.10	12.75
13+787	14+472	BH-A1	7.2 X 7.2	2.00	10.94	12.80	10.94
			7.2 X 7.2	3.00	11.36	13.49	11.36
			7.2 X 7.2	4.00	11.77	14.25	11.77
		BH-P1	7.2 X 7.2	2.00	14.90	3.53	NR
			7.2 X 7.2	3.00	17.35	3.92	NR
			7.2 X 7.2	4.00	19.89	4.46	NR
		BH-A2	7.2 X 7.2	2.00	16.41	10.36	NR
			7.2 X 7.2	3.00	19.04	11.75	NR
			7.2 X 7.2	4.00	21.75	13.40	NR
13+917	14+601	BH-CL	3.7 X 3.7	1.00	9.62	14.29	9.62
			3.7 X 3.7	1.50	9.94	18.97	9.94
			3.7 X 3.7	2.00	10.25	27.65	10.25
14+072	14+756	BH-CL	6 X 6	1.00	10.95	10.67	10.67
			6 X 6	1.50	11.20	11.50	11.20
			6 X 6	2.00	11.44	14.02	11.44
14+415	15+100	BH-CL	2.7 X 2.7	1.00	14.40	14.74	14.40
			2.7 X 2.7	1.50	16.00	21.75	16.00
			2.7 X 2.7	2.00	17.64	39.85	17.64

Chainage Old	Chainage New	BH. No.	Foundation Size (m x m)	Depth of foundation below EGL (m)	Net Safe Bearing Capacity from Shear Failure (t/m^2)	Net Allowable Bearing Pressure from settlement failure (t/m^2)	Recommended Net Allowable Bearing Capacity (t/m^2)
15+259	15+944	BH-CL	6 X 6	1.00	16.41	10.26	NR
			6 X 6	1.50	17.73	11.05	NR
			6 X 6	2.00	19.08	12.04	NR
15+416	16+101	BH-CL	6 X 6	1.00	14.84	12.59	NR
			6 X 6	1.50	16.05	12.94	NR
			6 X 6	2.00	17.28	13.35	NR
15+441	16+127	BH-A1	7.2 X 7.2	2.00	34.48	8.83	NR
			7.2 X 7.2	3.00	35.72	17.42	NR
			7.2 X 7.2	4.00	36.96	21.64	NR
		BH-A2	7.2 X 7.2	2.00	8.73	16.60	8.73
			7.2 X 7.2	3.00	9.05	17.50	9.05
			7.2 X 7.2	4.00	9.38	18.48	9.38
16+042	16+727	BH-A1	7.2 X 7.2	2.00	21.70	14.10	14.10
			7.2 X 7.2	3.00	25.23	14.87	14.87
			7.2 X 7.2	4.00	28.88	15.48	15.48
		BH-A2	7.2 X 7.2	2.00	22.09	13.77	13.77
			7.2 X 7.2	3.00	25.54	15.34	15.34
			7.2 X 7.2	4.00	29.12	17.42	17.42
16+231	16+917	BH-A1	7.2 X 7.2	2.00	29.28	19.47	19.47
			7.2 X 7.2	3.00	33.19	20.53	20.53
			7.2 X 7.2	4.00	37.22	21.94	21.94
		BH-A2	7.2 X 7.2	2.00	23.30	14.62	14.62
			7.2 X 7.2	3.00	26.45	15.38	15.38
			7.2 X 7.2	4.00	29.70	16.39	16.39
16+815	17+500	BH-CL	7.2 X 7.2	1.00	23.42	21.10	21.10
			7.2 X 7.2	1.50	25.11	21.53	21.53
			7.2 X 7.2	2.00	26.83	22.08	22.08

Note:-

- The maximum value of recommended net allowable bearing capacity shall be restricted to 30 t/m^2.

***Notes:* -**

From Table 2.1: Liquefaction Analysis, it has been obsereved that Liquefaction depth varies from 3.0 to 11.5 m below EGL in all the boreholes. Therefore before laying the open foundation at 1.0 to 4.0 m depth it is recommended to replace & compact the soil up to depth of Liquefaction below the foundation level.

1. *The design parameters may be considered for replaced/compacted Soil for calculating the SBC from shear and settlement criteria are as follows;*

   C=0, Phi = 32 degree, Sp. Gravity= 2.63 Bulk density=1.85 t/m^2, N = 25..

- *Bore holes which are liquefied greater than 4m depth, Some other suitable ground improvement methods may be adopted.*

Table 4.3: Recommended Net Allowable Bearing Capacity for shallow foundation for allowable settlement 25mm (Replaced / Compacted Soil)

Chainage Old	Chainage New	BH. No.	Foundation Size (m x m)	Depth of foundation below EGL (m)	Net Safe Bearing Capacity from Shear Failure (t/m^2)	Net Allowable Bearing Pressure from settlement failure (t/m^2)	Recommended Net Allowable Bearing Capacity (t/m^2)
11+523	12+208	BH-CL	2.7 X 2.7	1.00	16.5	10.8	10.8
			2.7 X 2.7	1.50	20.8	11.6	11.6
			2.7 X 2.7	2.00	25.2	12.3	12.3
11+614	12+299	BH-CL	5.5 X 5.5	1.00	25.2	8.7	8.7
			5.5 X 5.5	1.50	29.1	9.0	9.0
			5.5 X 5.5	2.00	33.1	9.3	9.3
11+657	12+342	BH-CL	2.5 X 2.5	1.00	17.6	11.0	11.0
			2.5 X 2.5	1.50	22.4	11.9	11.9
			2.5 X 2.5	2.00	27.3	12.7	12.7
13+218	13+903	BH-CL	3.7 X 3.7	1.00	17.5	14.2	14.2
			3.7 X 3.7	1.50	21.2	16.1	16.1
			3.7 X 3.7	2.00	25.0	18.5	18.5
13+787	14+472	BH-P1	7.2 X 7.2	2.00	40.9	10.9	NR
			7.2 X 7.2	3.00	49.5	11.4	NR
			7.2 X 7.2	4.00	58.5	12.2	NR
		BH-A2	7.2 X 7.2	2.00	40.9	9.9	NR
			7.2 X 7.2	3.00	49.5	10.4	NR
			7.2 X 7.2	4.00	58.5	10.7	NR
13+917	14+601	BH-CL	3.7 X 3.7	1.00	19.9	14.1	14.1
			3.7 X 3.7	1.50	24.0	15.6	15.6
			3.7 X 3.7	2.00	28.4	17.1	17.1
14+072	14+756	BH-CL	6 X 6	1.00	24.3	8.7	8.7
			6 X 6	1.50	27.9	8.7	8.7
			6 X 6	2.00	31.5	8.6	8.6
14+415	15+100	BH-CL	2.7 X 2.7	1.00	16.4	17.9	16.4
			2.7 X 2.7	1.50	20.6	22.6	20.6
			2.7 X 2.7	2.00	25.0	29.2	25.0
15+259	15+944	BH-CL	6 X 6	1.00	27.3	10.2	NR
			6 X 6	1.50	31.3	10.6	NR
			6 X 6	2.00	35.4	11.0	NR

Chainage Old	Chainage New	BH. No.	Foundation Size (m x m)	Depth of foundation below EGL (m)	Net Safe Bearing Capacity from Shear Failure (t/m^2)	Net Allowable Bearing Pressure from settlement failure (t/m^2)	Recommended Net Allowable Bearing Capacity (t/m^2)
15+416	16+101	BH-CL	6 X 6	1.00	24.3	8.7	NR
			6 X 6	1.50	27.9	8.9	NR
			6 X 6	2.00	31.6	9.2	NR
15+441	16+127	BH-A1	7.2 X 7.2	2.00	40.9	14.5	NR
			7.2 X 7.2	3.00	49.5	11.2	NR
			7.2 X 7.2	4.00	58.5	17.4	NR
16+042	16+727	BH-A1	7.2 X 7.2	2.00	40.9	9.0	9.0
			7.2 X 7.2	3.00	49.5	9.5	9.5
			7.2 X 7.2	4.00	58.5	9.9	9.9
16+231	16+917	BH-A2	7.2 X 7.2	2.00	38.9	9.8	9.8
			7.2 X 7.2	3.00	47.1	10.2	10.2
			7.2 X 7.2	4.00	55.7	10.6	10.6

Table 4.4: Recommended Net Allowable Bearing Capacity for shallow foundation for allowable settlement 50mm (Replaced / Compacted Soil)

Chainage Old	Chainage New	BH. No.	Foundation Size (m x m)	Depth of foundation below EGL (m)	Net Safe Bearing Capacity from Shear Failure (t/m^2)	Net Allowable Bearing Pressure from settlement failure (t/m^2)	Recommended Net Allowable Bearing Capacity (t/m^2)
11+523	12+208	BH-CL	2.7 X 2.7	1.00	16.5	21.5	16.5
			2.7 X 2.7	1.50	20.8	23.1	20.8
			2.7 X 2.7	2.00	25.2	24.7	24.7
11+614	12+299	BH-CL	5.5 X 5.5	1.00	25.2	17.5	17.5
			5.5 X 5.5	1.50	29.1	18.0	18.0
			5.5 X 5.5	2.00	33.1	18.7	18.7
11+657	12+342	BH-CL	2.5 X 2.5	1.00	17.6	22.0	17.6
			2.5 X 2.5	1.50	22.4	23.8	22.4
			2.5 X 2.5	2.00	27.3	25.4	25.4
13+218	13+903	BH-CL	3.7 X 3.7	1.00	17.5	28.4	17.5
			3.7 X 3.7	1.50	21.2	32.1	21.2
			3.7 X 3.7	2.00	25.0	37.1	25.0
13+787	14+472	BH-P1	7.2 X 7.2	2.00	40.9	21.8	NR
			7.2 X 7.2	3.00	49.5	22.9	NR
			7.2 X 7.2	4.00	58.5	24.3	NR
		BH-A2	7.2 X 7.2	2.00	40.9	19.9	NR
			7.2 X 7.2	3.00	49.5	20.9	NR
			7.2 X 7.2	4.00	58.5	21.4	NR

Chainage Old	Chainage New	BH. No.	Foundation Size (m x m)	Depth of foundation below EGL (m)	Net Safe Bearing Capacity from Shear Failure (t/m^2)	Net Allowable Bearing Pressure from settlement failure (t/m^2)	Recommended Net Allowable Bearing Capacity (t/m^2)
13+917	14+601	BH-CL	3.7 X 3.7	1.00	19.9	28.2	19.9
			3.7 X 3.7	1.50	24.0	31.2	24.0
			3.7 X 3.7	2.00	28.4	34.1	28.4
14+072	14+756	BH-CL	6 X 6	1.00	24.3	17.4	17.4
			6 X 6	1.50	27.9	17.3	17.3
			6 X 6	2.00	31.5	17.2	17.2
14+415	15+100	BH-CL	2.7 X 2.7	1.00	16.4	35.8	16.4
			2.7 X 2.7	1.50	20.6	45.3	20.6
			2.7 X 2.7	2.00	25.0	58.4	25.0
15+259	15+944	BH-CL	6 X 6	1.00	27.3	20.5	NR
			6 X 6	1.50	31.3	21.2	NR
			6 X 6	2.00	35.4	22.0	NR
15+416	16+101	BH-CL	6 X 6	1.00	24.3	17.4	NR
			6 X 6	1.50	27.9	17.9	NR
			6 X 6	2.00	31.6	18.5	NR
15+441	16+127	BH-A1	7.2 X 7.2	2.00	40.9	29.0	NR
			7.2 X 7.2	3.00	49.5	20.1	NR
			7.2 X 7.2	4.00	58.5	34.9	NR
16+042	16+727	BH-A1	7.2 X 7.2	2.00	40.9	18.1	18.1
			7.2 X 7.2	3.00	49.5	19.1	19.1
			7.2 X 7.2	4.00	58.5	19.8	19.8
16+231	16+917	BH-A2	7.2 X 7.2	2.00	38.9	19.7	19.7
			7.2 X 7.2	3.00	47.1	20.3	20.3
			7.2 X 7.2	4.00	55.7	21.2	21.2

Note:-

The maximum value of recommended net allowable bearing capacity shall be restricted to 30 t/m^2.

Based on the method of analysis given under Para 7.2 above, The values of Safe Load Carrying Capacity of piles in compression, uplift and lateral under static conditions have been tabulated below:-

Table 4.5: Safe Load Carrying Capacity of normal bored cast in-situ RCC Pile in Soil

Chainage Old	Chainage New	BH. No.	Diameter of Pile (m)	Length of piles below cut-off (m)	Cut-off level below EGL (m)	Safe load carrying capacity of single pile (T)		
						In compression	In uplift	In Lateral
								Fixed Head
13+787	14+472	BH-A1	1.0	20.0	2.0	168.0	149.0	15.4
				22.0		182.0	165.0	
				24.0		197.0	181.0	
				26.0		222.0	197.0	
				28.0		238.0	214.0	
				30.0		290.0	235.0	
			1.2	20.0		215.0	190.0	18.5
				22.0		233.0	211.0	
				24.0		252.0	232.0	
				26.0		285.0	253.0	
				28.0		305.0	275.0	
				30.0		376.0	301.0	
		BH-P1	1.0	20.0	2.0	123.0	104.0	5.3
				22.0		138.0	119.0	
				24.0		153.0	136.0	
				26.0		188.0	153.0	
				28.0		220.0	174.0	
				30.0		235.0	194.0	
			1.2	20.0		164.0	136.0	8.4
				22.0		182.0	156.0	
				24.0		201.0	178.0	
				26.0		248.0	200.0	
				28.0		272.0	226.0	
				30.0		309.0	252.0	
		BH-A2	1.0	20.0	2.0	152.0	127.0	5.9
				22.0		167.0	143.0	
				24.0		182.0	160.0	
				26.0		198.0	178.0	
				28.0		237.0	196.0	
				30.0		254.0	214.0	
			1.2	20.0		198.0	164.0	8.7
				22.0		217.0	185.0	
				24.0		236.0	207.0	

Chainage Old	Chainage New	BH. No.	Diameter of Pile (m)	Length of piles below cut-off (m)	Cut-off level below EGL (m)	Safe load carrying capacity of single pile (T)		
						In compression	In uplift	In Lateral
								Fixed Head
13+787	14+472	BH-A2	1.2	26.0	2.0	257.0	230.0	8.7
				28.0		309.0	253.0	
				30.0		330.0	276.0	
15+441	16+127	BH-A1	1.0	20.0		158.0	134.0	9.6
				22.0		185.0	150.0	
				24.0		200.0	166.0	
			1.2	20.0		205.0	172.0	13.4
				22.0		241.0	193.0	
				24.0		260.0	214.0	
		BH-A2	1.0	20.0		163.0	136.0	13.2
				22.0		178.0	153.0	
				24.0		195.0	171.0	
			1.2	20.0		212.0	175.0	17.2
				22.0		231.0	197.0	
				24.0		252.0	220.0	
16+042	16+727	BH-A1	1.0	20.0	2.0	161.0	140.0	13.3
				22.0		181.0	156.0	
				24.0		239.0	177.0	
			1.2	20.0		206.0	179.0	19.3
				22.0		232.0	200.0	
				24.0		312.0	226.0	
		BH-A2	1.0	20.0		164.0	128.0	9.4
				22.0		183.0	144.0	
				24.0		198.0	161.0	
			1.2	20.0		215.0	164.0	14.0
				22.0		234.0	185.0	
				24.0		257.0	207.0	
16+231	16+917	BH-A1	1.0	20.0	2.0	163.0	134.0	10.8
				22.0		184.0	155.0	
				24.0		237.0	178.0	
			1.2	20.0		212.0	173.0	16.6
				22.0		241.0	202.0	
				24.0		341.0	235.0	
		BH-A2	1.0	20.0	2.0	160.0	136.0	15.1
				22.0		183.0	151.0	

Chainage Old	Chainage New	BH. No.	Diameter of Pile (m)	Length of piles below cut-off (m)	Cut-off level below EGL (m)	Safe load carrying capacity of single pile (T)		
						In compression	In uplift	In Lateral Fixed Head
				24.0		197.0	167.0	
			1.2	20.0		207.0	175.0	21.9
				22.0		238.0	195.0	
				24.0		255.0	215.0	

Notes : -

1. Permissible lateral deflection has been taken as 5mm.
2. The self weight of the pile has been taken into account while computing the Safe Load Carrying Capacity of Pile in uplift only and not considered for vertical load capacity in compression.
3. The safe load carrying capacity of piles have been worked out on the basis of IS: 2911 (Part-1/sec-2) – 2010 as per provisions / assumptions provided therein & are only an assessment based on characteristics of the sub-strata obtained at the locations of the above BHs. The safe load carrying capacities as tabulated above will further depend substantially on the piling technique adopted and equipment used for making the piles in the field. However, for the final designs & constructions, the safe/allowable load carrying capacities of these piles should be taken by conducting actual initial load tests on these piles by casting them in the respective areas.
4. While erecting normal bored cast in-situ pile, utmost care should be taken while flushing/cleaning the bottom of pile particularly prior to start of pouring of concrete so as o rest the pile in virgin soil only for obtaining full point bearing as while computing safe load carrying capacity of pile no bottom softening during erection of pile has been considered.
5. Further the pile should have necessary structural strength to transmit / sustain the design load.

All The above recommendations are based on the field and laboratory tests conducted on selected soil/ rock core samples and our experience in this regard. If the actual substrata conditions during excavation for the foundation differ from the observations reported here, the design experts/consultants should be referred for suggestion, further investigations.

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6. IS 1893 : Part 1 : 2016 (Reaffirmed Year : 2021) Criteria for Earthquake Resistant Design of Structures - Part 1 : General Provisions and Buildings.
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17. IS: 2720 (Part 11)–(1993). Determination of the shear strength parameters of a specimen tested in unconsolidated undrained triaxial compression without the measurement of pore water pressure.
18. IS: 2720 (Part 13) 1986 Method of test for soils, direct shear test. New Delhi, India.
19. IS: 2720 (Part 3/See 1)–(1980) Methods of test for soils, determination of specific gravity of soil. New Delhi, India.
20. IS: 2720 (Part 5) 1985 Methods of test for soils, determination of liquid and plastic limit of soils. New Delhi, India.

Abbreviations

BH	Borehole
ERT	Electrical Resistivity Test
EGL	Existing Ground Level
GWT	Ground Water Table
IS	Indian Standards
SPT	Standard Penetration Test
DS	Disturbed Soil
R.L.	Reduced Level
m	Metre
sp. gr.	Specific Gravity
%	Percentage
mg /l	Milligram per litre
mg /kg	Milligram per kilogram
NR	Not Recommended

APPENDIX – A (FIELD DATA RESULTS)

Appendix No.	ITEMS
A-1	LOCATION PLAN
A-2	FIELD BORE HOLE LOGS
A-3	SUB SOIL PROFILE DIAGRAM

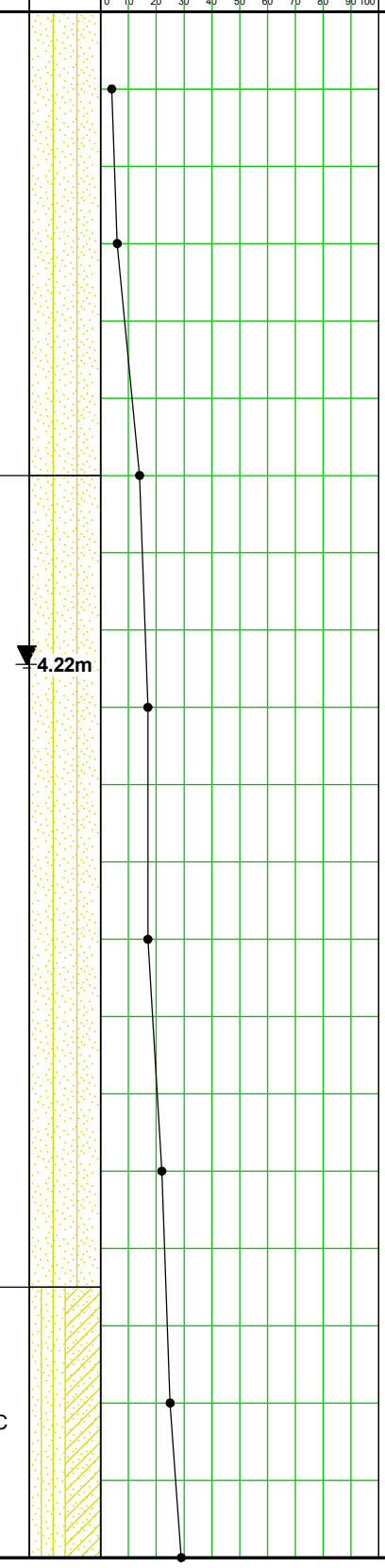

Ilyash Painter Thekedar
Apco Infratech Private Limite
CH_11+614 MNB (BH-CL)
CH_11+657 MNB (BH-CL)
CH_11+523 MNB (BH-CL)
Shreejee Lawns
World Institute of Tec
CH_12+125 MNB (BH-CL)
CH_12+431 MNB (BH-CL)
CH_13+218 MNB (BH-CL)
Kabirstan udaka
Govt High School Bhirawati
CH-13+787 MJB (BH-A2)
CH-13+787 MJB (BH-P1)
CH-13+787 MJB (BH-A1)
Udaka उदका
Bhirawati भिरावती
Google Earth
©2022 Google
Image © 2022 Maxar Technologies
N


CH_13+917 MNB (BH-CL)
Udaka उदका
CH_14+072 MNB (BH-CL)
CH_14+415 MNB (BH-CL)
Sohna-Manesar Rd
Barota बरोता
CH_15+259 MNB (BH-CL)
CH_15+416 MNB (BH-CL)
CH-15+441 MJB (BH-A1)
CH-15+441 MJB (BH-A2)
CH-16+042 MJB (BH-A1)
CH-16+042 MJB (BH-A2)
CH-16+231 MJB (BH-A1)
CH-16+231 MJB (BH-A2)
Rahuka रहका
Khanpur खानपुर
CH_16+815 MNB (BH-CL)
Google Earth
©2022 Google
Image © 2022 Maxar Technologies
N

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*11+523	*Northing :*3123968.349 m	*Easting :*709040.651 m
Reduced Level (m):(+)195.402	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*4.22	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*30-10-2021	*Date of Completion :*30-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5	0.5	SPT-1	2	2	2	4					
1.0											
1.5	1.5	SPT-2	2	3	3	6	Brown, Loose, Silty sand	SM			
2.0											
	2.25	UDS-1									
2.5											
3.0	3	SPT-3	4	6	8	14					
3.5											
4.0									4.22m		
4.5	4.5	SPT-4	6	7	10	17					
5.0											
	5.25	UDS-2									
5.5							Brown, Medium dense, Silty sand	SM			
6.0	6	SPT-5	4	8	9	17					
6.5											
7.0											
7.5	7.5	SPT-6	6	10	12	22					
8.0											
	8.25	UDS-3									
8.5											
9.0	9	SPT-7	8	11	14	25	Brown, Medium dense, Silty sand with clay	SM-SC			
9.5											
10.0	10	SPT-8	10	13	16	29					



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*11+614	*Northing :*3123947.903 m	*Easting :*708954.798 m
Reduced Level (m):(+)195.557	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*4.60	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*30-10-2021	*Date of Completion :*30-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5	0.5	SPT-1	3	3	5	8					
1.0							Brown, Loose, Sandy silt of low plasticity	ML-CL			
1.5	1.5	SPT-2	2	3	4	7					
2.0											
	2.25	UDS-1									
2.5											
3.0	3	SPT-3	5	7	8	15					
3.5											
4.0											
4.5	4.5	SPT-4	5	8	11	19			4.60m		
5.0											
	5.25	UDS-2									
5.5											
6.0	6	SPT-5	6	8	13	21	Brown, Medium dense, Sandy silt of low plasticity	ML-CL			
6.5											
7.0											
7.5	7.5	SPT-6	5	7	9	16					
8.0											
	8.25	UDS-3									
8.5											
9.0	9	SPT-7	4	6	8	14					
9.5											
10.0	10	SPT-8	4	7	9	16					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*11+657	*Northing :*3123935.677 m	*Easting :*708910.733 m
Reduced Level (m):(+)195.027	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*4.70	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*30-10-2021	*Date of Completion :*30-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5	0.5	SPT-1	3	3	4	7					
1.0											
1.5	1.5	SPT-2	2	3	5	8					
2.0											
	2.25	UDS-1									
2.5											
3.0	3	SPT-3	4	6	8	14					
3.5											
4.0							Brown, Loose to medium dense, Sandy silt of low plasticity	ML-CL			
4.5	4.5	SPT-4	5	9	11	20			4.70m		
5.0											
	5.25	UDS-2									
5.5											
6.0	6	SPT-5	6	8	12	20					
6.5											
7.0											
7.5	7.5	SPT-6	7	10	14	24					
8.0											
	8.25	UDS-3									
8.5											
9.0	9	SPT-7	5	6	10	16	Brown, Medium stiff to stiff, Silty clay of low plasticity	CL			
9.5											
10.0	10	SPT-8	4	7	9	16					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*12+125	*Northing :*3123758.29 m	*Easting :*708479.897 m
Reduced Level (m):(+)194.849	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*1.56	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*06-10-2021	*Date of Completion :*06-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	4	5	6	11					
1.5									1.56m		
2.0											
2.5	2.5	UDS-1					Brown, Medium dense, Silty sand	SM			
3.0											
3.5											
4.0	4	SPT-2	7	9	11	20					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	8	15	19	34					
7.5							Brown, Medium dense to dense, Sandy silt of low plasticity	ML-CL			
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	6	9	11	20					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*12+431	*Northing :*3123592.675 m	*Easting :*708224.151 m
Reduced Level (m):(+)195.631	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*1.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not used
*Date of Start :*06-10-2021	*Date of Completion :*06-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5									1.50m		
2.0							Brown, Medium dense, Silty sand	SM			
2.5	2.5	SPT-1	3	8	8	16					
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	13	31	33	64					
6.0											
6.5											
7.0	7	UDS-3					Brown, Dense to very dense, Silty sand with gravel	SM			
7.5											
8.0											
8.5	8.5	SPT-3	6	13	21	34					
9.0											
9.5											
10.0	10	UDS-4									

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+218	*Northing :*3123118.176 m	*Easting :*707594.763 m
Reduced Level (m):(+)195.027	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*3.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not used
*Date of Start :*31-10-2021	*Date of Completion :*31-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification
0.0		DS						
0.5	0.5	SPT-1	2	2	2	4	Brown, Loose, Silty sand	SM
1.0								
1.5	1.5	SPT-2	2	3	3	6		
2.0								
	2.25	UDS-1						
2.5								
3.0	3	SPT-3	4	5	7	12		
3.5								
4.0								
4.5	4.5	SPT-4	5	8	10	18		
5.0								
	5.25	UDS-2					Brown, Very stiff, Silty clay of low plasticity	CL
5.5								
6.0	6	SPT-5	6	9	12	21		
6.5								
7.0								
7.5	7.5	SPT-6	8	10	14	24		
8.0								
	8.25	UDS-3						
8.5								
9.0	9	SPT-7	5	7	10	17	Brown, Medium dense, Sandy silt of low plasticity	ML-CL
9.5								
10.0	10	SPT-8	6	9	11	20		

Graphic Log: 3.10m

(Depth v/s SPT N Value): 0 10 20 30 40 50 60 70 80 90 100

Special Observations

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122785.015 m	*Easting :*707152.851 m
Reduced Level (m):(+)194.731	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.53	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*09-11-2021	*Date of Completion :*10-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	2	3	3	6	Greyish brown, Medium stiff, Silty clay of medium plasticity	CI			
1.5											
2.0											
2.5	2.5	UDS-1							2.53m		
3.0											
3.5											
4.0	4	SPT-2	6	6	8	14					
4.5											
5.0											
5.5	5.5	UDS*									
6.0	6	SPT-3	5	7	9	16	Greyish brown, Stiff to very stiff, Silty clay of low plasticity	CL			
6.5											
7.0	7	SPT-4	4	5	9	14					
7.5											
8.0											
8.5	8.5	UDS-2									
9.0											
9.5											
10.0	10	SPT-5	6	8	12	20					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122785.015 m	*Easting :*707152.851 m
Reduced Level (m):(+)194.731	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.53	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*09-11-2021	*Date of Completion :*10-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	UDS-3									
12.0											
12.5							Greyish brown, Stiff to very stiff, Silty clay of low plasticity	CL			
13.0	13	SPT-6	8	10	16	26					
13.5											
14.0											
14.5	14.5	UDS-4									
15.0											
15.5											
16.0	16	SPT-7	13	15	16	31					
16.5											
17.0											
17.5	17.5	UDS*					Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
18.0	18	SPT-8	10	12	24	36					
18.5											
19.0	19	SPT-9	11	15	16	31					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122785.015 m	*Easting :*707152.851 m
Reduced Level (m):(+)194.731	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.53	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*09-11-2021	*Date of Completion :*10-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-5									
21.0											
21.5											
22.0	22	SPT-10	12	14	18	32					
22.5											
23.0											
23.5	23.5	UDS*									
24.0	24	SPT-11	14	16	18	34					
24.5											
25.0							Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5	25.5	SPT-12	13	17	20	37					
26.0											
26.5	26.5	UDS-6									
27.0											
27.5											
28.0	28	SPT-13	19	21	27	48					
28.5											
29.0											
29.5	29.5	UDS-7									
30.0							Greyish brown, Hard, Silty clay of medium plasticity with gravel	CI			

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122785.015 m	*Easting :*707152.851 m
Reduced Level (m):(+)194.731	*BH. No. :*BH-A1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.53	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*09-11-2021	*Date of Completion :*10-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0										0 10 20 30 40 50 60 70 80 90 100	
30.5											
31.0	31	SPT-14	21	31	40	71					
31.5											
32.0											
32.5	32.5	SPT-15	24	39	46	85					
33.0											
33.5											
34.0	34	SPT-16	27	42	51	93					
34.5											
35.0							Greyish brown, Hard, Silty clay of medium plasticity with gravel	CI			
35.5	35.5	UDS-8									
36.0											
36.5											
37.0	37	SPT-17	21	28	45	73					
37.5											
38.0											
38.5	38.5	UDS-9									
39.0											
39.5											
40.0	40	SPT-18	24	34	49	83					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122775.684 m	*Easting :*707140.474 m
Reduced Level (m):(+)194.755	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-11-2021	*Date of Completion :*09-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	2	2	2	4			2.55m		
3.0											
3.5											
4.0	4	UDS-2									
4.5											
5.0							Grey, Loose, Silty sand with clay	SM-SC			
5.5	5.5	SPT-2	2	3	4	7					
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	2	4	5	9					
9.0											
9.5											
10.0	10	UDS-4									

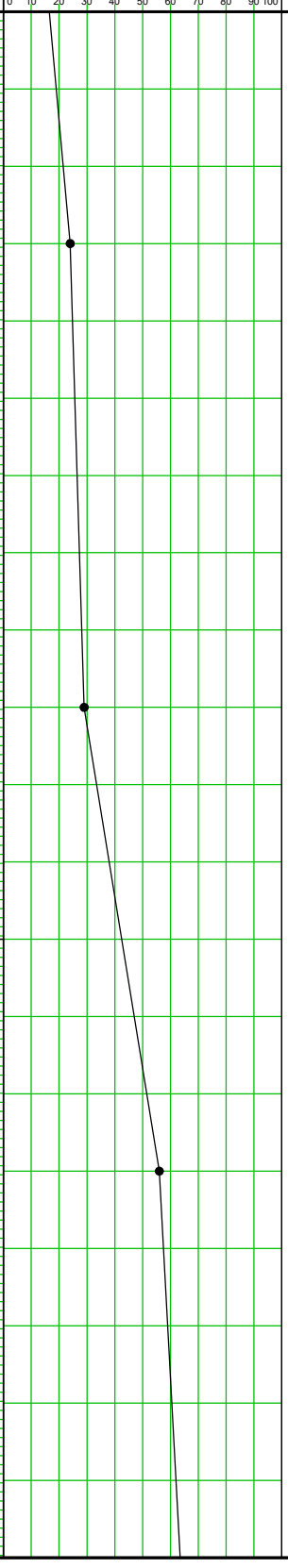
(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122775.684 m	*Easting :*707140.474 m
Reduced Level (m):(+)194.755	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-11-2021	*Date of Completion :*09-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-4	6	10	14	24					
12.0											
12.5											
13.0	13	UDS-5					Greyish brown, Very stiff, Silty clay of low plasticity	CL			
13.5											
14.0											
14.5	14.5	SPT-5	7	12	17	29					
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	12	22	34	56					
18.0							Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
18.5											
19.0	19	UDS-7									
19.5											
20.0											



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122775.684 m	*Easting :*707140.474 m
Reduced Level (m):(+)194.755	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-11-2021	*Date of Completion :*09-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-7	14	27	38	65					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	12	19	24	43					
24.0											
24.5											
25.0	25	UDS-9					Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	SPT-9	14	25	39	64					
27.0											
27.5											
28.0	28	UDS-10									
28.5											
29.0											
29.5	29.5	SPT-10	17	32	54	86					
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122775.684 m	*Easting :*707140.474 m
Reduced Level (m):(+)194.755	*BH. No. :*BH-P1	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.55	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-11-2021	*Date of Completion :*09-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0										0 10 20 30 40 50 60 70 80 90 100	
30.5											
31.0	31	UDS*									
31.5											
32.0											
32.5	32.5	SPT-11	12	19	28	47					
33.0											
33.5											
34.0	34	UDS-11									
34.5											
35.0							Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5	35.5	SPT-12	14	32	43	75					
36.0											
36.5											
37.0	37	UDS-12									
37.5											
38.0											
38.5	38.5	SPT-13	20	34	47	81					
39.0											
39.5											
40.0	40	SPT-14	22	30	42	72					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122766.353 m	*Easting :*707128.097 m
Reduced Level (m):(+)194.784	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-11-2021	*Date of Completion :*09-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	8	4	6	10					
1.5											
2.0											
2.5	2.5	UDS-1							2.50m		
3.0											
3.5							Grey, Loose, Silty sand with clay	SM-SC			
4.0	4	SPT-2	2	3	4	7					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	5	7	12	19					
7.5											
8.0											
8.5	8.5	UDS-3					Greyish brown, Very stiff to hard, Silty clay of low plasticity	CL			
9.0											
9.5											
10.0	10	SPT-4	7	9	15	24					

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122766.353 m	*Easting :*707128.097 m
Reduced Level (m):(+)194.784	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-11-2021	*Date of Completion :*09-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	9	12	18	30					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Greyish brown, Very stiff to hard, Silty clay of low plasticity	CL			
15.5											
16.0	16	SPT-6	10	13	16	29					
16.5											
17.0											
17.5	17.5	UDS*									
18.0	18	SPT-7	9	15	19	34					
18.5											
19.0											
19.5	19.5	SPT-8	11	15	24	39					
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122766.353 m	*Easting :*707128.097 m
Reduced Level (m):(+)194.784	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-11-2021	*Date of Completion :*09-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-6									
21.0											
21.5											
22.0	22	SPT-9	12	14	29	43					
22.5											
23.0							Greyish brown, Very stiff to hard, Silty clay of low plasticity	CL			
23.5	23.5	UDS-7									
24.0											
24.5											
25.0	25	SPT-10	13	20	24	44					
25.5											
26.0											
26.5	26.5	UDS-8									
27.0											
27.5											
28.0	28	SPT-11	12	25	38	63	Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
28.5											
29.0											
29.5	29.5	UDS-9									
30.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+787 km	*Northing :*3122766.353 m	*Easting :*707128.097 m
Reduced Level (m):(+)194.784	*BH. No. :*BH-A2	*BH Termination Depth (m):*40
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*2.50	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-11-2021	*Date of Completion :*09-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
30.0											
30.5											
31.0	31	SPT-12	18	30	42	72					
31.5											
32.0											
32.5	32.5	UDS-10									
33.0											
33.5											
34.0	34	SPT-13	20	34	45	79					
34.5											
35.0							Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
35.5	35.5	UDS-11									
36.0											
36.5											
37.0	37	SPT-14	23	37	44	81					
37.5											
38.0											
38.5	38.5	SPT-15	22	36	46	82					
39.0											
39.5											
40.0	40	SPT-16	24	33	44	77					

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*13+917	*Northing :*3122696.787 m	*Easting :*707035.822 m
Reduced Level (m):(+)194.850	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*2.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not used
*Date of Start :*31-10-2021	*Date of Completion :*31-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification
0.0		DS					Grey, Loose, Sandy silt of low plasticity	ML-CL
0.5	0.5	SPT-1	2	2	3	5		
1.0								
1.5	1.5	SPT-2	3	4	5	9		
2.0								
2.5	2.25	UDS-1						
3.0	3	SPT-3	5	6	10	16	Grey, Very stiff, Silty clay of medium plasticity	CI
3.5								
4.0								
4.5	4.5	SPT-4	4	5	7	12		
5.0								
5.5	5.25	UDS-2						
6.0	6	SPT-5	8	12	18	30	Grey, Dense, Sandy silt of low plasticity	ML-CL
6.5								
7.0								
7.5	7.5	SPT-6	7	10	24	34		
8.0								
8.5	8.25	UDS-3						
9.0	9	SPT-7	7	13	19	32	Grey, Very stiff to hard, Silty clay of low plasticity	CL
9.5								
10.0	10	SPT-8	5	12	17	29		

Graphic Log: 2.90m

(Depth v/s SPT N Value): 0 10 20 30 40 50 60 70 80 90 100

Special Observations

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*14+072	*Northing :*3122602.267 m	*Easting :*706910.449 m
Reduced Level (m):(+)194.471	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*3.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not used
*Date of Start :*31-10-2021	*Date of Completion :*31-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5	0.5	SPT-1	2	2	3	5					
1.0							Brownish grey, Loose, Silty sand with clay	SM-SC			
1.5	1.5	SPT-2	3	4	6	10					
2.0											
	2.25	UDS-1									
2.5											
3.0	3	SPT-3	4	6	9	15			3.10m		
3.5							Brownish grey, Very stiff, Silty clay of medium plasticity	CI			
4.0											
4.5	4.5	SPT-4	3	5	8	13					
5.0											
	5.25	UDS-2									
5.5											
6.0	6	SPT-5	9	12	20	32					
6.5											
7.0											
7.5	7.5	SPT-6	11	13	18	31	Brownish grey, Hard, Silty clay of low plasticity	CL			
8.0											
	8.25	UDS-3									
8.5											
9.0	9	SPT-7	7	12	18	30					
9.5											
10.0	10	SPT-8	6	13	20	33					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*14+415	*Northing :*3122396.987 m	*Easting :*706638.16 m
Reduced Level (m):(+)194.541	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*3.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*31-10-2021	*Date of Completion :*31-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification
0.0		DS						
0.5	0.5	SPT-1	2	3	3	6	Brown, Loose, Sandy silt of low plasticity	ML-CL
1.0								
1.5	1.5	SPT-2	2	3	4	7		
2.0								
	2.25	UDS-1						
2.5								
3.0	3	SPT-3	5	7	12	19	Brown, Very stiff, Silty clay of low plasticity	CL
3.5								
4.0								
4.5	4.5	SPT-4	4	8	13	21		
5.0								
	5.25	UDS-2						
5.5								
6.0	6	SPT-5	7	9	11	20		
6.5								
7.0								
7.5	7.5	SPT-6	8	11	13	24	Brown, Medium dense, Sandy silt of low plasticity	ML-CL
8.0								
	8.25	UDS-3						
8.5								
9.0	9	SPT-7	5	8	10	18		
9.5								
10.0	10	SPT-8	7	10	12	22		

Graphic Log: 3.00m

(Depth v/s SPT N Value): 0 10 20 30 40 50 60 70 80 90 100

Special Observations

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*15+259	*Northing :*3121873.019 m	*Easting :*705971.993 m
Reduced Level (m):(+)193.786	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*2.90	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*31-10-2021	*Date of Completion :*31-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5	0.5	SPT-1	2	4	5	9					
1.0											
1.5	1.5	SPT-2	3	5	7	12					
2.0											
2.5	2.25	UDS-1					Brown, Loose to medium dense, Sandy silt of low plasticity	ML-CL	2.90m		
3.0	3	SPT-3	2	3	4	7					
3.5											
4.0											
4.5	4.5	SPT-4	3	3	5	8					
5.0											
5.5	5.25	UDS-2									
6.0	6	SPT-5	9	13	20	33					
6.5											
7.0											
7.5	7.5	SPT-6	8	10	18	28	Brown, Very stiff, Silty clay of low plasticity	CL			
8.0											
8.5	8.25	UDS-3									
9.0	9	SPT-7	7	12	15	27					
9.5											
10.0	10	SPT-8	8	13	22	35					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*15+416	*Northing :*3121764.321 m	*Easting :*705861.877 m
Reduced Level (m):(+)194.416	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*3.20	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*31-10-2021	*Date of Completion :*31-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5	0.5	SPT-1	2	2	4	6					
1.0											
1.5	1.5	SPT-2	3	3	4	7					
2.0											
	2.25	UDS-1									
2.5											
3.0	3	SPT-3	2	3	3	6			3.20m		
3.5											
4.0											
4.5	4.5	SPT-4	2	4	5	9					
5.0							Brown, Loose to dense, Sandy silt of low plasticity	ML-CL			
	5.25	UDS-2									
5.5											
6.0	6	SPT-5	9	15	18	33					
6.5											
7.0											
7.5	7.5	SPT-6	10	14	18	32					
8.0											
	8.25	UDS-3									
8.5											
9.0	9	SPT-7	7	10	17	27					
9.5											
10.0	10	SPT-8	8	12	20	32					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*15+441	*Northing :*3121753.862 m	*Easting :*705851.853 m
Reduced Level (m):(+)194.160	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*10-11-2021	*Date of Completion :*11-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS-1									
0.5											
1.0	1	UDS-1									
1.5											
2.0							Brown, Loose, Silty sand with clay	SM-SC			
2.5	2.5	SPT-1	2	2	3	5					
3.0									3.00m		
3.5											
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	11	15	21	36					
6.0											
6.5											
7.0	7	UDS-3					Brown, Hard, Silty clay of low plasticity with gravel	CL			
7.5											
8.0											
8.5	8.5	SPT-3	12	17	22	39					
9.0											
9.5											
10.0	10	UDS-4									

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*15+441	*Northing :*3121753.862 m	*Easting :*705851.853 m
Reduced Level (m):(+)194.160	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*10-11-2021	*Date of Completion :*11-11-2021	

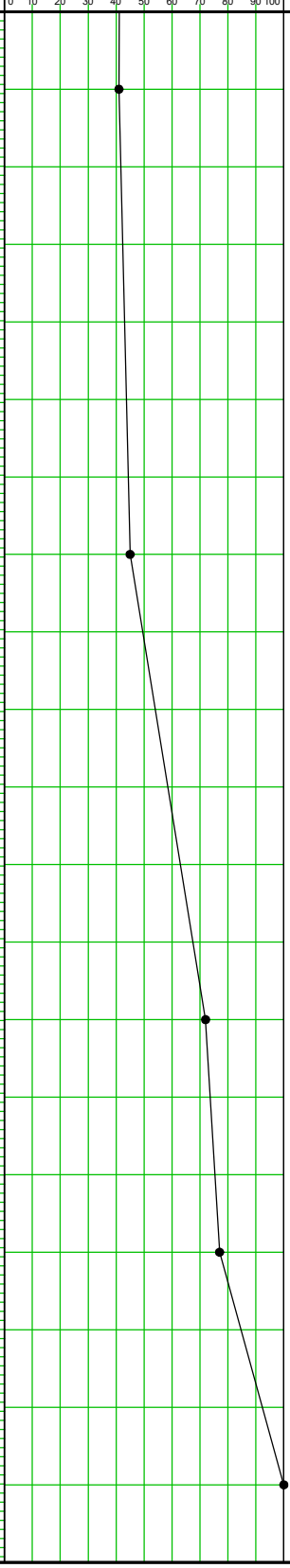
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	SPT-4	8	12	21	33					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	7	12	16	28					
15.0							Brown, Hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	9	15	27	42					
18.0											
18.5											
19.0	19	UDS-7									
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*15+441	*Northing :*3121753.862 m	*Easting :*705851.853 m
Reduced Level (m):(+)194.160	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.00	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*10-11-2021	*Date of Completion :*11-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-7	9	14	27	41					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-8	10	17	28	45					
24.0											
24.5											
25.0	25	UDS-9					Brown, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	SPT-9	17	29	43	72					
27.0											
27.5											
28.0	28	SPT-10	18	30	47	77					
28.5											
29.0											
29.5	29.5	SPT-11	28	42	58 (12cm)	>100					
30.0	29.95	DS-2									



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*15+441	*Northing :*3121739.334 m	*Easting :*705838.108 m
Reduced Level (m):(+)193.216	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*10-11-2021	*Date of Completion :*11-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	3	4	6	10					
1.5											
2.0											
2.5	2.5	UDS-1					Brown, Stiff, Silty clay of low plasticity	CL			
3.0									3.10m		
3.5											
4.0	4	SPT-2	4	5	7	12					
4.5											
5.0											
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	6	10	15	25					
7.5											
8.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	7	15	20	35					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*15+441	*Northing :*3121739.334 m	*Easting :*705838.108 m
Reduced Level (m):(+)193.216	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*10-11-2021	*Date of Completion :*11-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	11	14	25	39					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0							Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	SPT-6	12	16	27	43					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	13	17	25	42					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*15+441	*Northing :*3121739.334 m	*Easting :*705838.108 m
Reduced Level (m):(+)193.216	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*10-11-2021	*Date of Completion :*11-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	12	24	28	52					
22.5											
23.0											
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	13	27	29	56	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	15	25	30	55					
28.5											
29.0											
29.5	29.5	UDS-10									
30.0	30										

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+042	*Northing :*3121279.064 m	*Easting :*705482.626 m
Reduced Level (m):(+)194.075	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.65	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-10-2021	*Date of Completion :*09-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS-1									
0.5											
1.0	1	SPT-1	3	4	4	8					
1.5											
2.0											
	2.25	UDS-1									
2.5											
3.0											
3.5									3.65m		
4.0	4	SPT-2	3	4	7	11					
4.5											
5.0							Brown, Loose to medium dense, Silty sand with clay	SM-SC			
5.5	5.5	UDS*									
6.0	6	SPT-3	5	7	9	16					
6.5											
7.0	7	SPT-4	7	10	12	22					
7.5											
8.0											
8.5	8.5	UDS*									
9.0	9	SPT-5	5	8	10	18					
9.5											
10.0	10	SPT-6	7	10	12	22					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+042	*Northing :*3121279.064 m	*Easting :*705482.626 m
Reduced Level (m):(+)194.075	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.65	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-10-2021	*Date of Completion :*09-10-2021	

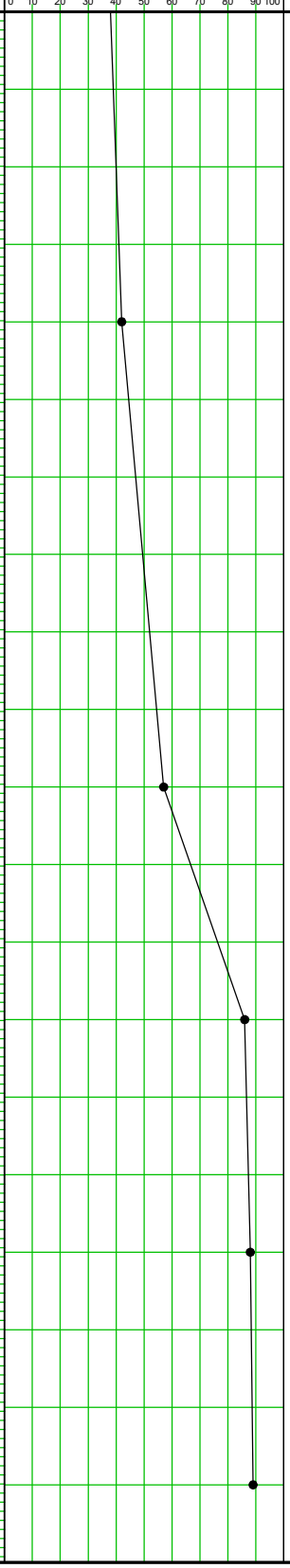
Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	UDS-2									
12.0											
12.5							Brown, Medium dense, Sandy silt of low plasticity	ML-CL			
13.0	13	SPT-7	8	9	12	21					
13.5											
14.0											
14.5	14.5	UDS-3									
15.0											
15.5											
16.0	16	SPT-8	9	14	17	31					
16.5											
17.0											
17.5	17.5	UDS-4					Brown yellowish, Hard, Silty clay of low plasticity with gravel	CL			
18.0											
18.5											
19.0	19	SPT-9	10	15	21	36					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+042	*Northing :*3121279.064 m	*Easting :*705482.626 m
Reduced Level (m):(+)194.075	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.65	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-10-2021	*Date of Completion :*09-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-5									
21.0											
21.5											
22.0	22	SPT-10	12	17	25	42					
22.5											
23.0											
23.5	23.5	UDS-6									
24.0											
24.5											
25.0	25	SPT-11	20	25	32	57	Brown yellowish, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	SPT-12	25	39	47	86					
27.0											
27.5											
28.0	28	SPT-13	32	39	49	88					
28.5											
29.0											
29.5	29.5	SPT-14	25	34	55	89					
30.0	29.95	DS-2									



UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+042	*Northing :*3121262.045 m	*Easting :*705472.02 m
Reduced Level (m):(+)194.105	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.68	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-10-2021	*Date of Completion :*09-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS-1									
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	3	4	5	9					
3.0											
3.5									3.68m		
4.0	4	UDS-2					Brown, Loose to medium dense, Silty sand with clay	SM-SC			
4.5											
5.0											
5.5	5.5	SPT-2	5	7	9	16					
6.0											
6.5											
7.0	7	UDS-3									
7.5	7.5	SPT-3	6	9	10	19					
8.0											
8.5	8.5	SPT-4	11	15	18	33					
9.0							Brown yellowish, Very stiff to hard, Silty clay of low plasticity	CL			
9.5											
10.0	10	UDS-4									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+042	*Northing :*3121262.045 m	*Easting :*705472.02 m
Reduced Level (m):(+)194.105	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.68	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-10-2021	*Date of Completion :*09-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0											
10.5											
11.0											
11.5	11.5	SPT-5	8	9	11	20					
12.0											
12.5											
13.0	13	UDS-5					Brown yellowish, Very stiff to hard, Silty clay of low plasticity	CL			
13.5											
14.0											
14.5	14.5	SPT-6	10	12	15	27					
15.0											
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-7	15	18	24	42					
18.0							Brown yellowish, Hard, Silty clay of low plasticity with gravel	CL			
18.5											
19.0	19	UDS-7									
19.5											
20.0											

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+042	*Northing :*3121262.045 m	*Easting :*705472.02 m
Reduced Level (m):(+)194.105	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.68	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*08-10-2021	*Date of Completion :*09-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-8	20	25	31	56					
21.0											
21.5											
22.0	22	UDS-8									
22.5											
23.0											
23.5	23.5	SPT-9	22	27	35	62					
24.0											
24.5											
25.0	25	UDS-9					Brown yellowish, Hard, Silty clay of low plasticity with gravel	CL			
25.5											
26.0											
26.5	26.5	SPT-10	25	30	47	77					
27.0											
27.5											
28.0	28	SPT-11	21	29	49	78					
28.5											
29.0											
29.5	29.5	SPT-12	27	40	50	90					
30.0	29.95	DS-2									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+231	*Northing :*3121114.308 m	*Easting :*705836.344 m
Reduced Level (m):(+)192.968	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-11-2021	*Date of Completion :*12-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS-1									
0.5											
1.0	1	UDS-1									
1.5											
2.0											
2.5	2.5	SPT-1	2	4	7	11					
3.0									3.13m		
3.5							Greyish brown, Medium dense, Silty sand with clay	SM-SC			
4.0	4	UDS-2									
4.5											
5.0											
5.5	5.5	SPT-2	5	11	16	27					
6.0											
6.5											
7.0	7	UDS-3									
7.5											
8.0											
8.5	8.5	SPT-3	12	22	26	48	Greyish brown, Dense, Sandy silt of low plasticity with gravel	ML-CL			
9.0											
9.5											
10.0	10	UDS-4									

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+231	*Northing :*3121114.308 m	*Easting :*705836.344 m
Reduced Level (m):(+)192.968	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-11-2021	*Date of Completion :*12-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5											
11.0											
11.5	11.5	SPT-4	10	17	22	39					
12.0											
12.5											
13.0	13	UDS-5									
13.5											
14.0											
14.5	14.5	SPT-5	8	13	19	32					
15.0							Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
15.5											
16.0	16	UDS-6									
16.5											
17.0											
17.5	17.5	SPT-6	10	19	26	45					
18.0											
18.5											
19.0	19	UDS-7									
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+231	*Northing :*3121114.308 m	*Easting :*705836.344 m
Reduced Level (m):(+)192.968	*BH. No. :*BH-A1	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.13	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-11-2021	*Date of Completion :*12-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	SPT-7	11	18	29	47	Greyish brown, Hard, Silty clay of low plasticity with gravel	CL			
21.0											
21.5											
22.0	22	UDS*									
22.5	22.5	SPT-8	30	64	36 (10cm)	>100					
23.0											
23.5	23.5	SPT-9	32	67	33 (9cm)	>100					
24.0											
24.5											
25.0	25	SPT-10	35	73	27 (7cm)	>100					
25.5											
26.0											
26.5	26.5	SPT-11	17	34	55	89	Greyish brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL			
27.0											
27.5											
28.0	28	SPT-12	16	31	49	80					
28.5											
29.0											
29.5	29.5	SPT-13	14	35	52	87					
30.0	30	DS-2									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+231	*Northing :*3121096.697 m	*Easting :*705376.865 m
Reduced Level (m):(+)193.065	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-11-2021	*Date of Completion :*12-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS-1									
0.5											
1.0	1	SPT-1	3	4	4	8					
1.5											
2.0											
2.5	2.5	UDS-1									
3.0									3.10m		
3.5											
4.0	4	SPT-2	4	5	7	12					
4.5											
5.0							Greyish brown, Loose to medium dense, Sandy silt of low plasticity	ML-CL			
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	7	10	13	23					
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	9	13	20	33					

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+231	*Northing :*3121096.697 m	*Easting :*705376.865 m
Reduced Level (m):(+)193.065	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-11-2021	*Date of Completion :*12-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
10.0										0 10 20 30 40 50 60 70 80 90 100	
10.5							Greyish brown, Loose to medium dense, Sandy silt of low plasticity	ML-CL			
11.0											
11.5	11.5	UDS-4									
12.0											
12.5											
13.0	13	SPT-5	10	12	16	28					
13.5											
14.0											
14.5	14.5	UDS-5									
15.0											
15.5							Greyish brown, Very stif to Hard, Silty clay of low plasticity with gravel	CL			
16.0	16	SPT-6	12	15	25	40					
16.5											
17.0											
17.5	17.5	UDS-6									
18.0											
18.5											
19.0	19	SPT-7	13	17	22	39					
19.5											
20.0											

UDS*-UDS not recovered

FIELD BOREHOLE LOG

*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+231	*Northing :*3121096.697 m	*Easting :*705376.865 m
Reduced Level (m):(+)193.065	*BH. No. :*BH-A2	*BH Termination Depth (m):*30
*Proposed / Existing Structure :*Major Bridge	*Water Table (m):*3.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*11-11-2021	*Date of Completion :*12-11-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
20.0											
20.5	20.5	UDS-7									
21.0											
21.5											
22.0	22	SPT-8	14	21	25	46					
22.5											
23.0							Greyish brown, Very stif to Hard, Silty clay of low plasticity with gravel	CL			
23.5	23.5	UDS-8									
24.0											
24.5											
25.0	25	SPT-9	15	25	28	53					
25.5											
26.0											
26.5	26.5	UDS-9									
27.0											
27.5											
28.0	28	SPT-10	16	20	27	47	Greyish brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL			
28.5											
29.0											
29.5	29.5	SPT-11	17	24	29	53					
30.0	30	DS-2									

UDS*-UDS not recovered

FIELD BOREHOLE LOG

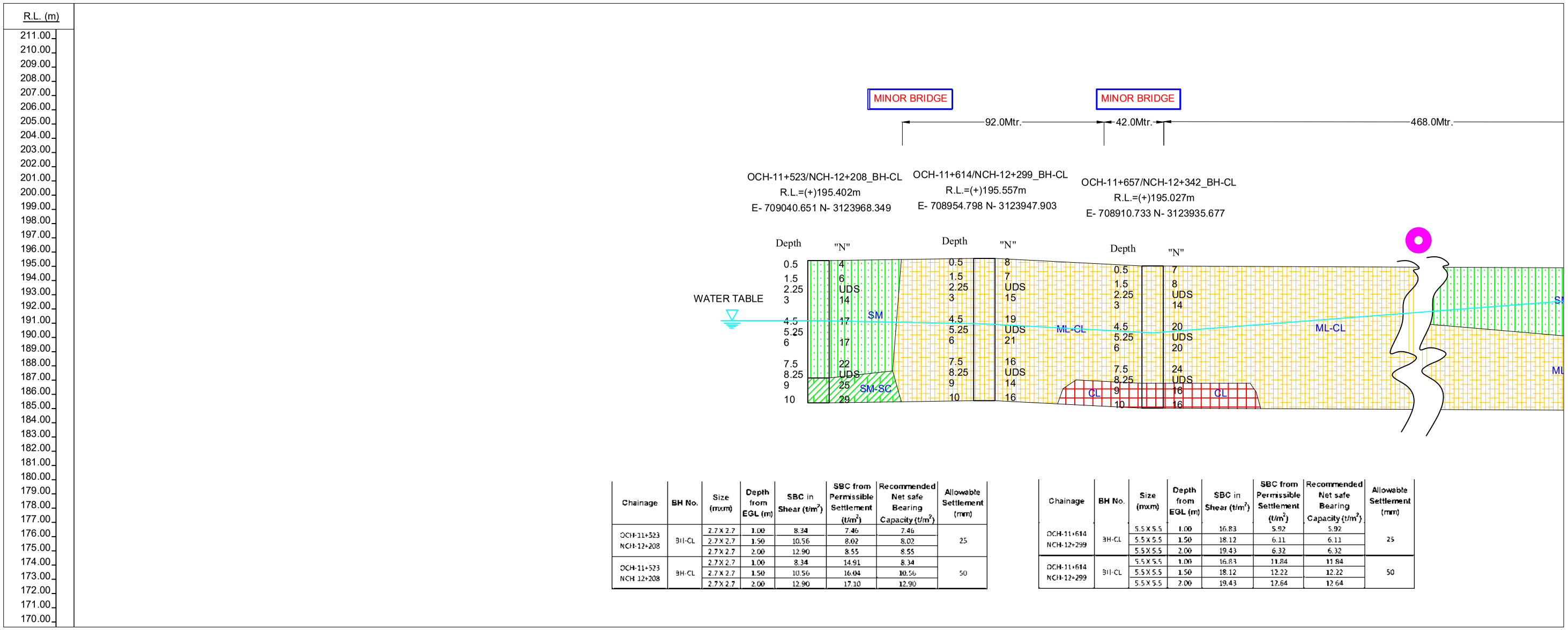
*Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana.		*Client :*HRIDCL
*BH Location/Chainage :*16+815	*Northing :*3120569.349 m	*Easting :*705153.768 m
Reduced Level (m):(+)194.981	*BH. No. :*BH-CL	*BH Termination Depth (m):*10
*Proposed / Existing Structure :*Minor Bridge	*Water Table (m):*4.10	*Inclination :* Vertical
*Boring type :*Rotary	*Dia. of Boring :*150 mm	*Depth of Casing (m) :*Not Used
*Date of Start :*04-10-2021	*Date of Completion :*20-10-2021	

Depth (m)	In-Situ Sample Depth (m)	Sample Type	Blow counts per 15cm N1	N2	N3	SPT N Value	Strata Description	IS Classification	Graphic Log	(Depth v/s SPT N Value)	Special Observations
0.0		DS									
0.5											
1.0	1	SPT-1	2	5	8	13					
1.5											
2.0											
2.5	2.5	UDS-1									
3.0											
3.5											
4.0	4	SPT-2	7	10	19	29			4.10m		
4.5											
5.0							Brown, Medium dense to dense, Sandy silt of low plasticity	ML-CL			
5.5	5.5	UDS-2									
6.0											
6.5											
7.0	7	SPT-3	5	7	12	19					
7.5											
8.0											
8.5	8.5	UDS-3									
9.0											
9.5											
10.0	10	SPT-4	14	19	24	43					

(Depth v/s SPT N Value) axis: 0 10 20 30 40 50 60 70 80 90 100

UDS*-UDS not recovered

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m^2)	SBC from Permissible Settlement (t/m^2)	Recommended Net safe Bearing Capacity (t/m^2)	Allowable Settlement (mm)
OCH-11+523 NCH-12+208	BH-CL	2.7 X 2.7	1.00	8.34	7.46	7.46	25
		2.7 X 2.7	1.50	10.56	8.02	8.02	
		2.7 X 2.7	2.00	12.90	8.55	8.55	
OCH-11+523 NCH 12+208	BH-CL	2.7 X 2.7	1.00	8.34	14.91	8.34	50
		2.7 X 2.7	1.50	10.56	16.04	10.56	
		2.7 X 2.7	2.00	12.90	17.10	12.90	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m^2)	SBC from Permissible Settlement (t/m^2)	Recommended Net safe Bearing Capacity (t/m^2)	Allowable Settlement (mm)
OCH-11+614 NCH-12+299	BH-CL	5.5 X 5.5	1.00	16.83	5.92	5.92	25
		5.5 X 5.5	1.50	18.12	6.11	6.11	
		5.5 X 5.5	2.00	19.43	6.32	6.32	
OCH-11+614 NCH-12+299	BH-CL	5.5 X 5.5	1.00	16.83	11.84	11.84	50
		5.5 X 5.5	1.50	18.12	12.22	12.22	
		5.5 X 5.5	2.00	19.43	12.64	12.64	

Note:-

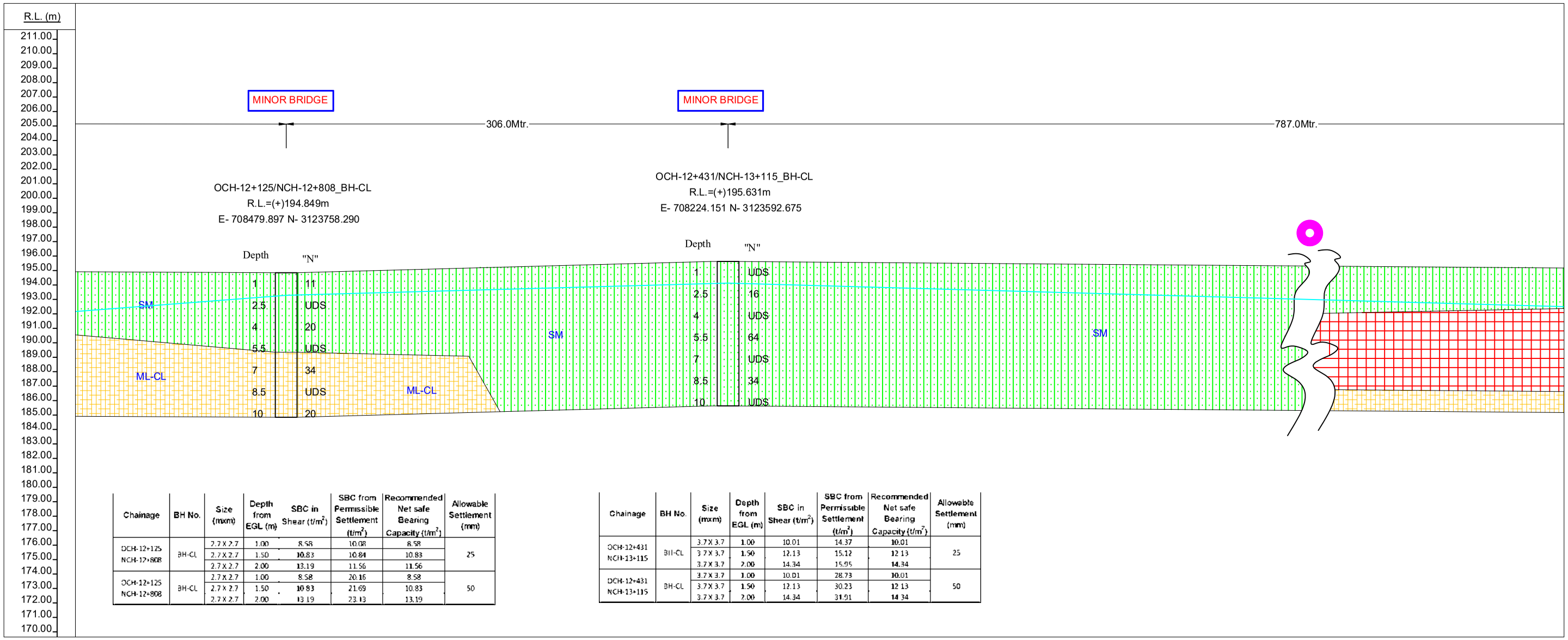
1. The soil stratum in some of the bore holes is found to be liquefiable up to certain depth as given in table 2.1. For these locations the SBC has been re-evaluated considering the soil parameters for replaced/ compacted soil. The modified SBC for the same is provided in the table 4.3 & table 4.4.
2. Bore holes which are liquefied greater than 4m depth, Some other suitable ground improvement methods may be adopted.

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m^2)	SBC from Permissible Settlement (t/m^2)	Recommended Net safe Bearing Capacity (t/m^2)	Allowable Settlement (mm)
OCH-11+657 NCH-12+342	BH-CL	2.5 X 2.5	1.00	14.04	8.06	8.06	25
		2.5 X 2.5	1.50	15.75	8.71	8.71	
		2.5 X 2.5	2.00	17.52	9.30	9.30	
OCH-11+657 NCH 12+342	BH CL	2.5 X 2.5	1.00	14.04	16.12	14.04	50
		2.5 X 2.5	1.50	15.75	17.41	15.75	
		2.5 X 2.5	2.00	17.52	18.60	17.52	

SYMBOL	DESCRIPTION
	SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line)
	SM-SC -Clayey Sand (Having fines Less Than 50% and in the hatched zone (4<PI<7)
	ML-CL -Sandy with clay (Having fines greater than 50% and in the hatched zone (LL<35 & 4<PI<7)
	CL-Silty Clay of low plasticity (Above A-line, LL<35)
	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)
	BOREHOLE REQUIRED / WATER TABLE

Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20) | SCALE:- HOR:- 1:2850 | SCALE:- VER:- 1:285

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m^2)	SBC from Permissible Settlement (t/m^2)	Recommended Net safe Bearing Capacity (t/m^2)	Allowable Settlement (mm)
OCH-12+125 NCH-12+808	BH-CL	2.7 X 2.7	1.00	8.58	10.08	8.58	25
		2.7 X 2.7	1.50	10.83	10.84	10.83	
		2.7 X 2.7	2.00	13.19	11.56	11.56	
OCH-12+125 NCH-12+808	BH-CL	2.7 X 2.7	1.00	8.58	20.16	8.58	50
		2.7 X 2.7	1.50	10.83	21.69	10.83	
		2.7 X 2.7	2.00	13.19	23.13	13.19	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m^2)	SBC from Permissible Settlement (t/m^2)	Recommended Net safe Bearing Capacity (t/m^2)	Allowable Settlement (mm)
OCH-12+431 NCH-13+115	BH-CL	3.7 X 3.7	1.00	10.01	14.37	10.01	25
		3.7 X 3.7	1.50	12.13	15.12	12.13	
		3.7 X 3.7	2.00	14.34	15.95	14.34	
OCH-12+431 NCH-13+115	BH-CL	3.7 X 3.7	1.00	10.01	28.73	10.01	50
		3.7 X 3.7	1.50	12.13	30.23	12.13	
		3.7 X 3.7	2.00	14.34	31.91	14.34	

Note:-

1. The soil stratum in some of the bore holes is found to be liquefiable up to certain depth as given in table 2.1. For these locations the SBC has been re-evaluated considering the soil parameters for replaced/ compacted soil. The modified SBC for the same is provided in the table 4.3 & table 4.4.
2. Bore holes which are liquefied greater than 4m depth, Some other suitable ground improvement methods may be adopted.

SYMBOL	DESCRIPTION
	SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line)
	SM-SC -Clayey Sand (Having fines Less Than 50% and in the hatched zone (4<PI<7)
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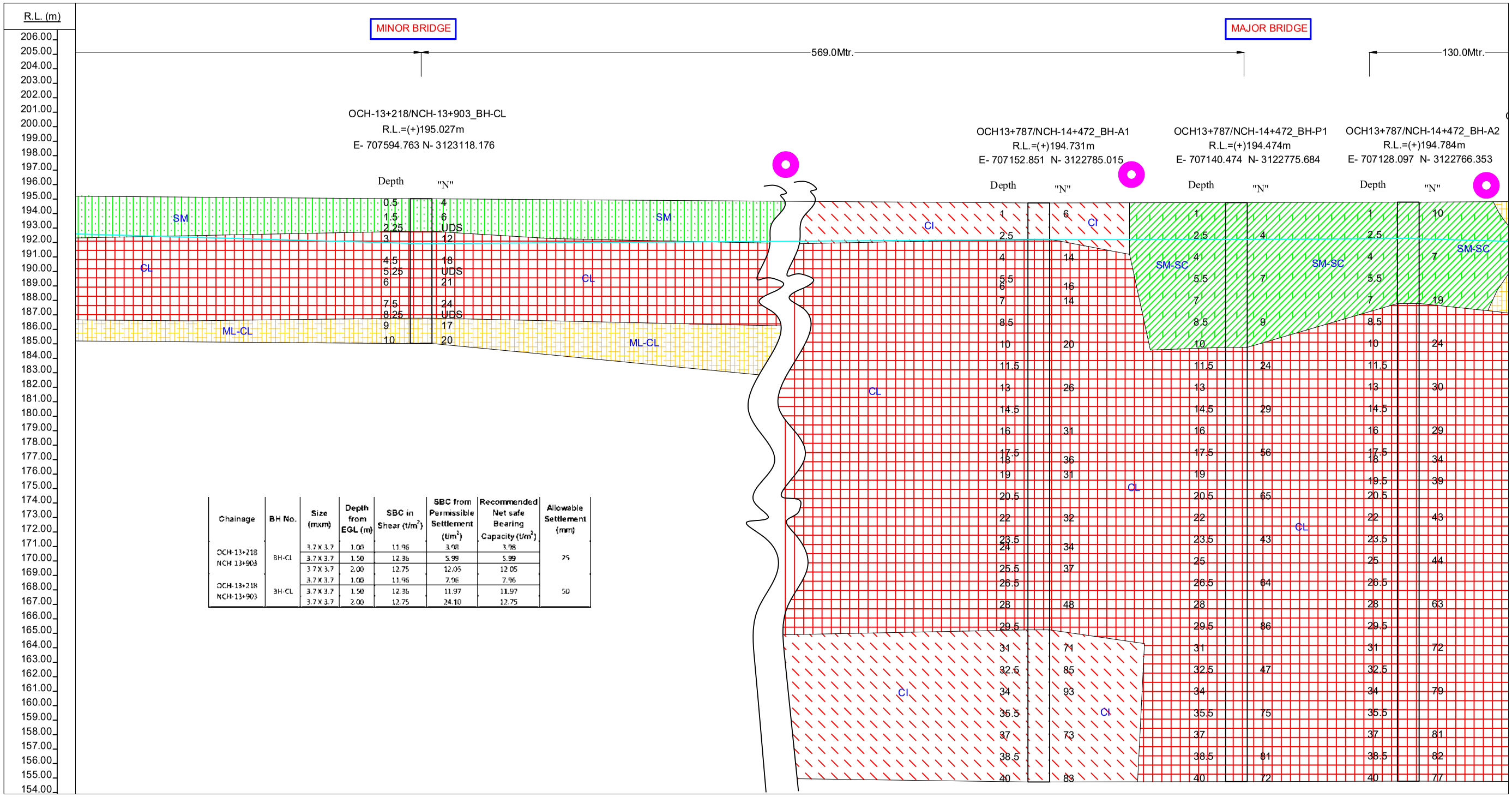
	CL-Silty Clay of low plasticity (Above A-line, LL<35)
	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)
	BOREHOLE REQUIRED / WATER TABLE

Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20) | SCALE:- HOR:- 1:2850 | SCALE:- VER:- 1:285

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-13+218 NCH 13+903	BH-CL	3.7 X 3.7	1.00	11.96	3.98	3.98	25
		3.7 X 3.7	1.50	12.36	5.99	5.99	
		3.7 X 3.7	2.00	12.75	12.05	12.05	
OCH-13+218 NCH-13+903	BH-CL	3.7 X 3.7	1.00	11.96	7.96	7.96	50
		3.7 X 3.7	1.50	12.36	11.97	11.97	
		3.7 X 3.7	2.00	12.75	24.10	12.75	

Note:-

1. The soil stratum in some of the bore holes is found to be liquefiable up to certain depth as given in table 2.1. For these locations the SBC has been re-evaluated considering the soil parameters for replaced/ compacted soil. The modified SBC for the same is provided in the table 4.3 & table 4.4.
2. Bore holes which are liquefied greater than 4m depth, Some other suitable ground improvement methods may be adopted.

SYMBOL	DESCRIPTION
	SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line)
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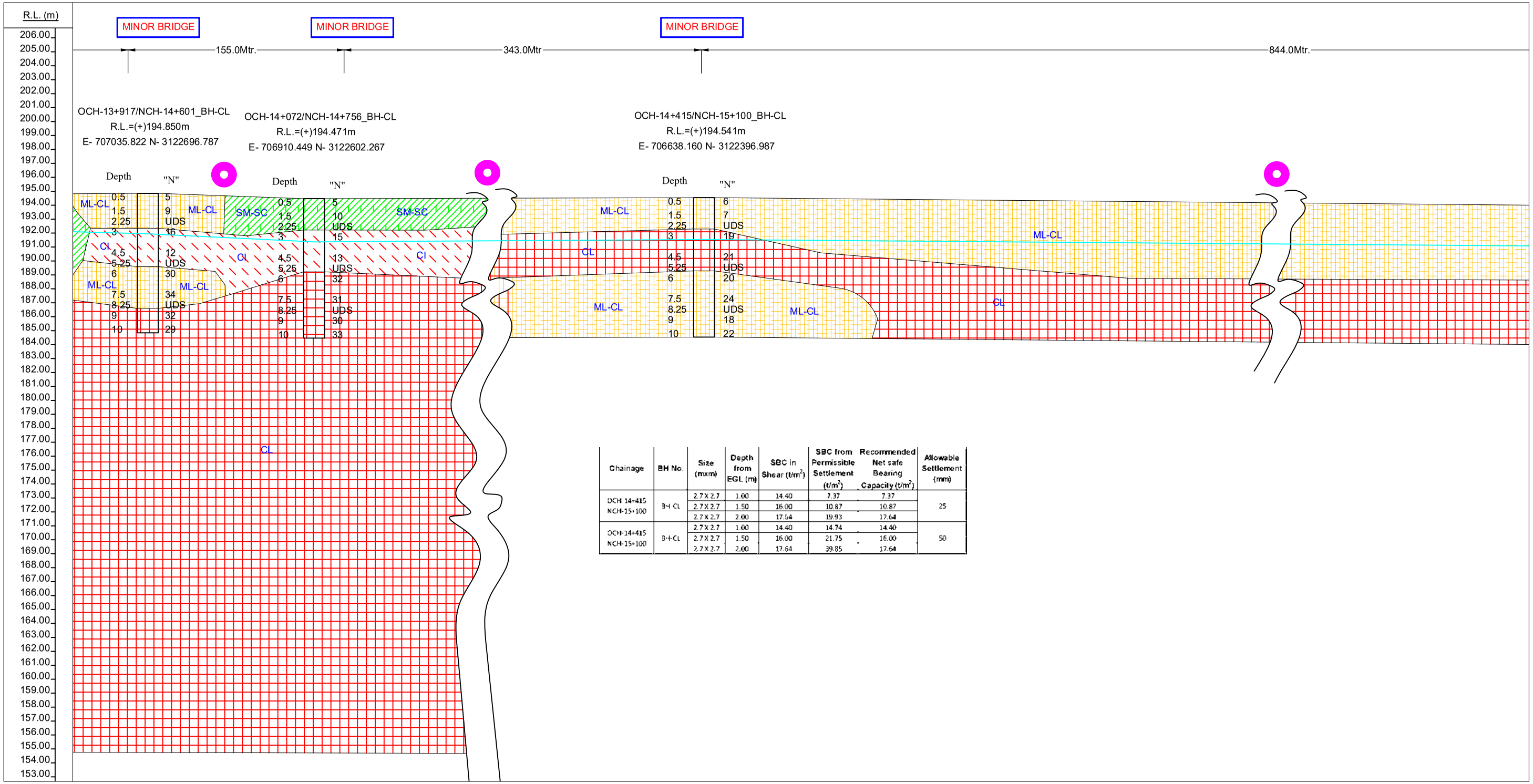
	CL-Silty Clay of low plasticity (Above A-line, LL<35)
	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)
	BOREHOLE REQUIRED / WATER TABLE

Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20) SCALE:- HOR:- 1:2850 SCALE:- VER:- 1:285

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-13+787 NCH 14+472	BH-A1	7.2 X 7.2	2.00	10.94	6.40	6.40	25
		7.2 X 7.2	3.00	11.36	6.75	6.75	
		7.2 X 7.2	4.00	11.77	7.13	7.13	
OCH-13+787 NCH-14+472	BH-A1	7.2 X 7.2	2.00	10.94	12.80	10.94	50
		7.2 X 7.2	3.00	11.36	13.49	11.36	
		7.2 X 7.2	4.00	11.77	14.25	11.77	
OCH 13+787 NCH-14+472	BH-P1	7.2 X 7.2	2.00	14.90	1.77	1.77	25
		7.2 X 7.2	3.00	17.35	1.96	1.96	
		7.2 X 7.2	4.00	19.89	2.23	2.23	
OCH-13+787 NCH-14+472	BH-P1	7.2 X 7.2	2.00	14.90	3.53	3.53	50
		7.2 X 7.2	3.00	17.35	3.92	3.92	
		7.2 X 7.2	4.00	19.89	4.46	4.46	
OCH-13+787 NCH-14+472	BH-A2	7.2 X 7.2	2.00	16.41	5.18	5.18	25
		7.2 X 7.2	3.00	19.04	5.88	5.88	
		7.2 X 7.2	4.00	21.75	6.70	6.70	
OCH-13+787 NCH 14+472	BH-A2	7.2 X 7.2	2.00	16.41	10.36	10.36	50
		7.2 X 7.2	3.00	19.04	11.75	11.75	
		7.2 X 7.2	4.00	21.75	13.40	13.40	

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-14+415 NCH-15+100	BH-CL	2.7 X 2.7	1.00	14.40	7.37	7.37	25
		2.7 X 2.7	1.50	16.00	10.87	10.87	
		2.7 X 2.7	2.00	17.54	19.93	17.64	
OCH-14+415 NCH-15+100	BH-CL	2.7 X 2.7	1.00	14.40	14.74	14.40	50
		2.7 X 2.7	1.50	16.00	21.75	16.00	
		2.7 X 2.7	2.00	17.64	39.85	17.64	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-13+917 NCH-14+601	BH-CL	3.7 X 3.7	1.00	9.62	7.15	7.15	25
		3.7 X 3.7	1.50	9.94	9.49	9.49	
		3.7 X 3.7	2.00	10.25	13.82	10.25	
OCH-13+917 NCH-14+601	BH-CL	3.7 X 3.7	1.00	9.62	14.29	9.62	50
		3.7 X 3.7	1.50	9.94	18.97	9.94	
		3.7 X 3.7	2.00	10.25	27.65	10.25	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-14+072 NCH-14+756	BH-CL	6 X 6	1.00	10.95	5.33	5.33	25
		6 X 6	1.50	11.20	5.75	5.75	
		6 X 6	2.00	11.44	7.01	7.01	
OCH-14+072 NCH-14+756	BH-CL	6 X 6	1.00	10.95	10.67	10.67	50
		6 X 6	1.50	11.20	11.50	11.20	
		6 X 6	2.00	11.44	14.02	11.44	

Note:-

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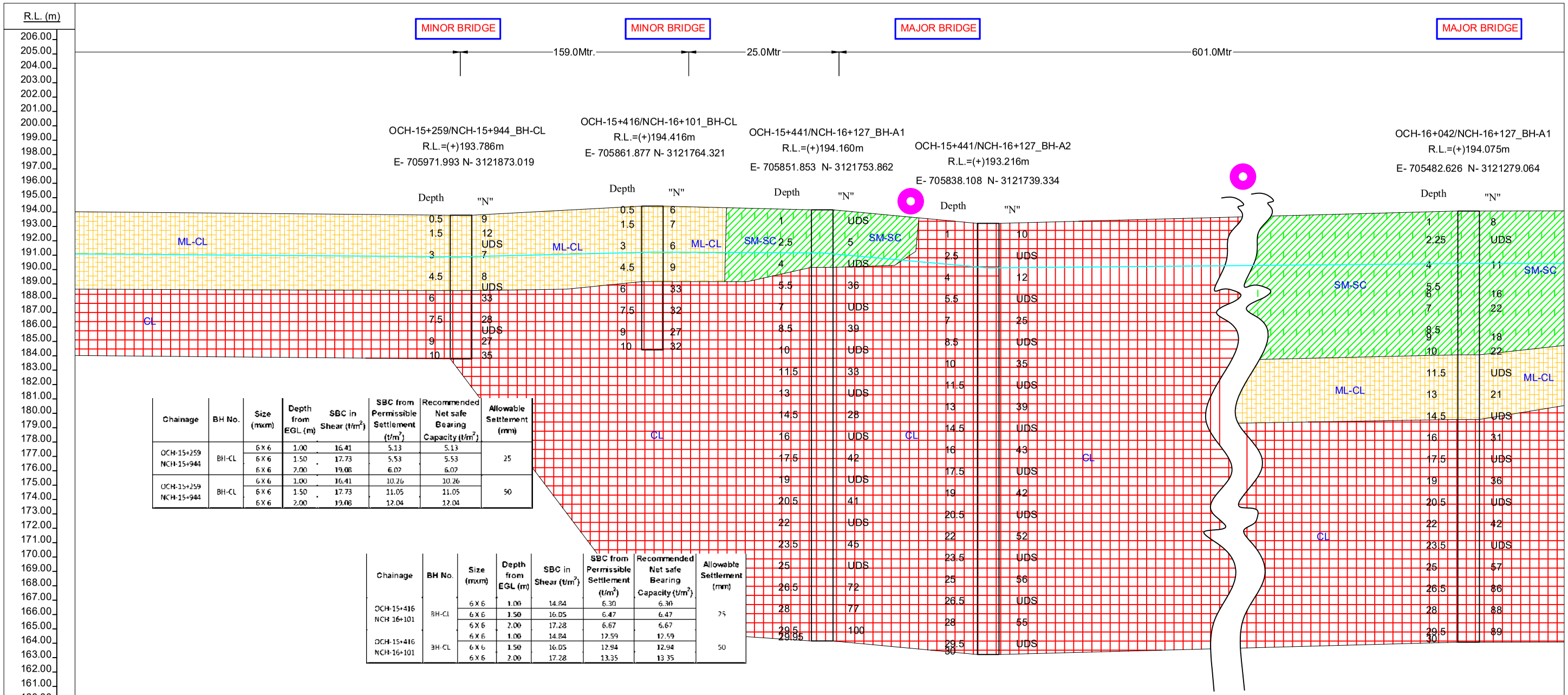
	CL-Silty Clay of low plasticity (Above A-line, LL<35)
	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)
	BOREHOLE REQUIRED / WATER TABLE

Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20) | SCALE:- HOR:- 1:2850 SCALE:- VER:- 1:285

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-15+259 NCH-15+944	BH-CL	6 X 6	1.00	16.41	5.13	5.13	25
		6 X 6	1.50	17.73	5.53	5.53	
		6 X 6	2.00	19.08	6.02	6.07	
OCH-15+259 NCH-15+944	BH-CL	6 X 6	1.00	16.41	10.26	10.26	50
		6 X 6	1.50	17.73	11.05	11.05	
		6 X 6	2.00	19.08	12.04	12.04	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-15+416 NCH-16+101	BH-CL	6 X 6	1.00	14.84	6.30	6.30	25
		6 X 6	1.50	16.05	6.47	6.47	
		6 X 6	2.00	17.28	6.67	6.67	
OCH-15+416 NCH-16+101	BH-CL	6 X 6	1.00	14.84	12.59	12.59	50
		6 X 6	1.50	16.05	12.94	12.94	
		6 X 6	2.00	17.28	13.35	13.35	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-15+441 NCH-16+127	BH-A1	7.2 X 7.2	2.00	34.48	4.41	4.41	25
		7.2 X 7.2	3.00	35.72	4.19	4.19	
		7.2 X 7.2	4.00	36.96	10.82	10.82	
OCH-15+441 NCH-16+127	BH-A1	7.2 X 7.2	2.00	34.48	8.83	8.83	50
		7.2 X 7.2	3.00	35.72	17.42	17.42	
		7.2 X 7.2	4.00	36.96	21.64	21.64	
OCH-15+441 NCH 16+127	BH-A2	7.2 X 7.2	2.00	8.73	8.30	8.30	25
		7.2 X 7.2	3.00	9.05	8.75	8.75	
		7.2 X 7.2	4.00	9.38	9.24	9.24	
OCH-15+441 NCH-16+127	BH-A2	7.2 X 7.2	2.00	8.73	16.60	8.73	50
		7.2 X 7.2	3.00	9.05	17.50	9.05	
		7.2 X 7.2	4.00	9.38	18.48	9.38	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-16+042 NCH-16+727	BH-A1	7.2 X 7.2	2.00	21.70	7.05	7.05	25
		7.2 X 7.2	3.00	25.23	7.43	7.43	
		7.2 X 7.2	4.00	28.88	7.74	7.74	
OCH-16+042 NCH 16+727	BH-A1	7.2 X 7.2	2.00	21.70	28.21	21.70	50
		7.2 X 7.2	3.00	25.23	14.87	14.87	
		7.2 X 7.2	4.00	28.88	15.48	15.48	

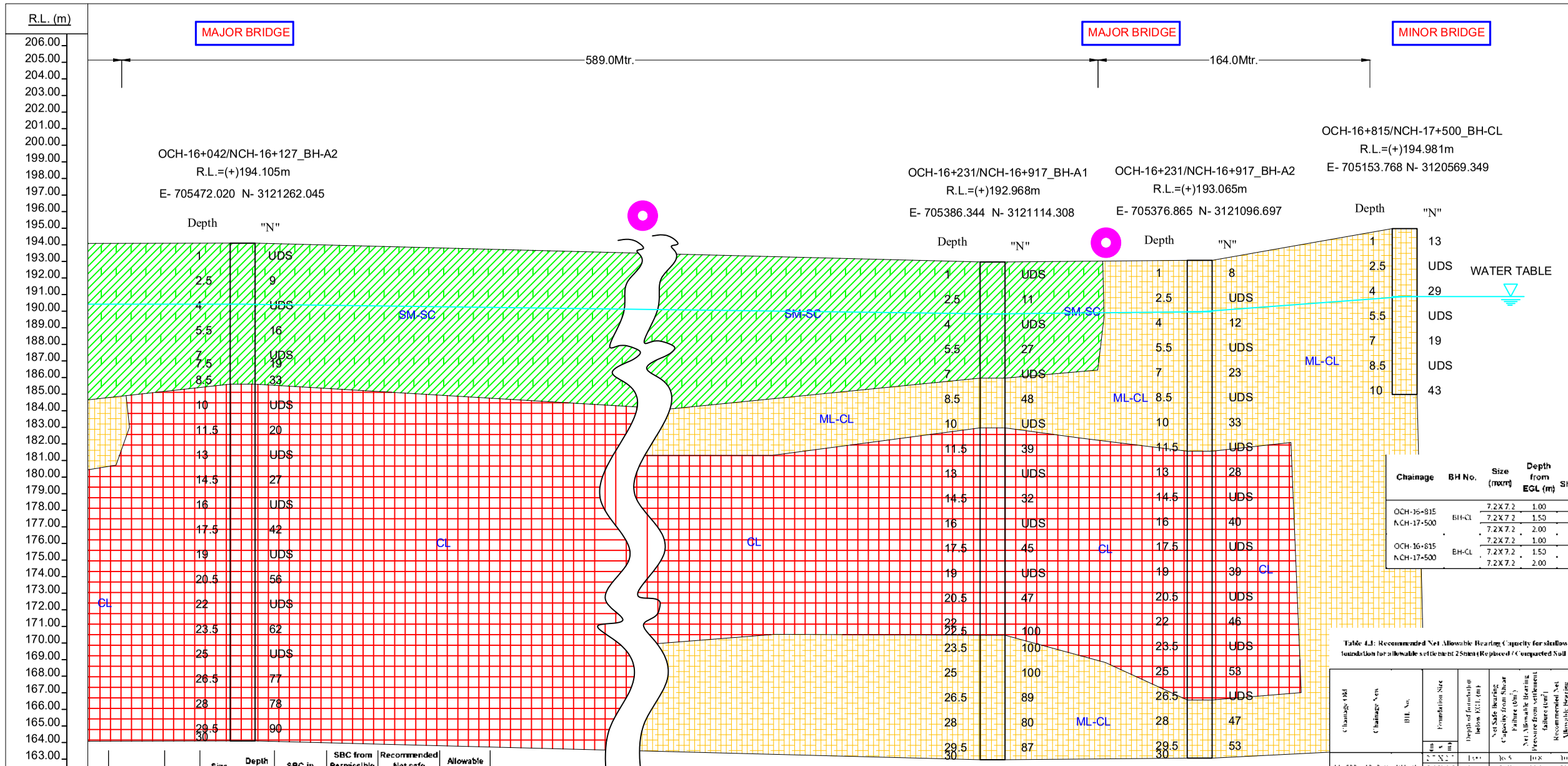
Note:-

1. The soil stratum in some of the bore holes is found to be liquefiable up to certain depth as given in table 2.1. For these locations the SBC has been re-evaluated considering the soil parameters for replaced/ compacted soil. The modified SBC for the same is provided in the table 4.3 & table 4.4.
2. Bore holes which are liquefied greater than 4m depth, Some other suitable ground improvement methods may be adopted.

SYMBOL	DESCRIPTION
	SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line)
	SM-SC -Clayey Sand (Having fines Less Than 50% and in the hatched zone (4<PI<7)
	ML-CL -Sandy with clay (Having fines greater than 50% and in the hatched zone (LL<35 & 4<PI<7)
	CL-Silty Clay of low plasticity (Above A-line, LL<35)
	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)
	BOREHOLE REQUIRED / WATER TABLE

Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20) | SCALE:- HOR:- 1:2850 | SCALE:- VER:- 1:285

CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-16+042 NCH-16+727	BH-A1	7.2 X 7.2	2.00	21.70	7.05	7.05	25
		7.2 X 7.2	3.00	25.73	7.43	7.43	
		7.2 X 7.2	4.00	28.88	7.74	7.74	
OCH-16+042 NCH-16+727	BH-A1	7.2 X 7.2	2.00	21.70	14.10	14.10	50
		7.2 X 7.2	3.00	25.23	14.87	14.87	
		7.2 X 7.2	4.00	28.88	15.48	15.48	
OCH-16+042 NCH-16+727	BH-A2	7.2 X 7.2	2.00	22.09	6.89	6.89	25
		7.2 X 7.2	3.00	25.54	7.67	7.67	
		7.2 X 7.2	4.00	29.12	8.71	8.71	
OCH-16+042 NCH-16+727	BH-A2	7.2 X 7.2	2.00	22.09	13.77	13.77	50
		7.2 X 7.2	3.00	25.54	15.34	15.34	
		7.2 X 7.2	4.00	29.12	17.42	17.42	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-16+231 NCH-16+917	BH-A1	7.2 X 7.2	2.00	29.28	9.73	9.73	25
		7.2 X 7.2	3.00	33.19	10.26	10.26	
		7.2 X 7.2	4.00	37.22	10.97	10.97	
OCH-16+231 NCH-16+917	BH-A1	7.2 X 7.2	2.00	29.28	19.47	19.47	50
		7.2 X 7.2	3.00	33.19	20.53	20.53	
		7.2 X 7.2	4.00	37.22	21.94	21.94	
OCH-16+231 NCH-16+917	BH-A2	7.2 X 7.2	2.00	29.30	7.31	7.31	25
		7.2 X 7.2	3.00	26.45	7.69	7.69	
		7.2 X 7.2	4.00	29.70	8.20	8.20	
OCH-16+231 NCH-16+917	BH-A2	7.2 X 7.2	2.00	29.30	14.67	14.67	50
		7.2 X 7.2	3.00	26.45	15.38	15.38	
		7.2 X 7.2	4.00	29.70	16.39	16.39	

Chainage	BH No.	Size (mxm)	Depth from EGL (m)	SBC in Shear (t/m²)	SBC from Permissible Settlement (t/m²)	Recommended Net safe Bearing Capacity (t/m²)	Allowable Settlement (mm)
OCH-16+815 NCH-17+500	BH-CL	7.2 X 7.2	1.00	23.42	10.55	10.55	25
		7.2 X 7.2	1.50	25.11	10.77	10.77	
		7.2 X 7.2	2.00	26.83	11.04	11.04	
OCH-16+815 NCH-17+500	BH-CL	7.2 X 7.2	1.00	23.42	21.10	21.10	50
		7.2 X 7.2	1.50	25.11	21.53	21.53	
		7.2 X 7.2	2.00	26.83	22.08	22.08	

Note:-

1. The soil stratum in some of the bore holes is found to be liquefiable up to certain depth as given in table 2.1. For these locations the SBC has been re-evaluated considering the soil parameters for replaced/ compacted soil. The modified SBC for the same is provided in the table 4.3 & table 4.4.
2. Bore holes which are liquefied greater than 4m depth, Some other suitable ground improvement methods may be adopted.

SYMBOL	DESCRIPTION
	SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line)
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	CL-Silty Clay of low plasticity (Above A-line, LL<35)
	CI- Clay of medium plasticity (Above A-line, 35≤LL<50)
	BOREHOLE REQUIRED / WATER TABLE

Note:- Fines= Percentage of Silty + Clay A-line=.73(wl-20) | SCALE:- HOR:- 1:2850 | SCALE:- VER:- 1:285

Table 4.3: Recommended Net Allowable Bearing Capacity for shallow foundation for allowable settlement 25mm (Replaced / Compacted Soil)

Chainage +Rd	Chainage Ven	BH No.	Foundation Size (m x m)	Depth of foundation below R.L (m)	Net Safe Bearing Capacity from Shear Failure (t/m²)	Net Allowable Bearing Pressure from settlement failure (t/m²)	Recommended Net Allowable Bearing Capacity (t/m²)
11-923	12-268	BH-CL	7.2X7.2	1.00	23.42	10.55	10.55
			7.2X7.2	1.50	25.11	10.77	10.77
			7.2X7.2	2.00	26.83	11.04	11.04
11-611	12-299	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
11-687	12-342	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
13-218	13-993	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
13-787	13-572	BH-A2	7.2X7.2	1.00	29.30	7.31	7.31
			7.2X7.2	2.00	26.45	7.69	7.69
			7.2X7.2	3.00	29.70	8.20	8.20
13-917	13-601	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
14-052	13-756	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
14-185	13-889	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
15-298	14-021	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
15-486	14-160	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
15-711	14-327	BH-A1	7.2X7.2	3.00	33.19	20.53	20.53
			7.2X7.2	1.00	29.28	19.47	19.47
			7.2X7.2	2.00	33.19	21.94	21.94
16-012	14-727	BH-A1	7.2X7.2	3.00	37.22	22.36	22.36
			7.2X7.2	1.00	29.28	19.47	19.47
			7.2X7.2	2.00	33.19	21.94	21.94
16-231	14-917	BH-A2	7.2X7.2	3.00	37.22	22.36	22.36
			7.2X7.2	1.00	29.30	7.31	7.31
			7.2X7.2	2.00	26.45	7.69	7.69

Table 4.4: Recommended Net Allowable Bearing Capacity for shallow foundation for allowable settlement 50mm (Replaced / Compacted Soil)

Chainage +Rd	Chainage Ven	BH No.	Foundation Size (m x m)	Depth of foundation below R.L (m)	Net Safe Bearing Capacity from Shear Failure (t/m²)	Net Allowable Bearing Pressure from settlement failure (t/m²)	Recommended Net Allowable Bearing Capacity (t/m²)
11-923	12-268	BH-CL	7.2X7.2	1.00	23.42	21.10	21.10
			7.2X7.2	1.50	25.11	21.53	21.53
			7.2X7.2	2.00	26.83	22.08	22.08
11-611	12-299	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
11-687	12-342	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
13-218	13-993	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
13-787	13-572	BH-A2	7.2X7.2	1.00	29.30	7.31	7.31
			7.2X7.2	2.00	26.45	7.69	7.69
			7.2X7.2	3.00	29.70	8.20	8.20
13-917	13-601	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
14-052	13-756	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
14-185	13-889	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
15-298	14-021	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
15-486	14-160	BH-CL	6.8X6.8	1.00	23.42	21.10	21.10
			6.8X6.8	1.50	25.11	21.53	21.53
			6.8X6.8	2.00	26.83	22.08	22.08
15-711	14-327	BH-A1	7.2X7.2	3.00	33.19	20.53	20.53
			7.2X7.2	1.00	29.28	19.47	19.47
			7.2X7.2	2.00	33.19	21.94	21.94
16-012	14-727	BH-A1	7.2X7.2	3.00	37.22	22.36	22.36
			7.2X7.2	1.00	29.28	19.47	19.47
			7.2X7.2	2.00	33.19	21.94	21.94
16-231	14-917	BH-A2	7.2X7.2	3.00	37.22	22.36	22.36
			7.2X7.2	1.00	29.30	7.31	7.31
			7.2X7.2	2.00	26.45	7.69	7.69

APPENDIX – B (LAB TEST RESULTS)

Appendix No.	ITEMS
B-1	SOIL CHARACTERISTICS SHEETS
B-2	RESULT OF CHEMICAL ANALYSIS OF SOIL SAMPLES
B-3	GSD CURVES

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						30-10-2021	to	30-10-2021	11+523 Minor Bridge	BH-CL	4.22 m	10.00 m	709040.651 m	3123968.349 m	(+)195.402 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Loose, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	4	7		SM		0	19	75	6	0	0	0	-	Nil	NP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-2	1.50	6	9		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-		SM		0	26	68	4	2	0	0	-	Nil	NP	-	1.65	12.16	1.47	2.62	DST	0.00	27	-	-	-	-	-	-	-	-	-
SPT-3	3.00	14	17	Brown, Medium dense, Silty sand	SM		0	20	73	6	1	0	0	-	Nil	NP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	17	18		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-		SM		0	39	53	6	1	1	0	-	Nil	NP	-	1.78	15.89	1.54	2.63	DST	0.00	29	-	-	-	-	-	-	-	-	-
SPT-5	6.00	17	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	22	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-	Brown, Medium dense, Silty sand with clay	SM-SC		5	36	51	6	1	1	0	25	20	5	-	1.82	17.46	1.55	2.65	DST	0.10	28	-	-	-	-	-	-	-	-	-
SPT-7	9.00	25	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	29	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEGTH
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AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						30-10-2021	to	30-10-2021	11+614 Minor Bridge	BH-CL	4.60 m	10.00 m	708954.798 m	3123947.903 m	(+)195.557 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Loose, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	8	14		ML-CL		6	47	40	7	0	0	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-2	1.50	7	10		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-	Brown, Medium dense, Sandy silt of low plasticity	ML-CL		8	52	31	7	1	1	0	28	21	7	-	1.78	15.10	1.55	2.66	DST	0.21	24	-	-	-	-	-	-	-	-	-
SPT-3	3.00	15	18		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	19	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-		ML-CL		7	55	28	6	2	2	0	27	20	7	-	1.83	19.12	1.54	2.66	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	6.00	21	18		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	16	15		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-		ML-CL		7	52	30	6	3	2	0	27	21	6	-	1.84	20.30	1.53	2.66	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	9.00	14	13		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	16	15		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEGTH
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SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						30-10-2021	to	30-10-2021	11+657 Minor Bridge	BH-CL	4.70 m	10.00 m	708910.733 m	3123935.677 m	(+)195.027 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS	0.00	-	-	Brown, Loose to medium dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	7	13		ML-CL		7	47	40	4	2	0	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-2	1.50	8	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-		ML-CL		6	45	38	6	3	2	0	26	20	6	-	1.73	15.25	1.50	2.66	DST	0.18	24	-	-	-	-	-	-	-	-	-
SPT-3	3.00	14	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	20	22		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-		ML-CL		8	45	41	3	1	2	0	28	21	7	-	1.83	18.89	1.54	2.66	DST	0.20	25	-	-	-	-	-	-	-	-	-
SPT-5	6.00	20	18		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	24	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-	Brown, Medium stiff to stiff, Silty clay of low plasticity	CL		11	50	28	6	3	2	0	32	21	11	-	1.93	26.81	1.52	2.68	UUT	0.56	5	-	-	-	-	-	-	-	-	-
SPT-7	9.00	16	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	16	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEGTH
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SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						06-10-2021	to	06-10-2021	12+125 Minor Bridge	BH-CL	1.56 m	10.00 m	708479.897 m	3123758.290 m	(+)194.849 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium dense, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	11	17		SM		0	24	67	5	3	1	0	-	Nil	NP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		SM		0	20	73	3	2	2	0	-	Nil	NP	-	1.76	14.33	1.54	2.62	DST	0.00	29	-	-	-	-	-	-	-	-	-
SPT-2	4.00	20	21		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Medium dense to dense, Sandy silt of low plasticity	ML-CL		7	48	31	7	3	4	0	27	20	7	-	1.89	19.60	1.58	2.66	DST	0.20	25	-	-	-	-	-	-	-	-	-
SPT-3	7.00	34	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		8	48	33	5	3	3	0	28	21	7	-	1.86	20.30	1.55	2.66	DST	0.21	24	-	-	-	-	-	-	-	-	-
SPT-4	10.00	20	18		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		06-10-2021	to	06-10-2021	12+431 Minor Bridge	BH-CL	1.50 m	10.00 m	708224.151 m	3123592.675 m	(+)195.631 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium dense, Silty sand	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM		0	20	72	4	3	1	0	-	Nil	NP	-	1.74	13.22	1.54	2.62	DST	0.00	28	-	-	-	-	-	-	-	-
SPT-1	2.50	16	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Brown, Dense to very dense, Silty sand with gravel	SM		0	29	61	3	2	5	0	-	Nil	NP	-	1.88	15.60	1.63	2.62	DST	0.00	31	-	-	-	-	-	-	-	-
SPT-2	5.50	64	46		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		SM		0	29	64	2	1	4	0	-	Nil	NP	-	1.84	16.54	1.58	2.63	DST	0.00	30	-	-	-	-	-	-	-	-
SPT-3	8.50	34	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

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SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		31-10-2021	to	31-10-2021	13+218 Minor Bridge	BH-CL	3.10 m	10.00 m	707594.763 m	3123118.176 m	(+)195.027 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	4	7	Brown, Loose, Silty sand	SM		0	14	79	6	1	0	0	-	Nil	NP	-	1.67	14.16	1.46	2.62	DST	0.00	27	-	-	-	-	-	-	-	-
SPT-2	1.50	6	9		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-		CL		10	54	29	5	1	1	0	31	21	10	-	1.83	20.30	1.52	2.67	UUT	0.53	5	-	-	-	-	-	-	-	-
SPT-3	3.00	12	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	18	18	Brown, Very stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-		CL		12	49	30	6	1	2	0	32	21	11	-	1.96	25.60	1.56	2.68	UUT	0.75	6	-	-	-	-	-	-	-	-
SPT-5	6.00	21	21		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	24	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-	Brown, Medium dense, Sandy silt of low plasticity	ML-CL		7	50	30	7	4	2	0	27	20	7	-	1.84	20.10	1.53	2.66	DST	0.21	24	-	-	-	-	-	-	-	-
SPT-7	9.00	17	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	20	17		ML-CL		8	48	33	6	2	3	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

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SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							09-11-2021	to	10-11-2021	13+787 Major Bridge	BH-A1	2.53 m	40.00 m	707152.851 m	3122785.015 m	(+)194.731 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %			Shrinkage Limit	Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index						Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Greyish brown, Medium stiff, Silty clay of medium plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	6	6		CI		16	65	13	5	1	0	0	39	24	15	-	1.65	14.00	1.45	2.70	UUT+	0.23	4	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-	Greyish brown, Stiff to very stiff, Silty clay of low plasticity	CL		13	55	23	4	3	2	0	33	22	11	-	1.93	27.11	1.52	2.68	UUT	0.49	4	-	-	-	-	-	-	-	-	-
SPT-2	4.00	14	14		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	5.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	6.00	16	16		CL		12	53	24	6	3	2	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	7.00	14	14		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	8.50	-	-		CL		11	53	26	6	1	3	0	31	20	11	-	1.95	26.06	1.55	2.67	UUT	0.70	5	-	-	-	-	-	-	-	-	-
SPT-5	10.00	20	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	11.50	-	-		CL		12	52	24	7	1	4	0	32	21	11	-	1.97	24.80	1.58	2.68	UUT	0.88	5	-	-	-	-	-	-	-	-	-
SPT-6	13.00	26	26		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	14.50	-	-	Greyish brown, Hard, Silty clay of low plasticity with gravel	CL		12	54	23	4	3	4	0	33	22	11	-	1.98	23.84	1.60	2.67	UUT	1.02	6	-	-	-	-	-	-	-	-	-
SPT-7	16.00	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	17.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	18.00	36	36		CL		13	49	26	2	5	3	2	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	19.00	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	20.50	-	-		CL		13	55	20	6	1	5	0	34	23	11	-	1.98	23.90	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	22.00	32	32				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	23.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

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AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location		B.H. No.		Depth of Water Table		Termination Depth		Cordinates (E,N)						R.L.		Ref. Code			
							09-11-2021	to	10-11-2021	13+787 Major Bridge		BH-A1		2.53 m		40.00 m		707152.851 m			3122785.015 m			(+)194.731 m		SR-544_21-22			
Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-11	24.00	34	34	Greyish brown, Hard, Silty clay of low plasticity with gravel	CL		11	51	21	9	2	6	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	25.50	37	37		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	26.50	-	-		CL		12	48	23	7	4	5	1	31	20	11	-	2.01	23.07	1.63	2.68	UUT	1.42	5	-	-	-	0.645	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	7.10 4.97 3.89 3.08	1.84 1.24 0.78 0.53	0.1100
SPT-13	28.00	48	48		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	29.50	-	-	Greyish brown, Hard, Silty clay of medium plasticity with gravel	CI		15	50	18	7	2	7	1	37	24	13	-	2.04	20.79	1.69	2.67	UUT	2.56	5	-	-	-	-	-	-	-	-
SPT-14	31.00	71	71		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	32.50	85	85		CI		16	51	16	4	3	10	0	38	24	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	34.00	93	93		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	35.50	-	-		CI		17	51	13	6	2	8	3	40	25	15	-	2.04	20.67	1.69	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-17	37.00	73	73		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	38.50	-	-		CI		16	53	15	5	2	9	0	39	24	15	-	2.05	20.45	1.70	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-18	40.00	83	83		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						08-11-2021	to	09-11-2021	13+787 Major Bridge	BH-P1	2.55 m	40.00 m	707140.474 m	3122775.684 m	(+)194.755 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM-SC		6	38	48	5	2	1	0	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	2.50	4	5		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-	Grey, Loose, Silty sand with clay	SM-SC		5	35	51	6	1	2	0	25	20	5	-	1.69	15.10	1.47	2.65	DST	0.09	25	-	-	-	-	-	-	-	-	-
SPT-2	5.50	7	8		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		SM-SC		5	40	45	7	2	1	0	25	20	5	-	1.71	15.60	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	9	10		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		11	53	29	5	1	1	0	31	21	10	-	1.97	24.74	1.58	2.67	UUT	0.82	5	-	-	-	-	-	-	-	-	-
SPT-4	11.50	24	24	Greyish brown, Very stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		13	55	24	3	2	3	0	34	23	11	-	1.98	23.88	1.60	2.68	UUT	0.95	6	-	-	-	-	-	-	-	-	-
SPT-5	14.50	29	29		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		11	57	20	6	1	5	0	31	21	10	-	2.01	22.08	1.65	2.68	UUT	1.85	5	-	-	-	-	-	-	-	-	-
SPT-6	17.50	56	56		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL		12	51	23	4	3	6	1	32	21	11	-	2.02	21.10	1.67	2.67	UUT	2.03	6	-	-	-	-	-	-	-	-	-
SPT-7	20.50	65	65	Greyish brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL		10	56	21	5	1	7	0	31	21	10	-	2.00	23.36	1.62	2.68	UUT	1.42	5	-	-	-	-	-	-	-	-	-
SPT-8	23.50	43	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		CL		13	51	19	6	3	8	0	34	23	11	-	2.03	21.78	1.67	2.68	UUT	2.08	5	-	-	-	-	-	-	-	-	-
SPT-9	26.50	64	64		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
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CEGTH
CEG TEST HOUSE
AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location		B.H. No.		Depth of Water Table		Termination Depth		Cordinates (E,N)						R.L.		Ref. Code			
							08-11-2021	to	09-11-2021	13+787 Major Bridge		BH-P1		2.55 m		40.00 m		707140.474 m			3122775.684 m			(+)194.755 m		SR-544_21-22			
Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
UDS-10	28.00	-	-	Greyish brown, Hard, Silty clay of low plasticity with gravel	CL		12	51	22	6	1	6	2	32	21	11	-	2.04	20.70	1.69	2.67	UUT	2.50	6	-	-	-	-	-	-	-	-
SPT-10	29.50	86	86		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	31.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	32.50	47	47		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-11	34.00	-	-		CL		13	51	20	5	2	9	0	33	22	11	-	2.03	21.06	1.68	2.67	UUT	2.37	6	-	-	-	-	-	-	-	-
SPT-12	35.50	75	75		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-12	37.00	-	-		CL		15	53	13	6	2	11	0	34	23	11	-	2.03	21.10	1.68	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	38.50	81	81		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	40.00	72	72		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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		08-11-2021	to	09-11-2021	13+787 Major Bridge	BH-A2	2.50 m	40.00 m	707128.097 m	3122766.353 m	(+)194.784 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Grey, Loose, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	10	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		SM-SC		5	36	53	6	0	0	0	25	20	5	-	1.73	15.42	1.50	2.65	DST	0.11	26	-	-	-	-	-	-	-	-	-
SPT-2	4.00	7	9		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		SM-SC		6	39	48	5	2	0	0	26	20	6	-	1.75	16.62	1.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	19	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		CL		11	58	23	5	1	2	0	31	20	11	-	1.95	25.16	1.56	2.67	UUT	0.75	5	-	-	-	-	-	-	-	-	-
SPT-4	10.00	24	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		CL		12	55	21	7	1	3	1	32	21	11	-	1.98	23.80	1.60	2.68	UUT	1.02	6	-	-	-	-	-	-	-	-	-
SPT-5	13.00	30	30		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		11	53	25	6	1	4	0	31	21	10	-	1.98	23.89	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	16.00	29	29	Greyish brown, Very stiff to hard, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	17.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	18.00	34	34		CL		13	55	20	5	2	5	0	34	23	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	19.50	39	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	20.50	-	-		CL		12	51	22	7	1	6	1	32	21	11	-	2.00	23.24	1.62	2.68	UUT	1.40	6	-	-	-	-	-	-	-	-	-
SPT-9	22.00	43	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	23.50	-	-		CL		10	51	24	6	2	7	0	30	20	10	-	2.01	23.30	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	25.00	44	44		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
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									Fine	Medium	Coarse	Fine	Coarse																				
UDS-8	26.50	-	-	Greyish brown, Hard, Silty clay of low plasticity with gravel	CL		11	50	20	7	3	9	0	31	20	11	-	2.03	21.69	1.67	2.67	UUT	2.18	5	-	-	-	-	-	-	-	-
SPT-11	28.00	63	63		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	29.50	-	-		CL		12	51	19	6	1	11	0	33	22	11	-	2.03	21.30	1.67	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	31.00	72	72		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	32.50	-	-		CL		13	51	21	3	2	10	0	34	23	11	-	2.05	21.08	1.69	2.68	UUT	2.56	5	-	-	-	-	-	-	-	-
SPT-13	34.00	79	79		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-11	35.50	-	-		CL		12	48	22	7	2	8	1	33	22	11	-	2.04	20.89	1.69	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	37.00	81	81		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-15	38.50	82	82		CL		10	52	21	6	1	10	0	31	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-16	40.00	77	77		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							31-10-2021	to	31-10-2021	13+917 Minor Bridge	BH-CL	2.90 m	10.00 m	707035.822 m	3122696.787 m	(+)194.850 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Grey, Loose, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	5	9		ML-CL		7	46	40	6	1	0	0	26	20	6	-	1.69	13.50	1.49	2.66	DST+	0.20	23	-	-	-	-	-	-	-	-	-
SPT-2	1.50	9	13		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-	Grey, Very stiff, Silty clay of medium plasticity	CI		19	71	5	4	1	0	0	44	24	20	-	1.91	27.10	1.50	2.70	UUT	0.44	4	-	-	-	0.800	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	7.73 5.29 3.77 3.12	2.14 1.88 1.24 0.74	0.1660
SPT-3	3.00	16	16		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	12	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-	Grey, Dense, Sandy silt of low plasticity	ML-CL		7	47	36	5	1	4	0	26	20	6	-	1.89	19.67	1.58	2.66	DST	0.21	25	-	-	-	-	-	-	-	-	-
SPT-5	6.00	30	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	34	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-	Grey, Very stiff to hard, Silty clay of low plasticity	CL		11	50	28	6	2	3	0	32	21	11	-	1.99	24.16	1.60	2.68	UUT	1.03	5	-	-	-	-	-	-	-	-	-
SPT-7	9.00	32	32		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	29	29		CL		12	54	25	3	2	4	0	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEGTH
CEG TEST HOUSE
AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						31-10-2021	to	31-10-2021	14+072 Minor Bridge	BH-CL	3.10 m	10.00 m	706910.449 m	3122602.267 m	(+)194.471 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brownish grey, Loose, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	5	9		SM-SC		5	37	51	7	0	0	0	25	20	5	-	1.69	12.50	1.50	2.65	DST+	0.09	26	-	-	-	-	-	-	-	-	-
SPT-2	1.50	10	15		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-	Brownish grey, Very stiff, Silty clay of medium plasticity	CI		16	71	10	3	0	0	0	38	24	14	-	1.89	25.46	1.51	2.71	UUT	0.51	4	-	-	-	0.795	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	5.89 4.88 3.90 3.13	2.37 1.72 1.16 0.70	0.156
SPT-3	3.00	15	15		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	13	13		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-	Brownish grey, Hard, Silty clay of low plasticity	CL		11	52	25	7	1	4	0	32	21	11	-	1.99	24.10	1.60	2.68	UUT	1.02	5	-	-	-	-	-	-	-	-	-
SPT-5	6.00	32	32		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-		CL		12	53	23	6	1	5	0	33	22	11	-	1.99	24.19	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	9.00	30	30		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	33	33		CL		11	54	21	7	3	4	0	32	21	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							31-10-2021	to	31-10-2021	14+415 Minor Bridge	BH-CL	3.00 m	10.00 m	706638.160 m	3122396.987 m	(+)194.541 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Loose, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	6	11		ML-CL		6	48	38	7	1	0	0	26	20	6	-	1.67	12.50	1.48	2.66	DST+	0.19	23	-	-	-	-	-	-	-	-
SPT-2	1.50	7	10		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-	Brown, Very stiff, Silty clay of low plasticity	CL		14	52	21	7	2	4	0	34	23	11	-	1.86	20.30	1.55	2.68	UUT	0.71	4	-	-	-	-	-	-	-	-
SPT-3	3.00	19	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	21	21		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-	Brown, Medium dense, Sandy silt of low plasticity	ML-CL		8	53	28	7	1	3	0	28	21	7	-	1.86	20.24	1.55	2.66	DST	0.22	24	-	-	-	-	-	-	-	-
SPT-5	6.00	20	19		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	24	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-		ML-CL		7	53	30	5	3	2	0	27	20	7	-	1.86	20.60	1.54	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	9.00	18	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	22	18		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						31-10-2021	to	31-10-2021	15+259 Minor Bridge	BH-CL	2.90 m	10.00 m	705971.993 m	3121873.019 m	(+)193.786 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Loose to medium dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	9	16		ML-CL		7	52	32	6	2	1	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-2	1.50	12	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-		ML-CL		6	54	33	4	3	0	0	26	20	6	-	1.76	17.13	1.50	2.66	DST	0.19	24	-	-	-	-	-	-	-	-	-
SPT-3	3.00	7	9		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	8	10		ML-CL		8	55	30	5	1	1	0	28	21	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-	Brown, Very stiff, Silty clay of low plasticity	CL		11	56	22	6	1	4	0	32	21	11	-	1.99	24.23	1.60	2.67	UUT	1.05	5	-	-	-	-	-	-	-	-	-
SPT-5	6.00	33	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	28	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-		CL		12	49	26	6	2	3	2	33	22	11	-	2.00	24.80	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	9.00	27	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	35	35		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							31-10-2021	to	31-10-2021	15+416 Minor Bridge	BH-CL	3.20 m	10.00 m	705861.877 m	3121764.321 m	(+)194.416 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Loose to dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	0.50	6	11		ML-CL		7	53	32	5	2	1	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-2	1.50	7	10		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-		ML-CL		5	55	32	5	3	0	0	29	22	7	-	1.76	17.54	1.50	2.65	DST	0.18	24	-	-	-	-	-	-	-	-	-
SPT-3	3.00	6	7		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	4.50	9	10		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.25	-	-		ML-CL		7	56	31	4	1	1	0	29	22	7	-	1.86	17.51	1.58	2.66	DST	0.20	25	-	-	-	-	-	-	-	-	-
SPT-5	6.00	33	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	7.50	32	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.25	-	-		ML-CL		9	51	32	6	1	1	0	29	22	7	-	1.87	17.18	1.60	2.66	DST	0.19	26	-	-	-	-	-	-	-	-	-
SPT-7	9.00	27	21		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	10.00	32	23		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							10-11-2021	to	11-11-2021	15+441 Major Bridge	BH-A1	3.00 m	30.00 m	705851.853 m	3121753.862 m	(+)194.160 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS-1	0.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-	Brown, Loose, Silty sand with clay	SM-SC		5	37	51	6	1	0	0	25	20	5	-	1.64	13.10	1.45	2.65	DST	0.10	25	-	-	-	-	-	-	-	-	-
SPT-1	2.50	5	6		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-		CL		10	46	28	7	3	5	1	30	20	10	-	1.99	23.68	1.61	2.67	UUT	1.13	6	-	-	-	-	-	-	-	-	-
SPT-2	5.50	36	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		CL		12	51	26	5	1	5	0	33	22	11	-	2.00	23.60	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	8.50	39	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		11	46	30	6	1	4	2	32	21	11	-	1.99	23.62	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	11.50	33	33		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		12	44	28	8	3	5	0	33	22	11	-	1.98	23.70	1.60	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	28	28	Brown, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		13	48	24	6	2	7	0	34	23	11	-	2.00	23.16	1.62	2.68	UUT	1.38	6	-	-	-	-	-	-	-	-	-
SPT-6	17.50	42	42		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL		11	43	30	7	3	6	0	31	20	11	-	1.99	22.90	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	20.50	41	41		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL		11	47	28	7	1	6	0	31	20	11	-	2.00	22.41	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	23.50	45	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		CL		12	46	26	6	1	9	0	33	22	11	-	2.03	21.10	1.68	2.68	UUT	2.35	6	-	-	-	-	-	-	-	-	-
SPT-9	26.50	72	72		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
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CEG TEST HOUSE AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		10-11-2021	to	11-11-2021	15+441 Major Bridge	BH-A1	3.00 m	30.00 m	705851.853 m	3121753.862 m	(+)194.160 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-10	28.00	77	77	Brown, Hard, Silty clay of low plasticity with gravel	CL		10	41	30	4	5	10	0	30	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	29.50	100 (27cm)	100 (27cm)		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DS-2	29.95	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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							10-11-2021	to	11-11-2021	15+441 Major Bridge	BH-A2	3.10 m	30.00 m	705838.108 m	3121739.334 m	(+)193.216 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
DS	0.00	-	-	Brown, Stiff, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	10	10		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		CL		12	68	13	5	1	1	0	33	22	11	-	1.72	15.43	1.49	2.68	UUT	0.39	4	-	-	-	0.795	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	8.54 6.28 4.71 4.14	2.03 1.82 1.16 0.74	0.166
SPT-2	4.00	12	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	CL		14	61	15	5	1	3	1	34	23	11	-	1.97	24.81	1.58	2.68	UUT	0.85	5	-	-	-	-	-	-	-	-
SPT-3	7.00	25	25		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		CL		13	57	18	6	2	4	0	33	22	11	-	1.99	23.60	1.61	2.67	UUT	1.19	4	-	-	-	-	-	-	-	-
SPT-4	10.00	35	35		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-		CL		11	57	20	6	1	5	0	32	21	11	-	2.00	23.16	1.62	2.68	UUT	1.36	5	-	-	-	-	-	-	-	-
SPT-5	13.00	39	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		12	56	17	3	5	7	0	33	22	11	-	2.00	23.19	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	16.00	43	43		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		13	61	14	5	1	5	1	34	23	11	-	1.99	22.96	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	19.00	42	42		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		11	60	16	3	4	6	0	31	20	11	-	2.01	22.40	1.64	2.68	UUT	1.79	5	-	-	-	-	-	-	-	-
SPT-8	22.00	52	52		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		CL		12	60	15	6	1	6	0	32	21	11	-	2.03	22.73	1.65	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	56	56		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-		CL		12	53	20	7	1	7	0	33	22	11	-	2.01	21.97	1.65	-	-	-	-	-	-	-	-	-	-	-	-	-

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CEG TEST HOUSE AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.						Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
							10-11-2021	to	11-11-2021	15+441 Major Bridge	BH-A2	3.10 m	30.00 m	705838.108 m	3121739.334 m	(+)193.216 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																			
SPT-10	28.00	55	55	Brown, Very stiff to hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-10	29.50	-	-		CL		13	55	17	4	3	8	0	34	23	11	-	2.03	22.03	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-
-	30.00		-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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		08-10-2021	to	09-10-2021	16+042 Major Bridge	BH-A1	3.65 m	30.00 m	705482.626 m	3121279.064 m	(+)194.075 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS-1	0.00	-	-	Brown, Loose to medium dense, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	8	13		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.25	-	-		SM-SC		5	35	54	2	3	1	0	25	20	5	-	1.71	14.16	1.50	2.65	DST	0.10	26	-	-	-	-	-	-	-	-	-
SPT-2	4.00	11	13		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	5.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	6.00	16	17		SM-SC		6	37	50	3	2	2	0	26	21	5	-	1.77	16.00	1.53	2.65	DST+	0.11	27	-	-	-	-	-	-	-	-	-
SPT-4	7.00	22	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	8.50	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	9.00	18	17		SM-SC		4	23	64	5	2	2	0	25	20	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	10.00	22	19	Brown, Medium dense, Sandy silt of low plasticity	ML-CL		6	54	31	5	1	2	1	26	20	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	11.50	-	-		ML-CL		7	58	25	4	3	3	0	27	21	6	-	1.86	20.86	1.54	2.66	DST	0.20	24	-	-	-	-	-	-	-	-	-
SPT-7	13.00	21	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	14.50	-	-	Brown yellowish, Hard, Silty clay of low plasticity with gravel	CL		10	59	24	2	1	4	0	30	20	10	-	1.98	23.84	1.60	2.68	UUT	1.06	5	-	-	-	-	-	-	-	-	-
SPT-8	16.00	31	31		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	17.50	-	-		CL		12	58	21	3	1	5	0	33	22	11	-	1.99	23.54	1.61	2.67	UUT	1.23	4	-	-	-	-	-	-	-	-	-
SPT-9	19.00	36	36		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	20.50	-	-		CL		11	55	23	4	1	5	1	32	21	11	-	2.00	23.41	1.62	2.68	UUT	1.40	4	-	-	-	-	-	-	-	-	-
SPT-10	22.00	42	42		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	23.50	-	-		CL		12	49	24	5	3	7	0	34	23	11	-	2.04	20.86	1.69	2.68	UUT	2.74	4	-	-	-	-	-	-	-	-	-

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CEGTH
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AND RESEARCH CENTRE PVT LTD

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		08-10-2021	to	09-10-2021	16+042 Major Bridge	BH-A1	3.65 m	30.00 m	705482.626 m	3121279.064 m	(+)194.075 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-11	25.00	57	57	Brown yellowish, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	26.50	86	86		CL		11	48	21	7	4	8	1	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	28.00	88	88		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-14	29.50	89	89		CL		10	53	20	4	2	11	0	31	20	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DS-2	29.95	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.					Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
						08-10-2021	to	09-10-2021	16+042 Major Bridge	BH-A2	3.68 m	30.00 m	705472.020 m	3121262.045 m	(+)194.105 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS-1	0.00	-	-	Brown, Loose to medium dense, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM-SC		5	34	55	5	1	0	0	25	20	5	-	1.69	12.76	1.50	2.65	DST	0.11	25	-	-	-	-	-	-	-	-	-
SPT-1	2.50	9	12		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-		SM-SC		3	43	44	7	3	0	0	25	20	5	-	1.75	14.26	1.53	2.65	DST	0.12	26	-	-	-	-	-	-	-	-	-
SPT-2	5.50	16	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-		SM-SC		4	45	40	8	2	1	0	26	21	5	-	1.76	14.80	1.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.50	19	18		SM-SC		4	32	58	5	1	0	0	25	19	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-4	8.50	33	25	Brown yellowish, Very stiff to hard, Silty clay of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-		CL		12	60	20	3	4	1	0	33	22	11	-	1.96	24.30	1.58	2.68	UUT	0.85	4	-	-	-	-	-	-	-	-	-
SPT-5	11.50	20	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		11	61	18	3	5	2	0	32	21	11	-	1.96	23.88	1.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-6	14.50	27	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-	Brown yellowish, Hard, Silty clay of low plasticity with gravel	CL		13	59	18	4	1	5	0	34	23	11	-	1.99	22.70	1.62	2.67	UUT	1.40	4	-	-	-	0.650	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.46 6.91 6.14 5.01	1.84 1.18 0.88 0.49	0.1030
SPT-7	17.50	42	42		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL		12	56	20	3	2	7	0	33	22	11	-	2.02	22.40	1.65	2.68	UUT	1.83	5	-	-	-	-	-	-	-	-	-
SPT-8	20.50	56	56		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	22.00	-	-		CL		12	55	17	5	3	6	2	32	21	11	-	2.02	21.89	1.66	2.68	UUT	1.98	4	-	-	-	-	-	-	-	-	-
SPT-9	23.50	62	62				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	25.00	-	-		CL		13	50	19	7	2	9	0	34	23	11	-	2.04	20.79	1.69	2.67	UUT	2.50	4	-	-	-	-	-	-	-	-	-

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CEGTH
CEG TEST HOUSE
AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		08-10-2021	to	09-10-2021	16+042 Major Bridge	BH-A2	3.68 m	30.00 m	705472.020 m	3121262.045 m	(+)194.105 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-10	26.50	77	77	Brown yellowish, Hard, Silty clay of low plasticity with gravel	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-11	28.00	78	78		CL		12	55	16	6	3	7	1	33	22	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-12	29.50	90	90		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DS-2	29.95	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

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		11-11-2021	to	12-11-2021	16+231 Major Bridge	BH-A1	3.13 m	30.00 m	705836.344 m	3121114.308 m	(+)192.968 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS-1	0.00	-	-	Greyish brown, Medium dense, Silty sand with clay	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	1.00	-	-		SM-SC		6	37	48	7	1	1	0	26	20	6	-	1.71	13.46	1.51	2.65	DST	0.11	26	-	-	-	-	-	-	-	-	-
SPT-1	2.50	11	14		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	4.00	-	-		SM-SC		5	33	51	6	2	3	0	25	20	5	-	1.80	15.20	1.56	2.65	DST	0.10	27	-	-	-	-	-	-	-	-	-
SPT-2	5.50	27	23		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	7.00	-	-	Greyish brown, Dense, Sandy silt of low plasticity with gravel	ML-CL		8	50	32	3	2	5	0	27	20	7	-	1.88	17.64	1.60	2.66	DST	0.22	27	-	-	-	-	-	-	-	-	-
SPT-3	8.50	48	32		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	10.00	-	-	Greyish brown, Hard, Silty clay of low plasticity with gravel	CL		10	52	28	5	1	4	0	31	21	10	-	1.99	23.41	1.61	2.68	UUT	1.19	5	-	-	-	0.665	0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0	9.51 6.36 5.22 4.01	1.70 1.28 0.84 0.54	0.1130
SPT-4	11.50	39	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	13.00	-	-		CL		12	47	26	7	3	5	0	33	22	11	-	1.99	23.80	1.61	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-5	14.50	32	32		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	16.00	-	-		CL		11	45	31	4	2	5	2	32	21	11	-	2.00	22.46	1.63	2.67	UUT	1.48	6	-	-	-	-	-	-	-	-	-
SPT-6	17.50	45	45		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	19.00	-	-		CL		12	47	26	5	4	6	0	32	21	11	-	1.99	22.30	1.63	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	20.50	47	47		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS*	22.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-8	22.50	100 (25cm)	-	Greyish brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		7	49	28	4	2	10	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	23.50	100 (19cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-10	25.00	100 (22cm)	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

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		11-11-2021	to	12-11-2021	16+231 Major Bridge	BH-A1	3.13 m	30.00 m	705836.344 m	3121114.308 m	(+)192.968 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-11	26.50	89	37	Greyish brown, Very dense, Sandy silt of low plasticity with gravel	ML-CL		8	51	27	6	1	7	0	28	21	7	-	1.95	19.00	1.64	2.66	DST+	0.18	29	-	-	-	-	-	-	-	-
SPT-12	28.00	80	34		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-13	29.50	87	35		ML-CL		7	44	29	9	3	8	0	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DS-2	30.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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						11-11-2021	to	12-11-2021	16+231 Major Bridge	BH-A2	3.10 m	30.00 m	705376.865 m	3121096.697 m	(+)193.065 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS-1	0.00	-	-	Greyish brown, Loose to medium dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	8	13		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		8	53	30	7	1	1	0	28	21	7	-	1.74	15.26	1.51	2.66	DST	0.20	24	-	-	-	-	-	-	-	-	-	-
SPT-2	4.00	12	14		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		ML-CL		7	55	28	6	1	3	0	27	20	7	-	1.82	17.26	1.55	2.67	DST	0.19	25	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	23	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		6	51	31	6	2	4	0	26	20	6	-	1.87	18.62	1.58	2.66	DST	0.20	26	-	-	-	-	-	-	-	-	-	-
SPT-4	10.00	33	24		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-4	11.50	-	-	Greyish brown, Very stif to Hard, Silty clay of low plasticity with gravel	CL		11	50	27	5	3	4	0	31	20	11	-	1.98	24.41	1.59	2.68	UUT	0.95	5	-	-	-	-	-	-	-	-	-	-
SPT-5	13.00	28	28		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-5	14.50	-	-		CL		12	46	28	7	1	6	0	33	22	11	-	1.99	23.10	1.62	2.67	UUT	1.31	6	-	-	-	-	-	-	-	-	-	-
SPT-6	16.00	40	40		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-6	17.50	-	-		CL		10	53	25	4	3	5	0	30	20	10	-	1.99	22.76	1.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-7	19.00	39	39		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-7	20.50	-	-		CL		11	49	26	6	2	6	0	32	21	11	-	2.02	22.89	1.64	2.68	UUT	1.65	5	-	-	-	-	-	-	-	-	-	-
SPT-8	22.00	46	46		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-8	23.50	-	-		CL		12	44	28	7	1	7	1	33	22	11	-	2.01	22.70	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-9	25.00	53	53				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-9	26.50	-	-	Greyish brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		8	48	30	6	2	6	0	28	21	7	-	1.91	20.16	1.59	2.66	DST	0.18	27	-	-	-	-	-	-	-	-	-	-
SPT-10	28.00	47	23		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

CEG TEST HOUSE AND RESEARCH CENTRE PVT LTD

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		11-11-2021	to	12-11-2021	16+231 Major Bridge	BH-A2	3.10 m	30.00 m	705376.865 m	3121096.697 m	(+)193.065 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	$C_v \times 10^{-4}$ (cm^2/Sec)	$M_v \times 10^{-2}$ (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
SPT-11	29.50	53	24	Greyish brown, Dense to very dense, Sandy silt of low plasticity with gravel	ML-CL		7	44	32	6	2	7	2	27	20	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DS-2	30.00	-	-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

SOIL CHARACTERISTICS

Project	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.	Date of Boring			Chainage (km.)/Location	B.H. No.	Depth of Water Table	Termination Depth	Cordinates (E,N)		R.L.	Ref. Code
		04-10-2021	to	20-10-2021	16+815 Minor Bridge	BH-CL	4.10 m	10.00 m	705153.768 m	3120569.349 m	(+)194.981 m	SR-544_21-22

Sample Type	Depth from G.L. (m)	Observed SPT Value (N)	Corrected SPT Value (N_c)	Soil Description	IS Classification	IS Symbol	Grain Size Distribution % wt retained							Atterberg Limits %				Bulk Density (g/cm^3)	Natural Moisture Content (%)	Dry Density (g/cm^3)	Specific Gravity	Shear Strength			Free Swell Index (%)	Swelling Pressure (kg/cm^2)	Permeability (cm/sec)	Consolidation Parameters				
							Clay	Silt	Sand			Gravel		Liquid Limit	Plastic Limit	Plasticity Index	Shrinkage Limit					Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (φ°)				Void Ratio (e_0)	Pressure (kg/cm^2)	C_v x 10^{-4} (cm^2/Sec)	M_v x 10^{-2} (cm^2/Kg)	Compression Index (C_c)
									Fine	Medium	Coarse	Fine	Coarse																				
DS	0.00	-	-	Brown, Medium dense to dense, Sandy silt of low plasticity	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-1	1.00	13	20		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-1	2.50	-	-		ML-CL		7	46	41	3	1	2	0	27	20	7	-	1.81	16.23	1.56	2.66	DST	0.20	25	-	-	-	-	-	-	-	-	-
SPT-2	4.00	29	32		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-2	5.50	-	-		ML-CL		6	45	38	7	3	1	0	26	20	6	-	1.84	18.42	1.55	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPT-3	7.00	19	17		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UDS-3	8.50	-	-		ML-CL		8	47	37	2	2	4	0	28	21	7	-	1.88	19.10	1.58	2.66	DST	0.19	26	-	-	-	-	-	-	-	-	-
SPT-4	10.00	43	27		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

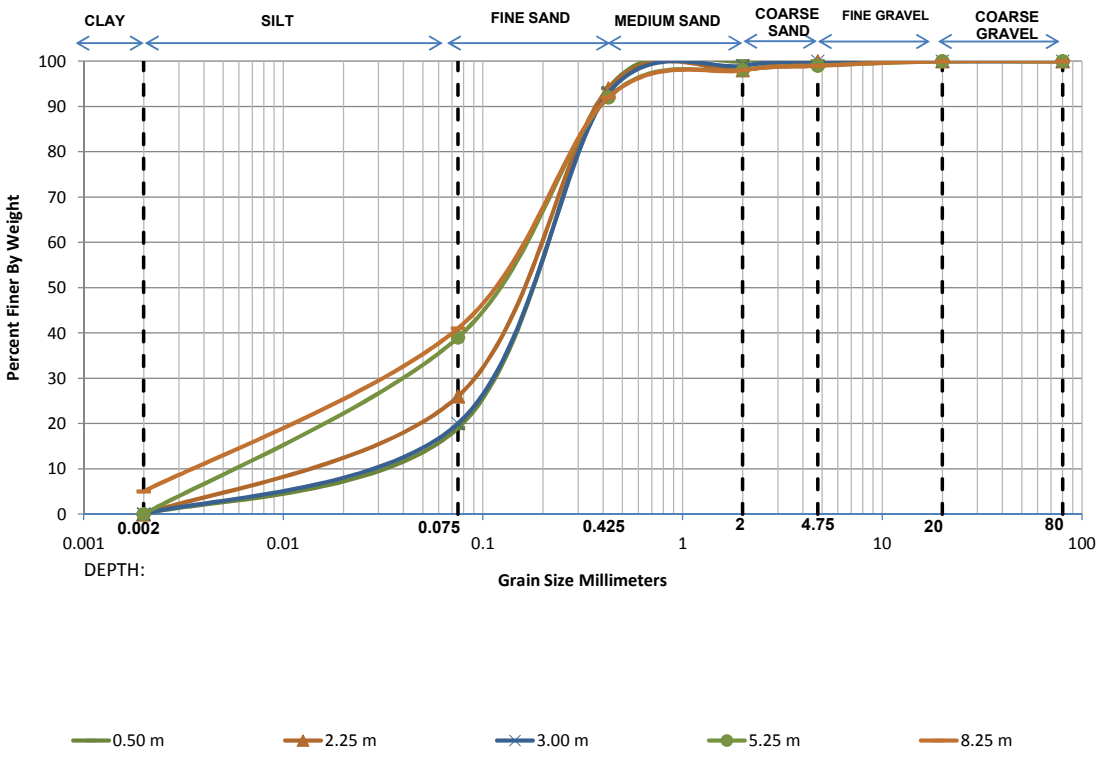
CEGTH
CEG TEST HOUSE
AND RESEARCH CENTRE PVT LTD

RESULT OF CHEMICAL ANALYSIS OF SOIL SAMPLES

Sr. No	Chainage Old	Chainage New	BH No.	Depth of collected sample (m)	pH	Chlorides (Cl^-)		Sulphate (SO_3^{2-})	
						(mg/kg)	(%)	(mg/kg)	(%)
1.	11+657	12+342	CL	2.25	7.41	69.88	0.0070	31.47	0.0031
2.	13+787	14+472	A1	2.5	8.27	72.14	0.0072	23.74	0.0024
				11.50	8.91	68.12	0.0068	22.78	0.0023
3.	15+441	16+127	A2	2.25	7.82	65.45	0.0065	26.98	0.0027
				20.50	8.21	71.99	0.0072	21.78	0.0022
4.	16+042	16+727	A1	2.25	7.45	77.33	0.0077	31.55	0.0032
				17.50	7.78	69.78	0.0070	36.98	0.0037
5.	16+231	16+917	A2	2.5	7.45	66.55	0.0067	33.69	0.0034
				20.50	7.88	74.99	0.0075	31.54	0.0031

GRAIN SIZE DISTRIBUTION CURVES

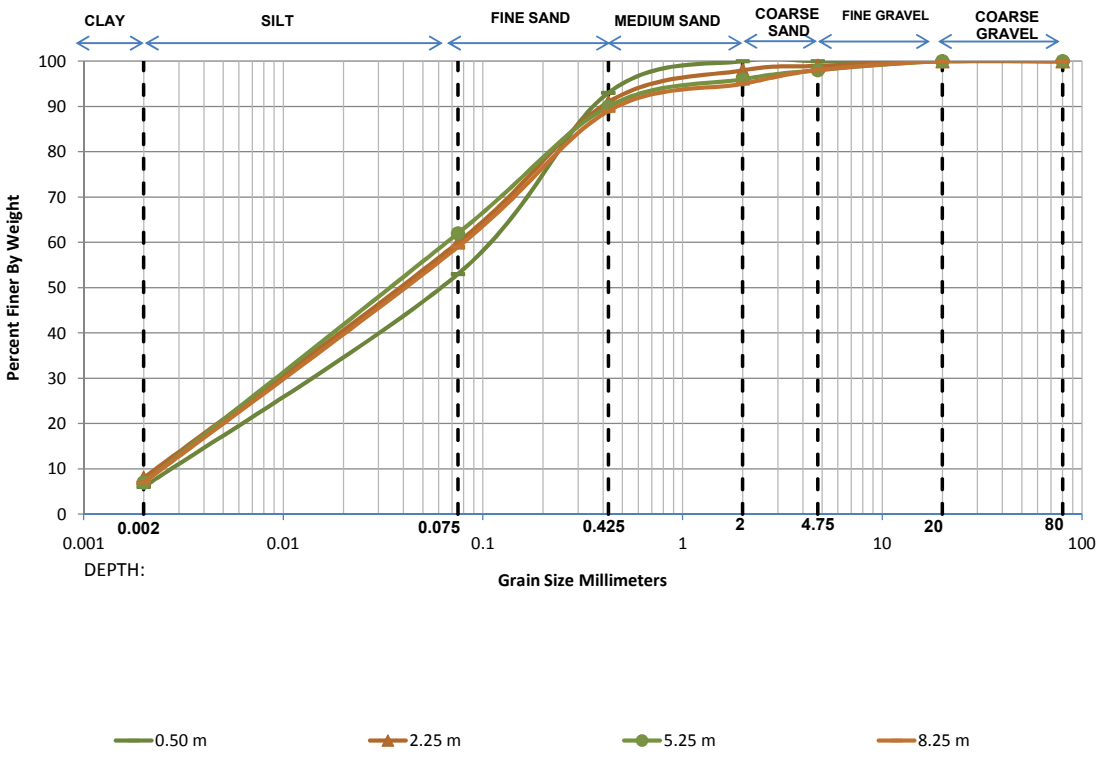
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	11+523 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	0.00	19.00	75.00	6.00	0.00	0.00	0.00	0.0309	0.1165	0.2168	7.02	2.03
2.25 m	0.00	26.00	68.00	4.00	2.00	0.00	0.00	0.0175	0.0891	0.1945	11.12	2.33
3.00 m	0.00	20.00	73.00	6.00	1.00	0.00	0.00	0.0281	0.1126	0.2157	7.66	2.09
5.25 m	0.00	39.00	53.00	6.00	1.00	1.00	0.00	0.0084	0.0496	0.1539	18.38	1.91
8.25 m	5.00	36.00	51.00	6.00	1.00	1.00	0.00	0.0064	0.0437	0.1485	23.07	1.99

GRAIN SIZE DISTRIBUTION CURVES

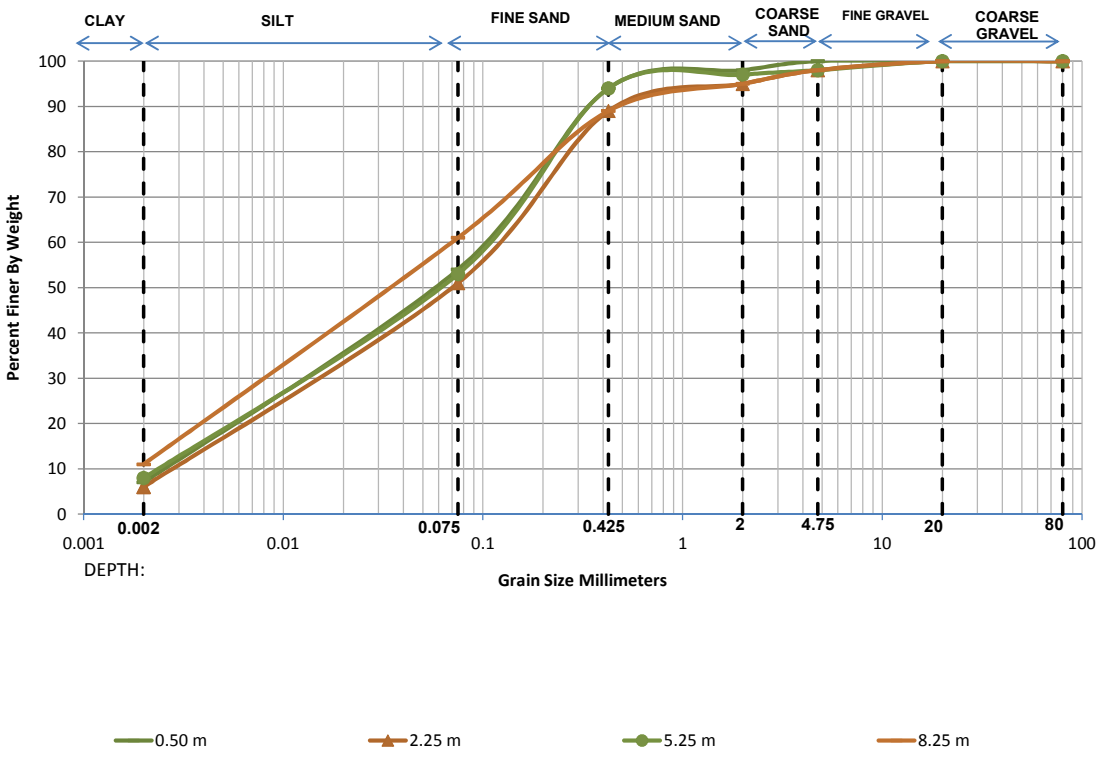
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	11+614 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	6.00	47.00	40.00	7.00	0.00	0.00	0.00	0.0045	0.0270	0.0989	21.93	1.63
2.25 m	8.00	52.00	31.00	7.00	1.00	1.00	0.00	0.0029	0.0198	0.0750	25.72	1.80
5.25 m	7.00	55.00	28.00	6.00	2.00	2.00	0.00	0.0035	0.0199	0.0703	19.98	1.59
8.25 m	7.00	52.00	30.00	6.00	3.00	2.00	0.00	0.0036	0.0214	0.0778	21.86	1.65

GRAIN SIZE DISTRIBUTION CURVES

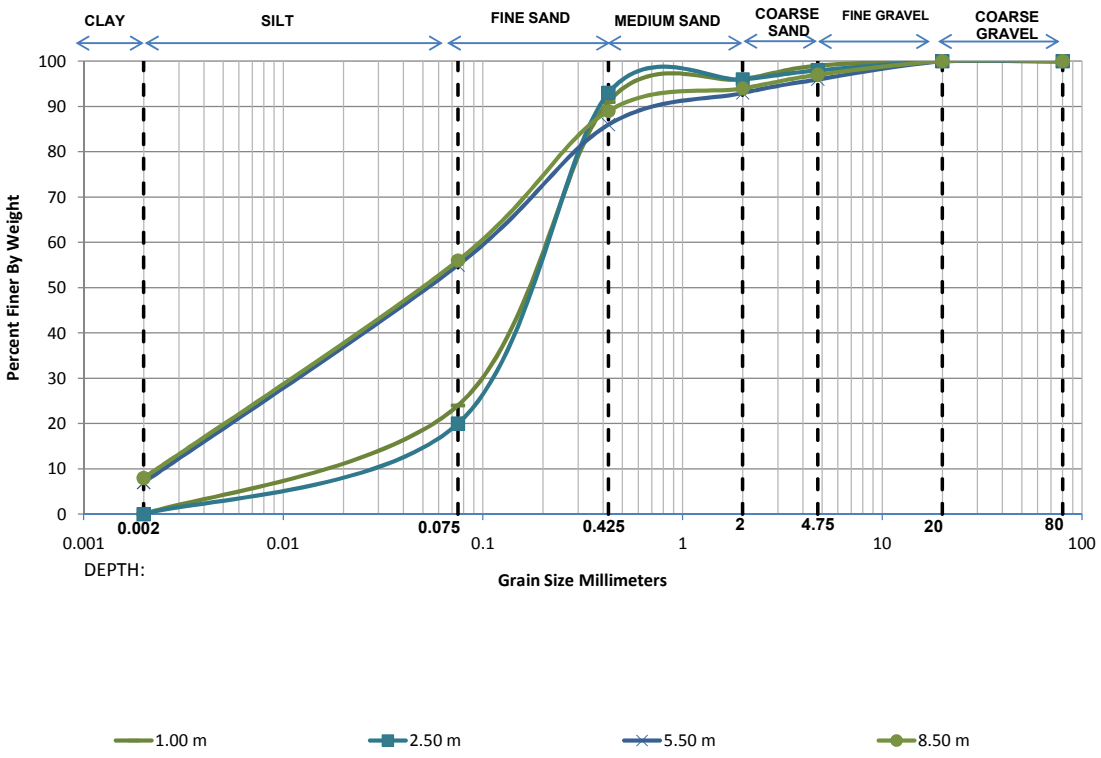
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	11+657 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	7.00	47.00	40.00	4.00	2.00	0.00	0.00	0.0037	0.0251	0.0946	25.92	1.82
2.25 m	6.00	45.00	38.00	6.00	3.00	2.00	0.00	0.0046	0.0286	0.1101	24.09	1.62
5.25 m	8.00	45.00	41.00	3.00	1.00	2.00	0.00	0.0030	0.0248	0.0986	33.09	2.09
8.25 m	11.00	50.00	28.00	6.00	3.00	2.00	0.00	-	0.0163	0.0724	-	-

GRAIN SIZE DISTRIBUTION CURVES

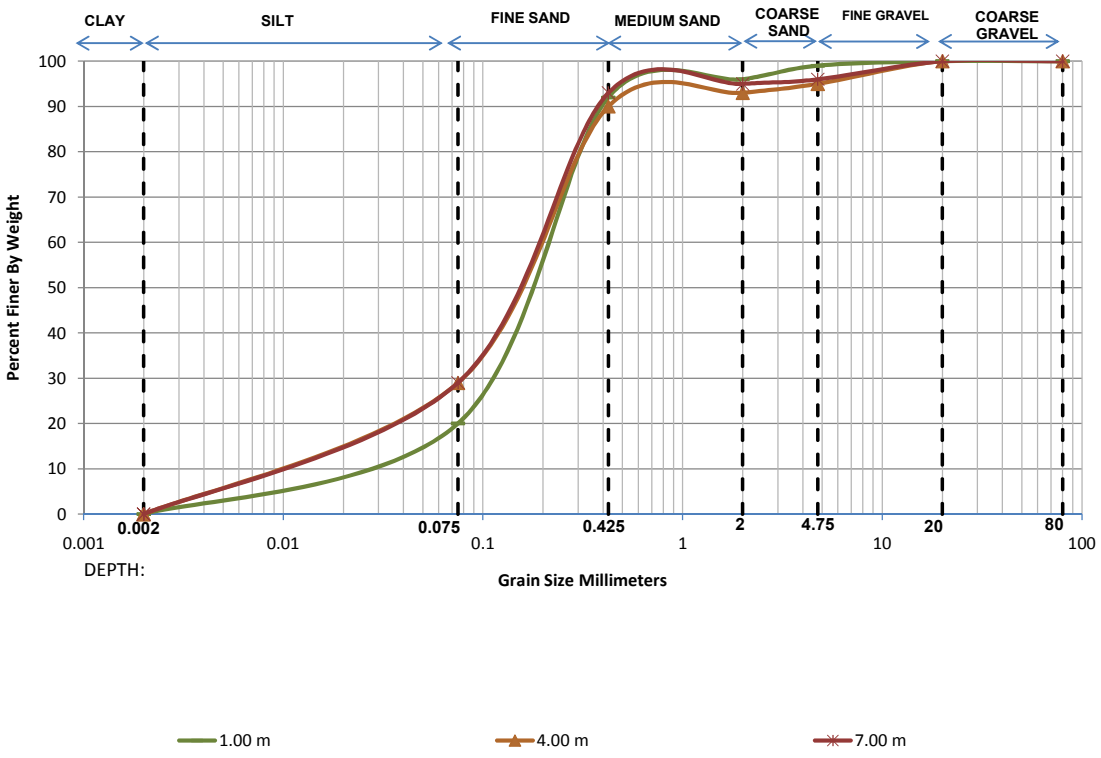
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	12+125 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	0.00	24.00	67.00	5.00	3.00	1.00	0.00	0.0201	0.0970	0.2072	10.30	2.26
2.50 m	0.00	20.00	73.00	3.00	2.00	2.00	0.00	0.0281	0.1125	0.2148	7.63	2.10
5.50 m	7.00	48.00	31.00	7.00	3.00	4.00	0.00	0.0036	0.0238	0.0943	26.06	1.67
8.50 m	8.00	48.00	33.00	5.00	3.00	3.00	0.00	0.0029	0.0222	0.0887	30.09	1.89

GRAIN SIZE DISTRIBUTION CURVES

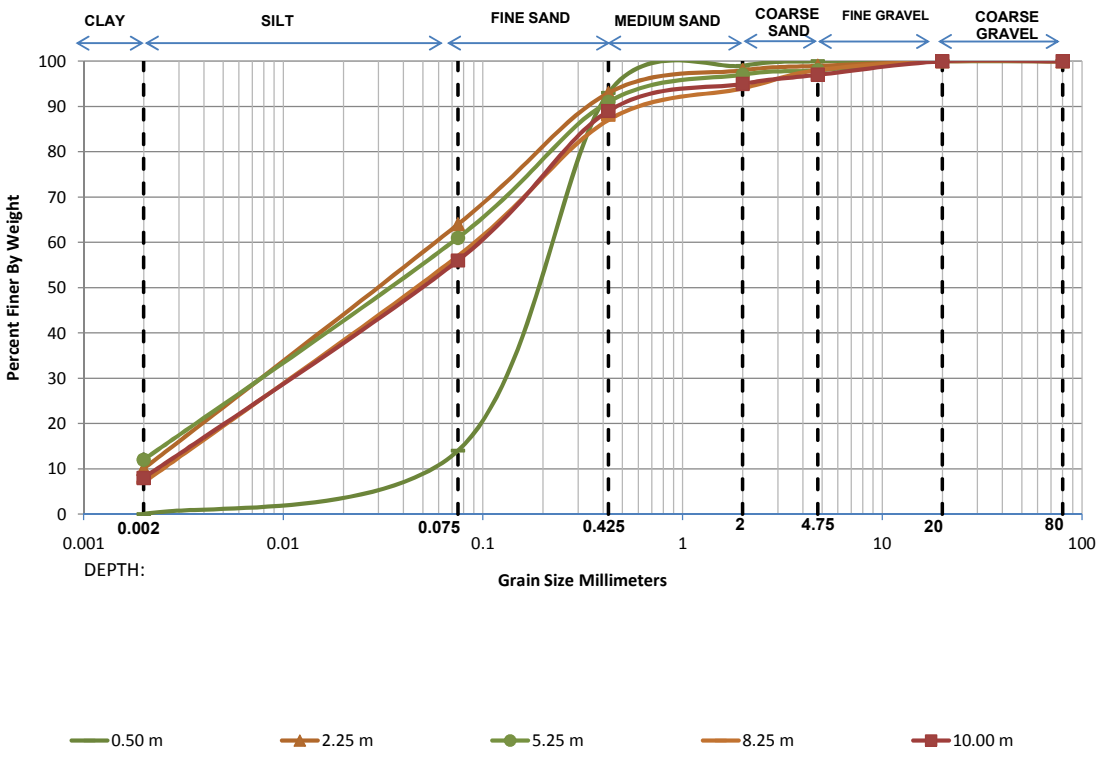
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	12+431 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	0.00	20.00	72.00	4.00	3.00	1.00	0.00	0.0281	0.1128	0.2171	7.73	2.09
4.00 m	0.00	29.00	61.00	3.00	2.00	5.00	0.00	0.0141	0.0785	0.1926	13.61	2.26
7.00 m	0.00	29.00	64.00	2.00	1.00	4.00	0.00	0.0143	0.0784	0.1861	13.05	2.32

GRAIN SIZE DISTRIBUTION CURVES

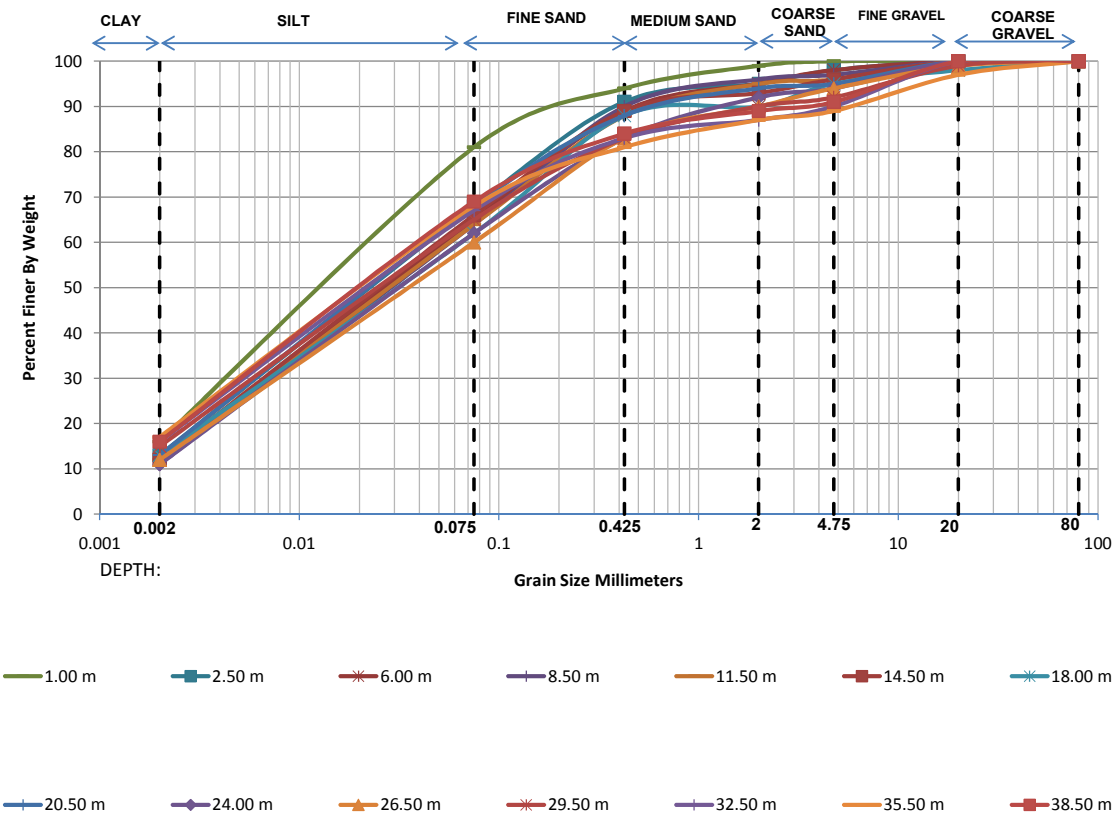
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	13+218 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	0.00	14.00	79.00	6.00	1.00	0.00	0.00	0.0508	0.1385	0.2338	4.61	1.62
2.25 m	10.00	54.00	29.00	5.00	1.00	1.00	0.00	0.0020	0.0160	0.0656	32.81	1.96
5.25 m	12.00	49.00	30.00	6.00	1.00	2.00	0.00	-	0.0154	0.0724	-	-
8.25 m	7.00	50.00	30.00	7.00	4.00	2.00	0.00	0.0036	0.0225	0.0851	23.75	1.66
10.00 m	8.00	48.00	33.00	6.00	2.00	3.00	0.00	0.0029	0.0222	0.0887	30.11	1.88

GRAIN SIZE DISTRIBUTION CURVES

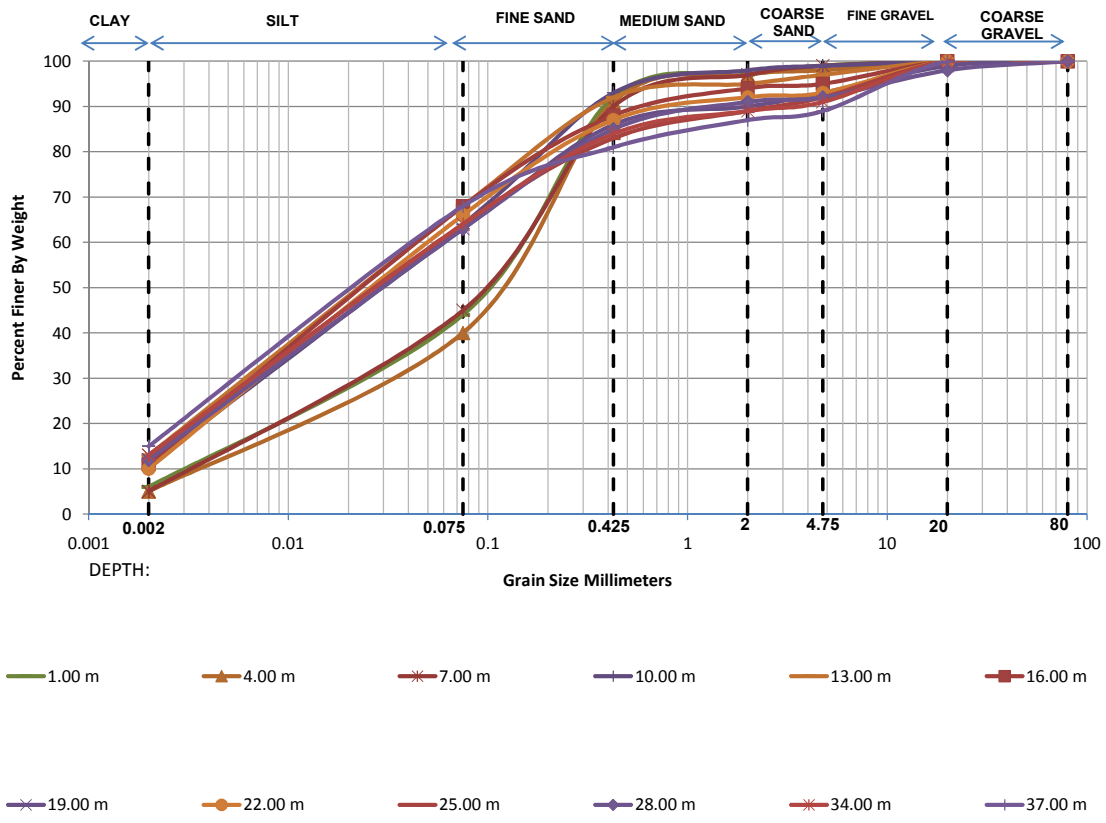
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	13+787 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	16.00	65.00	13.00	5.00	1.00	0.00	0.00	-	0.0075	0.0373	-	-
2.50 m	13.00	55.00	23.00	4.00	3.00	2.00	0.00	-	0.0120	0.0568	-	-
6.00 m	12.00	53.00	24.00	6.00	3.00	2.00	0.00	-	0.0137	0.0630	-	-
8.50 m	11.00	53.00	26.00	6.00	1.00	3.00	0.00	-	0.0150	0.0654	-	-
11.50 m	12.00	52.00	24.00	7.00	1.00	4.00	0.00	-	0.0140	0.0651	-	-
14.50 m	12.00	54.00	23.00	4.00	3.00	4.00	0.00	-	0.0134	0.0609	-	-
18.00 m	13.00	49.00	26.00	2.00	5.00	3.00	2.00	-	0.0140	0.0697	-	-
20.50 m	13.00	55.00	20.00	6.00	1.00	5.00	0.00	-	0.0119	0.0567	-	-
24.00 m	11.00	51.00	21.00	9.00	2.00	6.00	0.00	-	0.0156	0.0698	-	-
26.50 m	12.00	48.00	23.00	7.00	4.00	5.00	1.00	-	0.0155	0.0750	-	-
29.50 m	15.00	50.00	18.00	7.00	2.00	7.00	1.00	-	0.0110	0.0621	-	-
32.50 m	16.00	51.00	16.00	4.00	3.00	10.00	0.00	-	0.0097	0.0574	-	-
35.50 m	17.00	51.00	13.00	6.00	2.00	8.00	3.00	-	0.0087	0.0549	-	-
38.50 m	16.00	53.00	15.00	5.00	2.00	9.00	0.00	-	0.0092	0.0536	-	-

GRAIN SIZE DISTRIBUTION CURVES

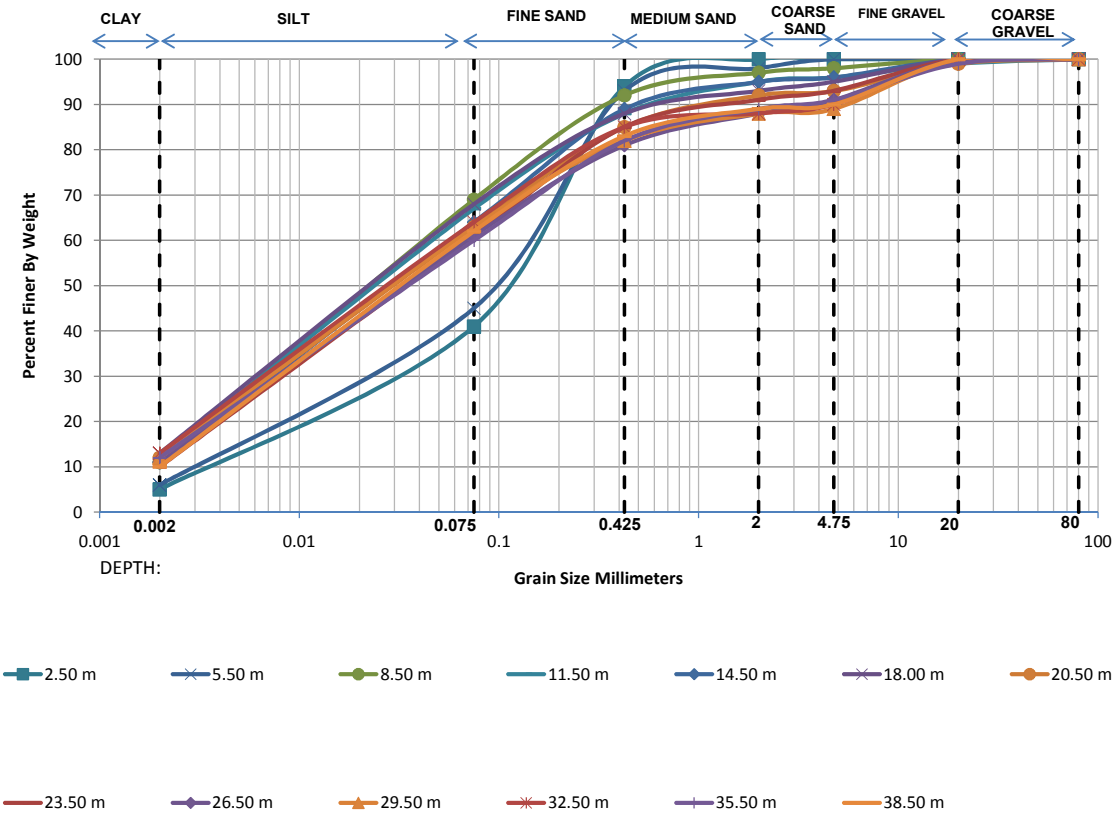
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	13+787 Major Bridge
B.H. No.	BH-P1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	6.00	38.00	48.00	5.00	2.00	1.00	0.00	0.0049	0.0374	0.1367	27.73	2.08
4.00 m	5.00	35.00	51.00	6.00	1.00	2.00	0.00	0.0066	0.0456	0.1541	23.53	2.06
7.00 m	5.00	40.00	45.00	7.00	2.00	1.00	0.00	0.0060	0.0369	0.1353	22.44	1.67
10.00 m	11.00	53.00	29.00	5.00	1.00	1.00	0.00	-	0.0151	0.0655	-	-
13.00 m	13.00	55.00	24.00	3.00	2.00	3.00	0.00	-	0.0120	0.0569	-	-
16.00 m	11.00	57.00	20.00	6.00	1.00	5.00	0.00	-	0.0135	0.0573	-	-
19.00 m	12.00	51.00	23.00	4.00	3.00	6.00	1.00	-	0.0144	0.0674	-	-
22.00 m	10.00	56.00	21.00	5.00	1.00	7.00	0.00	0.0020	0.0150	0.0613	30.65	1.85
25.00 m	13.00	51.00	19.00	6.00	3.00	8.00	0.00	-	0.0130	0.0648	-	-
28.00 m	12.00	51.00	22.00	6.00	1.00	6.00	2.00	-	0.0143	0.0673	-	-
34.00 m	13.00	51.00	20.00	5.00	2.00	9.00	0.00	-	0.0130	0.0648	-	-
37.00 m	15.00	53.00	13.00	6.00	2.00	11.00	0.00	-	0.0101	0.0556	-	-

GRAIN SIZE DISTRIBUTION CURVES

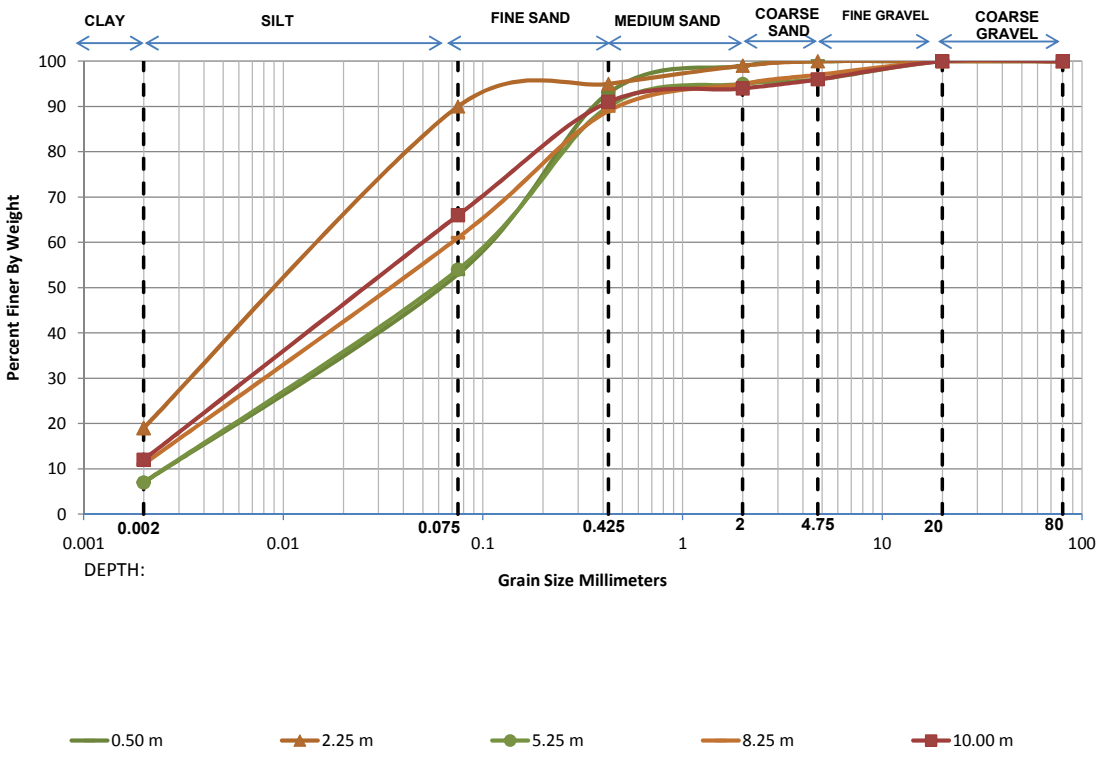
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	13+787 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	5.00	36.00	53.00	6.00	0.00	0.00	0.00	0.0065	0.0438	0.1457	22.56	2.04
5.50 m	6.00	39.00	48.00	5.00	2.00	0.00	0.00	0.0049	0.0360	0.1314	26.96	2.02
8.50 m	11.00	58.00	23.00	5.00	1.00	2.00	0.00	-	0.0134	0.0557	-	-
11.50 m	12.00	55.00	21.00	7.00	1.00	3.00	1.00	-	0.0130	0.0589	-	-
14.50 m	11.00	53.00	25.00	6.00	1.00	4.00	0.00	-	0.0150	0.0653	-	-
18.00 m	13.00	55.00	20.00	5.00	2.00	5.00	0.00	-	0.0119	0.0567	-	-
20.50 m	12.00	51.00	22.00	7.00	1.00	6.00	1.00	-	0.0143	0.0673	-	-
23.50 m	10.00	51.00	24.00	6.00	2.00	7.00	0.00	0.0020	0.0170	0.0724	36.21	2.00
26.50 m	11.00	50.00	20.00	7.00	3.00	9.00	0.00	-	0.0159	0.0723	-	-
29.50 m	12.00	51.00	19.00	6.00	1.00	11.00	0.00	-	0.0142	0.0673	-	-
32.50 m	13.00	51.00	21.00	3.00	2.00	10.00	0.00	-	0.0131	0.0648	-	-
35.50 m	12.00	48.00	22.00	7.00	2.00	8.00	1.00	-	0.0155	0.0750	-	-
38.50 m	10.00	52.00	21.00	6.00	1.00	10.00	0.00	0.0020	0.0165	0.0699	34.96	1.94

GRAIN SIZE DISTRIBUTION CURVES

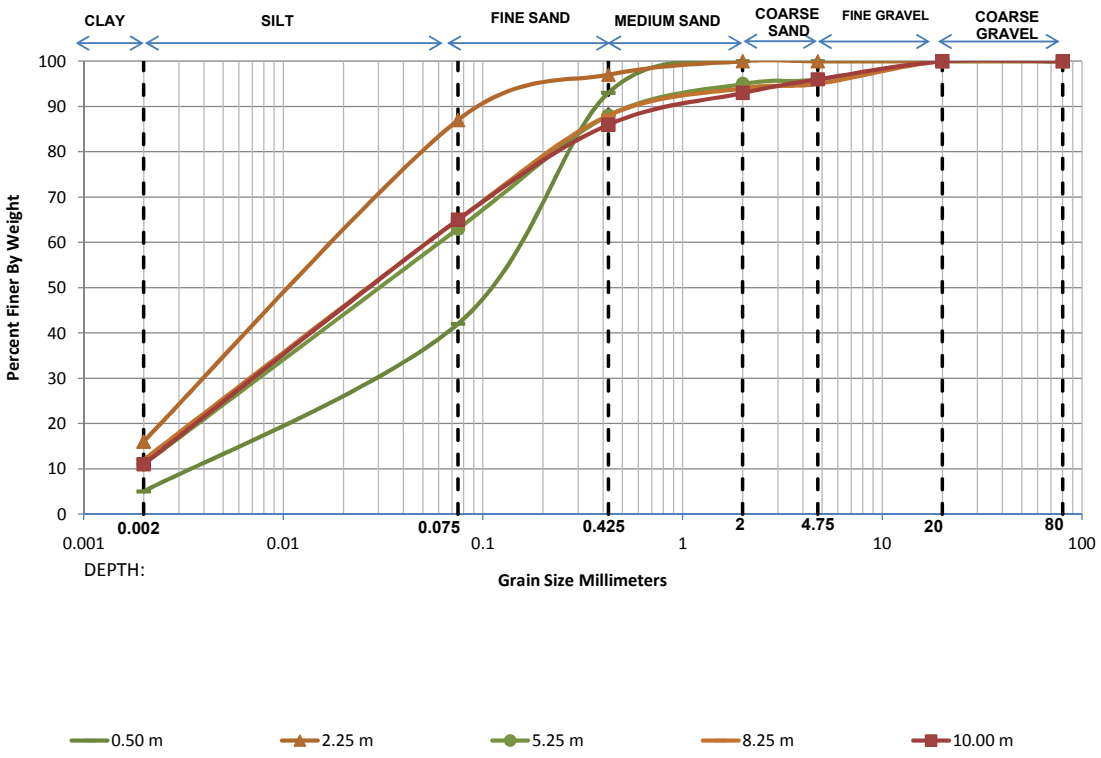
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	13+917 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	7.00	46.00	40.00	6.00	1.00	0.00	0.00	0.0037	0.0258	0.0991	27.01	1.84
2.25 m	19.00	71.00	5.00	4.00	1.00	0.00	0.00	-	0.0053	0.0280	-	-
5.25 m	7.00	47.00	36.00	5.00	1.00	4.00	0.00	0.0036	0.0248	0.0964	26.45	1.76
8.25 m	11.00	50.00	28.00	6.00	2.00	3.00	0.00	-	0.0163	0.0724	-	-
10.00 m	12.00	54.00	25.00	3.00	2.00	4.00	0.00	-	0.0134	0.0610	-	-

GRAIN SIZE DISTRIBUTION CURVES

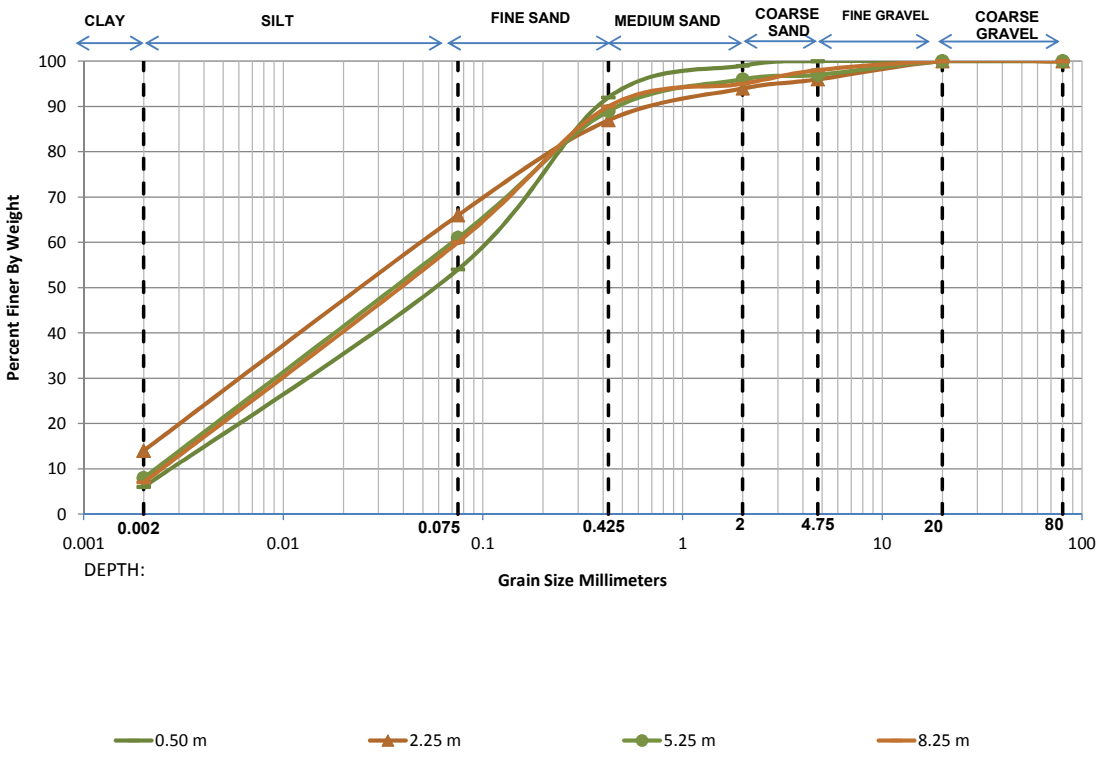
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	14+072 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	5.00	37.00	51.00	7.00	0.00	0.00	0.00	0.0063	0.0419	0.1434	22.63	1.93
2.25 m	16.00	71.00	10.00	3.00	0.00	0.00	0.00	-	0.0070	0.0321	-	-
5.25 m	11.00	52.00	25.00	7.00	1.00	4.00	0.00	-	0.0153	0.0676	-	-
8.25 m	12.00	53.00	23.00	6.00	1.00	5.00	0.00	-	0.0137	0.0629	-	-
10.00 m	11.00	54.00	21.00	7.00	3.00	4.00	0.00	-	0.0145	0.0631	-	-

GRAIN SIZE DISTRIBUTION CURVES

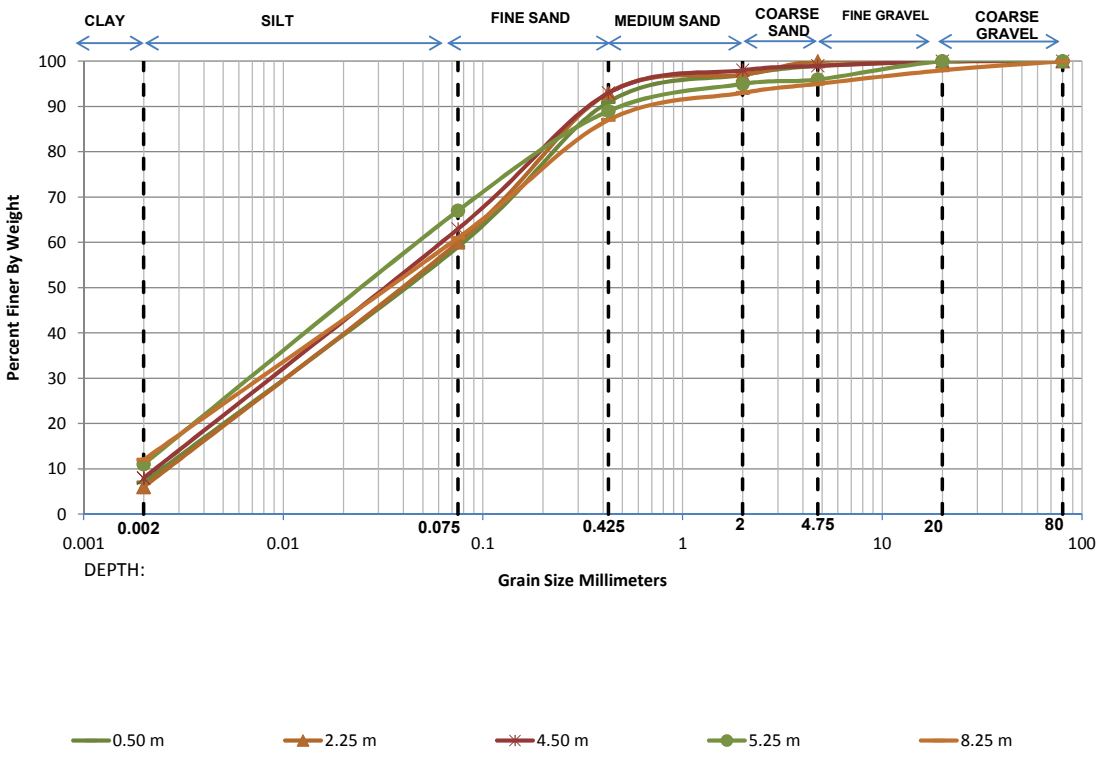
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	14+415 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	6.00	48.00	38.00	7.00	1.00	0.00	0.00	0.0045	0.0261	0.0954	21.31	1.60
2.25 m	14.00	52.00	21.00	7.00	2.00	4.00	0.00	-	0.0116	0.0603	-	-
5.25 m	8.00	53.00	28.00	7.00	1.00	3.00	0.00	0.0029	0.0192	0.0725	24.95	1.75
8.25 m	7.00	53.00	30.00	5.00	3.00	2.00	0.00	0.0035	0.0209	0.0750	21.16	1.64

GRAIN SIZE DISTRIBUTION CURVES

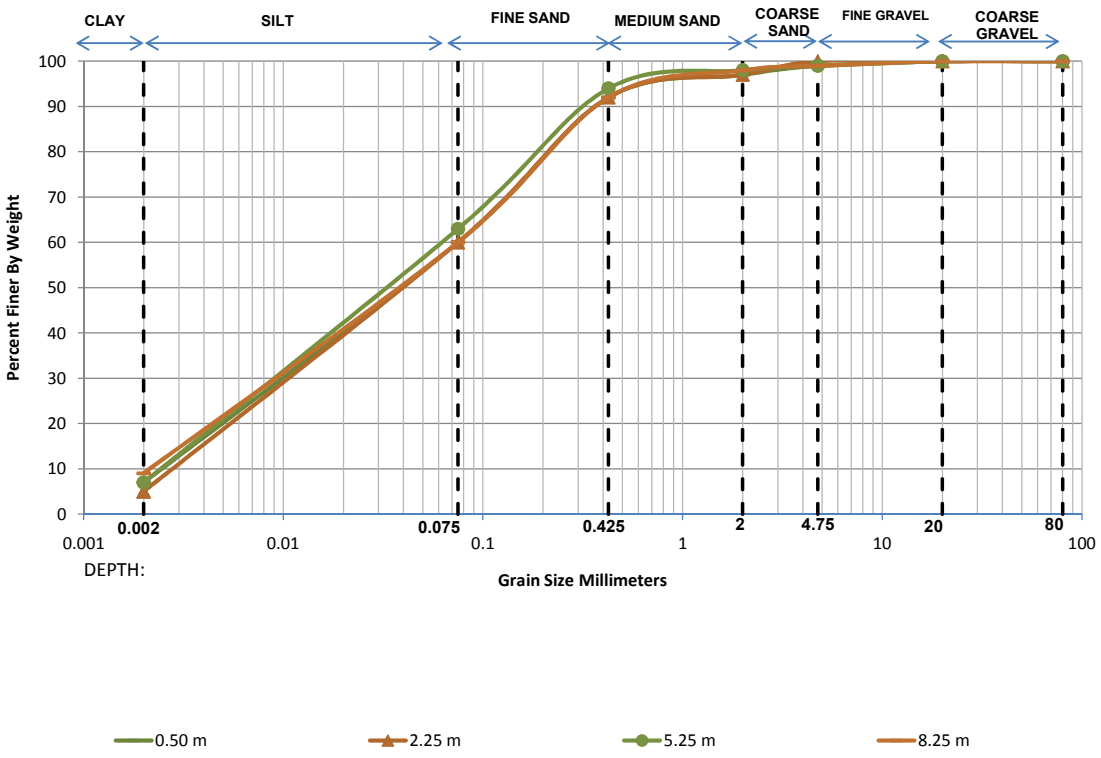
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	15+259 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	7.00	52.00	32.00	6.00	2.00	1.00	0.00	0.0036	0.0215	0.0777	21.83	1.67
2.25 m	6.00	54.00	33.00	4.00	3.00	0.00	0.00	0.0043	0.0222	0.0750	17.37	1.52
4.50 m	8.00	55.00	30.00	5.00	1.00	1.00	0.00	0.0029	0.0184	0.0680	23.49	1.73
5.25 m	11.00	56.00	22.00	6.00	1.00	4.00	0.00	-	0.0139	0.0592	-	-
8.25 m	12.00	49.00	26.00	6.00	2.00	3.00	2.00	-	0.0153	0.0723	-	-

GRAIN SIZE DISTRIBUTION CURVES

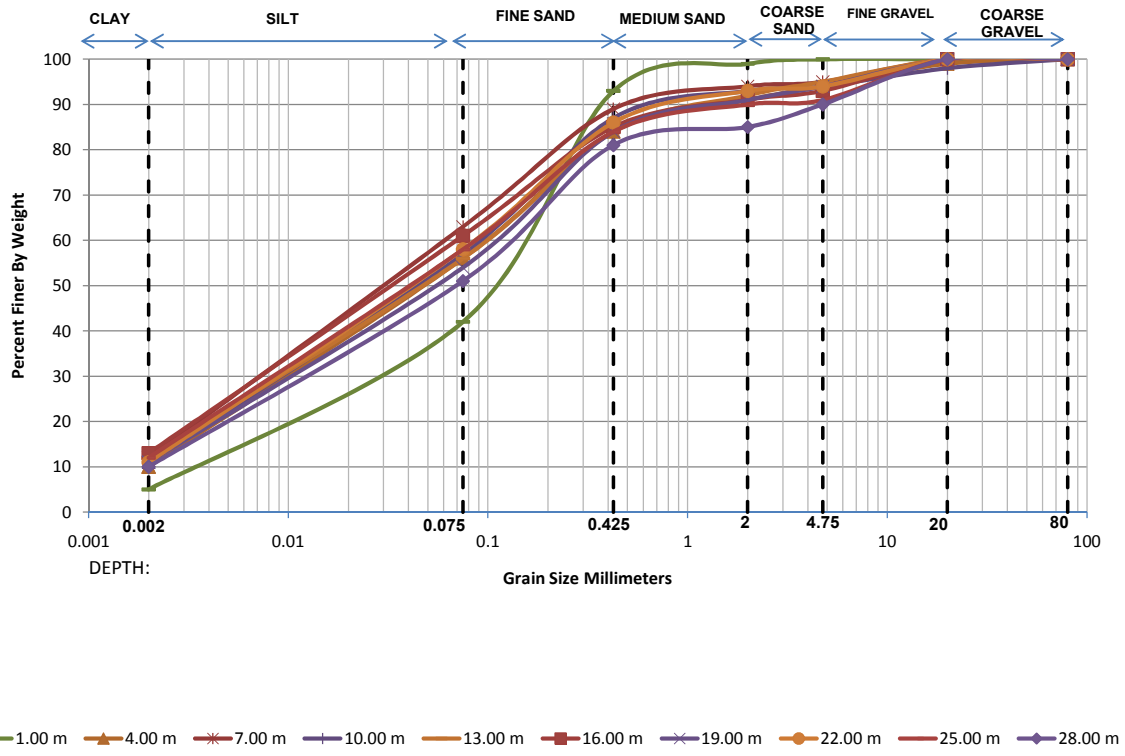
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	15+416 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
0.50 m	7.00	53.00	32.00	5.00	2.00	1.00	0.00	0.0035	0.0210	0.0750	21.15	1.65
2.25 m	5.00	55.00	32.00	5.00	3.00	0.00	0.00	0.0053	0.0234	0.0750	14.25	1.39
5.25 m	7.00	56.00	31.00	4.00	1.00	1.00	0.00	0.0035	0.0196	0.0682	19.43	1.60
8.25 m	9.00	51.00	32.00	6.00	1.00	1.00	0.00	0.0024	0.0189	0.0750	31.20	1.97

GRAIN SIZE DISTRIBUTION CURVES

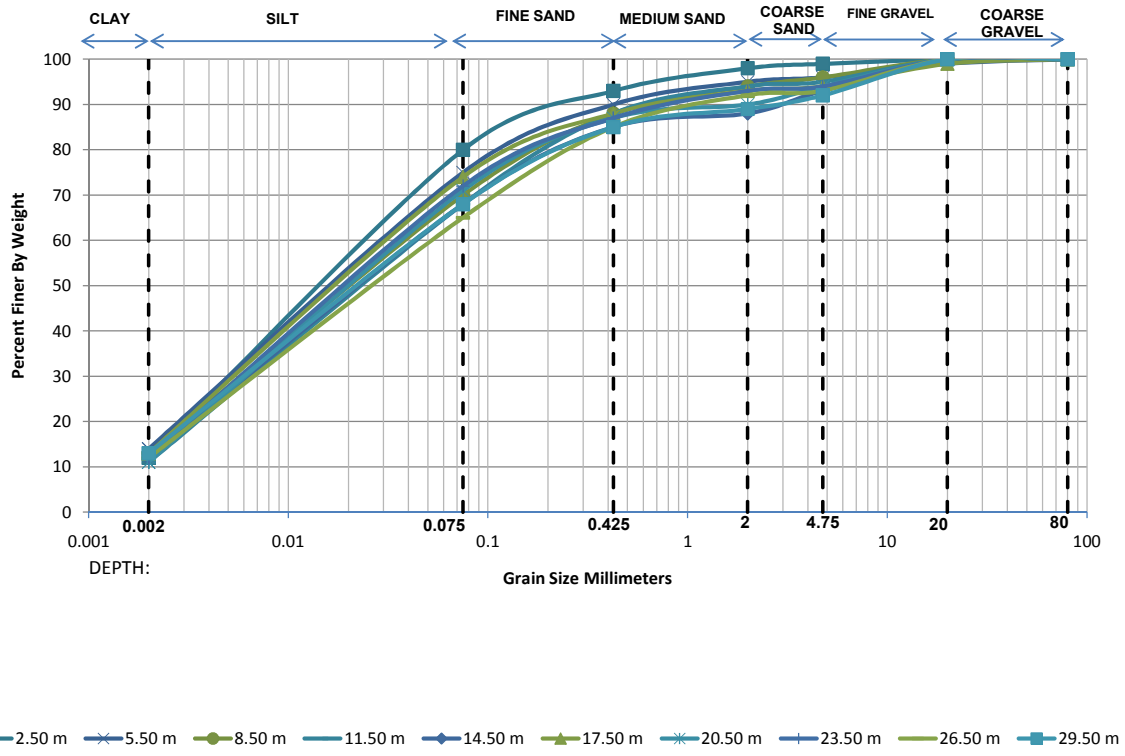
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	15+441 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	5.00	37.00	51.00	6.00	1.00	0.00	0.00	0.0063	0.0419	0.1431	22.59	1.94
4.00 m	10.00	46.00	28.00	7.00	3.00	5.00	1.00	0.0020	0.0198	0.0911	45.53	2.16
7.00 m	12.00	51.00	26.00	5.00	1.00	5.00	0.00	-	0.0145	0.0674	-	-
10.00 m	11.00	46.00	30.00	6.00	1.00	4.00	2.00	-	0.0183	0.0856	-	-
13.00 m	12.00	44.00	28.00	8.00	3.00	5.00	0.00	-	0.0178	0.0915	-	-
16.00 m	13.00	48.00	24.00	6.00	2.00	7.00	0.00	-	0.0143	0.0723	-	-
19.00 m	11.00	43.00	30.00	7.00	3.00	6.00	0.00	-	0.0202	0.1015	-	-
22.00 m	11.00	47.00	28.00	7.00	1.00	6.00	0.00	-	0.0177	0.0817	-	-
25.00 m	12.00	46.00	26.00	6.00	1.00	9.00	0.00	-	0.0166	0.0821	-	-
28.00 m	10.00	41.00	30.00	4.00	5.00	10.00	0.00	0.0020	0.0236	0.1214	60.70	2.30

GRAIN SIZE DISTRIBUTION CURVES

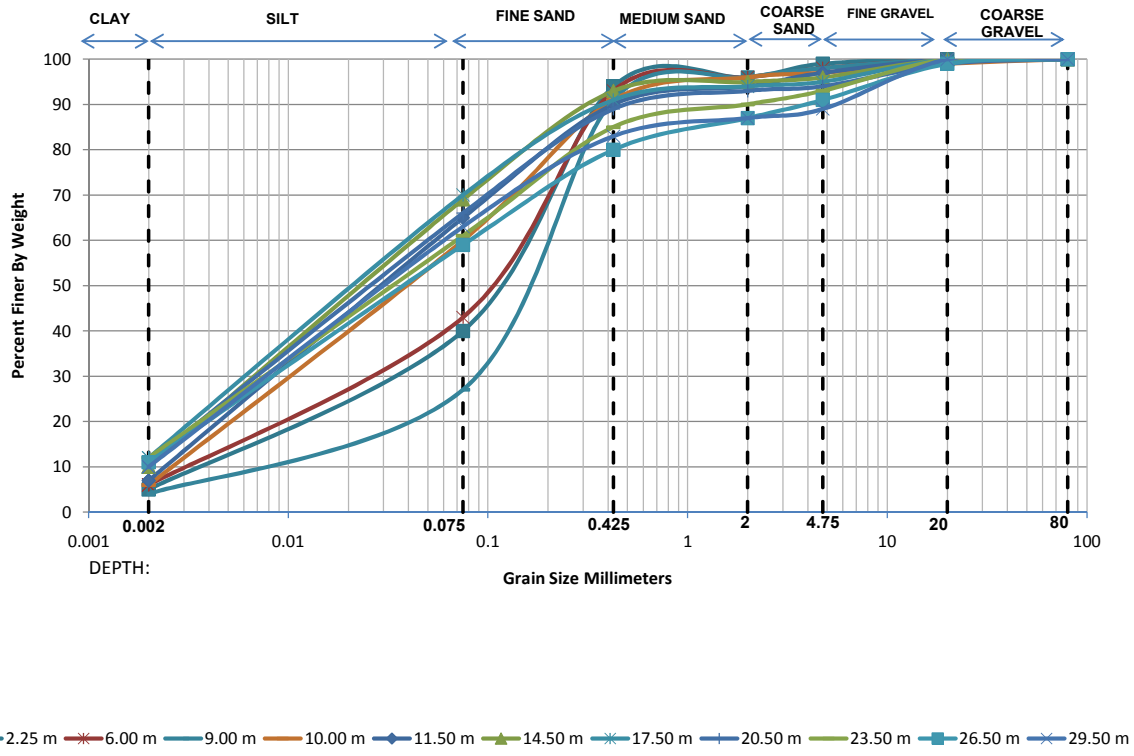
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	15+441 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	12.00	68.00	13.00	5.00	1.00	1.00	0.00	-	0.0102	0.0404	-	-
5.50 m	14.00	61.00	15.00	5.00	1.00	3.00	1.00	-	0.0096	0.0452	-	-
8.50 m	13.00	57.00	18.00	6.00	2.00	4.00	0.00	-	0.0114	0.0531	-	-
11.50 m	11.00	57.00	20.00	6.00	1.00	5.00	0.00	-	0.0135	0.0573	-	-
14.50 m	12.00	56.00	17.00	3.00	5.00	7.00	0.00	-	0.0126	0.0568	-	-
17.50 m	13.00	61.00	14.00	5.00	1.00	5.00	1.00	-	0.0105	0.0469	-	-
20.50 m	11.00	60.00	16.00	3.00	4.00	6.00	0.00	-	0.0127	0.0521	-	-
23.50 m	12.00	60.00	15.00	6.00	1.00	6.00	0.00	-	0.0116	0.0502	-	-
26.50 m	12.00	53.00	20.00	7.00	1.00	7.00	0.00	-	0.0136	0.0628	-	-
29.50 m	13.00	55.00	17.00	4.00	3.00	8.00	0.00	-	0.0118	0.0565	-	-

GRAIN SIZE DISTRIBUTION CURVES

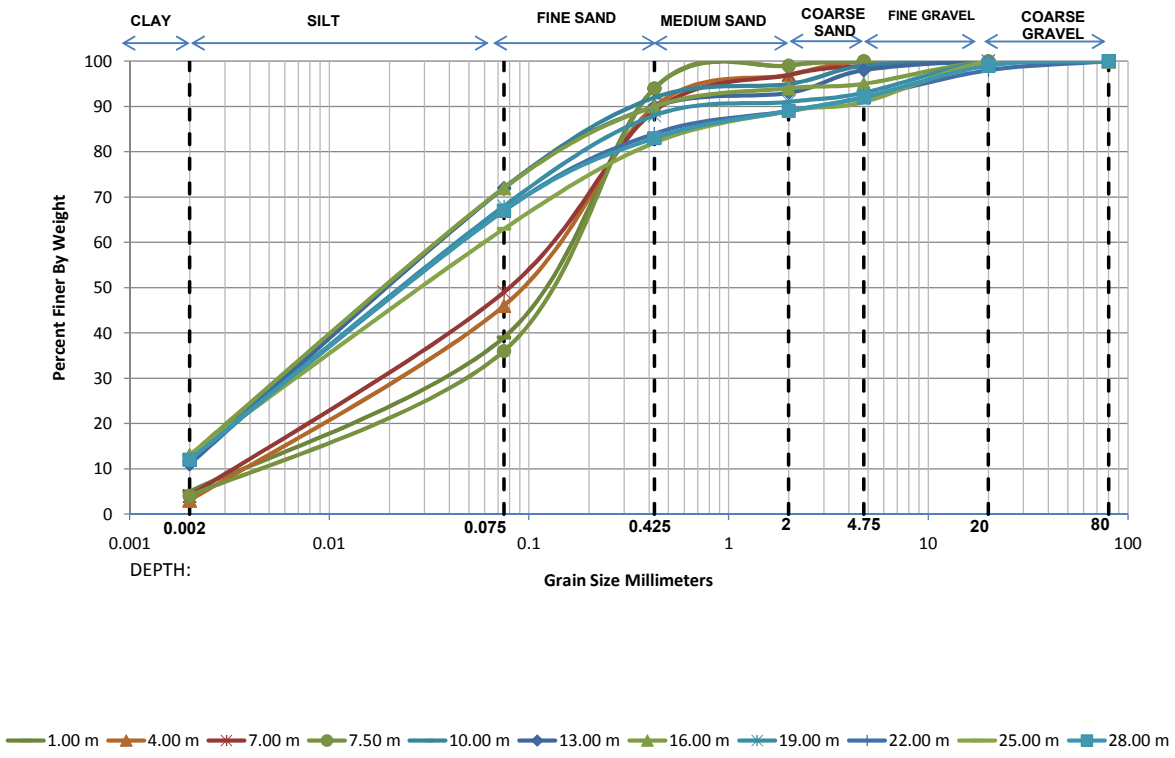
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	16+042 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.25 m	5.00	35.00	54.00	2.00	3.00	1.00	0.00	0.0066	0.0458	0.1485	22.58	2.15
6.00 m	6.00	37.00	50.00	3.00	2.00	2.00	0.00	0.0050	0.0391	0.1390	27.78	2.20
9.00 m	4.00	23.00	64.00	5.00	2.00	2.00	0.00	0.0125	0.0867	0.2007	16.06	3.00
10.00 m	6.00	54.00	31.00	5.00	1.00	2.00	1.00	0.0043	0.0221	0.0750	17.39	1.51
11.50 m	7.00	58.00	25.00	4.00	3.00	3.00	0.00	0.0035	0.0185	0.0640	18.38	1.54
14.50 m	10.00	59.00	24.00	2.00	1.00	4.00	0.00	0.0020	0.0143	0.0561	28.04	1.81
17.50 m	12.00	58.00	21.00	3.00	1.00	5.00	0.00	-	0.0122	0.0536	-	-
20.50 m	11.00	55.00	23.00	4.00	1.00	5.00	1.00	-	0.0142	0.0611	-	-
23.50 m	12.00	49.00	24.00	5.00	3.00	7.00	0.00	-	0.0152	0.0723	-	-
26.50 m	11.00	48.00	21.00	7.00	4.00	8.00	1.00	-	0.0168	0.0784	-	-
29.50 m	10.00	53.00	20.00	4.00	2.00	11.00	0.00	0.0020	0.0160	0.0676	33.78	1.91

GRAIN SIZE DISTRIBUTION CURVES

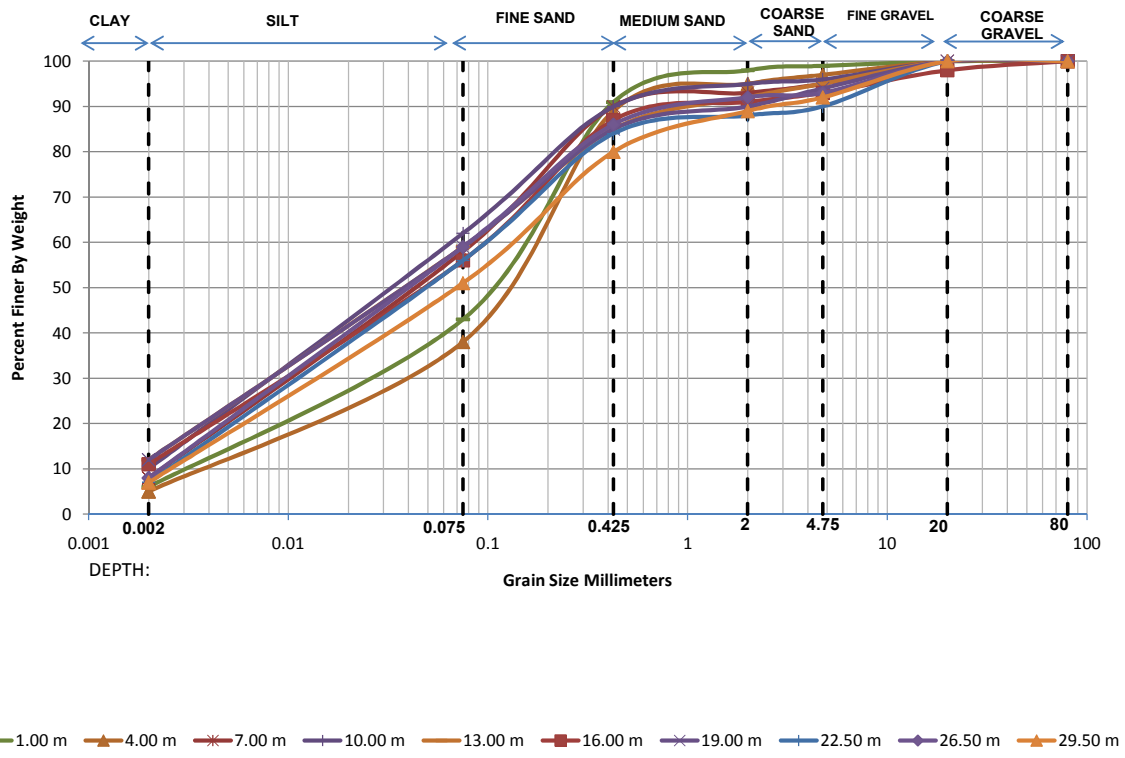
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	16+042 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	5.00	34.00	55.00	5.00	1.00	0.00	0.00	0.0067	0.0479	0.1530	22.80	2.24
4.00 m	3.00	43.00	44.00	7.00	3.00	0.00	0.00	0.0092	0.0381	0.1303	14.16	1.21
7.00 m	4.00	45.00	40.00	8.00	2.00	1.00	0.00	0.0071	0.0331	0.1189	16.76	1.30
7.50 m	4.00	32.00	58.00	5.00	1.00	0.00	0.00	0.0090	0.0559	0.1636	18.26	2.13
10.00 m	12.00	60.00	20.00	3.00	4.00	1.00	0.00	-	0.0118	0.0505	-	-
13.00 m	11.00	61.00	18.00	3.00	5.00	2.00	0.00	-	0.0125	0.0508	-	-
16.00 m	13.00	59.00	18.00	4.00	1.00	5.00	0.00	-	0.0109	0.0500	-	-
19.00 m	12.00	56.00	20.00	3.00	2.00	7.00	0.00	-	0.0127	0.0570	-	-
22.00 m	12.00	55.00	17.00	5.00	3.00	6.00	2.00	-	0.0129	0.0587	-	-
25.00 m	13.00	50.00	19.00	7.00	2.00	9.00	0.00	-	0.0133	0.0671	-	-
28.00 m	12.00	55.00	16.00	6.00	3.00	7.00	1.00	-	0.0128	0.0586	-	-

GRAIN SIZE DISTRIBUTION CURVES

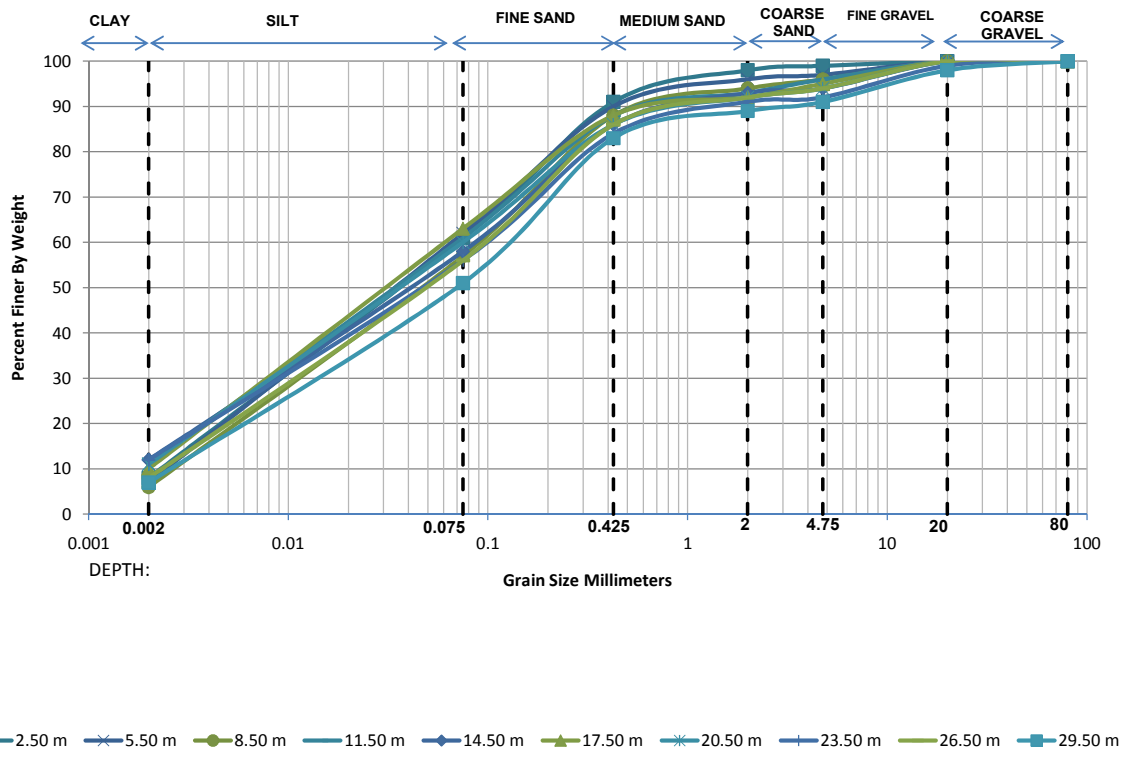
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	16+231 Major Bridge
B.H. No.	BH-A1



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
1.00 m	6.00	37.00	48.00	7.00	1.00	1.00	0.00	0.0050	0.0390	0.1427	28.59	2.14
4.00 m	5.00	33.00	51.00	6.00	2.00	3.00	0.00	0.0068	0.0498	0.1658	24.36	2.20
7.00 m	8.00	50.00	32.00	3.00	2.00	5.00	0.00	0.0029	0.0209	0.0809	27.63	1.85
10.00 m	10.00	52.00	28.00	5.00	1.00	4.00	0.00	0.0020	0.0168	0.0700	35.02	2.01
13.00 m	12.00	47.00	26.00	7.00	3.00	5.00	0.00	-	0.0161	0.0781	-	-
16.00 m	11.00	45.00	31.00	4.00	2.00	5.00	2.00	-	0.0190	0.0897	-	-
19.00 m	12.00	47.00	26.00	5.00	4.00	6.00	0.00	-	0.0161	0.0781	-	-
22.50 m	7.00	49.00	28.00	4.00	2.00	10.00	0.00	0.0036	0.0230	0.0903	25.12	1.63
26.50 m	8.00	51.00	27.00	6.00	1.00	7.00	0.00	0.0029	0.0201	0.0779	26.69	1.78
29.50 m	7.00	44.00	29.00	9.00	3.00	8.00	0.00	0.0037	0.0268	0.1242	33.70	1.57

GRAIN SIZE DISTRIBUTION CURVES

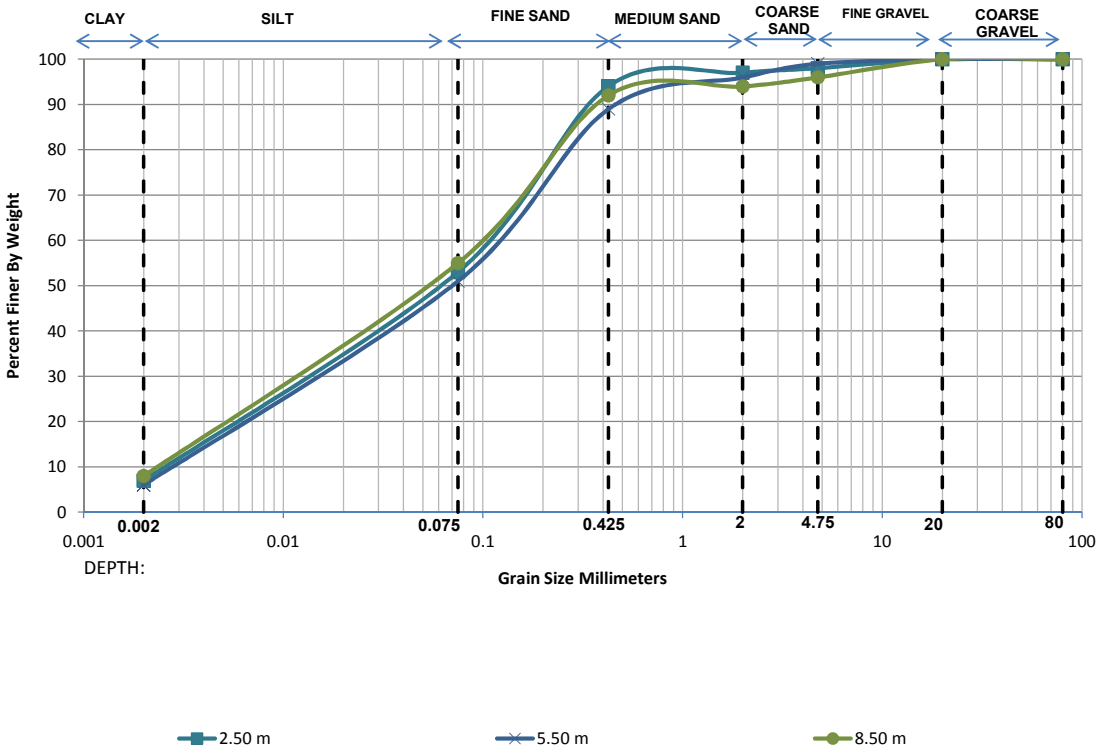
Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	16+231 Major Bridge
B.H. No.	BH-A2



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	8.00	53.00	30.00	7.00	1.00	1.00	0.00	0.0029	0.0193	0.0726	24.94	1.77
5.50 m	7.00	55.00	28.00	6.00	1.00	3.00	0.00	0.0035	0.0199	0.0703	19.98	1.59
8.50 m	6.00	51.00	31.00	6.00	2.00	4.00	0.00	0.0044	0.0237	0.0847	19.35	1.52
11.50 m	11.00	50.00	27.00	5.00	3.00	4.00	0.00	-	0.0162	0.0724	-	-
14.50 m	12.00	46.00	28.00	7.00	1.00	6.00	0.00	-	0.0167	0.0818	-	-
17.50 m	10.00	53.00	25.00	4.00	3.00	5.00	0.00	0.0020	0.0163	0.0677	33.84	1.95
20.50 m	11.00	49.00	26.00	6.00	2.00	6.00	0.00	-	0.0166	0.0750	-	-
23.50 m	12.00	44.00	28.00	7.00	1.00	7.00	1.00	-	0.0178	0.0914	-	-
26.50 m	8.00	48.00	30.00	6.00	2.00	6.00	0.00	0.0029	0.0220	0.0898	30.50	1.84
29.50 m	7.00	44.00	32.00	6.00	2.00	7.00	2.00	0.0037	0.0270	0.1177	31.87	1.68

GRAIN SIZE DISTRIBUTION CURVES

Project Name	Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana.
Location/Chainage	16+815 Minor Bridge
B.H. No.	BH-CL



Depth	Grain Size Distribution % wt retained							D10	D30	D60	Cu	Cc
	Clay	Silt	Sand			Gravel						
			Fine	Medium	Coarse	Fine	Coarse					
2.50 m	7.00	46.00	41.00	3.00	1.00	2.00	0.00	0.0037	0.0259	0.0984	26.79	1.86
5.50 m	6.00	45.00	38.00	7.00	3.00	1.00	0.00	0.0046	0.0286	0.1103	24.13	1.62
8.50 m	8.00	47.00	37.00	2.00	2.00	4.00	0.00	0.0030	0.0231	0.0915	30.94	1.97

APPENDIX – C
(ANALYSIS & RECOMENDATION)

Appendix No.	ITEMS
C-1	SAMPLE CALCULATION FOR COMPUTATION OF LIQUEFACTION POTENTIAL
C-2	SAMPLE CALCULATION FOR COMPUTATION OF ALLOWABLE BEARING CAPACITY OF SUB-STRATA FOR RAFT FOUNDATION
C-3	SAMPLE CALCULATION FOR COMPUTATION OF SAFE LOAD CARRYING CAPACITY OF NORMAL BORED CAST-IN-SITU RCC PILE IN COMPRESSION & UPLIFT
C-4	SAMPLE CALCULATION FOR COMPUTATION OF SAFE LOAD CARRYING CAPACITY OF NORMAL BORED CAST-IN-SITU RCC PILE IN LATERAL

Liquefaction Analysis as per IRC:75-2015 & RDSO BS-118

Chainage (Km)	11+523	BH No.:-	BH-CL	Liquefiable upto=	3.00m		Water Table depth considered for analysis (m):-	0.00

Depth Below G.L. (z) in m	Observed SPT Value	Saturated Density (t/m^3)	Submerged Density (t/m^3)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Moisture Content @ 100% saturation	Strata Type	Liquefaction Check for Cohesive Strata	Fine Content (%)	Stress Reduction Coefficient (rd)	Total Overburden Press (σ_v), t/m^2	Effective Overburden (σ'_v), t/m^2	Critical Stress Ratio (CSR)	C_{60}	Stress Normalization Factor(C_N)	SPT Corrected $(N1)_{60}$	α	β	$(N1)_{60CS}$	$CRR_{M=7.5}$	K_M	Kα	Kσ	CRR_{Mw}	FOS	Conclusion
0.50	4	1.91	0.91					Cohesionless		26	0.996	0.95	0.45	0.326	1.000	1.70	6.8	4.39	1.12	12.02	0.131	1.19	1	1.00	0.157	0.48	Liquefiable
1.50	6	1.91	0.91					Cohesionless		26	0.989	2.86	1.36	0.324	1.000	1.70	10.2	4.39	1.12	15.84	0.169	1.19	1	1.00	0.201	0.62	Liquefiable
3.00	14	1.95	0.95					Cohesionless		20	0.977	5.73	2.73	0.320	1.000	1.70	23.8	3.61	1.08	29.31	0.426	1.19	1	1.00	0.508	1.59	Non Liquefiable
4.50	17	1.95	0.95					Cohesionless		20	0.966	8.66	4.16	0.314	1.000	1.54	26.1	3.61	1.08	31.79	NA	1.19	1	1.00	NA	>1	Non Liquefiable
6.00	17	1.95	0.95					Cohesionless		39	0.954	11.59	5.59	0.309	1.000	1.32	22.5	5.00	1.20	32.01	NA	1.19	1	1.00	NA	>1	Non Liquefiable
7.50	22	1.95	0.95					Cohesionless		39	0.943	14.52	7.02	0.304	1.000	1.18	26.0	5.00	1.20	36.19	NA	1.19	1	1.00	NA	>1	Non Liquefiable
9.00	25	1.97	0.97	25.00	20.00	5.00	26.78	Cohesive	Liquefiable	41	0.931	17.45	8.45	0.300	1.000	1.08	26.9	5.00	1.20	37.30	NA	1.19	1	1.00	NA	>1	Non Liquefiable
10.00	29	1.97	0.97	25.00	20.00	5.00	26.78	Cohesive	Liquefiable	41	0.907	19.42	9.42	0.292	1.000	1.02	29.6	5.00	1.20	40.50	NA	1.19	1	1.00	NA	>1	Non Liquefiable

Calculation of SBC for shallow foundations as per IS : 6403 - 1981

INPUT DATA

CH. (KM) :- 12+431

BH NO. :- BH-CL

Type of footing

1 Continuous Strip
2 Rectangular
3 Square
4 Circular

Square **3**

Angle of internal friction (ϕ^o)	31.00
Cohesion (c in t/m^2)	0.00
Void ratio (e), $e = (G.\gamma_w/\gamma_d)-1$	0.70
Direction of load with vertical (^{o})	0.00
Density of foundation soil (t/m^3) γ_{bulk}	1.74
Depth of water table(m)	0.00
Factor of safety	2.50

S.no.	Depth (m) of footing (D_f) below EGL	Width (m)
1	1.00	3.70
2	1.50	3.70
3	2.00	3.70

SHEAR FAILURE CRITERIA

Assumptions and formula used in calculation as per IS:6403-1981 are given below -

NOTE: The type of failure used for bearing capacity analysis depends upon the value of void ratio (see IS 6403 : 1981, Page No. 9, Table No. 3).

The ultimate net bearing capacity in case of general shear failure is given by (from IS 6403 : 1981, page No. 8)

$$q_d = c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

The ultimate net bearing capacity in case of local shear failure is given by (from IS 6403 : 1981, page No. 8)

$$q'_d = (2/3)\,c\,N'_c\,s_c\,d_c\,i_c + q\,(N'_q-1)\,s_q\,d_q\,i_q + (1/2)\,B\,\gamma\,N'_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$$

Where,

$d_c = 1+ 0.2\,(D_f/B)*SQRT(N_\phi)$

$d_q = d_\gamma = 1$ for $\phi < 10^o$

$d_q = d_\gamma = 1 + 0.1\,(D_f/B)*SQRT(N_\phi)$ for $\phi > 10^o$

(from IS 6403 : 1981, page No. 9)

$N_\phi = \tan^2(\pi/4 + \phi/2)$

ϕ' is friction angle for local shear failure = $\tan^{-1}(0.67\tan\phi)$

OUTPUT

The computer aided results for shear failure criteria are tabulated below. The results are interpolated values of bearing capacity obtained from general and local shear failure criteria.

Bearing capacity factors : (from IS 6403 : 1981, page No. 8, Table No. 1)

ϕ	31.00	ϕ'	21.93
N_c	32.67	N'_c	16.80
N_q	20.63	N'_q	7.76
N_γ	25.99	N'_γ	7.06

Shape factors : (from IS 6403 : 1981, page No. 8, Table No. 2)

S.no.	Width(m)	S_c	S_q	S_γ
1	3.70	1.30	1.20	0.80
2	3.70	1.30	1.20	0.80
3	3.70	1.30	1.20	0.80
		1.30	1.20	0.80
		1.30	1.20	0.80
		1.30	1.20	0.80

Depth factors : (from IS 6403 : 1981, page No. 9)

S.no.	Depth(m)	Width(m)	dc	d_q	d_γ
1	1.00	3.70	1.10	1.05	1.05
2	1.50	3.70	1.14	1.07	1.07
3	2.00	3.70	1.19	1.10	1.10

Inclination factors : (from IS 6403 : 1981, page No. 9)

$i_c = (1-\alpha/90)^2$	$i_q = (1-\alpha/90)^2$	$i_\gamma = (1-\alpha/\phi)^2$
1.00	1.00	1.00

Water table factor : (from IS 6403 : 1981, page No. 9)

S.no.	Depth(m)	Width(m)	Z_w/B	W'
1	1.00	3.70	-0.27	0.50
2	1.50	3.70	-0.41	0.50
3	2.00	3.70	-0.54	0.50

Safe Bearing Capacity

S.no.	Depth(m)	Width(m)	SBC in (t/m^2)		
			General shear	Local shear	Recommended
1	1.00	3.70	21.40	6.35	10.01
2	1.50	3.70	25.64	7.78	12.13
3	2.00	3.70	30.05	9.28	14.34

SETTLEMENT CALCULATION AS PER 8009 Part-1 1976 (KM): 12+431																	BH NO. :- BH-CL			
Layer	Depth below FGL (m)	From (m)	To (m)	Layer Thickness	Stress at Foundation level (kg/Cm2)	Length (m)	Breadth (m)	Layer Thickness(m)	Dispersed Length (m)	Dispersed Breadth (m)	Stress Increment at top for cohesionless layer & at mid Depth for cohesive layer (kg/Cm2)	Average N-Value	Water Table Correction Factor	Influence Factor (I)	Settlement (mm) for 10 t/m2 (from IS:8009 (Part I), Fig. 9, Page NO. 17)	Settlement in Non-Cohesive Soil Si (mm)	Total Settlement (mm)	Depth Factor	Rigidity Factor	Corrected Total Settlement (mm)
Layer 1		1.00	6.55	5.55				5.55	3.70	3.700	1.437	30	0.50	0.9400	9.35	26.86	26.86			
	1.00				1.44	3.70	3.70											0.93	1.00	25.00
Layer 1		1.50	7.05	5.55				5.55	3.70	3.700	1.512	30	0.50	0.9400	9.35	28.27	28.27			
	1.50				1.51	3.70	3.70											0.88	1.00	25.00
Layer 1		2.00	7.55	5.55				5.55	3.70	3.700	1.595	30	0.50	0.9400	9.35	29.83	29.83			
	2.00				1.60	3.70	3.70											0.84	1.00	25.00

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 20.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.00 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.00	2.00	0.00	2.00					0.65	200	0.07											
1.00		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								314.29		3.78	
1.00		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								314.29		87.49	
1.00		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								314.29		50.35	
1.00		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								314.29		51.56	
1.00		14.50	15.00	1.02	6	1.00	0.43	0.98	50	1.32								314.29		9.09	
1.00		15.00	22.00	1.02	6	1.00	0.43	0.98	700	1.35	1.35	0.98	1.02	6	9	1.72	0.57	314.29	7857.14	127.86	90.54
																				330.14	90.54

Qu,comp.= qs + Qp

Qa,comp.= (330.14 + 90.54) / 2.5

Qa,comp.= 168.27 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 330.14 / 3 + 39.27

Qa,uplift = 149.32 T

Say **Qa,comp.= 168.00 T** **Qa,uplift = 149.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 22.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.00 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.00	2.00	0.00	2.00					0.65	200	0.07											
1.00		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								314.29		3.78	
1.00		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								314.29		87.49	
1.00		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								314.29		50.35	
1.00		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								314.29		51.56	
1.00		14.50	15.00	1.02	6	1.00	0.43	0.98	50	1.32								314.29		9.09	
1.00		15.00	24.00	1.02	6	1.00	0.43	0.98	900	1.35	1.35	0.98	1.02	6	9	1.72	0.57	314.29	7857.14	164.40	90.54
																				366.67	90.54

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (366.67 + 90.54) / 2.5 Qa,uplift = 366.67 / 3 + 43.2

Qa,comp.= 182.88 T Qa,uplift = 165.42 T

Say **Qa,comp.= 182.00 T** **Qa,uplift = 165.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 24.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.00 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.00	2.00	0.00	2.00					0.65	200	0.07											
1.00		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								314.29		3.78	
1.00		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								314.29		87.49	
1.00		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								314.29		50.35	
1.00		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								314.29		51.56	
1.00		14.50	15.00	1.02	6	1.00	0.43	0.98	50	1.32								314.29		9.09	
1.00		15.00	25.50	1.02	6	1.00	0.43	0.98	1050	1.35								314.29		191.80	
1.00		25.50	26.00	1.42	5	1.00	0.33	1.01	50	1.35	1.35	0.98	1.02	6	9	1.72	0.57	314.29	7857.14	9.14	90.54
																				403.21	90.54

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (403.21 + 90.54) / 2.5 Qa,uplift = 403.21 / 3 + 47.12

Qa,comp.= 197.50 T Qa,uplift = 181.53 T

Say **Qa,comp.= 197.00 T** **Qa,uplift = 181.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 26.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.00 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.00	2.00	0.00	2.00					0.65	200	0.07											
1.00		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								314.29		3.78	
1.00		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								314.29		87.49	
1.00		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								314.29		50.35	
1.00		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								314.29		51.56	
1.00		14.50	15.00	1.02	6	1.00	0.43	0.98	50	1.32								314.29		9.09	
1.00		15.00	25.50	1.02	6	1.00	0.43	0.98	1050	1.35								314.29		191.80	
1.00		25.50	28.00	1.42	5	1.00	0.33	1.01	250	1.35	1.35	1.01	1.42	5	9	1.57	0.45	314.29	7857.14	45.70	117.21
																				439.77	117.21

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (439.77 + 117.21) / 2.5 Qa,uplift = 439.77 / 3 + 51.05

Qa,comp.= 222.79 T Qa,uplift = 197.64 T

Say **Qa,comp.= 222.00 T** **Qa,uplift = 197.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 28.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.00 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.00	2.00	0.00	2.00					0.65	200	0.07											
1.00		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								314.29		3.78	
1.00		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								314.29		87.49	
1.00		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								314.29		50.35	
1.00		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								314.29		51.56	
1.00		14.50	15.00	1.02	6	1.00	0.43	0.98	50	1.32								314.29		9.09	
1.00		15.00	25.50	1.02	6	1.00	0.43	0.98	1050	1.35								314.29		191.80	
1.00		25.50	29.50	1.42	5	1.00	0.33	1.01	400	1.35								314.29		73.12	
1.00		29.50	30.00	2.56	5	1.00	0.26	1.04	50	1.35	1.35	1.01	1.42	5	9	1.57	0.45	314.29	7857.14	12.32	117.21
																				479.50	117.21

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (479.5 + 117.21) / 2.5 Qa,uplift = 479.5 / 3 + 54.98

Qa,comp.= 238.69 T Qa,uplift = 214.81 T

Say **Qa,comp.= 238.00 T** **Qa,uplift = 214.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 30.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.00 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.00	2.00	0.00	2.00					0.65	200	0.07											
1.00		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								314.29		3.78	
1.00		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								314.29		87.49	
1.00		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								314.29		50.35	
1.00		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								314.29		51.56	
1.00		14.50	15.00	1.02	6	1.00	0.43	0.98	50	1.32								314.29		9.09	
1.00		15.00	25.50	1.02	6	1.00	0.43	0.98	1050	1.35								314.29		191.80	
1.00		25.50	29.50	1.42	5	1.00	0.33	1.01	400	1.35								314.29		73.12	
1.00		29.50	32.00	2.56	5	1.00	0.26	1.04	250	1.35	1.35	1.04	2.56	5	9	1.57	0.45	314.29	7857.14	61.58	197.83
																				528.76	197.83

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (528.76 + 197.83) / 2.5 Qa,uplift = 528.76 / 3 + 58.9

Qa,comp.= 290.64 T Qa,uplift = 235.16 T

Say **Qa,comp.= 290.00 T** **Qa,uplift = 235.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 20.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.20 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.20	2.00	0.00	2.00					0.65	200	0.07											
1.20		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								377.14		4.53	
1.20		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								377.14		104.99	
1.20		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								377.14		60.42	
1.20		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								377.14		61.88	
1.20		14.50	18.00	1.02	6	1.00	0.43	0.98	350	1.47								377.14		78.42	
1.20		18.00	22.00	1.02	6	1.00	0.43	0.98	400	1.64	1.64	0.98	1.02	6	9	1.72	0.57	377.14	11314.29	92.35	136.16
																				402.59	136.16

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (402.59 + 136.16) / 2.5 Qa,uplift = 402.59 / 3 + 56.55

Qa,comp.= 215.50 T Qa,uplift = 190.74 T

Say **Qa,comp.= 215.00 T** **Qa,uplift = 190.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 22.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.20 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.20	2.00	0.00	2.00					0.65	200	0.07											
1.20		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								377.14		4.53	
1.20		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								377.14		104.99	
1.20		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								377.14		60.42	
1.20		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								377.14		61.88	
1.20		14.50	18.00	1.02	6	1.00	0.43	0.98	350	1.47								377.14		78.42	
1.20		18.00	24.00	1.02	6	1.00	0.43	0.98	600	1.64	1.64	0.98	1.02	6	9	1.72	0.57	377.14	11314.29	138.52	136.16
																				448.76	136.16

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (448.76 + 136.16) / 2.5 Qa,uplift = 448.76 / 3 + 62.2

Qa,comp.= 233.97 T Qa,uplift = 211.79 T

Say **Qa,comp.= 233.00 T** **Qa,uplift = 211.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 24.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.20 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.20	2.00	0.00	2.00					0.65	200	0.07											
1.20		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								377.14		4.53	
1.20		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								377.14		104.99	
1.20		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								377.14		60.42	
1.20		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								377.14		61.88	
1.20		14.50	18.00	1.02	6	1.00	0.43	0.98	350	1.47								377.14		78.42	
1.20		18.00	25.50	1.02	6	1.00	0.43	0.98	750	1.64								377.14		173.15	
1.20		25.50	26.00	1.42	5	1.00	0.33	1.01	50	1.64	1.64	0.98	1.02	6	9	1.72	0.57	377.14	11314.29	11.45	136.16
																				494.85	136.16

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (494.85 + 136.16) / 2.5 Qa,uplift = 494.85 / 3 + 67.86

Qa,comp.= 252.40 T Qa,uplift = 232.81 T

Say **Qa,comp.= 252.00 T** **Qa,uplift = 232.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 26.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.20 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.20	2.00	0.00	2.00					0.65	200	0.07											
1.20		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								377.14		4.53	
1.20		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								377.14		104.99	
1.20		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								377.14		60.42	
1.20		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								377.14		61.88	
1.20		14.50	18.00	1.02	6	1.00	0.43	0.98	350	1.47								377.14		78.42	
1.20		18.00	25.50	1.02	6	1.00	0.43	0.98	750	1.64								377.14		173.15	
1.20		25.50	28.00	1.42	5	1.00	0.33	1.01	250	1.64	1.64	1.01	1.42	5	9	1.57	0.45	377.14	11314.29	57.27	174.06
																				540.66	174.06

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (540.66 + 174.06) / 2.5 Qa,uplift = 540.66 / 3 + 73.51

Qa,comp.= 285.89 T Qa,uplift = 253.73 T

Say **Qa,comp.= 285.00 T** **Qa,uplift = 253.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 28.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.20 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.20	2.00	0.00	2.00					0.65	200	0.07											
1.20		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								377.14		4.53	
1.20		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								377.14		104.99	
1.20		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								377.14		60.42	
1.20		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								377.14		61.88	
1.20		14.50	18.00	1.02	6	1.00	0.43	0.98	350	1.47								377.14		78.42	
1.20		18.00	25.50	1.02	6	1.00	0.43	0.98	750	1.64								377.14		173.15	
1.20		25.50	29.50	1.42	5	1.00	0.33	1.01	400	1.64								377.14		91.63	
1.20		29.50	30.00	2.56	5	1.00	0.26	1.04	50	1.64	1.64	1.01	1.42	5	9	1.57	0.45	377.14	11314.29	15.26	174.06
																				590.28	174.06

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (590.28 + 174.06) / 2.5 Qa,uplift = 590.28 / 3 + 79.17

Qa,comp.= 305.74 T Qa,uplift = 275.93 T

Say **Qa,comp.= 305.00 T** **Qa,uplift = 275.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

NAME OF PROJECT:- "GTI for Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan in the state of Haryana."

Length of Pile below cut of level = 30.00 m **Bore Hole No =** BH-A1 **Ch. (KM)** 13+787 **Dia of pile =** 1.20 m **Cut-off Level =** 2.00 m below EGL

Restricting PD to 15D **Water Table depth considered for analysis =** 0.00 m **Scour Depth =** Non-scourable **Liquefaction Depth =** NL

Dia. of Pile	Cut-off Depth	Soil layers		Properties of layers/for Skin Friction							For End Bearing										
		from	to	c	Ø	k	α	γeff	ΔL	pd (s.f)	Pd (e.b)	γeff	c	Ø	Nc	Nq	Ny	As/cm	Ap	qs	Qp
(m)	(m)	(m)	(m)	kg/cm^2	deg			gm/cc	cm	kg/cm^2	kg/cm^2	gm/cc	kg/cm^2	deg				cm^2	cm^2	t	t
1.20	2.00	0.00	2.00					0.65	200	0.07											
1.20		2.00	2.50	0.23	4	1.00	1.00	0.65	50	0.15								377.14		4.53	
1.20		2.50	8.50	0.49	4	1.00	0.88	0.93	600	0.44								377.14		104.99	
1.20		8.50	11.50	0.70	5	1.00	0.65	0.95	300	0.87								377.14		60.42	
1.20		11.50	14.50	0.88	5	1.00	0.51	0.97	300	1.15								377.14		61.88	
1.20		14.50	18.00	1.02	6	1.00	0.43	0.98	350	1.47								377.14		78.42	
1.20		18.00	25.50	1.02	6	1.00	0.43	0.98	750	1.64								377.14		173.15	
1.20		25.50	29.50	1.42	5	1.00	0.33	1.01	400	1.64								377.14		91.63	
1.20		29.50	32.00	2.56	5	1.00	0.26	1.04	250	1.64	1.64	1.04	2.56	5	9	1.57	0.45	377.14	11314.29	76.32	290.15
																				651.34	290.15

Qu,comp.= qs + Qp Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,comp.= (651.34 + 290.15) / 2.5 Qa,uplift = 651.34 / 3 + 84.82

Qa,comp.= 376.60 T Qa,uplift = 301.94 T

Say **Qa,comp.= 376.00 T** **Qa,uplift = 301.00 T**

*FOS for Vertical Capacity of pile in compression = 2.5

**FOS for Uplift Capacity of pile = 3.0

Lateral Load capacity of Pile

BH-A1
Ch. (KM): 13+787

Type of Strata = Clayey

Le = Embedded Length of Pile in Meter = 22.000 m **Fck = 35.0 N/mm^2** **D = 100 cm**

Bed level 0.0 m

Pile cap bottom level -2.0 m

E	=	Young's Modulus of Pile (Kg/cm^2)	=	$5000\sqrt{F_{ck}}$ N/mm^2	=	295803.99	Kg/cm^2
I	=	Moment of Inertia (cm^2)	=	$\pi xD^4/64$	=	4908738.5	cm^4
c	=	weighted mean of cohesion along the length of pile from the top of scour depth to bottom of pile			=	0.690	Kg/cm^2
q_u	=	Unconfined Compression Strength	=	2 x c	=	1.380	Kg/cm^2
k_1	=	Modulus of Subgrade Reaction for cohesive soil (from Table 4)			=	2.484	kg/cm^3
K	=		=	$k_1 x 0.3/(1.5xB)$	=	0.497	kg/cm^3
R,		Relative stiffness factor in Preloaded Clay	R =	$\sqrt[4]{EI/KD}$	=	**413.5**	cm

For Long Pile If $L_e > 3.5R$

L1	=	=	**0.000**	cm
L_1/R		=	0.00	

For Fixed Head Pile

L_f/R	=	**2.000**	From Fig. 4	
Lf	=	826.95	cm	
Equivalent length of cantilever L= $L1+L_F$: 0.00 + 826.94777	=	**826.95**	cm	

Y = Pile Head Deflection (Cm) = $\frac{Q(L_1 + L_F)^3}{12\ EI}$ (for fixed Head pile)

Q = Lateral Load in Kg

Lateral Load For Pile Head Deflection 0.5 cm	Q	=	15406.04	Kg
		=	**15.4**	**T**

Lateral Load capacity of Pile

BH-A1
Ch. (KM): 13+787

Type of Strata = Clayey

Le = Embedded Length of Pile in Meter = 22.000 m **Fck = 35.0 N/mm^2** **D = 120 cm**

Bed level 0.0 m

Pile cap bottom level -2.0 m

E =	Young's Modulus of Pile (Kg/cm^2)	=	$5000\sqrt{F_{ck}}$ N/mm^2	=	295803.99	Kg/cm^2	
I =	Moment of Inertia (cm^2)	=	$\pi xD^4/64$	=	10178760.2	cm^4	
c =	weighted mean of cohesion along the length of pile from the top of scour depth to bottom of pile			=	0.690	Kg/cm^2	
q_u =	Unconfined Compression Strength	=	2 x c	=	1.380	Kg/cm^2	
k_1 =	Modulus of Subgrade Reaction for cohesive soil (from Table 4)			=	2.484	kg/cm^3	
K =		=	$k_1 x 0.3/(1.5xB)$	=	0.414	kg/cm^3	
R,	Relative stiffness factor in Preloaded Clay R =		$\sqrt[4]{EI/KD}$	=	**496.2**	cm	

For Long Pile If $L_e > 3.5R$

L1 =		=	**0.000**	cm	
L_1/R		=	0.00		

For Fixed Head Pile

L_f/R	=	**2.000**	From Fig. 4	
Lf	=	992.34	cm	
Equivalent length of cantilever L= $L1+L_F$ 0.00 + 992.33732	=	**992.34**	cm	

Y = Pile Head Deflection (Cm) = $\frac{Q(L_1 + L_F)^3}{12\ EI}$ (for fixed Head pile)

Q = Lateral Load in Kg

Lateral Load For Pile Head Deflection 0.5 cm	Q	=	18487.24	Kg
		=	**18.5**	**T**

7. APPROVED MANUFACTURES/SUPPLIERS LIST

APPROVED MANUFACTURES/SUPPLIERS LIST/R1

All materials and products shall conform to the Outline Construction Specification (OCS), BIS codes and other relevant codes etc. and shall be of make as approved by the Engineer.

The list of approved makes for products and materials is given below. Other equivalent manufacturers may also be considered with prior approval of the Engineer, if found conforming to all standards. Such requests should be made with all documents to the Engineer at least 45 days before the material is required and any order shall be placed only after receiving the written approval of the Engineer.

S. No.	Details of Materials/ Products	Manufacturer's Name
1.	Cement	ACC, Ultratech, Ambuja Cements, JK Lakshmi, JSW, JK Cement, Lafarge, *Shree Cement, Birla Cement, Grasim*
2.	Reinforcement Bars	*SAIL, JSW STEEL, TATASTEEL, RINL, JSPL*
3.	Epoxy	FOSROC, SIKA QUALCRETE, BASF, CICO, MC–BAUCHEMIE, MAPEI, CHRYSO, Huntsmen Advanced Materials
4.	Expansion Joints for Viaduct	Prequalified Manufacturers as per RDSO's latest approved list
5.	Admixtures	FOSROC, SIKA, MBT, MC-BAUCHEMIE, PIDILITE, CHRYSO, BASF, MAPEI, CICO
6.	Pile Integrity Testing	CIMEC, Geodynamics, AIMIL, CBRI, Pile Dynamic, CEGTH, FUGRO
7.	*Anchor Fastener	HILTI, FISHER, *BOSCH*, (Please note that ETA Certification is mandatory for using/supplying fasteners for load bearing structural members)
8.	Structural Steel	TATA, SAIL, ESSAR, *JSPL, JSW*
9.	Pre- stressing Strand (LRPC)	TATA SSL Ltd, USHA MARTIN
10.	*Pot/Elastomeric /Spherical Bearings	Prequalified Manufactures as per RDSO's latest approved list.
11.	HDPE Sheathing	Rex *Polyextrusion*, Gwalior Poly Pipes Ltd, Dynamic Prestress, JK Prestressing
12.	Formwork Release Agent	FOSROC, MC BAUCHEMIE, CICO, BASF, MAPEI, MBT, CHRYSO
13.	*Prestressing System	Freyssinet, BBR, VSL, Dynamic, Killick Nixon, Tensacciai (India Ltd.), JK Prestressing, Usha Martin, VSIL

S. No.	Details of Materials/ Products	Manufacturer's Name
14.	*Reinforcement Couplers	DEXTRA, , SANFIELD, SPLICETECH COUPLERS
15.	Hollow Sections, Pipes	Surya Pipes, Hi-Tech Pipes, JSW, JSPL, TATA.
16.	Drainage Pipes	Tirupati Plastomatics, Duraline, REX, STIPL
17.	Acrylic Textured Coatings	Spectrum, Surfa Nova, Jotun, Asian Paints, Berger, Hempel, DULUX
18.	Non Shrink Grout	FOSROC, Fairmate, BASF, SIKA, CICO, MBT, MC-Bauchemie, CHRYSO
19.	Bonding Coat	CICO, FOSROC, BASF, SIKA, MAPEI, MC-BAUCHEMIE, CHRYSO
20.	Polysuphide Sealant	CICO, PIDILITE, BASF, FOSROC, SIKA, CHRYSO
21.	*Steel Structural Fasteners	Sundram Fasteners, Nelson, *Dextra India,* Panchsheel, Pooja Forge (Please note that ETA Certification is mandatory for using/supplying fasteners for load bearing structural members)
22.	*Corrosion Protection Paints	Berger, Johnson Nicholson, Nerolac, Asian Paints, Akzo Nobel, Jotun
23.	Fire Resistant Paint	Akzo Nobel, PPG, Jotun
24.	Water stopper/ Bar	Greenstreak, Duron, Maruti, Kanta Rubber
25.	*Liquid Polymer membrane waterproofing	BASF, MAPEI , NINA, CICO, MYK Schomburg, Geo-Constech
26.	Curing Compound	FOSROC, CHRYSO, CICO, MC- BAUCHEMIE, MAPEI, MBT
27.	*Polycarbonate Sheets	Gallina Acroplus, Coxwell, Poly U, Fabic, Lexan, (SABIC Innovative Plastics), DANPALON, GE Plastics, VMI Plastics, Power Chem Plast
28.	Fly Ash	Thermal Plants, Ashcrete, Ultra Pozz, Star Pozz, Ashtech
29.	*Pre-Coated Profiled Metal Sheetings	TATA Blue Scope, Multicolor, Essar Steel, Bhushan Steel, Ispat Profile India
30.	Fly Ash Block/ AAC Block	Siporex, Ascolite, J.K. Laxmi, Ashtech
31.	Rock Bolts/Swellex Bolts	Geo Constech, DSI, Atlas Copco, FIREP International, Minova, Supanchor, Srons, Argentium
32.	Soft eye GFRP	Dextra, FIREP International, Minova, Hughes Brothers, Geo Constech
33.	Polymer	WALLGRIP, TRISHUL, Shubham Minerals, Goldy Minerals, GeoPolymer

S. No.	Details of Materials/ Products	Manufacturer's Name
34.	Welding electrodes	Ador welding Ltd.(Advani-Oerlikon),ESAB, D&H Welding Electrodes, Modi Arc
35.	Aluminium Sheets	Hindustan Aluminium, Jindal, Balco
36.	Vitrified Tiles	Asian Tiles, Somany, Johnson, Bell Ceramics, Kajaria, Simpolo
37.	Ceramic Tiles	NITCO, Orient, Regency Ceramics
38.	Wall Putty	JK White, Birla
39.	Flush Doors	Samrat, Kanchan, Prima Swastik, Kutty, Diamond
40.	Adhesives	Pidilite, Araldite, Toyo Ferrous Crete
41.	Plywood	Duroply, Century Plywood, Green Plywood, Kitply
42.	Veneers	Green Plywood, Century Plywood, Kitply
43.	FloatGlass/Toughened Glass/Insulated Glass/Laminated Glass	Saint Gobbain, Modiguard, Tata Float, Float Glass, Asahi Float
44.	Heavy Duty Chequered Tiles	NITCO. Hindustan Tiles, Super Tiles & Marbles Pvt.Ltd.
45.	Heavy Duty Vitrified Tiles	Kajaria World
46.	Emulsion Paint	Asian Paints, Berger, Nerolac, Johnson & Nicholson, Dulux, ICI
47.	Synthetic Enamel	Asian Paints, Berger, Nerolac, Johnson & Nicholson, Dulux, ICI
48.	Paver Blocks	As approved by the Engineer
49.	Sanitary & Bath Fittings	Hindware, Parryware, Jaquar, HR & Johnson, Cera, , Somany, Asian Granito
50.	Aluminium doors & windows	Sehgal & Sehgal Industries
51.	Yellow Tactile Tiles	Palican
52.	SS Railing	The Cavalier, D Line India, DOORMAT, Panchal Enterprises, SS Enterprises
53.	Glass Mosaic Tiles	Mridul Enterprises, Krishna, Italia, Bissazza, Kenzai, Opio
54.	Granite Slabs & Tiles	As approved by the Engineer.
55.	Steel fibre	Precision, SIC, Berkert
56.	Seamless pipes	Maharashtra seamless, Srons, Argentium, Machino International
57.	Resin & cement	SIKA, Ashoka chemicals, Buildcon, Techno precision

S. No.	Details of Materials/ Products	Manufacturer's Name
	capsules	
58.	Instrumentation (load cells, pressure cells, Bi-reflex targets, MBPX, stress cells, extensometers, inclinometer, piezometer, strain cell etc.)	Encardio-Rite, PMT, Systel

NOTE: For the categories marked as *, the enclosed undertaking performa should be duly filled and signed by authorized representatives of concerned agencies.

UNDERTAKING

Name of Contract: **Date of start of work:**

1983Category of work: **Date of completion of work:**

This is to certify that work of …… (Category to be mentioned) at …… (Location) of the contract.....(Name of contract) has been executed/completed in accordance with the manufacturer's/supplier's specifications and as per the approved method statement.

The work has been jointly inspected by authorised representative of ……(Manufacturer/supplier), …… (Executing agency) &…….. (Contractor) during its execution and all non-conformities observed during inspection have been complied to achieve the best industry standards.

The undersigned take full responsibility of the overall adequacy, accuracy, effectiveness & warranty (upto design life) of the completed work as per the provision of the contract……. (Contract number) and Outline Construction Specifications of the Part 2- Employer's Requirements.

(Stamp and Signature)	**(Stamp and Signature)**	**(Stamp and Signature)**
Manufacturer Representative	**Executing agency Representative**	**Contractor Representative**

8. KMZ File of Package C-4 Alignment

KMZ file of Alignment of Package C-4 shall be downloaded from HRIDC website under Active Tender section at the following URL:

http://www.hridc.co.in/active-tender.php

LIST OF CONTENTS

APPENDIX 1
DRAWING LIST

1. GENERAL

The Tender Documents contains a set of reference/Tender drawings that are applicable to the Contract Works. The Tenderer shall incorporate into the Tender only those drawings from that set which amplify aspects of the Contractor's Technical Proposals. General information drawings will not be included in the Contract. The dimensions mentioned in the tender drawings are indicative and may vary as per the design of the Contractor.

The List of Drawings issued with the Tender documents is stated in Part-2 Employer's Requirements - Tender Drawings and Documents.

APPENDIX – 2

CONTRACT KEY DATES AND COMPLETION DATE

Key Dates	Weeks from		Description of Stage	Delay Damage for each week of delay or part thereof for non-achieving the key dates
	LOA	Commencement Date		
Key Date 1	8		Submission and approval of Definitive Design of Shafts including construction methodology. (Duration of 8 weeks includes two weeks for third party checking by DDC appointed by the Employer and approval by GC.)	0.001% of the fixed lump sum price quoted in Schedule 'A'.
Key Date 2	16		Submission and approval of Definitive Design for Cut & Cover Tunnel and NATM tunnel (soil) including construction methodology. (Duration of 16 weeks includes three weeks for third party checking by DDC appointed by the Employer and approval by GC.)	0.001% of the fixed lump sum price quoted in Schedule 'A'.
Key Date 3		30	Completion of Construction of Permanent Ventilation Shaft No. 3 and 4 at Chainage 27680m	0.002% of the fixed lump sum price quoted in Schedule 'A'.
Key Date 4		32	Completion of Construction cum Utility Shaft at Chainage 26950m	0.002% of the fixed lump sum price quoted in Schedule 'A'.
Key Date 5		34	Completion of Construction of Permanent Ventilation Shaft No. 1 and 2 at Chainage 26080m	0.002% of the fixed lump sum price quoted in Schedule 'A'.
Key Date 6		85	Construction of Cut & Cover Tunnel No. 1 between Chainage 28480 and Chainage 29580.	-
Key Date 7		90	Completion of excavation and primary support of Tunnel No. 1 between Construction cum Utility Shaft and Permanent Ventilation Shaft No. 3.	-
Key Date 8		95	Completion of excavation and primary support from Permanent Ventilation Shaft No.1 (Chainage 26080m) to Portal P-1 (Chainage 24880m) in Tunnel No.1.	

Key Dates	Weeks from		Description of Stage	Delay Damage for each week of delay or part thereof for non-achieving the key dates
	LOA	Commencement Date		
Key Date 9		95	Completion of excavation and primary support of Tunnel No. 1 between Permanent Ventilation Shaft No. 3 and Chainage 28480.	-
Key Date 10		111	Completion of excavation and primary support of Tunnel No. 1 between Permanent Ventilation Shaft No. 1 and Construction cum Utility Shaft.	0.002% of the fixed lump sum price quoted in Schedule 'A'.
Key Date 11		137	Construction of Cut & Cover Tunnel No. 2 between Chainage 28480 and Chainage 29580.	-
Key Date 12		141	Secondary lining of Tunnel 1 from Portal P-1 (Chainage 24880m) to Chainage 28480 m including invert concreting.	0.002% of the fixed lump sum price quoted in Schedule 'A'.
Key Date 13		142	Completion of excavation and primary support of Tunnel No. 2 between Construction cum Utility Shaft and Permanent Ventilation Shaft No. 4.	-
Key Date 14		142	Completion of excavation and primary support of Tunnel No. 2 between Portal P-2 and Permanent Ventilation Shaft No. 4.	-
Key Date 15		147	Completion of excavation and primary support between Portal P-1 and Permanent Ventilation Shaft No. 2 in Tunnel-2.	-
Key Date 16		152	Completion of **General Electrical Services** works in Tunnel-1.	-
Key Date 17		153	Completion of Ballastless track in Tunnel-1	-
Key Date 18		154	Completion of Tunnel-1 in all respect	0.003% of the fixed lump sum price quoted in Schedule 'A'.
Key Date 19		163	Completion of excavation and primary support of Tunnel No. 2 between Permanent Ventilation Shaft No. 2 and Construction cum Utility Shaft.	0.002% of the fixed lump sum price quoted in Schedule 'A'.

Key Dates	Weeks from		Description of Stage	Delay Damage for each week of delay or part thereof for non-achieving the key dates
	LOA	Commencement Date		
Key Date 20		193	Secondary lining of Tunnel 2 from Portal P-1 (Chainage 24880m) to Chainage 28480 m including invert concreting.	
Key Date 21		204	Completion of **General Electrical Services** works in Tunnel-2.	-
Key Date 22		205	Completion of Ballastless track in Tunnel-2	-

Permanent Ventilation Shaft No. 1 & 2 – Chainage 26080
Construction cum Utility Shaft – Chainage 26950
Permanent Ventilation Shaft No. 3 & 4 – Chainage 27680

Note- Delay damage recovered for not achieving Key Date-18 shall not be returned to the Contractor even if the entire Works are completed within the stipulated Time for Completion.

APPENDIX 3

WORKS AREAS AND TEMPORARY POWER SUPPLY

3. WORK AREA (WITHIN ROW) ACCESS DATES

3.1 General

"Works Areas" means the areas of the Site within the Right of Way of HORC including vacant land in KMP ROW and any additional areas which may be obtained by the Contractor and agreed by the Engineer as additional working area.

a) The dates on which Work Areas (within ROW) are available to the Contractor for the commencement of the Works are defined as Work Area Access Dates (AD).

b) The Work Area Access Dates that apply to this Contract are stated in terms of days after the Commencement Date of the Works.

c) Where Work Areas are to be made available to the Contractor, they shall be available within the specified day. Where Work Areas are to be vacated, they shall be released not later than midnight on the specified day.

3.2 Work Area Access Schedule

The access to and possession of Works Area (within ROW) shall be made available as per Part A Contract Data of Particular Conditions of the Contract (PCC).

3.3 ELECTRICAL GENERAL

Temporary electrical Site installations and distribution systems shall be in accordance with:-

(a) Indian Electricity Rules

(b) The Power Companies' Supply Rules;

(c) Electricity and its subsidiary Regulations;

(d) IEE Wiring Regulations (16^{th} Edition);

(e) BS 7375 Distribution of Electricity on Construction and Building Sites;

(f) BS 4363 Distribution Assemblies for Electricity Supplies for Construction and Building Sites; and

(g) BS 6164 Safety in Tunnelling in the Construction Industry.

(h) Any other applicable national standards

3.4 MATERIALS, APPLIANCES AND COMPONENTS

All materials, appliances and components used within the distribution system shall comply with BS 4363 and BS 7375 Appendix A.

3.5 DESIGN CONSIDERATIONS

(i) Distribution equipment utilised within the temporary electrical distribution system shall incorporate the following features:-

(a) flexibility in application for repeated use;

(b) suitability for transport and storage;

(c) robust construction to resist moisture and damage; and

(d) safety in use.

(ii) All cabling shall be run at high level whenever possible and firmly secured to ensure they do not present a hazard or obstruction to people and equipment.

(iii) The installation on Site shall allow convenient access to authorised and competent operators to work on the apparatus contained within.

3.6 MAINS VOLTAGE

(i) The Site mains voltage shall be as per the Electricity Authority, 415V/ 3 phase 4 wire system.

(a) Single phase voltage shall be as per the Electricity Authority, 230V supply.

(b) Reduced voltages shall conform to BS 7375.

(ii) Types of Distribution Supply

The following voltages shall be adhered to for typical applications throughout the distribution systems:

(a) fixed plant - 415V/ 3 phase;

(b) movable plant fed by trailing cable - 415V /3 phase;

(c) installations in Site buildings - 230V /1 phase;

(d) fixed flood lighting - 230V/ 1 phase;

(e) portable and hand held tools - 115V /1 phase;

(f) Site lighting (other than flood lighting) - 115V /1 phase; and

(g) portable hand-lamps (general use) - 115V /1 phase.

(iii) When the low voltage supply is energised via the Employer's transformer, any power utilised from that source shall be either 415V 3 phase or / 230V. 1 phase as appropriate. The Contractor shall carry out any conversion that may be necessary to enable him to use power from that source.

3.7 PROTECTION OF CIRCUITS

(i) Protection shall be provided for all main and sub-circuits against excess current, under and over voltage, residual current and earth faults. The protective devices shall be capable of interrupting (without damage to any equipment or the mains or sub-circuits) any short circuit current that may occur.

(ii) Discrimination between circuit breakers, circuit breakers and fuses shall be in accordance with:-

(a) BS 88;

(b) BS EN 60898;

(c) BS 7375; and

(d) Any other appropriate Indian Standards.

3.8 EARTHING

(i) Earthing and bonding shall be provided for all electrical installations and equipment to prevent the possibility of dangerous voltage rises and to ensure that faults are rapidly cleared by installed circuit protection.

(ii) Earthing systems shall conform to the following standards:-

(e) IEE Wiring Regulations (16th Edition);

(b) BS 7430;

(c) BS 7375; and

(d) IEEE Standard 80 Guide for Safety in AC Substation Grounding.

3.9 PLUGS, SOCKET OUTLETS AND COUPLERS

Low voltage plugs, sockets and couplers shall be colour coded in accordance with BS 7375, and constructed to conform to BS EN 60309. High voltage couplers and 'T' connections shall be in accordance with BS 3905.

3.10 CABLES

(i) Cables shall be selected after full consideration of the conditions to which they will be exposed and the duties for which they are required. Supply cables up to 3.3KV shall be in accordance with BS 6346.

(ii) For supplies to mobile or transportable equipment where operation of the equipment subjects the cable to flexing, the cable shall conform to one of the following specifications appropriate to the duties imposed on it:

(a) BS 6708 flexible cables for use at mines and quarries;

(b) BS 6007 rubber insulated cables for electric power and lighting; and

(c) BS 6500 insulated flexible cords and cables.

(iii) Where low voltage cables are to be used, reference shall be made to BS 7375. The following specifications shall also be referred to particularly for underground cables:-

(a) BS 6346 for armoured PVC insulated cables; and

(b) BS 6708 Flexible cables for use at mines and quarries.

(iv) All cables which have a voltage to earth exceeding 65 V (except for supplies from welding transformers to welding electrodes) shall be of a type having a metal sheath and/or armour which shall be continuous and effectively earthed. In the case of flexible or trailing cables, such earthed metal sheath and/or armour shall be in addition to the earth core in the cable and shall not be used as the sole earth conductor.

(v) Armoured cables having an over sheath of polyvinyl chloride (PVC) or an oil resisting and flame retardant compound shall be used whenever there is a risk of mechanical damage occurring.

(vi) For resistance to the effects of sunlight, overall non-metallic covering of cables shall be black in colour.

(vii) Cables which have applied to them a voltage to earth exceeding 12 V but not normally exceeding 65 V shall be of a type insulated and sheathed with a general purpose or heat resisting elastomer.

(viii) All cables which are likely to be frequently moved in normal use shall be flexible cables.

Flexible cables shall be in accordance with BS 6500 and BS 7375.

3.11 LIGHTING INSTALLATION

(i) Where Site inspection of the Works is required during the nights, the Lighting circuits shall be run separate from other sub-circuits and shall be in accordance with BS 7375 and BS 4363.

(ii) Voltage shall not exceed 55 V to earth except when the supply is to a fixed point and where the lighting fixture is fixed in position.

(iii) Luminaries shall have a degree of protection not less than IP 54. In particularly

bad environments where the luminaries are exposed to excesses of dust and water, a degree of protection to IP 65 shall be employed.

(iv) The Contractor shall upgrade the lighting level to a minimum of 200 lux by localised lighting in all areas where required by the Engineer,.

(v) Mechanical protection of luminaries against damage by impact shall be provided by use of wire guards or other such devices whenever risk of damage occurs.

3.12 ELECTRICAL MOTORS

(i) Totally enclosed fan cooled motors to BS 4999:Part 105 shall be used.

(ii) Motor control and protection circuits shall be as stipulated in BS 6164. Emergency stops for machinery shall be provided.

3.13 INSPECTION AND TESTING

Electrical installations on Site shall be inspected and tested in accordance with the requirements of the IEE Wiring Regulations (16^{th} Edition)

3.14 IDENTIFICATION

Identification labels of a type reviewed without objection by the Engineer shall be affixed to all electrical switches, circuit breakers and motors to specify their purpose.

3.15 MAINTENANCE

(i) Strict maintenance and regular checks of control apparatus and wiring distribution systems shall be carried out by an electrician (duly qualified to carry out the said checks) to ensure safe and efficient operation of the systems. The Contractor shall submit for review by the Engineer details of his maintenance schedule and maintenance works record.

(ii) All portable electrical appliances shall be permanently numbered (scarf tag labels or similar) and a record kept of the date of issue, date of the last inspection carried out and the recommended inspection period.

APPENDIX 4

PROJECT CALENDAR

4. GENERAL

4.1. For the Project, the Contractor shall adopt 7 days a week calendar, identical calendar for the purpose of programming and Execution of Works. Official documents shall be transacted during 5 days week - Monday through Friday, except for National (Govt. of India) Holidays.

4.2. The Project Weeks shall be commenced on a Monday. A day shall be deemed to commence at 0001 hour on the morning of the day in question. Where reference is made to the completion of an activity by a particular week, this shall mean by midnight on the Sunday of that week. Requirements for the computation of Key Date are given in Appendix 2 to the Employer's Requirements.

4.3. A 7-day week calendar shall be adopted for various (Work) programme schedules for scheduling purposes. For Project purposes, the presentation shall be in 'Week"' units.

APPENDIX – 5

INTERFACE, COORDINATION AND COOPERATION WITH OTHER PARTIES

5.1 LIST OF CONTRACT PACKAGES IN HORC

S. No.	Package	Name of Work
1.	C-1	Priority Section - Construction of Earthwork, Bridges, Station Buildings, Retaining Walls and other miscellaneous works in connection with laying of New BG Double Railway line of HORC Project from Km 49.7 to Km 55.6 and its connectivity (new BG single line) from proposed Manesar Station of HORC to existing Patli Railway Station of IR Network.
2.	T-1	T-1: Laying of Track and track related works including supply of ballast, special sleepers, switches and crossings track fittings but excluding supply of Rails and line Sleepers in connection with laying of New BG Double Railway Line of HORC project from Km 32.00 to Km 61.5 and its connectivities to IR Network from Manesar to Patli Stations and New Patli to Patli & New Patli to Sultanpur Stations.
3.	Br-1	Fabrication, assembly & launching of 1X76.2 m span Open Web Girder (OWG) each over three lines on NH-352W (Pataudi Road) between Manesar and Patli stations including supplying & fixing of H-beam sleepers in connection with laying of New BG Double Railway Line of HORC project at Km 54.498.
4.	C-23	Design and Construction of Civil Works (Earthwork, Bridges, Station Buildings, Retaining Walls and other miscellaneous Works) from km 29.58 to km 49.70 & from km 55.60 to km 61.50 and its connectivities to IR network from New Patli to Patli station & New Patli to Sultanpur station including modifications/civil works at Sultanpur Station in connection with laying of New BG Double Railway line of HORC project.
5.	C-4	C-4: Composite Contract package in connection with New BG Railway Line of HORC project for: (i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580; (ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680; (iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680. (iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.

6.	C-5	Design and Construction of Viaduct (from Km 21.34 to Km 24.856), Earthwork, Viaduct, Bridges, Retaining Walls & other miscellaneous Works in Connection with laying of New BG Double Railway Line of HORC project from km -2.10 to km 12.00 and km 18.00 to km 24.856
7.	C-6	Design and Construction of Earthwork, Bridges, Station Buildings, Retaining Walls and other miscellaneous Works, in Connection with laying of New BG Double Railway Line of HORC project from Km 61.5 to Km 125.98 and its connectivities from proposed Badsa station of HORC to Existing Sultanpur station on IR Network and proposed Mandothi station to existing Asaudha Station on IR network.
8.	E-1	Design, Supply, Installation, Testing & Commissioning of OHE and General Electrical services in connection with laying of New BG Double Railway line of HORC Project from Km -2.14 to Km 125.98 (*including* Tunnel portion i.e from Km 24.856 to km 29.680) and its connectivities to IR/DFC networks from Prithla to New Prithla, New Patli to Patli, New Patli to Sultanpur, Badsa to Sultanpur and Mandothi to Asaudha including modifications in Sultanpur and Asaudha station yards.
9.	ST-1	Design, Supply, Installation, Testing & Commissioning of Signalling & Telecommunication in connection with laying of New BG Double Railway line of HORC Project from Km -2.14 to Km 125.98 and its connectivities to IR/DFC networks from Prithla to New Prithla, Manesar to Patli, New Patli to Patli, New Patli to Sultanpur, Badsa to Sultanpur and Mandothi to Asaudha including modifications in Patli , Sultanpur and Asaudha station yards.
10.	T-2	Design, Supply and laying of Track and Track related works in connection with laying of New BG Double Railway Line of HORC project from Km -2.14 to Km 24.856, Km 29.680 to Km 32.00 and from Km 61.50 to Km 125.98 including its connectivities from proposed Badsa station of HORC to existing Sultanpur station on IR Network and proposed Mandothi station to existing Asaudha Station on IR Network

Note:

The above list is only tentative and has been provided for giving overview of the Project to the Tenderers. However, it may undergo change in future at the sole discretion of HRIDC.

5.2 GENERAL

5.2.1 This Appendix describes the Contractor's responsibilities with regard to interface management and coordination and includes interfacing with other contractors employed by the Employer (referred to as "Interfacing Contractors" hereinafter), and Interfacing Parties including entities such as local authorities, statutory bodies, public utility companies, private service providers, consultants or contractors whether or not specifically mentioned in the Contract. This responsibility is not limited to a particular number of Interfacing Contractors and Interfacing Parties, and all interfaces as required in the Contract are the sole responsibility of the Contractor.

5.2.2 Interfaces internal to the Contract are the sole responsibility of the Contractor and are not covered by this Appendix.

5.3 RESPONSIBILITIES OF THE CONTRACTOR

5.3.1 So as to ensure that the whole Project including Interfacing Contractors' works as well as the Contractor's Works shall be executed in the most efficient manner in the best interest of the Employer, the Contractor shall:

a) Take the lead in the management of the coordination process with Interfacing Contractors and Interfacing Parties.

b) Accord access to the Site and/or services to any related party in the Contract including members of the Interfacing Contractors, Interfacing Parties and the Engineer/Employer.

c) Not impede the work of the Interfacing Contractors and Interfacing Parties and shall accord them all reasonable opportunities and facilities.

5.3.2 The Contractor shall, in accordance with the Works Requirements, coordinate and integrate the:

a) Contractor's own Works under the Contract with the works of the Interfacing Contractors and Interfacing Parties.

b) Works of the Interfacing Contractors and Interfacing Parties.

5.3.3 The Contractor shall comply with any instruction which the Engineer may give. The Contractor's responsibilities shall neither be mitigated nor in any way affected by virtue of similar responsibilities being placed on the Interfacing Contractors. The Contractor shall be responsible for the detailed coordination of his manufacturing, installation, construction, testing and commissioning activities.

5.3.4 The Contractor shall carefully review any pertinent information made available by the Engineer relating to the nature and programming of all related parties' contracts and use such information in his planning of the Works.

5.3.5 The Contractor shall communicate and exchange information directly with the Interfacing Contractors and Interfacing Parties with a copy to the Engineer for information. Information as necessary to fulfil the Contractor's interface obligations shall be directly requested and obtained from the Interfacing Contractors and Interfacing Parties with a copy to the Engineer for information and receipt acknowledged.

5.3.6 The Contractor shall ensure that the Contractor's requirements, including any design inputs to other packages, are provided to all related parties of the Interfacing Contractors and Interfacing Parties before the cut-off dates as identified in the Interface Management Plan to be developed by the Contractor and consented to by the Engineer.

5.3.7 Where other contracts requiring interface are yet to be awarded, the Contractor shall proceed with coordination activities with the Engineer, until such time as the Interfacing Contractors are employed by the Employer.

5.3.8 The Contractor shall take all reasonable steps to ensure that the Works are integrated with the manufacture, installation, execution and testing of such other works and shall in particular but without limitation to:

a) Comply with any instruction which the Engineer may give for the integration of the Works with the design of any other part of the Project;

b) Consult, liaise and cooperate with those responsible for carrying out such other works, including where necessary, in the preparation of the respective designs and drawings, the preparation of coordinated programmes, method statements, coordination drawings and specifications together with arrangements of service priorities and zoning to coordinate the priorities of tasks and division of the area together with the items mentionedpreviously; and

5.3.9 Participate in the Integrated Testing and Commissioning of the Works with the Interfacing Contractors and Interfacing Parties and demonstrate to the satisfaction of the Engineer that the Works have been constructed in a manner compatible with the works of the Interfacing Contractors and Interfacing Parties.

5.3.10 There shall be a continuous requirement for coordination by the Contractor between Interfacing Contractors/Interfacing Parties.

5.3.11 During the Works the Contractor shall provide within the Site the facilities including, but not limited to, staging, storage and unloading, and temporary storage areas for the temporary use of Interfacing Contractors and/or Interfacing Parties, as may reasonably be required during the construction/installation and commissioning process. Where separate locations need to be provided for each of the Interfacing Contractors and/or Interfacing Parties, prior to construction commencing, specific details shall be coordinated and agreed between the Contractor and the Interfacing Contractors and/or Interfacing Parties.

5.3.12 The Contractor shall attend meetings with Interfacing Contractor and Interfacing Parties (if necessary) and raise/provide correspondence in this regard in accordance with the Works Requirements and/or as instructed by the Engineer. The identity of the Interfacing Contractor(s) and/or Interfacing Parties may not be known before the execution of the Contract but this shall not be a grounds for the Contractor to object to the subsequent appointment of any Interfacing Contractor and/or Interfacing Party.

5.3.13 The Contractor shall in accordance with the requirements of the Contract and instructions of the Engineer coordinate his own Works with the works of Interfacing Contractors and/or Interfacing Parties strictly adhering to the Coordination and Interfacing Programme and shall accord the Interfacing Contractors and/or Interfacing Party's all reasonable opportunities for carrying out their works.

5.3.14 If the Contractor suffers delay by reason of failure caused by any Interfacing Contractor/Interfacing Party to meet the specified installation interfacing and/or coordination completion dates resulting in delay beyond the extent which could be reasonably foreseen by an experienced contractor at the time when the Coordination and Interfacing Programme is formulated and consented by the Engineer, then the Engineer shall take such delay into consideration in determining any extension of time to which the Contractor is entitled under the Contract.

5.3.15 If any act or omission of the Contractor, whether directly or indirectly, results in the delay in execution of the works of an Interfacing Contractor and/or Interfacing Party associated with the execution of the project, the matter shall be settled by the Engineer

5.3.16 All requests for information or clarification, acknowledgement of receipt of information and any official communication between the Contractor and Interfacing Contractors/Interfacing Parties shall be made in writing with a copy to the Engineer for information.

5.3.17 The Contractor shall notify the Engineer in writing of any problems encountered in obtaining necessary information and/or lack of cooperation from an Interfacing Contractor/Interfacing Party. In the event that the Engineer considers that the resolution of an interface is not proceeding satisfactorily, the Engineer shall review the matter and establish a coordinated plan directing the Contractor and the Interfacing Contractors/ Interfacing Parties regarding the required action.

5.3.18 The Contractor shall prepare minutes recording all the matters discussed and agreed at all the meetings.

5.3.19 The Contractor shall ensure that copies of all correspondence, drawings, meeting minutes, programmes, etc. relating to the Contractor's coordination and interfacing meetings with the Interfacing Contractors and Interfacing Parties or the sharing of correspondence, drawings, programmes, etc. are issued to all concerned parties and the Engineer no later than seven days from the date of such meetings and the date of issue of such correspondence, drawings, programmes, etc.

5.3.20 Should it appear to the Engineer that the Three Month Rolling Programme does not conform with the Coordination and Interfacing Programme, the Contractor shall be required to revise all such programmes so as to conform to the approved Contractual Works Programme.

5.4 INTERFACE ADMINISTRATION SYSTEM

5.4.1 The Contractor shall establish an Interface Administration System (the "IAS") and participate in the activities with the Interfacing Contractors and Interfacing Parties. The IAS shall include, but not be limited to, the following provision of:

a) An Interface Manager who shall be responsible for and the authority to resolve interfacematters to the satisfaction of the Engineer;

b) The necessary support team for the IAS;

c) Procedures and details for response to, confirmation of and making written agreements with regard to interfaces;

d) Details of the arrangement for attendance at coordination and interface meetings (including those that may be arranged by Interfacing Contractors, Interfacing Parties or the Engineer). The representatives of Contractor, Interfacing Contractors and InterfacingParties shall be empowered to make agreements on coordination and interfaces. The Contractor shall arrange regular meetings for the Engineer to monitor the status of coordination and interfaces and may arrange special coordination and interface meetingsas may be necessary to resolve specific issues. The Engineer can require the Contractor to arrange a special coordination and interface meetings if necessary. The Contractor mayrequest assistance from the Engineer to arrange coordination and interface meetings on particular subjects;

e) Details to the Engineer of regular status information and/or details of coordination and interfaces including copies of relevant correspondence and material; and

f) Details to the Engineer of access to information for the purpose of conducting audits on interface compliance and for confirming that interface coordination and interface management is proceeding consistently with the requirements of the Contract.

5.4.2 CONSTRUCTION INTERFACE

a) Construction coordination and interface shall be required throughout the duration of the Contract and shall commence from the time of the LOA until the Taking Over of the Works.

b) The Contractor shall coordinate and interface with the Interfacing Contractors and Interfacing Parties to execute the respective construction activities efficiently.

c) The Contractor shall cooperate with Interfacing Contractors and Interfacing Parties on all Site- related matters including but not limited to Site access and occupation, safety, verification of work compatibility and survey control, etc. The Contractor shall advise the Interfacing Contractors and Interfacing Parties in advance when a construction item is ready for site inspection to verify compatibility with the Interfacing Contractors' and Interfacing Parties' needs and shall facilitate access to the Site for the Interfacing Contractors and Interfacing Parties.

d) At or near the completion of the construction of any interface-related element of the Contractor's Work, the Contractor shall:

   i) Advise the Interfacing Contractors and Interfacing Parties that the as-constructed interface- related Works can be inspected and provide the necessary access to the Site and its occupation.

ii) Agree in writing to the Interfacing Contractors and Interfacing Parties, and as consented bythe Engineer, on the adoption of any Interfacing Contractors' and/ or Interfacing Parties' applicable comments on the constructed Works.

e) On advice from the Interfacing Contractor or Interfacing Party that an as-constructed interface- related element is ready for inspection, the Contractor shall:

f) Conduct on-site inspections of the Works elements and give comments in writing to the Interfacing Contractor and/or Interfacing Party.

g) Agree in writing to the Interfacing Contractor or Interfacing Party that the as-constructed Works meet the coordination and/or interface requirements.

h) Prior to applying for a Taking-Over Certificate, the Contractor shall obtain written confirmation from each Interfacing Contractor and each Interfacing Party, that the interface elements meet the requirements of the Interfacing Contractors and Interfacing Parties. If any Interfacing Contractor or Interfacing Party withholds such confirmation, the Engineer shall decide on further action, as requested by the Contractor prior to the issue of a Taking-Over Certificate.

i) Where Contractor's Works are identified as failing to meet the requirements of the Contract and such shall impact the Interfacing Contractors' works or Interfacing Parties' works, the Contractor shall submit the proposed remedial measures to the Engineer for review and shall copy the same to the Interfacing Contractors and/or Interfacing Parties.

j) The Contractor shall coordinate and interface with the Engineer with respect to all construction/installation activities and shall follow the Engineer's instructions for requesting access for such activities.

k) The Contractor shall undertake construction/ installation in accordance with the approved (Contractual) Works Programme. The Contractor shall coordinate and interface with Interfacing Contractors and/or Interfacing Parties for the planning and execution of the testing and commissioning activities.

5.5 INTERFACE DOCUMENTS

5.5.1 Preparation of Interface Documents

The Contractor shall prepare as required the following coordination and interface documents which shall be used to completely define the Contractor's coordination and interface details:

a. Interface Table;

b. Coordination and Interfacing Programme; and

c. Interface Management Plan (IMP).

5.5.2 These coordination and interface documents shall be submitted for review by the Engineer in order to obtain the Engineer's Approval. For all subsequent updates, these documents shall be submitted to the Engineer for information, review and comment. A summary of principal issues with suitable solutions shall be included in each Monthly Progress Report.

5.6 INTERFACE TABLE FOR SUPPLY AND INSTALLATION ITEMS

5.6.1 The Interface Table shall include at least (but without limitation) the items related with the Contractor's Contract described in Appendix 5. The Interface Table, which describes the relationships between the Contractor and Interfacing Contractors and/or the Interfacing Parties and their roles and responsibilities, shall be submitted to the Engineer for consideration after further development of Interface Table.

5.6.2 The Interface Table shall indicate the demarcation of scope of responsibilities between the Contractor and the Interfacing Contractors and the Interfacing Parties.

5.6.3 Within sixty (60) days of notification from the Engineer of the identity of each Interfacing Contractor, the Contractor shall develop and submit to the Engineer an Interface Table that is mutually acceptable to both the Contractor and the Interfacing Contractors and Interfacing Parties.

5.7 COORDINATION AND INTERFACING PROGRAMME

5.7.1 The Contractor shall prepare and submit a Coordination and Interfacing Programme to the Engineer in accordance with the Works Requirements and/or as instructed by the Engineer as detailed below.

5.7.2 The Coordination and Interfacing Programme shall be submitted to the Engineer for consent within sixty (60) days from the Letter of Acceptance (LOA) to allow for checking and monitoring by the Engineer.

5.7.3 The Coordination and Interfacing Programme shall include detailed activities describing all aspects of the works of Interfacing Contractors and Interfacing Parties to meet all Sections or Milestones given in the Contract and be clearly linked to other programmes such as the (Contractual) Works Programme (or Work Segment Programmes) to streamline the Works and the works of the Interfacing Contractors and Interfacing Parties.

5.7.4 The Coordination and Interfacing Programme shall indicate the physical areas to which the Interfacing Contractors and Interfacing Parties require access, with access dates, durations required and the required degree of completion of the Works prior to the access dates by Interfacing Contractors and Interfacing Parties.

5.7.5 It is the Contractor's responsibility to ensure timely coordination with the Interfacing Contractors and Interfacing Parties to review, revise and finalise his Coordination and Interfacing Programmes so as not to affect the progress of the Works and/or the works of the Interfacing Contractors and Interfacing Parties.

5.7.6 The Contractor shall note that the following conditions apply to the works of the Interfacing Contractors and/or Interfacing Parties:

a) The Interfacing Contractors and/or Interfacing Parties shall not have exclusive access to any part of the Site except with the consent of the Engineer;

b) The Contractor shall take note that concurrent time allocations for certain areas may be given to more than one Interfacing Contractors and or Interfacing Parties. The Contractorshall coordinate the Works in such areas with the works of the Interfacing Contractors and/or Interfacing Parties and report to the Engineer for his review and consent;

c) The absence of a Coordination and Interfacing Programme date or construction/ installation period for the Interfacing Contractors and/or Interfacing Parties in a specific area shall not prejudice the right of the Engineer to establish a reasonable Coordination and Interfacing Programme date or construction/installation period for thatarea;

d) The Contractor and the Interfacing Contractors shall comply with the Sections or Milestones and other successive activities specified in the Coordination and Interfacing Programme.

5.8 INTERFACE MANAGEMENT PLAN (IMP)

5.8.1 The Contractor shall develop and submit to the Engineer, within sixty (60) days from the LOA, an IMP for all interface issues that may arise during the construction, testing and commissioning of the Works, in consultation with the Interfacing Contractors / Interfacing Parties and the Engineer. The IMP shall allow adequate time periods for each of the Interfacing Contractors/ Interfacing Parties and the Contractor to install their Plant, equipment and Materials in the designated areas.

5.8.2 The IMP shall:

a) Identify all the systems and sub-systems and facilities with interfacing requirements;

b) Define as far as possible the authority and responsibility of the contractor's, the Interfacing Contractor's and interfacing party's involved in interface management and development;

c) Identify the information to be exchanged, together with the management and technical skills required for the associated development of the works, at each phase of the contractor's and Interfacing Contractor's and Interfacing Parties' project life-cycles;

d) Address the Contractual Works Programme (or Work Segment Programmes) of the Contract to meet the Contractor's sections or Milestones and the Interfacing Contractors' sections or milestones and highlight any programme risks requiring the Engineer's attention;

e) Include relevant consideration of the requirements of "Environment Social Health and Safety Manual" as described in Appendix 13;

f) Address the supply, installation, testing and commissioning programmes of the Contract to meet Interfacing Contractors' Sections or Milestones, and highlight any programme risks requiring management attention; and

g) Indicate dates for commencement and completion of each principal activity by the Contractor and those of the Interfacing Contractors and Interfacing Parties, including delivery and installation of Plant, equipment and Materials.

5.8.3 After the Engineer reviews and issues approval to the IMP, the Contractor shall execute the Works accordingly.

5.8.4 The Contractor shall raise and apprise the Engineer immediately of any difficulty in developing a mutually acceptable IMP.

5.8.5 Employer's / Engineer's Input

a) The Employer or Engineer or both will coordinate the activities of the Contractor with reference to interfacing with third parties during all the phases of the Contract.

b) The Employer or Engineer, within the scope of the relevant Contract provisions, may assist the Contractor in the following fields:

(1) Coordination and interface with state and local authorities for the timely receipt of required permits, certificates and approvals related to the construction process;

(2) Coordination and interface with state and local authorities for the implementation of acquisition procedures for any additional land areas that may be required by the Contractor; and

(3) Any other fields or activities related to the Contract as may be required for the purposes of facilitating the Contractor's performance.

c) The Engineer shall conduct a coordination and interface meeting with the interfacing parties every fortnight with the Contractor which may be attended by the Employer. The primary objective of the meeting will be to review progress of the coordination and interface activities.

d) The support and assistance of the Employer and/or the Engineer shall not release the Contractor of any of his obligations under this Contract.

5.9 DETAILED INTERFACE DESCRIPTION (DID)

5.9.1 The DID is the document that provides a clear technical description of each of interface in the Interface Table.

5.9.2 Any revision to the DID shall be mutually acceptable to both the Interfacing Contractors and Interfacing Parties. Only then shall this be submitted to the Engineer for his review.

5.9.3 DID shall contain the following items:

S. No.	Detailed Interface Description
1	Item number and name of interface in Interface Table
2	Name of the Contractor and Interfacing Contractor/Interfacing Party
3	Confirmation Table of both the Contractor and Interfacing Contractor/Interfacing Party
4	Creation date and modification date
5	Correction history
6	The following items shall be described: physical interface, functional interface, protocols, software and data interface, naming conversion, design constrains, environmental conditions, and drawings
7	Reference Documents

5.10 CONTENTS OF INTERFACE MANAGEMENT PLAN

Interface Management Plan (IMP) should be prepared including necessary contents referring Table 1. The intention of each section is described by the text inside angle brackets.

Table1: Sample Contents of Interface Management Plan

1	Introduction	
	1.1	Purpose of Document

		<Describe the methodology to be adopted by the Contractor in managing all interface issues >
	1.2	Overview <Project overview of the Contractor and the Interfacing Contractor>
2	Resource Management	
	2.1	Organization and Roles & Responsibilities
	2.2	Resource Requirement <Detailed description of the manpower, tools, logistics shall be included in this section>
3	Interface Requirements	
	3.1	Allocation of Interfacing Requirements <This is an introduction to Section3.2>
	3.2	Interface Description between Contractors <Task Allocation Table (TAT) shall be included in this section>
	3.3	Areas of Concern <Process for managing the interface concern>
4	Process Management	
	4.1	Change of Interfacing Requirement <The process for the management of interface requirement change shall be addressed in this section.>
	4.2	Verification and Validation of Interfacing Requirements <The approach to be adopted by the Contractor to manage verification and validation of interfacing requirements shall be addressed in this section.>
	4.3	Testing and Commissioning on Interfaces <The approach to be adopted by the Contractor for the management of Interface in the Testing and Commissioning stage shall be addressed in this section.>
	4.4	Quality Procedures <All Contractor's internal quality procedures applicable for the interface management shall be listed here.>
	4.5	Systems Assurance Plans <Considered requirement of the Systems Assurance.>
5	Document Management	
	5.1	Reference Documents <All applicable reference documents shall be listed in this section.>

	5.2	Structure of Reference Documents <The Structure of reference documents shall be addressed in this section.>
	5.3	Version Control of Interface Documents <Configuration management of interface documents shall be addressed in this section.>
6	Communication	
	6.1	Terms of Reference of Interface Meetings <The terms of reference of interface meetings shall be addressed here.>
	6.2	Exchange of Information between Contractors <The process for the exchange of information between the pair-wise contractors shall be stated here.>
	6.3	Submission to Employer <The approach to be adopted by the pair-wise contractors on the Submission of the Interface Management Plan to Employer shall be described here.>
	6.4	Request for Employer Attention <The criteria and methodology on requesting for Employer attention shall be mentioned here.>
7	Interface Hazard Management	
	7.1	Strategy and Approach
8	Programme	
	8.1	Key Activities <Include schedule of meetings, schedule of exchange of information, etc.>
	8.2	Section and Milestone <Include Design Freeze Dates, Integrated Test Dates, Critical Items dates, etc. Should include reference to appropriate programmes so that any future changes in programme date need not result in resubmission of this plan for approval.>
	8.3	Critical Items/ Critical Paths <This section shall highlight all the critical items and critical paths to the Employer.>

5.11 INTERFACE TABLE

5.11.1 Interface Table between C-4 and C-23

S. No	Interface Items	Requirements
1.	Drainage arrangement	C-4 Contractor shall design & construct side drains of adequate capacity to cater the surface runoff coming from the cutting towards Dhulawat station in the portion of C-23 Contractor.
2.	Cross Section of cutting	C-4 Contractor shall provide stable slope of cutting at junction to C-23 Contractor.

5.11.2 Interface Table between C-4 and C-5

S. No	Description	Remarks
1.	Cross Section of bank	C-4 Contractor shall provide stepped profile of bank at junctions to C-5 Contractor.
2.	Handing Over of site	C-4 Contractor shall design & construct abutment A-2 (near portal P-1) and hand over the site to C-5 contractor.

5.11.3 Interface Table between C-4 and E-1

S. No	Description	Remarks
1.	Handing Over of site	C-4 Contractor shall hand over the site to E-1 contractor for ROCS works.

5.11.4 Interface Table between C-4 and Electrification Contractor

S. No	Description	Remarks
1.	Handing Over of site	C-4 Contractor shall complete the tunnel and hand over the site to Electrification contractor for ROCS.

5.11.5 Interface Table between C-4 and Signalling & Telecom Contractor

S. No	Description	Remarks
1.	Handing Over of site	C-4 Contractor shall complete the tunnel and hand over the site to **Signalling & Telecom** contractor for S&T works.

5.11.6 Interface Table between C-4 and Firefighting system

S. No	Description	Remarks
1.	Handing Over of site	C-4 Contractor shall complete the tunnel and hand over the site to **Firefighting system** contractor for Firefighting works

5.12 Interface requirements specified above are by no means exhaustive and it remains the Contractors' responsibilities to develop, update and execute jointly Interface Requirements during design & throughout the execution of Works, to ensure that:

i. all interface issues between the Contracts/Systems are satisfactorily resolved;
ii. design, supply, installation and testing of equipment are fully co-ordinated; and
iii. all equipment and facilities supplied under the Contracts are fully compatible with each other, whilst meeting the requirements of the respective Specifications.

APPENDIX 6

PROGRAMME REQUIREMENTS

6. GENERAL

6.1 PURPOSE OF PROGRAMME

6.1.1 There are two primary purposes for the requirement of Programme (Scheduling) information described in this document:

a) Evaluation of tender.

b) Status Reports during Construction

To provide the Engineer with status reports for managing, monitoring and coordinating the awarded contracts during their execution within the overall multi-contract project schedule.

The requirements are organized in two stages. The first stage is a requirement for all Bidders and shall be submitted as part of Bid. The second stage is a requirement of the Employer and describes a series of reports to be submitted by the Contractor to the Engineer during the execution of contract, following the award of contract.

6.1.2 The Tenderer/Contractor shall programme his work at all times to meet the Key Date stated in Appendix 2 to the Employer's Requirements and the specified interface periods for the design and installation of the Works with those of the Interfacing Contractors and shall during the progress of the Works constantly monitor his progress against the programmes described below.

6.1.3 The Tenderer/Contractor shall include in all programmes his work obligations towards shared access, shared Site areas and other coincident or adjacent Works Areas.

6.1.4 The Works Programme, and all more detailed or revised versions, shall be submitted to the Engineer in hard copy as well as soft copy for his consent in accordance with the provisions of the GC.

6.2 METHODOLOGY

6.2.1 The computerized Critical Path Method (CPM) network using the Precedence Diagramming Method (PDM), has been selected by the Employer as the technique for contract management system and in co-coordinating the multi-contract project. This technique shall also be employed by the Tenderer in preparing their Tender submissions and by the Contractor in their Construction Stage submissions.

6.2.2 Unless otherwise agreed by the Engineer, all programmes submitted by the Contractor shall be produced using computerized Critical Path Method (CPM) Networks developed implementing the Precedence Diagramming Method (PDM) with Cost Loaded Charts and Tables.

6.2.3 The Contractor shall implement and use throughout the duration of the Contract, a computerized system to plan, execute, maintain and manage the planning, design, pre-construction, construction, and sub-contracts in executing the CPM scheduling by PDM. The reports, documents and data provided shall be an accurate representation of the current status of the Works and of the work remaining to be accomplished; shall provide a sound basis for identifying problems, deviations from the planned works, and for making decisions; and shall enable timely preparation of the same for presentation to the Engineer.

6.3 PROGRAMME MANAGEMENT SOFTWARE

6.3.1 CPM programming software used shall be Primavera Project Planning (P6) Program - Ver 21.12 or later. Any other compatible system capable of direct file interchange capability with software program used by the Employer - Primavera (P6), Ver 21.12 or later can be used with Engineer's consent. Scheduling software and relevant instruction manuals, licensed for use in connection with the contract, shall be provided by the Contractor according to the Employer's specifications

6.3.2 The Tenderer may use a system other than Primavera but will be required to demonstrate that full electronic data transfer to Primavera is available and that the various levels of reporting and coding capabilities are at least equivalent to Primavera. Compatibility and comparable performance between Primavera and the Tenderer's proposed system shall be demonstrated in his Tender submission. Should compatibility not be demonstrated to the Employer's satisfaction the Contractor shall utilise Primavera for development, stat using, updating and revision of all the Programmes during the duration of the Contract. Upon the Engineer's consent of a system other than Primavera, the Contractor shall supply the Engineer with an original licensed copy, including manuals and approved training of the software and any subsequent versions thereof at no extra cost.

6.4 POST CONTRACT AWARD

6.4.1 The Contractor shall develop his Tender Programme into the Initial Works Programme including an outline Narrative Statement and submit its more detailed version as per the key dates mentioned in Appendix 2 to the Engineer for approval.

6.4.2 The first Three Month Rolling Programme shall be submitted within thirty (30) days of the date of commencement and all subsequent editions shall accompany the Monthly Progress Report. The Monthly Progress Reports shall also include a Programme Update as described below. These programmes shall subsequently be updated as described below.

6.4.3 The Contractor shall take into account the programmes of Interfacing Contractors while finalizing the Works Programme It is the Contractor's responsibility to ensure timely co-ordination with the Interfacing Contractors to review, revise and finalise his Work Programme so as not to affect the progress of Works/ and or the works of the Interfacing Contractors. The Detailed Works Programme when approved by the Engineer after incorporating requirement of Interfacing Contractors shall form the Baseline Programme against which actual progress of the Contract shall be reckoned. As the work progresses, it may be necessary to update/ revise the Baseline programme but such updating shall only be carried out with the prior consent of the Engineer or when directed by them.

6.4.4 For Initial & Detailed Work Programme submission, one (1) original and three (3) copies each of the following Programmes and Reports shall be submitted to the Engineer:

a) Programme: Baseline CPM Network

b) Programme: Baseline Milestone based Cost Activity Schedule

c) Baseline Schedule Report

d) Narrative Statement

e) Baseline Physical Progress 'S' curve

f) Baseline Resource Charts

6.4.5 The Engineer shall review and comment on the Contractor's programmes and information submitted under this Clause. The Engineer will confirm his consent or otherwise of the submissions within thirty (30) calendar days.

6.4.6 The Engineer shall require the Contractor to re-submit within thirty (30) calendar days if he is of the opinion that the programmes and information submitted by the Contractor is unlikely to meet the Contract Key Date.

6.4.7 If in the opinion of the Engineer, any of the Contractor's revised programmes or Baseline Schedule Report is not acceptable, it shall be construed as a failure of the Contractor to meet the Contract Key Date.

6.4.8 Notwithstanding the above, the Engineer may at any time during the course of the Contract require the Contractor to reproduce the computer-generated Baseline Schedule Report described above to reflect actual activity dates and generate schedules based upon "what if" statements. The initial computer-generated report after receiving the Engineer's consent will serve as the base against which the contract progress will be measured. Any changes to the Report reflected in subsequent Baseline Schedule Reports shall also require the Engineer's consent.

6.4.9 Failure to include any element of work required for performance of the Contract shall not relieve the Contractor from completing all works required under the Contract to achieve the original or any extended key completion date.

6.5 WORKS PROGRAMME

6.5.1 The Works Programme shall show the Contractor's plan for organising and carrying out whole of the Works.

6.5.2 The Works Programme shall be a computerised Critical Path Method (CPM) network developed using the Precedence Diagramming Method (PDM) and shall be present in bar chart and time-scaled network diagram format to a weekly or monthly time scale.

6.5.3 Tasks in the Works Programme shall be sufficiently detailed to describe activities and events that include, but are not limited to, the following:

a) Key Date,

b) all physical work to be undertaken in the performance of the Contract obligations, including Temporary Works,

c) the requested date for issue of any drawings or information by the Engineer,

d) incorporation of principal aspects of the Design Submission Programme,

e) procurement of major materials and the delivery and/or partial delivery date on-Site of principal items of Contractor's Equipment,

f) any off-site work such as production or pre-fabrication of components,

g) installation of temporary construction facilities,

h) interface periods with Interfacing Contractors or utility undertakings,

i) design, supply and/or construction activities of sub-contractors,

j) any outside influence which will or may affect the Works.

6.5.4 The Works Programme shall show achievement of all Key Date.

6.5.5 Activity descriptions shall be unique, describing discrete elements of work. Any activity creating an imposed time or other constraint shall be fully defined by the Contractor.

6.5.6 The Works Programme shall be organised in a logical work-breakdown-structure including work stages and phases, and shall clearly indicate the critical path(s).

Each activity in the Works Programme shall be coded to indicate:

a) Activity ID and Activity Code.

b) The Engineer may request additional activity coding to the extent available without restraint to the Contractor's utilisation of the programme software. When requested the Contractor shall add the required additional coding to the Programme. The Contractor shall use additional code fields as requested to comply with the requirements and for the use of the Contractor.

6.5.7 Activity duration shall not exceed two (2) weeks, unless otherwise consented to by the Engineer, except non-construction activities such as submittals, submittal reviews, procurement and delivery of materials or equipment and concrete curing. The Contractor shall submit a Programme/Project Calendar cross reference clearly indicating the allowance for holidays.

6.5.8 The Works Programme, in each submission, shall be accompanied by an Activity Report and a Narrative Statement as described below in both electronic and hard copy format (time scale logic diagrams in A1 size, reports in A4 size).

6.5.9 Activity Report shall list all activities, and events in the Works Programme, sorted by activity identification number.

The Activity Report shall include the following for each activity and event:

a) activity identification number and description,

b) duration expressed in Days,

c) early and late start, & early and late finish dates. Planned start and finish dates,

d) calculated total float and free float,

e) predecessor(s) and successor(s), accompanying relationships and lead/lag duration,

f) imposed time or date constraints,

g) calendar.

6.5.10 Narrative Statement

The Narrative shall be a comprehensive statement of the Contractor's plan and approach for the execution of the Works and the achievement of Key Date, handover dates, submission dates and any intermediate dates. It shall incorporate outline method statements in respect of major items of work including construction sequences and primary item of plant, Construction Equipment, Temporary Works and the like. It shall fully explain the reasons for the main logic links in the Programme and include particulars of how activity durations are established. This shall include estimated quantities, production rates, hours per shift, work days per week and a listing of the major items of Construction Equipment planned for use on the project. Activities, which may be expedited by use of overtime or additional shifts, shall be identified and explained. A listing of holidays, and other special non-work days being used for the computer reports shall be included.

6.5.11 Baseline Physical Progress 'S' Curve

The Contractor shall also submit a forecast Cumulative Physical Progress 'S' curve based on the time-phased distribution of cost in the CPM Network Logic Diagram, expressed in percentage terms. This 'S' curve shall be generated from the computerized CPM Network Logic Diagram.

6.5.12 Baseline Resource Charts

The Contractor shall also submit a Resource Charts, generated from the Contractor's CPM Network Diagram, showing the anticipated manpower and main Construction Equipment usage during the execution of the Project.

As an additional monitoring facility, indicator resources shall be assigned to relevant activities for the major items of work. Indicator resources shall be directly allocated for excavation (cum.), piling (no.), diaphragm walling (m.), concrete (cum.), tunnel lining (m), etc. Resource indicators may be input as a daily rate, expected required rate, or as an activity total in the relevant units. These are purely indicative quantities and do not form part of contract.

6.5.13 All submissions of proposed Works Programmes subsequently, after approval of the Initial Works Programme, shall include the actual physical progress of work and forecast of the remaining work. Actual progress shall be stated in percent complete, remaining duration, and actual start and finish dates for each activity in the Works Programme.

6.6 INITIAL WORKS PROGRAMME

6.6.1 The Initial Works Programme submitted as under Clause 6.4 above need not include the full details. It should be a condensed version with combined activities of longer. The outline Narrative Statement shall be in sufficient detail to clearly show the Contractor's intention.

6.6.2 After the Engineer's consent to the Initial Works Programme, the Contractor shall submit to the Engineer an expanded and more detailed version of the Initial Works Programme containing all of the information and detail required as per Key Date mentioned in Appendix 2.

6.6.3 Such submission shall make use of the Tender Programme submitted earlier but refined to include the best estimates of dates for the work of Interfacing Contracts which has impact on the Contractor's programme. Such programmes shall be amended subsequently to incorporate the actual dates/ schedule of the affecting contracts. It is the Contractor's responsibility to ensure timely co-ordination with the Interfacing Contractors to finalise the Initial Programme, without affecting progress of the work.

6.7 WORKS PROGRAMME REVISIONS

6.7.1 The Contractor shall immediately notify the Engineer in writing of the need for any changes in the Works Programme, whether due to a change of intention or of circumstances or for any other reason. Where such proposed change affects timely completion of the Works or any other Key Date the Contractor shall within fourteen (14) days of the date of notifying the Engineer submit for the Engineer's consent its proposed revised Works Programme and accompanying Narrative Statement. The proposed revised Works Programme shall show the sequence of operations of any and all works related to the change and the impact of changed work or changed conditions.

6.7.2 If at any time the Engineer considers the actual or anticipated progress of the work reflects a significant deviation from the Works Programme, he may request the Contractor to submit a proposed revised Programme which together with an accompanying Activity Report and Narrative Statement, shall be submitted by the Contractor within fourteen (14) days after the Engineer's instruction. The proposed revised Works Programme shall show the sequence of operations of any and all work related to the change and the impact of changed work or changed conditions.

6.7.3 All activities that have negative float must be analysed by the Contractor to identify the impact on the timely completion of the Works or on the achievement of Key Date.

6.8 THREE MONTH ROLLING PROGRAMME

6.8.1 The Three-Month Rolling Programme shall be an expansion of the current Works Programme, covering sequential periods of three months. The Three-Month Rolling Programme shall provide more detail of the Contractor's plan, organisation and execution of the work within these periods. In particular, the Contractor shall expand each activity planned to occur during the next three (3) month period, if necessary, to a daily level of detail.

6.8.2 The Three-Month Rolling Programme shall be developed as a Critical Path Method (CPM) network, and shall be presented in bar chart and time-scaled network diagram format. Bar charts shall be presented on an A4 and time-scaled networks diagrams on an A1 size reproducible media. Tasks in the programme shall be derivatives of and directly related to tasks in the approved Works Programme.

6.8.3 The Contractor shall describe the discrete work elements and work element inter-relationships necessary to complete all works and any separable parts thereof including work assigned to sub-contractors.

6.8.4 Activity duration shall not exceed two (2) weeks unless otherwise consented to by the Engineer.

6.8.5 Each activity in the Three-Month Rolling Programme shall be coded, or described so as clearly to indicate the corresponding activity in the Works Programme.

6.9 THREE MONTH ROLLING PROGRAMME REVISIONS AND UPDATE

6.9.1 The Three-Month Rolling Programme shall be extended forward each month as described under Clause 6. 4 above. Each submission of the Three-Month Rolling Programme shall be accompanied by a Programme Analysis Report, describing actual progress to date, and the forecast for activities occurring over the next three-month period.

6.9.2 If the Three Month Rolling Programme is at variance with the Works Programme, the Programme Analysis Report shall be accompanied by a supporting Narrative Statement describing the Contractor's plan for the execution of the activities to be undertaken over the three-month period, including programme assumptions and methods to be employed in achieving timely completion.

6.9.3 The Contractor shall revise the Three-Month Rolling Programme or propose revisions of the Works Programme, or both, from time to time as may be appropriate to ensure consistency between them.

6.10 THREE WEEK ROLLING BAR CHART SCHEDULE

Once a week, on a day mutually agreed to by the Engineer and the Contractor, a meeting will be held to assess progress by the Contractor during the previous work week. The Contractor shall submit a construction schedule listing activity completed and in-progress from the previous week and the activities scheduled for the succeeding two weeks based on the detailed Works Programme. Copies of the schedule shall be submitted on A3 sized paper.

6.11 PROJECT CALENDAR

For the Project, the Contractor shall adopt 7 days a week calendar, identical calendar for the purpose of programming and Execution of Works. Official documents shall be transacted during 5 days week - Monday through Friday, except for National (Govt. of India) Holidays. For Project purposes, a week begins at 0001 hours on a Monday and ends at 2359 hours on a Sunday. The completion of an activity or the achievement of an event when given a week number shall be taken to mean midnight on the Sunday at the end of the numbered week. An access date or activity start date when given as a week number shall be taken to mean 0001 hours on a Monday of the Numbered week.

6.12 PROGRAMMING PERSONNEL

The Contractor shall submit, as part of its Staff Organization Plan, the names and required information for the staff to be employed on Works Programming. The Works Programmer shall hold reputable professional qualifications and relevant experience as per Attachment C-1 to Employer's Requirements – Construction .The programmer shall be employed by the Contractor full time on the Contract until the completion or such earlier time.

6.13 PROGRAMME AND REPORT SUBMISSION FORMAT

The Contractor shall submit one (1) original and three (3) copies and a soft copy of all submissions to the Engineer. All submissions shall be in A0, A1, A3 or A4 size, as appropriate except as may otherwise be agreed by the Engineer.

The format for all Programme and Report submissions shall be strictly in accordance with the format or as requested by the Engineer.

APPENDIX 7
MEETINGS

7. MEETINGS

7.1 Kick-Off Meeting

The Engineer shall hold Kick-Off Meeting within 7 calendar days from the Commencement Date. Purpose of the Meeting is formally to notify all parties concerned under the Contract thatthe project has begun, and every party has a common understanding and his role from the Commencement Date until issuance of the Taking-Over Certificate.

At the Kick-Off Meeting, followings will be, but not limited, discussed.

a) Outline of the Works

b) Communication rules (process, emails, approvals, etc.)

c) Other matters regarding proceeding and management of the Contract.

d) Profile of the Site

e) Time Schedule List of Contractual Events/Submissions, including Milestones, Time(s) for Completion and Defects Notification Period(s).

f) Introduction of key persons of the Contractor and Employer, with role, Function and authority of each person.

g) Role and responsibility of Emergency notification process.

7.2 Regular Meetings

7.2.1 The Engineer shall hold regular meetings with the Contractor as necessary for the proper management and co-ordination of the Works. The Contractor's representative and other personnel as considered necessary by the Engineer, shall attend such meetings.

7.2.2 Within twenty eight (28) days after the Commencement Date, the Engineer and the Contractor's Representative shall agree upon a programme for weekly and monthly meetings covering the first three (3) months after such twenty eight (28) days. The Contractor's Representative shall make sure that the Contractor's Personnel designated to attend meetings make themselves available for the meetings. The Engineer shall prepare the agenda for the meetings and the relevant documents to be submitted to the meeting, including as a minimum the minutes of the previous meeting. Thereafter, the programme for weekly and monthly meetings shall be updated monthly in the monthly progress meetings.

7.2.3 The Engineer may initiate ad-hoc meetings as and when the need arises, through prior consultation with the Contractor's Representative where possible, and the Contractor's Representative and other Contractor's Personnel designated by the Engineer and/or the Contractor's Representative shall attend such meetings. The Engineer shall prepare a proposed agenda of the meeting, for prior consultation with the Contractor's Representative where possible.

7.3 Monthly Progress Meeting

A Monthly Progress Meeting shall be called by the Engineer and shall be held every month within three (3) days following issuance of the Contractor's Monthly Progress Report. If the day specified, is not a working day, then the meeting shall be heldon the next working day after the specified date. The Engineer shall notify the Contractor of any change in the date or time, or both, of the meeting. The main purpose of the meeting is to discuss progress of the Works and if there is any delay in progress, being encountered by the Contractor, the Contractor shall indicate the cause of delay and present the method of recovery.The results of the discussions of the meeting shall be included in the Contractor's next MonthlyProgress Report to be provided.

7.4 Co-ordination Meeting

The Contractor shall organize co-ordination meetings as required with related parties. Before conducting such co-ordination meetings with the related parties, the Contractor shall give priornotice and agenda of the meeting to the Engineer and the Employer.

7.5 Meetings called by the Contractor

The Contractor's Representative may request the Engineer to meet him and other Contractor's Personnel whenever necessary to discuss the issues pertaining to the Works and the Contract. The Engineer shall comply with the request where physically possible. The Contractor shall prepare a proposed agenda for the meeting and submit it to the Engineer when making request for the meeting.

7.6 Other Meetings

The Contractor's Representative shall attend, and shall arrange for representatives of the Subcontractors, public departments, transportation companies, utility undertakings and other contractors employed by the Employer to attend, meetings when required by the Engineer. The Contractor shall inform the Engineer in 48 hours (or such a shorter period as agreed by the Engineer) before conducting meetings with the public departments, transportation companies, utility undertakings and/or the other contractors and shall give the Engineer an opportunity to attend such meetings.

7.7 Minutes of Meetings

The Engineer in principle shall be responsible for the preparation of the minutes of meetings, circulating it to the parties who attended the meeting before the next relevant meeting. The Engineer shall also be responsible for the minutes of ad-hoc meetings in a similar manner, unless otherwise agreed with the Employer.

7.8 MONTHLY PROGRESS REPORTS

7.8.1 GENERAL

The Contractor shall submit to the Engineer, a Monthly Progress Report. The first report shall cover the period up to the end of the first calendar month following the Commencement Date. Reports shall be submitted monthly thereafter, each within 7 days after the last day of the period to which it relates. It shall be submitted in a format to which the Engineer shall have given his consent and shall contain sections/sub-sections.

7.8.2 FINANCIAL STATUS

a) A narrative review of all significant financial matters, and actions proposed or taken in respect to any outstanding matters.

b) A spread sheet summarising each activity, the budget, costs incurred during the period, costs to date, costs to go, cost forecast (total of costs to date and costs to go) and cost variance (difference between cost forecast and budget).

c) A spread sheet indicating the status of all payments due and made.

d) A report on of the status of any outstanding claims. The report shall in particular provide interim updated accounts of continuing claims.

7.8.3 PHYSICAL PROGRESS

a) It shall describe the status of work performed, significant accomplishments, including critical items and problem areas, corrective actions taken or planned and other pertinent activities, and shall, in particular, address interface issues, problems and resolutions.

b) It shall include a simplified representation of progress measured in percentage terms compared with percentage planned as derived from the Works Programme.

7.8.4 PROGRAMME UPDATE (For Entire Project)

a) The monthly Programme Update which shall be prepared by recording actual activity completion dates and percentage of activities completed up to the end of the month together with estimates of remaining duration and expected activity completion based on current progress. The Programme Update shall be accompanied by an Activity Report and a Narrative Statement. The Narrative Statement shall explain the basis of the Contractor's submittal:

(1) Early Work and Baseline Submittals – explains determination of activity duration and describes the Contractor's approach for meeting required Key Date as specified in the Contract.

(2) Updated Detail Programme Submittals – state in narrative the Works actually completed and reflected along Critical Path in terms of days ahead or behind allowable dates. Specific requirements of narrative are:

i. If the Updated Detailed Work Programme indicates an actual or potential delay to Contract Completion date or Key Date, identify causes of delays and provide explanation of Work affected and proposed corrective action to meet Key Date or mitigate potential delays. Identify deviation from previous month's critical path.

ii. Identify by activity number and description, activities in progress and activities scheduled to be completed.

iii. Discuss Variation Order Work Items, if any.

b) The Programme Status which shall:

(1) show Works Programme status up to and including the current report period, display Cumulative progress to date and a forecast of remaining work.

(2) be presented as a bar-chart size A3 or A4 and as a time-related logic network diagram on an A1 media, including activity listings;

c) The Activity Variance Analysis which shall analyse activities planned to start prior to or during the report period but not started at the end of the report period as well as activities started and/or completed in advance of the Works Programme.

7.8.5 KEY DETAILS STATUS

A report on the status of all Key details due to have been achieved during the month and forecasts of achievement of any missed Key details, and those due in the next month.

7.8.6 THREE MONTH ROLLING PROGRAMME

The monthly issue of the Three-Month Rolling Programme.

7.8.7 PLANNING AND CO-ORDINATION

a) A summary of all planning/co-ordination activities during the month and details of outstanding actions.

b) A schedule of all submissions and consents/approvals obtained/outstanding.

7.8.8 PROCUREMENT REPORT

a) A summary of all significant procurement activities during the month, including action taken to overcome problems.

b) A report listing major items of plant and materials which will be incorporated into the Works. The items shall be segregated by type as listed in the Specifications and the report should show as a minimum the following activities:

(1) purchase Order Date - Scheduled/Actual,

(2) manufacturer/Supplier and Origin,

(3) letter of Credit Issued date,

(4) manufacturer/Supplier Ship Date - Scheduled/Actual,

(5) method of Shipment,

(6) arrival Date in India- Scheduled/Actual.

7.8.9 SAFETY

A review of all safety aspects during the month including reports on all accidents and actions proposed to prevent further occurrence.

7.8.10 ENVIRONMENTAL AND SOCIAL

A review of all the environmental and social issues during the past month to include all monitoring reports, mitigation measures undertaken, and activities to control environmental impacts.

APPENDIX 8
MANAGEMENT PLANS AND SUBMISSIONS

8 MANAGEMENT PLANS

8.1 General

8.1.1 In order to ensure the Contractor understands and complies with the requirements of the Contract, a series of Management Plan shall be developed. These Management Plans will serve to structure the submittals in a manner that the Contractor can develop and prepare the submittals and the Engineer can review and comment on a prescribed programme.

8.1.2 The Management Plans shall be configured as a family of "stand-alone" plans and associated documents, each covering one of the subjects listed below.

8.1.3 The plans and documents shall be co-ordinated with each other and shall collectively define describe and encompass the Contractor's proposed methods, procedures, processes, organisation, sequencing of activities etc. and shall show how these combine together to assure that the work truly meets the requirements of the specifications in respect of the subject listed.

8.1.4 All plans and documents shall be submitted as per Key Dates mentioned in Appendix 2. Further submissions shall be made:

a) when required in accordance with the Works Programme;
b) whenever the development of the Contractor's designs or planning allows the plan to be developed further;
c) in response to comments made by the Engineer:
d) whenever any change occurs that invalidates the information contained in the previously submitted and reviewed document, within 14 days of the occurrence of such change; and
e) when requested by the Engineer from time to time.

8.2 General Organisation

The plans listed below shall be developed and submitted by the Contractor for the Engineer's review:

a) Project Management Plan
   1) Contractor's Project Plan
   2) Interface Management Plan

b) Works Quality Management Plan
   1) Works Quality Management Plan
   2) RAMS Plan
   3) Electromagnetic Compatibility Management Plan
   4) Software Quality Assurance Plan

c) Design, Procurement and Manufacturing Management Plan
   1) Design Plan
   2) Factory Testing Plan
   3) Procurement, Manufacturing and Delivery Plan

d) Construction and Installation Management Plan

1) Construction and Installation Plan
2) Environment, Social Health and Safety, Management Plan

e) Completion Management Plan
1) Commissioning Plan
2) Operational and Maintenance Manuals Plan
3) Training Plan
4) Spares Management Plan
5) Defects Management Plan

8.3 Project Management Plan

The overall management of the Works shall be the Contractor's responsibility. The organisation of the resources for the design, procurement, manufacture, delivery, installation, testing and commissioning, and setting to work is to be developed into a Project Management Plan. Each section of this plan shall fully describe the Contractor's understanding of the Works and management skills and structure required to achieve the same.

8.3.1 Contractor's Project Plan

a) The Contractor's Project Plan shall provide a clear overview of the Contractor's organisation, management systems and methods to be used for execution and completion of the Works.

b) The Contractor's Project Plan shall include a summary description of each and every stage of implementation of the Works, clearly showing the principal organisational interfaces both within the Contractor's own organisation (including sub-contractors of every tier) and with Other Contractors and Relevant Authorities, defining how each of these interfaces is to be managed and controlled. An organisation chart shall be produced to illustrate the subdivision of the work into elements for effective technical and managerial control, the reporting structure and the interface relationship among all parties involved. Names, addresses, telephone and fax numbers of all principle contacts shall be listed.

c) The Contractor's Project Plan shall contain structured organisation charts showing the hierarchical relationship of the Contractor's organisation (including sub contractors of every tier). The organisation charts shall be produced as a "family" such that the basic chart shows the overall organisation structure supported by subsidiary charts detailing the internal structure of various departments or sections of the overall organisation.

d) The Contractor's Project Plan shall include full details of the qualifications, experience, authority and responsibility of the personnel assigned to all key positions of the Contractor's organisation (including sub-contractors of every tier). As a minimum, this shall include all levels down to senior managers and shall include the personnel responsible for each individual department and functional group. A clear reference shall be given as to the location of staff (e.g. site resident or factory based, etc). Names, addresses, telephone and fax numbers of all principle contacts shall be listed.

e) The Contractor's Project Plan shall define the Contractor's management structure for the execution of the Works and for the control of the quality of the Works and shall, without limitation, identify and set out:

(1) the procedure for audit;

(2) the procedures for the control of receipt and issue of all Works related correspondence so as to ensure traceability;

(3) the procedures for filing system to be implemented to maintain the Contractor's records during the course of the work. The filing systems used by the Contractor and sub contractors of any tier shall be compatible as for as is necessary;

(4) the procedures for the identification, production, verification, internal approval, review (when required) by the Engineer, distribution, implementation and recording of changes to all drawings, reports and specifications;

(5) the procedures for the evaluation, selection, engagement and monitoring of sub-contractor/suppliers together with the means of application of quality assurance to their work including audit and acceptance;

(6) the procedure for the regular review and revision of each type of quality plan and its supplemental individual specific quality plans to ensure their continuing suitability and effectiveness, in addition to the methods to be used for revision and issue of revised documentation;

(7) the procedures for the control, calibration and maintenance of inspection, testing and measuring equipment;

(8) the procedures for the selection, indexing, disposition and maintenance of project record for storage in the archives. A list of items to be archived, including their periods of retention shall be submitted for review by the Engineer;

(9) the procedures for identifying training needs and for the provision of training of all personnel performing activities affecting quality; and

(10) the procedures for the control of non-conformity.

f) The Contractor's Project Plan shall include details of Contractor's Office.

8.3.2 Interface Management Plan

The Contractor shall prepare Interface Management Plan in accordance with Appendix 5.

8.4 **Works Quality Management Plans**

8.4.1 The Contractor shall submit for review by the Engineer Works Quality Management plan in accordance with the requirements of Appendix 11

8.4.2 RAMS Plans

a) The Contractor shall implement a formal Reliability Plan and a formal Maintainability Plan in accordance with the PS.

b) The Contractor shall submit for review by the Engineer the Contractor's Reliability Plan and Maintainability Plan in accordance with the requirements of General Specification (S&T). The Contractors Reliability Plan and a Maintainability Plan shall include Failure Modes, Effects and Criticality Analysis and the production of a Reliability Critical Items List.

c) The contractor shall submit for review by the Engineer the Contractor's Systems Safety Plan. The Systems Safety Plan shall address all the factors referenced in this Specification and as required by the Particular Specification(S&T).

8.4.3 Software Quality Assurance Plan

Where software is a design deliverable, the Contractor shall submit a Software Quality Assurance Plan in accordance with the requirements of Appendix 11 The Software Quality Assurance Plan shall address all elements of the design and development of software

required as part of the Works.

8.5 **Design, Procurement and Manufacturing Plan**

The Design, Procurement and Manufacturing Plan shall be configured as a family of "stand- alone" plans and associated documents each covering one of the subjects listed below. The plans shall be coordinated with each other and shall collectively define, describe and encompass the Contractor's proposed methods, procedures, processes, organization, sequencing of activities, etc. and shall show how these combine together to assure that the Works fully meet the requirements of the Specification in respect of the subjects listed.

8.5.1 Design Plan

a) Design shall be undertaken in various phases to ensure a smooth flow of information for review by the Engineer. Submissions shall be strictly in accordance with the Design Submissions Programme.

b) The Contractor shall perform his designs for the Works and prepare a Design Plan for his design work in accordance with the following design stages. The Contractor shall submit to the Engineer for his review, relevant design information.

8.5.2 Factory Testing Plan

a) The Contractor shall prepare and submit for review by the Engineer the Contractor's Factory Testing Plan detailing and explaining how the Contractor will plan, perform, and document all inspections and tests that will be conducted to verify and validate the Works prior to delivery to the Site. The plan shall consist of a narrative description supported by graphics, diagrams and tabulations as required.

The plan shall contain but not be limited to the following topics:

(1) the Contractor's strategy for inspection and Factory Acceptance Tests of all constituent parts of the Works and how this relates to the sequence of delivery;

(2) the sequencing and interrelationships of the inspections and tests including:

i. First Article Inspection

ii. all Quality Hold Points; and

iii. all Quality Control Points;

(3) the type and extent of inspection and Factory Acceptance Tests to be undertaken and the parts of the Works to be proven by that testing;

(4) the objective of each inspection or test, what particular design and operating criteria the test or inspection will prove and how the success of the test or inspection will be demonstrated or measured;

(5) organisation chart and CV of key personnel in inspection and test team;

(6) the plan for the production and submission of the inspection and test procedures tothe Engineer for review including the submission of the inspection and test reports and records; and

(7) Type Tests, Routine Tests, First Article Inspections and any other tests constituting the Factory Acceptance Tests.

a) The Contractor shall arrange for all equipment and systems manufactured for incorporation into the Permanent Works to undergo a Factory Acceptance Test (FAT) before shipment from the place of manufacture. Any particular requirements for inspection and testing at the place of manufacture are prescribed in the PS.

b) The Contactor shall be responsible for re-inspecting and re-testing any failed inspection and Factory Acceptance Test including regression testing on previously passed items.

c) Inspections and tests that are to be witnessed by the Employer or the Engineer shall be sensibly grouped and scheduled so that as many inspections and tests as possible may be witnessed during a single visit.

d) If required, Type Tests as detailed in relevant Particular Specifications shall be performed on all items of equipment to be installed as part of the Permanent Works under the Contract. The Type testing shall be based on the environmental class of the sites into which the equipment will be installed.

e) For all production items a First Article Inspection shall be undertaken. Latest drawings, inspection & test procedures, specifications and quality documentation for inspection of equipment shall be submitted for First Article Inspection to the Engineer. Routine production testing methods shall be detailed for review by the Engineer. Routine testing shall ensure that all samples of a production item are within the tolerances required for complete interchangeability.

f) The Contractor shall prepare two copies of an inspection or test report immediately after the completion of each inspection or test whether or not witnessed by the Employer or the Engineer. If the Employer or the Engineer has witnessed the inspection or test, he will countersign the inspection or test report to indicate his review of the information and conclusions (i.e. whether or not the equipment being inspected or tested has passed satisfactorily) contained therein. If the Employer or the Engineer has not witnessed the inspection or test (i.e. if a waiver has been granted, or the Employer or the Engineer has not witnessed the inspection or test for some other reason in accordance with the Contract), the Contractor shall forward two copies of the inspection or test report without delay to the Engineer. The Engineer will countersign the report to indicate his review of the information and conclusions (i.e. whether or not the equipment being inspected or tested has passed satisfactorily) and return one copy to the Contractor. Where the results of the inspection or test do not meet the requirements of the Specification, the Employer or the Engineer may call for a re-inspection or re-test.

g) For standard equipment which is serial or bulk manufactured, manufacturer's type test certificates (or equivalent) may, subject to review by the Engineer be accepted.

h) Test equipment and instrumentation shall be subject to approved calibration tests within a properly controlled calibration scheme, and signed calibration certificates shall be supplied to the Engineer in duplicate. Such calibration checks shall be undertaken prior to

testing and if required by the Engineer shall be repeated afterwards.

i) Materials and equipment shall not be released for shipment until all applicable inspections and tests including Factory Acceptance Tests have been satisfactorily completed.

8.5.3 Procurement, Manufacturing and Delivery Plan

a) The Contractor shall prepare a procurement, manufacturing and delivery plans in respect of all items and goods. Separate parts of the plan shall be prepared for Contractor or sub-contractor off-site activities. Each plan shall identify the scope of work to be applied. In relation to such scope of work, it shall, without limitation, define:

(1) the organization of the Contractor's staff directly responsible for the day-to-day management of the manufacturing activity on or off the Site;

(2) the specific allocations of responsibility and authority given to identified personnel for the day-to-day management of the work with particular reference to the supervision, inspection and testing of the work;

(3) the interfacing or co-ordination required with the Contractor's other related plans;

(4) the specific methods of manufacture to identify any relevant method statements and develop those method statements to a degree of sufficient detail reviewed by the Engineer; and

(5) the list of procedures and work instructions to manage and control the quality of work during purchasing, manufacturing and delivery, including without limitation:

i. the purchasing of items and goods and ensuring they comply with the requirements of the Specification, including (without limit) purchasing documentation and specific Verification arrangements for Contractor/Engineer inspection of material or manufactured product prior to release for use;
ii. the manufacturing process so as to ensure compliance with the design;
iii. the manufacturing process so as to ensure clear identification and traceability of material and manufactured parts;
iv. the inspection and testing of incoming materials, in process and final product so as to ensure specified requirements for the material and/or manufactured product are met;
v. the identification of the inspection and test status of all material and manufactured products during all stages of the manufacturing process to ensure that only products that have passed the required inspections and tests are dispatched for use and/or installation;
vi. review and disposal of non-conforming material or product so as to avoid unintended use;
vii. the assessment and disposal of non-conforming material and manufactured product and approval for reworking or rejection as scrap;
viii. the identification of preventive action so as to prevent recurrence of similar non- conformance; and
ix. the handling, storage, packaging, preservation and delivery of manufactured product.

b) The Contractor shall prepare and submit the inspection and testing plans to manage and control any test and inspection activities ;

c) The Contractor shall propose a structured set of inspection hold points. The hold points shall be structured such that a formal hold point is allowed for each significant element of the manufacturing process. At each hold point, the Engineer shall hold a formal inspection or advise that the inspection had been waived.

d) Once the inspection and any required remedial actions are completed to the satisfaction of the Engineer, the Engineer shall not withhold his notice of no objection for shipping unreasonably, provided all pre-delivery assembly and testing has been successfully completed.

e) Any unit delivered without the Engineer notice of no objection shall be rejected at the Site and all expenses thereby shall be borne by the Contractor.

8.6 Construction and Installation Management Plan

The Construction and Installation Management Plan shall be configured as a family of "stand-alone" plans and associated documents each covering one of the subjects listed below.

The plans shall be co-ordinated with each other and shall collectively define, describe andencompass the Contractor's proposed methods, procedures, processes, organization, sequencing of activities, etc and shall show how these combine together to ensure that theworks truly meet the requirements of the Specification in respect of the subjects listed

8.6.1 Construction and Installation Plan

a) The Contractor shall prepare plans for the construction and installation activities on and off the site and shall ensure that these are properly related to the subsequent testing and commissioning activity.

b) Separate parts of the plan shall be prepared for other contractor(s) or sub-contractor(s) off-site activities.

c) Each construction plan shall identify the scope of activity to be controlled. In relation to scope of such activity, it shall, without limitation, define:

(1) the organisation of Contractor's staff directly responsible for the day to day management of the activity on or off the site;

(2) the specific allocations of responsibility and authority given to identified personnel for the day to day management of the works with particular reference to the supervision, inspection and testing of works;

(3) the interfacing or co-ordination required with the Contractor's other related plans;

(4) the specific methods of construction and installation to identify any relevant method statements to a sufficient degree of detail reviewed

by the Engineer;

(5) a detailed method statement which shall include but not be limited to;

i. description of main operations and sub-operations;
ii. sequence of sub-operations;
iii. quantities of the work and production rates to be achieved;
iv. resources to be employed; and
v. quality checks to be carried out, supervision being exercised and safetyprecautions to be employed;

(6) the list of procedures and work instructions to manage and control the quality of construction and installation works, including without limitation:

i. the inspection and testing activities of incoming materials, in process and final product so as to ensure specified requirements for the material and/or product are met;
ii. the purchasing of materials and ensuring they comply with the requirement of the specification, including purchasing documentation and specific Verification arrangements for Contractor/Engineer inspection of material or manufactured product prior to release for use/installation;
iii. the construction processes including Temporary Works so as to ensure compliance with drawings and specification. In addition, any software to be used in construction, installation and commissioning process shall be identified and details of the Verification and validation processes for the software application shall be given;
iv. the construction and installation process so as to ensure clear identification and traceability of material and manufactured product;
v. the identification of the inspection and test status of all material and manufactured product during all stages of the construction and installation process to ensure that only products that have passed the inspections and tests are dispatched for use and/or installation;
vi. review and disposition of non-conforming material or product so as to avoid unintended use/installation;
vii. the assessment and disposition of non-conforming material and product and approval of reworking or rejection as scrap;
viii. the identification of preventive action so as to prevent recurrence of similar non- conformance; and
ix. The handling, storage, packaging, preservation and delivery of product; and

d) The Contractor shall prepare and submit inspection and test plans to manage and control any test and inspection activities.

e) The following particulars shall be submitted to the Engineer for review within 28 days of the Commencement Date of the Works;

(1) drawings showing the layout within the Site of the Contractor's accommodation, project signboards, access roads and major facilities required early in the Contract;
(2) drawings showing the details to be included on Project signboards.

f) Drawings showing the location of stores, storage areas, work areas and other major facilities shall be submitted to the Engineer for review as early as possible, but in any case, not later 28 days before construction of the facilities.

8.6.2 Environment, Social, Health and Safety (ESHS) Plan

ESHS plan shall be submitted by the Contractor in accordance with ESHS manual given in Appendix 13 for the Engineer's review within 28 days of issue of Letter of Acceptance.

8.6.3 Completion Management Plan

General

a) The Contractor shall organise the services required under the Contract to bring the Works into service under one plan. This co-ordinated approach shall allow the Engineer to review all aspects of completion in an integrated manner.

b) The Completion Management Plan shall be configured as an integrated plan with associated documents, covering the subjects described herein.

c) The plans shall be co-ordinated with each other and shall collectively define, describe and encompass the Contractor's proposed methods, procedures, processes, organisation, sequencing of activities and the like, and shall show how these combine together to assure that the Works truly meet the requirements of the Contract with respect to the matters listed herein after.

8.6.4 Commissioning Plan

a) The Contractor shall submit the first draft of the Commissioning Plan to the Engineer within 180 days of the Commencement Date of the Works.

b) The Commissioning Plan shall consist of the following for all Signalling & Telecommunication work:

(1) Installation Tests Schedule

The Contractor shall submit to the Engineer a comprehensive schedule of the installation tests as required by relevant Particular Specifications and in accordance with the Installation Programme. The schedule shall be submitted within the period of time laid down in the Particular Specifications , or, if none is given, not later than 56 days in advance of the date for the commencement of the Installation Tests. Pre-Installation Inspection shall include the verification of FAT/Quality test report, Invoice, OEM manuals etc. Post installation test shall include the installation of equipment as per approved drawing, Particular specification etc. Power supply test shall be the part of Post-installation test.

(2) System Acceptance Tests Plan

The Contractor shall submit to the Engineer, a comprehensive System Acceptance Tests Plan including all requirements detailed in the relevant Particular Specification(S&T). The plan shall be submitted within the period of time laid down in the Particular Specification(S&T) or, if none is given, not later than 112 days in advance of the date for the commencement of the System Acceptance Tests. System Acceptance test shall include the functional test of all equipment from the SM panel.

(3) Integrated Testing & Commissioning Plan

The Contractor shall submit to the Engineer a comprehensive Integrated Testing and Commissioning Plan including all requirements detailed in Particular Specifications . The plan shall be submitted within the period of time laid down in Particular Specifications , or, if none is given not later than 112 days in advance of the date for the commencement of Integrated Testing and Commissioning. This test shall include the test of equipment from the IMD/ control centre of the project.

8.6.5 Operation and Maintenance Manuals Plan

a) The Contractor shall develop an Operation and Maintenance Manuals Plan to suit staged commissioning of the system and to ensure timely preparation of the Operation and Maintenance Manuals and the "As-Built" Documents in a format and to a level of detail reviewed without objection by the Engineer.

b) The Contractor shall submit the Operation and Maintenance Manuals Plan not later than 45 days prior to the issue of the Taking Over certificate for the works and according to the staged commissioning, if applicable, of the proposed systems.

8.6.6 Training Plan

a) The Contractor shall ensure the timely preparation of the Contractor's Training Plan in a format and to a level of detail reviewed without objection by the Engineer and fulfilling the requirements.

b) The Contractor shall submit the Training Plan by the date stated in the Particular Specifications , or, if none is given, not less than 84 days prior to the start of installation activities for the works.

8.6.7 Spares Management Plan

a) The Contractor shall submit for review by the Engineer a Spares Management Plan to furnish a priced manufacturer-recommended list of spare parts, necessary to support continuous operation of all such equipment for a minimum period of 24 months after the commencement of revenue operations.

b) The Contractor shall submit the Spares Management Plan not less than 182 days prior to the issue of the Taking Over Certificate for the Works.

8.6.8 Defects Management Plan

The Contractor shall submit for review by the Engineer a Defects Management Plan to repair, replace and perform any remedial item upon the Works identified by the Engineer during Defects Notification Period (DNP). The first submission of this plan is required not less than 365 days prior to the issue of the Taking Over Certificate for the Works. The Contractor shall;

a) endeavour to complete all necessary work in a timely responsible manner;
b) not proceed with any remedial work without the consent of the Engineer;
c) submit a plan that details the method and timing of any proposed work; and
d) update the plan monthly, showing progress of the work and time to completion.

APPENDIX 9

DOCUMENTS, DRAWING AND CAD STANDARDS

9. General

A document may consist of document cover, revision history, table of contents, text and attachment(s) in this sequence where applicable.

1) Cover format (Times New Roman)
2) Heading and name of client shall be on top, in capital, size 10.
3) Name of the project in bold letters, size 22.
4) Content of document in bold capitals, size 16.
5) Document reference number in bold capitals, size 12.
6) Company name: capitals, size 14.
7) Company logo in size 35 x 40 (W x H) mm.
8) Address of the company in regular letters, size 10.
9) Document Format (Time New Roman)
10) General Regulations
11) Letter size: 12.
12) Paper size A4 (A3 is used for table and figures).
13) Periods and semicolons shall be placed right after the preceding letter or number.
14) The space between paragraphs and headings shall be 1.15 lines.
15) Main headings shall be placed in number order, with a period placed right after the number, followed by a space, with a heading text in bold capital letters. For example.:

9.1 IN BOLD CAPITAL

Other headings are placed in number order, with a period placed right after the number, followed by a space, with a heading in regular letters. For ex.:

a) In normal letter.
b) Notes

Notes relating to tables shall be included in the table; in case they are not able to be included, it shall be clearly specified that they are notes relating to a particular table reference.

The text of notes is usually given in italics.

9.2 Language of Communication and Units

The language for communications shall be the English language. The Contractor shall utilize the SI system of measurement units.

9.3 Photographs

The Contractor shall take digital photographs of the Works at least on monthly basis and include them in the Contractor's Monthly Progress Reports. These photographs shall be taken at locations agreed with the Engineer as appropriate to record progress, quality and

other relevant aspects of the Works. The number of the photographs shall be sufficient to cover all aspects of the Works in progress.

The digital photograph shall be colour jpeg image format with standard aspect ratio 4:3 and resolution of 300 DPI for all graphics in the printing. Read Only Memory (ROM) based electronic media of digital photographs shall be included as an integral part of the submittal. The locations and directions of the photographs taken shall be marked on a key plan of the Site, to be included in the submittal.

Each photograph shall be properly numbered and dated and include a brief explanatory note of the subject matter of the photograph, for ease of understanding.

Immediately before the issue of any Taking-Over Certificates for Works or Sections, the Contractor shall commission a professional photographer (or any person with equivalent skills) and take photographs of (where applicable, the interior to be taken by wide angle lenses) of exterior and all salient sections and features of the Works, for record purposes. The Contractor shall submit to the Engineer for approval as an integral part of the As-Built Documents, four (4) separately bound sets of colour prints of such record photographs, including one (1) set of Read Only Memory (ROM)-based electronic media containing an original jpeg image file of each photograph in accordance with the directory and naming convention agreed with the Engineer. The number of colour print images in a set shall not exceed 100, and each hard copy set of photographs shall be of A4 size with a cover page indicating information such as date, titles of the project and the Contract, and name of the Employer and the Contractor. Each of the photographs shall be properly numbered, dated and include a brief explanatory note of the subject matter.

9.4 Videos

On a monthly basis, or earlier if directed by the Engineer, the Contractor shall take digital video records to record the progress of the Works on Site (minimum duration of each to be ten minutes, covering all the areas of the Site where works are ongoing) as agreed with the Engineer, and submit the videos every month along with the Monthly Progress Report. The first video shall be made before the Commencement of the Works on the Site.

Within twenty-eight (28) days of receipt of the Letter of Acceptance, but in no case later than the Commencement Date, the Contractor shall submit to the Engineer a proposal for the provision of digital video recordings along with commentary of the progress of the Works.

The videos shall be taken by a competent person from an approved professional service provider (or any person with equivalent skills). The video shooting locations are to be identified in the afore mentioned proposal. This video should be submitted in a video format acceptable to the Engineer, with or without editing.

Immediately before the issue of the Taking-Over Certificate for the whole of the Works, the Contractor shall complete video recording and start editing the videos taken, to produce a 60- minute digital video-audio presentation with a suitable title. Each section of the video shall indicate the date on which it was taken. The presentation material shall have narration in English. The Contractor shall use a professional service provider to video, edit and produce the presentation material.

9.5 DRAWING AND CAD STANDARDS

a) The purpose of this document is to define the minimum Drafting and CAD standard to be achieved by the Contractor for all drawings produced by the Contractor for the purpose of the works.

b) By defining a common format for the presentation of drawings and CAD files, the exchange of drawn information is improved and will maximize the use of CAD in the coordination process.

c) All submissions shall be made in accordance with the Employer's Requirements in a format reviewed without objection and in accordance with the requirements in :

i. The Contract;

ii. The Document submittal instructions to Consultants and Contractors.

d) Paper and drawing sizes shall be "A" series sheets as specified in BS3429.

e) The following software (latest and updated version) compatible with Intel-Windows based computers shall be used, unless otherwise stated, for the various required electronic submissions.

Document Type	**Electronic Document Format**
Text Documents	**MS Word**
Spread Sheets	**MS Excel**
Data Base Files	**MS Access**
Presentation Files	**MS PowerPoint**
Programmes	**Primavera for Windows, Suretrack**
AutoCAD Graphics	**AutoCAD**
Photographic	**Adobe Photoshop**
Desktop Publishing	**Page Make 6.5,5**
CADD Drawings	**AutoCAD**

f) Media for Electronic File Submission - Email

One copy shall be submitted unless otherwise stated in CD-ROM

g) Internet File Formats/Standards

The following guidelines shall be followed when the Contractor uses the Internet browser as the communication media to share information with the Employer.

a) All the data formats or standards must be supported by Microsoft Internet Explorer (latest version) running on windows professional (latest version).

b) The following list shows the file types and the corresponding data formats to be used on Internet. The Contractor shall comply with them unless prior consent is obtained for a different Data format from the Employer's Requirements:

File Type	**Data Format**

Photo Image	Joint Photographic Experts Group (JPEG)
Image other than Photo	GIF to JPEG
Computer Aid Design files (CAD)	Computer Graphics Metafile (CGM)
Video	Window video (.avi)
Sound	Wave file (.wav)

h) The following states the standards to be used on Internet when connecting to database(s). The Contractor shall comply with them unless prior consent is obtained for a different standard from the Employer's Requirements

Function to be Implemented	**Standard to be Complied With**
Database connectivity	Open Database Connectivity (ODBC)
Publishing hypertext language on the World Wide Web	Hypertext Markup Language (HTML)

The hard copy of all documents shall be the contractual copy.

1) GENERAL REQUIREMENTS

General:

i) The Contractor shall adopt a title block similar to that used in the Drawings for all drawings prepared under the Contract.

ii) Each drawing shall be uniquely referenced by a drawing number and shall define both the current status and revision of the drawing.

iii) The current status of each drawing shall be clearly defined by the use of a single letter code as follows:

P - Preliminary Design Drawing

D - Definitive Design Drawing

C - Construction Reference Drawing

W - Working Drawing

B - As-Built Drawing

M - As Manufactured Drawing

E - Employer's Drawing

Types of drawings:

i) 'Design drawings' mean all drawings except shop drawings and as-built drawings.

ii) 'Working drawings' are design drawings of sufficient detail to fully describe the Works and adequate to use for construction or installation.

iii) 'Site drawings and sketches' are drawings, often in sketch form, prepared on site to describe modifications of the Working drawings, where site conditions warrant changes that do not invalidate the design.

iv) 'Shop drawings' are special drawings prepared by the manufacturer or fabricator of various items within the Works to facilitate manufacture or fabrication.

v) 'As-built drawings' show the Works exactly as constructed or installed. They are usually prepared by amending the working drawings to take into account changes necessitated by site conditions and described in Site drawings. These drawings shall be completed on a regular basis as the works progress, and shall not be left until completion of the entire works.

2) COMPUTER AIDED DESIGN STANDARDS

a) Introduction
Scope of Use

Data input procedures between the Engineer and contractors must be co-ordinated, and the key parameters used to form CAD data files must be standardized. The production of all CAD data files shall comply with the following requirements.

b) Objectives

The main objectives of the CAD standards are as follows:

i. To ensure that the CAD data files produced for Project are co-ordinated and referenced in a consistent manner.

ii. To provide the information and procedures necessary for a CAD user from one discipline or external organization to access (and use as background reference), information from a CAD data file prepared by another discipline or external organization.

iii. To standardize the information contained within CAD data files which may be common to more than one discipline such as drawing borders, title boxes, grid lines etc.

iv. To establish procedures necessary for the management of CAD data files.

v. To ensure all contractors use 'Model space' and "Paper space' in the production of their CAD files.

c) General

i. To facilitate co-ordination between contractors, it is a requirement that all drawings issued by contractors for co-ordination or record purposes shall be produced using CAD methods. Drawings shall be issued in digital format in addition to the paper copies.

ii. The intent of the issue of digital information is to aid the related design by others. The definitive version of all drawings shall always be the paper orpolyester film copies which have been issued by the contractor or organization originating the drawing.

iii. (Drawings and drawing packages issued for co-ordination, record purposes or for acceptance shall be accompanied by a complete set of the corresponding CAD data files.

iv. Any contractor or organization making use of the CAD data from others shall be responsible for satisfying himself that such data is producing an accurate representation of the information on the corresponding paper drawing which is satisfactory for the purpose for which he is using it. Provided the general principles of this section have been achieved by the originator of the CAD data, contractors making use of the CAD data from others shall not be entitled to require alterations in the manner in which such CAD data is being presented to them.

v. In particular, automatic determination of physical dimensions from the data file shall always be verified against the figured dimensions on the paper or polyester drawings. Figured dimensions shall be taken as correct where discrepancies occur.

vi. The purpose is to ensure that total co-ordination is achieved between the CAD 'Model Space" file and the "Paper Drawing" output during the revision cycle of the design and production process. Duplicated data in "Model and Paper Space" file will not be acceptable unless an automatic update link exists between the two data sets. "Paper Space" files are not typically required as part of the CAD Media Receipt from contractors, unless specifically requested.

d) CAD Quality Control Check

(i) Random CAD Quality Control Audits will be carried out by Engineer on all CAD media received and transmitted.

(ii) These checks DO NOT verify the technical content of the CAD data received or transmitted (as this is the responsibility of the originating organization), however compliance with Project CAD and Draughting Standards shall be checked.

(iii) In addition, all contractors who transmit and receive CAD data from the Project shall have CAD quality control procedures in place. A typical control procedure shall contain CAD data quality checking routines coupled with standards for CAD data transmittal and archiving.

e) CAD Data Transfer Media and Format

i. Data exchange format between the Engineer and the Contractor, shall be as follows:

Documents including design sheets, tables and figures: Word (*.docx), Excel (*.xlsx) and PDF (*.pdf).

Drawings: Autodesk's AutoCad 2016 or higher release. Electronic

Data Transfer Media: Pen Drive/Hard disk.

ii. All documents/drawings shall be labelled on the data shield with: Name of Company/ Consultant

Project Tile Document/Drawing

Filenames

iii. The Contractor shall ensure the supplied media is free from virus.

f) CAD Media Receipt & Transmittal

i. CAD Media Transmittal (from the Contractor to Engineer) – this will consist of the following:

a) CAD Digital Media (disk(s), CD's or tape(s)) shall typically contain CAD "Model Space" and "Paper Space" files.

b) CAD data sheet

c) CAD issue/revision sheet

d) CAD quality Checklist confirming compliance

e) Plot of each "Model Space" file issued on an A1 drawing sheet (to best fit).

ii. The above CAD media will be collectively known as "CAD Media Transmittal Set". The CAD data file transmittal format required by Employer' Representative from all contractors shall be in AutoCAD (version 14)

iii. All CAD media received from contractors will be retained by Engineer except for SCSI disk (if used) as an audit trial/archive of a specific contractor's design evolution.

iv. CAD Media Receipt (from Engineer to the Contractor)

a. CAD Media should normally be obtained from the respective interfacing contractor(s), but should Engineer issue CAD media it will consist of the following:

a) CAD Digital Media (disk(s) or tape(s) typically contain only CAD "Model Space" files.

b) CAD data sheet

c) CAD issue/revision sheet

b) The above CAD media will be collectively known as the "CAD Media Receipt Set". The CAD data file transmittal format used by Engineer to all contractors will be in AutoCAD (version 14).

c) Each CAD transmittal disk/tape will be labelled with proper disk label as approved by the Engineer. Any CAD data transmitted without this label is assumed to be provisional information not to have been quality checked and therefore not formally issued.

a) Revisions

i. All "Revisions", 'In Abeyance' and 'Deletions' shall be located on a common layer. This layer can be turned on or off for plotting purposes.

ii. The following example text indicates the current CAD file revision, i.e., "Revision [A]". This shall be allocated to a defined layer on all CAD "Model Space" files, in text of a size that will be readable when the CAD "Model Space" file is fitted to the screen, with all levels on.

iii. Libraries, Blocks, & Block Names

a. All Construction Industry symbols produced as CAD Cells shall typically conform to British Standard BS1192 – part 3.

b. All Blocks created shall be Primitive (i.e., Not Complex) and shall be placed Absolute (i.e. NOT Relative).

c. The Contractor's specific block libraries shall be transmitted to Engineer together with an associated block library list containing the filename (max. 6 characters) and block description. The contractor shall ensure that the library is regularly updated and circulated to all other users, together with the associated library listing.

d. All Blocks of a common type, symbols or details should initially be created within a CAD "Model Space File" specifically utilized for that purpose. These files will be made available on request by Engineer.

e. All Blocks created will typically be 2D unless 3D is specifically requested. In both instances they shall have an origin at a logical point located within the extents of each Block's masked area or volume.

b) CAD Dimensioning

Automatic CAD Dimensioning will be used at all times. Any dimensional change must involve the necessary revision to the model space file. If the CAD Quality Control Checks find that the revisions have not been correctly carried out, the rejection of the entire CAD submission will result.

c) CAD Layering

All CAD elements shall be placed on the layers allocated for each different discipline. The layer naming convention to be adopted by the Contractor shall be submitted for acceptance and inclusion within these standards.

d) Global origin, Location & Orientation on the Alignment Drawing.

Location or Plan information in "Model Space" files shall coincide with the correct location and orientation on the Project grid for each specific contract.

Location plans shall have at least three setting out points shown on each CAD "Model Space" file. Each setting out point shall be indicated by a simple cross-hair together with related Eastings and Northings co-ordinates. The Civil Contractor(s) will establish the three setting out co-ordinates for their respective works, which will then be used by all other contractors including the Contractor.

e) Line Thickness and Colour

To assist plotting by other users, the following colour codes will be assigned to the following line thickness/pen sizes.

Colour	**Code No**	**Line Thickness**
Red	10	0.18
White	7	0.25
Yellow	2	0.35
Brown	34	0.5

Blue	130	0.7
Orange	30	1.0
Green	3	1.4
Grey	253	2.0

f) CAD Utilization of 2D & 3D Files

Although the project standard is 2D CAD files, certain disciplines and contractors may use 3D CAD files for specific applications or where the isolated use of 3D aids the design and visualization process (i.e. Architecture, Survey and Utilities). In these specific instances 3D CAD data will only be transmitted if all other users can use this data. If this is not the case, a 3D to 2D translation shall be processed by the creator prior to issue.

g) CAD File Numbering

Contractors CAD File Numbering shall be described in 5.2.1 above. Employer CAD File Numbering Unlike most of the contractors, Employer will not be required to produced numerous CAD files. This will follow the numbering system Except that the status of the drawing in 5.2.1 (E) shall be "E".

h) CAD File Naming Convention – General
CAD "Model Space" files shall be named in accordance with general drawing conventions

APPENDIX- 10

CONSTRUCTION & SITE MANAGEMENT

10. THE SITE

10.1 Location and Boundaries

10.1.1 Works Areas are those areas identified in *Appendix 3* to these Employer's Requirements and on the Drawings.

10.1.2 Within 28 days from Commencement Date, the contractor shall submit detailed and comprehensive Site Environmental, Social, Health and Safety plan (Appendix-13 of Employer's Requirements) based on Environmental, Social, Health and Safety (ESHS) manual.

10.1.3 Within 28 days of the date commencement, the contractor shall submit detailed Quality Plan (Appendix-11 of Employer's Requirements) demonstrating the proposed method of achieving the required quality standards of the Employer as defined in the Employer's Requirements.

10.1.4 Normal working hours at site will be as stated in the Contract Data. However, the Contractor, if required, shall carry out work during night hours or in shifts with the approval of the Engineer. No increase in rates or extra payments shall be admissible for night work.

10.2 ACCESS TO THE SITE

10.2.1 The Contractor shall be deemed to have inspected, examined and made himself fully familiar with the access routes necessary for the proper execution of the Works and accounted for in the Accepted Contract Amount any costs arising in connection with the accessibility to the ROW. The Employer will not be responsible for any claims which may arise from the use of or otherwise in connection with any access route. The Employer does not guarantee the suitability or availability of any particular access route and will not entertain any claim for any non- suitability or non-availability of any such route for use (whether continuous or otherwise) during the Contract Period.

10.2.2 *The Contractor shall make its own arrangements for access required to the Site. The Contractor shall negotiate with the landowners or other appropriate government agencies to seek temporary occupation of land and seeking necessary permission for construction of temporary access roads.*

10.3 CONTRACTOR OPERATIONS OUTSIDE THE SITE

10.3.1 The Contractor shall be solely responsible for acquiring any additional land (land in addition tothe Site) required by him for his Temporary Works areas outside the ROW, at his own expense,including maintaining and reinstating the same on completion of the Works to the entire satisfaction of the land owner and the Engineer.

10.3.2 The Contractor shall make the necessary arrangements with landowners and relevant government authorities for any work to be undertaken outside the Site. Two copies of all the relevant documents/ permissions/ agreements, etc., as required by the Engineer in respect of the land arranged by the Contractor outside the Site, shall be submitted to the Engineer. Before commencing operations, the Contractor shall also submit to the Engineer a detailed plan and a programme of the Works to be carried out in the works area, including areas outside the Site.

10.3.3 When using and/or occupying works areas on existing public roads, the Contractor shall undertake all necessary procedures and mitigation measures as per the requirements set by the relevant authorities.

10.3.4 The Contractor shall submit to the Engineer proposals for the use and occupation of such works areas. Any such proposal shall be submitted to the Engineer at least twenty-eight (28) days prior to the start of the programmed use of the specific works area.

10.3.5 On completion of the Works, the land arranged by the Contractor outside the Site shall be restored back to its original condition to the entire satisfaction of the land owner and the Engineer.

10.4 SITE SECURITY

10.4.1 The Contractor shall be wholly responsible for security on the Site and any other areas being used by him or any Subcontractors for the purposes of the Contract. The Contractor shall implement and cause Subcontractors to implement proper security management procedures in accordance with the approved security management plan described in Appendix 13 (Environmental, Social, Health and Safety Management Manual)

10.4.2 The Contractor shall assign on the Site an appropriate safety and security organisation headed by experienced and professionally qualified safety and security personnel, who shall be primarily responsible for the Contractor's security services and shall fully cooperate with the Employer's security organization throughout the Time for Completion.

10.4.3 The Contractor shall prepare and submit to the Engineer for approval a security management plan (it may be included in the Environment, Social, Health and Safety Management Plan) fully complying with not only the relevant applicable Laws but also the regulations of the Employer which may be imposed from time to time on the Project within twenty-eight (28) days after the Commencement Date or at least one week before commencing the Works on the Site or any other area being used by the Contractor (whichever is the earlier). The plan shall include detailed procedures for daily security management operations as described in Appendix 13 (ESHS Manual) of General Specifications.

10.5 Possession of Third Parties Facilities

10.5.1 The definition of "Possession" to be applied in this Clause is 'possession of a segment or stretch of the Works and/or Indian Railways (IR) track(s) and/or other related authorities required by the Contractor from the Employer and/or IR and/or other related authorities for execution of the Works during the Time for Completion and/or after issue of the Taking- Over Certificate and during the Defects Notification Period for maintenance / rectification of any defects in the Works.

10.5.2 While undertaking construction activities within an existing railway line or road under the Contractor's Possession, the Contractor shall abide by the rules/guidelines included within the relevant manuals of Indian Railways and/or the National Highways Authority of India (NHAI)/Public Works Department (PWD)/ Panchayats/ Municipal Corporations and/or any other authority.

10.5.3 The Contractor shall undertake any construction activities on existing 'live' or operating lines only after the grant of Possession by the relevant authorities.

10.5.4 An area under the Contractor's Possession is the sole responsibility of the Contractor and all issues relating to safe working within that area, including the movement of traffic, are his responsibility.

10.5.5 If the Contractor has more than one work front within the same Possession, one person shall be nominated by the Contractor as the person responsible for the coordination for all work fronts within the Possession.

10.5.6 The Contractor shall ensure that construction activities shall be undertaken strictly within the area which is under the Contractor's Possession.

10.5.7 The Contractor shall appoint a responsible person who shall coordinate with the Employer, IR/ relevant authorities, Interfacing Contractors and Interfacing Parties as applicable and who shall act as the Possession Coordinator for the Contractor. The person appointed shall have experience of IR/ relevant authorities operations and shall be fully aware of IR Rules and Regulations related to possession of track for construction of railway works and in accordance with IR/ relevant authorities regulations to issue Possession requests. For the purposes of the Works, such person shall be duly certified in accordance with the said Rules and Regulations, if required.

10.5.8 The Contractor shall use Possessions on the line as follows:

10.5.9 For each particular Possession and depending on the duration and the location of the Possession, alternative route(s) may be required, such alternative diversion route(s) if required to be constructed, shall be at the Contractor's cost.

10.5.10 The normal alternative mode of transport will be proposed by the Contractor, and the route and timings of this alternative transport are to be agreed with the Engineer / IR / Road Authorities / Panchayat prior to obtaining Possessions.

10.5.11 The Employer shall provide assistance necessary to the Contractor to enable him to obtain the Possessions required by him, subject to being approved by IR, NHAI or relevant authorities. No claim shall be entertained by the Employer on this account.

10.5.12 The Contractor's request for Possession shall include a technical and organizational schedule and submit the same to the Engineer for his consent.

10.5.13 The Contractor shall submit his requests for Possessions well in advance as per requirements of relevant authorities.

10.6 Damage and Interference

10.6.1 General

Work shall be carried out in such a manner that there is no damage to or interference with:

a) watercourses and drainage system,

b) Utilities,

c) Structures (including foundations), roads including street fixtures or other properties;

d) Public or private vehicular or pedestrian access, and

e) Monuments, graves or burial grounds other than to the extent that it is necessary for themto be removed and reinstated to permit the execution of the Works.

10.6.2 Heritage structures shall not be damaged or disfigured on any account. The Contractor shall inform the Engineer as soon as practicable of any items which are not stated in the Contract to be removed or diverted but which the Contractor considers necessary to be removed or diverted to enable the Works to be carried out. Such items shall not be removed or diverted until the approval of the Engineer has been obtained.

10.6.3 Assets/ items of the Employer, Indian Railway (IR), Other Contractors and any other entities and relevant authorities which include, but are not limited to, water, sewage, gas authority, electrical, OFC communication cables etc. carried out shall be replaced /

reinstated by the Contractor to the same condition as existed before the Works started and to the satisfaction of the Engineer and the concerned entity.

10.6.4 In case of damage to the existing cables, the Contractor shall have suitable procedure for cable joining under the technical supervision of IR or the relevant authority.

10.6.5 The Contractor shall indemnify the Engineer, Employer, Indian Railway, Other Contractors and relevant authorities against any damages or any penal action, any claim or legal action as a result of the damages.

10.7 Utilities

The Contractor shall follow the requirements on care for utilities as specified in this Appendix below.

10.8 Structures, Roads and Other Properties

10.8.1 The Contractor shall carry out a precondition survey of all roads and structures and drainage channels adjacent to the Site. Contractor originated deterioration of the roads and damage to adjacent structures and drainage facilities shall be reported to the Engineer with appropriate records.

10.8.2 The Contractor shall maintain / replace / reinstate to the same condition as existed before the Works started and to the satisfaction of the Engineer and the concerned entity.

10.9 Access

10.9.1 Where existing access to premises either public or private is damaged or unusable, alternative access shall be provided by the Contractor to enable the Works to proceed. The arrangements for the alternative access shall be as agreed by the Engineer, the relevant authorities and the owners of the premises affected.

10.9.2 Unless agreed otherwise, the permanent access shall be reinstated as soon as practicable after the Works are complete and the alternative access shall be removed immediately when it is no longer required, and the ground surfaces reinstated. Proper signage and guidance shall be provided for traffic/ users diversions.

10.10 Trees

10.10.1 Materials, including excavated materials, shall not be banked around trees. Trees shall always be protected from damages.

10.10.2 Unless otherwise consented to by the Engineer, trees shall not be trimmed or cut as stated in Appendix 13 [ESHS Manual]

10.11 Removal of monuments, graves, burial grounds and other obstruction

If any graves and other obstructions are required to be removed in order to execute the Works and such removal has not already been arranged, the Contractor shall draw the Engineer's attention to them in good time to make the necessary arrangement for authorization for removal.

10.12 Protection of the Other Adjacent Structures and Works

The Contractor shall take all necessary precautions during the construction to protect structuresor works being carried out by others, adjacent to or within the Site from the effects of vibrations,undermining or any other earth movements or the diversion of water flow, arising from its work

10.13 Defined Area and Train Operation

10.13.1 When the Project under construction has been made available for track and system related installation works, the area will be classified as a Defined Area for train movement. The definedarea shall be controlled by the Lead Contractor (as nominated by Engineer) with regard to access.

10.13.2 All persons whose duties require them to work within a Defined Area must have been required to be examined for safety knowledge and to have been safety inducted. Evidence of safety induction must be exhibited whenever present or working in a defined area. All persons present in defined areas are required to observe safety rules and procedures to be defined by the Contractor and reviewed without objection by the Engineer.

10.13.3 The Contractor shall ensure that the necessary rules and procedures for all persons are published from time to time and communicated to the workers and/or agents and the Interfacing Contractors on the Site. The Contractor shall also ensure that all such rules and procedures are being followed during the course of all works and construction activities at the Site.

10.13.4 When overhead lines are energized, Train Sets/Cars may be moving in the Defined Area. No work shall be undertaken on the tracks when Train Sets/Cars are moving. Procedures for obtaining access to the energized tracks will be detailed in the rules. The Contractor shall make requests for obtaining access to the energized track or in the vicinity of the tracks as per the approved and notified rules and procedures.

10.13.5 After overhead lines are installed, the lines are energized, the Contractor shall comply with the rules / measures against electric shock.

10.14 Site Clearance

The contractor shall clear the Site as required by demolishing all buildings, structures (above and below ground such as brick, concrete, steel, etc.) and removing all rubbish as agreed by the Engineer. *If any payment/compensation is payable to the structures owner, the same shall be paid by the Employer to the structures owner.* The Site shall also be cleared of vegetation, trees, stumps roots, etc. Cutting of trees within ROW wherever required for execution of the Works shall be done by the Contractor. Permission for cutting of trees will be obtained by the Employer. Compensatory plantation is not included in the Scope of the Works. All material so cleared from the site shall be disposed off by the Contractor outside the ROW as directed by the Engineer.

10.15 MOBILIZATION AND DEMOBILIZATION

10.15.1 General

a) The Contractor shall mobilize to the Site the Contractor's Equipment and the Contractor's Personnel as appropriate for the execution and completion of the Works in strict accordance with the requirements of the Contract.

b) The Contractor shall demobilize Contractor's Equipment and Contractor's Personnel from the Site as appropriate when they are no longer required to be on the Site.

10.15.2 Engineer's Consents

a) The Contractor shall inform the Engineer regarding mobilization of Contractor's Equipment, including that required for use by any Subcontractor, at least seven (7) days before the date planned for the mobilization of same to the Site. The Contractor should note that:

i. the Contractor shall be solely responsible for the consequence of any such mobilization;

ii. the relevant insurances shall be in place as evidenced by insurance documents included in the application;

b) The Contractor's Equipment shall be mobilized to the Site complete with all necessary spare parts, consumables and the like indispensable for proper operation and maintenance thereof. The Contractor shall provide maintenance facility complete with qualified maintenance personnel on or in the vicinity of the Site.

c) The Contractor shall obtain a written consent from the Engineer before removing any of the Contractor's Equipment from the Site or any managerial person among the Contractor's Personnel mobilized exclusively for the Contract. Provided that the proposed demobilization is in accordance with the Contractual Works Programme to which the Engineer has given consent and that the Contractor shall be solely responsible for any consequences of such demobilization, the Engineer shall not unreasonably withhold consent.

d) Although they are deemed intended for exclusive use on the Works as set forth in Sub-Clause4.17 of the General Conditions of the Contract, the Contractor may divert any of the Contractor's Equipment to other uses within the Site, provided that the Contractor's written undertaking to return the same to the Works whenever needed is submitted to the Engineer and the Engineer's written consent to such diversion is granted.

10.16 Records

In addition to the Monthly Progress Reports described in Appendix 7 of the Employer's Requirements, the Contractor shall submit to the Engineer, on a daily basis, details of the mobilization and demobilization of any of the Contractor's Equipment or any managerial person among the Contractor's Personnel.

Without undue delay after demobilization from the Site, the Contractor shall submit to the Engineer copies of certified evidence of lawful re-export from the Country of any Contractor's Equipment imported into the Country on a temporary basis exclusively for use on the Contract.

10.17 Mobilization

10.17.1 The Contractor shall mobilize to the Site the Contractor's Equipment and the Contractor's Personnel as appropriate for the execution of the design, construction and completion of the Works. An Initial Mobilization Plan for the 3 months following the Commencement

Date shall be submitted to the Engineer within 7 days after the Letter of Acceptance has been received by the Contractor. An overall Mobilization Plan for the Works shall be submitted to the Engineer for his approval within 90 days after the Commencement Date.

10.17.2 In the event that manufacturing activities are to be carried out outside the Republic of India, the Contractor shall submit detailed organizational structure(s) for such manufacturing teams. This submission shall include the organization of such teams and details of the key personnel, including contact address, i.e., the addresses of the locations where such manufacturing activities are carried out and the e-mail address of each key personnel.

10.17.3 The Mobilization Plan shall include, but not be limited to the following:

a) Details of each major item of Contractor's Equipment, i.e., the name, size and capacity etc. of each item.

b) The number of each equipment and the time of mobilization and duration of the use of each equipment.

c) The name and details of key personnel for each section of the Works and their responsibilities.

d) Details and time for installation of temporary facilities for the Works including temporary facilities for the Employer and the Engineer.

e) The numbers of Contractor's Personnel, including site engineers, administrative staff and labour in each trade category.

10.18 Demobilization

Demobilization shall be carried out in accordance with the provision of Sub-Clause 4.22 [Contractor's Operation on Site], and Sub-Clause 11.11 [Clearance of Site] of General Conditions. Upon receiving the Performance Certificate under Sub-Clause 11.9 [Performance Certificate], the Contractor shall carry out the Clearance of the Site and the Contractor shall inform in writing to the Employer the completion of Demobilization or Clearance of Site and obtain the consent of the Employer. In case the Clearance of Site has not been completed in a specified period by the Contractor, the Employer may carry out the Clearance of Site. The Employer shall be entitled subject to Sub-Clause 20.2 [Claims for Payment and/or EOT] to payment by the Contractor of the costs reasonably incurred in connection with, or attributable to, such sale or disposal and reinstating and/or cleaning the Site, less an amount equal to the moneys from the sale (if any). In case the Taking-Over is conducted section by section, the Contractor shall inform in writing to the Employer the completion of Demobilization of the section and obtain the consent of the Employer or the Engineer as a representative or on behalf of the Employer.

10.19 SITE *OFFICE AND RESTING* ACCOMMODATION FOR THE EMPLOYER/ ENGINEER

10.19.1 One Site *office* Accommodation (total area *500* sqm) for the Engineer's & Employer's Staff including Meeting Room shall be provided. *In addition, one resting accommodation of about 300 sqm area consisting of four suites with attached toilet facilities, drawing, dining, kitchen and other incidental facilities along with full furnishing shall also be provided by the Contractor. The land for the above accommodation shall be provided by the Employer free of cost. The Contractor shall provide one cook and one housekeeping staff round the clock at the resting accommodation. In office, one pantry staff and one housekeeping shall be provided round the clock.*

10.19.2 Offices shall be accessible only from a corridor within the building. The corridor and reception area shall be provided with an external double door. The office will be provided with electronic surveillance system as approved by Engineer.

10.19.3 Materials for the construction shall be new, robust and durable. The building shall be weather proof, vermin proof, well insulated thermally and acoustically. Internal walls shall be soundproof. Electrical power/lighting, shall be provided to each room, including air-conditioning and heating to maintain the internal temperature within the range of 20 to 24 degrees Celsius at all times.

10.19.4 Internal doors shall be flush, fitted with door closers, mortice locks with keys and lever handles.

10.19.5 External doors shall be a pair of solid core doors, external quality, hung on heavy duty hinges, one leaf fitted with barrel bolts top and bottom and the other leaf fitted with a Yale or similar lock.

10.19.6 Windows, of area not less than 10% of the floor area, shall be provided to all rooms, securely barred, fitted with blinds and having opening sections fitted with locks and mosquito screens.

10.19.7 The building shall be provided with a continuous water supply and drainage to Kitchen, Washroom and Toilets. The Toilets shall be equipped with low level suites and be adequately ventilated through the ceiling.

10.19.8 The Kitchen shall be fitted out with a 2-drainer stainless steel double sink unit, worktop with cupboards under, tiling above the sank and worktop and wall mounted cupboards.

10.19.9 Fire and Safety regulations shall be complied with and firefighting equipment shall be provided in accordance with the statutory requirements.

10.19.10 The Contractor shall provide, erect, and maintain appropriate name boards as specified, for each of the offices. The working shall be agreed with the Engineer.

10.19.11 The Contractors shall provide the following new furniture and equipment for the exclusive use of the Engineer's Staff:

Table A: Equipment for the exclusive use of the Engineer's/Employer's Staff at Site Office

No.	Item	Nos.
Furniture		
1	Sofa set	**2**
2	Desk with side drawers.	**10**
3	Swivel Office Chair with arm rests	**8**
4	Swivel Office chair without arm rests.	**10**
5	Typist Chair	**12**
6	Visitor's Chair	**1**

No.	Item	Nos.
7	3-Shelf Bookcase	**2**
8	4-Drawer Lockable Filing Cabinet	**5**
9	Lockable Cupboard 2m high, with shelves.	**10**
10	Table	**3**
11	Bookshelf 2000x850x350mm (5 shelves)	**5**
12	White Board 2000x1000mm	**4**
13	TV set LED Screen	**1**
14	Projector Screen for Meeting Room (72"x72")	**1**
15	Wall Clock	**2**
16	Coffee Machine	**1**
17	Cupboard Table height	**1**
18	Printer cum scanner cum Photocopier A4/A3 (Canon, HP) capable of reduction	**2**
19	Wifi internet connectivity with *at least* 100mbps	**1**
20	Desktop Computers (Dell, HP) with following configuartions: Processor- i5 12th GEN Intel; Operating System- Windows 11 Professional 64 bit; Video Card- intel; Memory- 16 GB Ram, DDR4; Hard Drive-1TB. SSD; Monitor- 22 inch	**4**
21	Paper shredder	**1**
22	Desk Tray sets	**2**
23	Desk mounted pencil sharpeners	**4**
24	4-hole paper punches	**4**
25	Wastepaper baskets	**2**
26	Refrigerator 400 liters	**1**
27	Potable Water-cooler cum dispenser	**1**
28	Microwave oven (700W)	**1**
29	Cups, glasses, plates, cutlery for 12 persons,	**2**

No.	Item	Nos.
30	Electric kettle, coffee, and tea pots	**As required**
31	Office consumables for the duration of site activities	**As required**
32	Front Door Mat	**As required**
33	Flashlight	**1**
34	Locker with Key (900x300x500)	**For 10 Persons**

Table B: Items for the exclusive use of the Engineer's/Employer's Staff *at Resting Accommodation*

No.	Item	Nos.
Furniture		
1	Double Bed with Side Table, Mattress, Bed Sheet, Pillow	**2 sets**
2	Single Bed with Side Table, Mattress, Bed Sheet, Pillow	**6 sets**
3	Sofa set with Centre Table for seating of 12 persons	**1 set**
4	2 Seater Sofa set with Centre Table	**2 set**
5	Dining Table	**For 8 persons**
6	Study table with side drawer and Chairs	**4 Set**
7	Visitor's Chair	**16**
8	3-Shelf Bookcase	**1**
9	Lockable Cupboard 2m high, with shelves.	**2**
10	White Board 2000x1000mm	**1**
11	TV set LED Screen 60"	**1**
12	Wall Clock	**5**
13	Coffee Machine	**1**
14	Cupboard Table height	**1**

No.	Item	Nos.
15	Printer cum scanner cum Photocopier A4 (Canon, HP) capable of reduction	**1**
16	Desktop Computers (Dell, HP) with following configuartions: Processor- i5 12th GEN Intel; Operating System- Windows 11 Professional 64 bit; Video Card- intel; Memory- 16 GB Ram, DDR4; Hard Drive-1TB. SSD; Monitor- 22 inch	**1**
17	Wifi internet connectivity with *at least* 100mbps	**1**
18	Refrigerator 400 liters	**1**
19	Potable Water-cooler cum dispenser	**1**
20	Kitchen Items	**As required**
21	Gas Stove	**1**
22	Domestic Cooking Gas Cylinder	**2**
23	Microwave oven (700W)	**1**
24	Cups, glasses, plates, cutlery for 12 persons,	**2 set**
25	Electric kettle, coffee, and tea pots	**As required**
26	Front Door Mat	**As required**
27	Flashlight	**1**
28	Dressing table	**2**

10.19.12 The Contractor shall provide *02* SUV type vehicles *(not older than 2022 initially)* for use of the *Employer's* Staff from the Commencement Date till completion of the Contract. *The vehicles shall be replaced after two years with vehicles of current make.* The Contractor shall also bear the expenditure of deploying experienced drivers along with fuel and other incidental expenses associated with the operation of the vehicle. *The approximate kilometers to be run every month will be 3000 km for each vehicle.* Only experienced drivers shall be deployed. *Vehicles along with drivers shall be made available round the clock throughout the Contract period*.

10.19.13 The Contractor shall provide brand new protective clothing and safety equipment for *30* persons for exclusive use of the *Engineer's /Employer's* Staff, comprising, as a minimum – Safety Helmets, Steel-toed construction boots (size to be notified), Gum boots, Day-Glo waistcoat, industrial safety goggles, Ear protectors. *These shall be replaced as and when required, however, they shall be replaced at least once a year. The consumables for PPE kit i.e mask, ear plugs etc. shall be supplied on daily basis.*

10.19.14 The Contractor shall provide an adjacent shaded parking area for 5 cars.

The Contractor shall arrange for upkeep, service and security of the offices and compound. The office area shall be thoroughly cleaned and rubbish and waste to be removed, at least once a day as per current rules and regulations.

10.19.15 Communication System for Employer's/ Engineer's Staff

The Contractor shall provide seven sets of walkie talkie for use of Employer's /Engineer's staff. This shall include arrangement of licensing from concerned authorities and maintenance of the walkie talkies. In case of a walkie talkie set not being available due to any reason replacement shall be provided on real time basis by the Contractor.

10.20 SURVEY AND SETTING OUT

10.20.1 General

a) A survey shall be carried out of the Site to establish its precise boundaries and the existing ground levels within it. This survey shall include a drone cum photographic survey sufficient to provide a full record of the state of the Site before commencing the work with particular attention paid to those areas where reinstatement will be carried out later on. The survey shall be carried out before the site clearance wherever possible and in any case prior to the commencement of work in any Works Area. The survey shall be carried out by the Contractor and agreed with the Engineer. Videography by drone shall also be done at all work places every one month as per Outline Construction Specifications for Civil Works.

b) The Contractor shall plan and programme for the validation of any Site data provided by the Employer and develop a Survey Plan and Programme. The Contractor shall submit a Survey Plan and Programme to the Engineer for consent within 28 days after the Commencement Date. Generally, the contents of the Survey Plan and Programme shall comprise the following:

(1) The Contractor shall revalidate/derive the elevations of Secondary Control Points (SCPs) and Tertiary Control Points (TCPs) using the Reduced Level (RL) of the Standard Benchmark (Type M) at SDC Quarters, Palwal with MSL value of 195.41 metres. Survey and levelling should be done using Total Station and Digital level. Thereafter, the Contractor shall establish a horizontal and vertical control system (x, y, z) at the Site which shall be approved by the Engineer. Final drawings and profiles shall be prepared based on the above Reduced Levels.

(2) The Contractor shall carry out validation of the Site data provided by the Employer, and any additional topographic surveys considered necessary by the Contractor, in order to:

i. validate the Horizontal and Vertical Alignment with no change in alignment;

ii. prepare Alignment "Plan and Profile" Drawings; and

iii. review the data with which the Contractor shall eventually draw up the cross-section drawings at required locations.

The Contractor shall summarize the results of their validation of the Site data and any additional surveys carried out in a Survey Report and develop a Site Location Map, and aStructure Setting-Out Map and submit them to the Engineer for consent. Finally, the Contractor shall set out the Works to commence the construction with consistent accuracy and entirely throughout the construction stages.

10.20.2 Horizontal and Vertical Control System

a) A set of the benchmarks comprising a horizontal control system (x, y) and vertical control system (z) shall be established at the Site based on the Temporary Bench Marks which are established and maintained by the Employer *only after revalidation is done as per Sub-Clause 10.20.1 (b) of Appendix 10, Section VII-9: Appendices* and the Global Navigation Satellite System (GNSS) Survey, applying the Universal Transverse Mercator (UTM) coordinate system and World Geodetic System 84 (WGS 84). A description of the various benchmarks along the route alignment has been provided by the Employer along with their height above Mean Sea Level. The Contractor shall ensure that the horizontal and vertical position (x, y. z) of each HORC benchmark shall not be subject to any interference and that they shall not be affected by any of the Permanent and Temporary Works.

b) All pillars shall be of CC in dimensions of 450 mm x 450 mm x 900 mm with a projection of 300 mm above ground . The exposed surfaces of the pillars shall be appropriately painted with enamel paint of a colour as specified by the Engineer so as to be easily identifiable. The foundation shall be as indicated in the Reference Information/Reports. Details shall be developed by the Contractor and be submitted to the Engineer for review. Each pillar shall be protected by retractable fencing or other similar measures so as to prevent the occurrence of any movement, disturbance, interference and/or damage.

c) The Contractor shall establish additional benchmarks (x, y, z) which shall be staked and identified, and clearly painted in a different colour from the HORC benchmarks as approved by the Engineer. These temporary benchmarks shall be used for running a closed traverse for checking the HORC benchmarks. The pillars for additional benchmarks shall be staked at an interval of 500 m on both sides of the alignment at ROW and at abutment locations of major RUB.

d) The Contractor shall plan and programme to establish a horizontal and vertical control system at the Site by GNSS and correlate and adjust the system based on the benchmarks provided by the Employer or with reference to the existing control points as specified by the Engineer. The Contractor shall develop such plan and programme as part of the Survey Plan and Programme and submit to the Engineer. The Survey Plan shall include, but not be limited to, details of survey methods, error adjustment/correction, accuracy achieved, means to maintain accuracy, and coordination with others with respect to consistent accuracy in entirety.

e) The Contractor shall summarize the Traverse Survey results with verification studies in a HORC Benchmark Establishing Report.

f) Upon establishing the HORC Benchmarks and completing all necessary adjustments, the final and detailed survey data of the HORC Benchmarks shall be submitted to the Engineer for consent. Upon receipt of the Engineer's consent to the HORC Benchmark Establishing Report, the system shall be the sole horizontal and vertical control system (x, y, z), with reference pillars provided with coordinates (x, y, z), as described herein and shall be referred to as the HORC Benchmarks which shall be consistently applied to the Works under this Contract. A HORC Benchmark Establishing Report containing Traverse Survey results shall also be included as part of the Survey Report.

g) The HORC Benchmarks shall be periodically checked (at such intervals as consented to by the Engineer) by running closed traverses and closed level works. The Contractor shall submit the results to the Engineer for review. The periodical checks shall include the nearest equivalent benchmarks established by Interfacing Contractor(s), with whom the Contractor shall communicate and coordinate. If any discrepancy deemed to be crucial is found, the Contractor shall carry out appropriate corrective measures under the instruction of the Engineer.

h) The equipment to be used in the survey to establish the horizontal control system shall be Static GNSS System (horizontal/vertical) and Total Stations of 1" accuracy and to establish the vertical control system shall be Digital Level (and/or auto levels) which have sufficient accuracy to meet the requirements given hereinafter. The Contractor shall submit a certificate from the manufacturer or his authorized service agent for the equipment and peripherals. The date of the calibration certificate shall not be more than one (1) month from the date of commencing the survey. The calibration shall be checked and re-validated at pre-determined intervals, and in any event before the expiry of the calibration certificate.

i) Universal Transverse Mercator & Global Coordinates of TBM are described in Reference Information/Reports for the Contractor's reference.

10.20.3 Requirements for Horizontal Control

a) The Contractor shall establish a horizontal control system at the Site by GNSS, providing each HORC Benchmark with a horizontal coordinate (x, y). The horizontal coordinate (x, y) shall be checked with reference to the existing control points, if available. The Contractor shall coordinate with adjacent Interfacing Contractor(s) to ensure that the HORC Benchmarks established by the Contractor and the equivalent benchmarks established by the Interfacing Contractor(s) are consistent. The Contractor shall include the survey results and the description in the Survey Report as described in the following paragraphs. Upon consent of the Engineer, the system shall be the sole horizontal control system for the Works under this Contract.

b) The horizontal control system shall be developed by GNSS and by running a closed traverse on the HORC Benchmarks and the temporary benchmarks along the alignment.

c) The maximum length of a traverse to be closed shall be around 5km and the number of azimuth courses within an azimuth check shall not exceed twenty-five (25). The Contractor shall compute angular closing error of the traverse followed by linear error. Limits of traverse for horizontal control shall have the following accuracy:

Angular error of closure:	15" (N)0.5 (N: number of angles measured) Where N shall not exceed twenty-five (25)
Total linear error of closure:	1 in 25,000 (after angular adjustment)

d) The error within the permissible limits of the traverse line shall be balanced by the Transit Method. In case the errors are beyond the above permissible limits, a traverse survey shall be carried out until the resulted error is within the permissible limits.

e) The Contractor shall summarize the established coordinates (x, y) with necessary adjustments of all HORC Benchmarks, along with raw observation data downloaded from the Total Station, together with the calculation process and descriptions of all HORC Benchmarks and submit them to the Engineer for his review.

10.20.4 Requirements for Vertical Control

a) The Contractor shall establish a vertical control system at the Site by Direct Levelling, providing each HORC Benchmark with a vertical coordinate (z). The vertical coordinate (z) shall be *established using the Reduced Level (RL) of the Standard Benchmark (Type M) at SDC Quarters, Palwal with MSL value of 195.41 metres,* to ensure the entire vertical control system is consistent, including the equivalent system of adjacent Interfacing Contractor(s). The Contractor shall include the survey results and the description in the

Survey Report as described in the following paragraphs. Upon consent of the Engineer the system shall be the sole vertical control system for the Works under this Contract.

b) The vertical control system shall be developed by running a closed level work on the HORC Benchmarks and the temporary benchmarks along the alignment. The Contractor shall close the level work at an appropriate interval and find out the closing error as described in the following paragraph.

c) Each level work shall be connected with the HORC Benchmarks which have consistent accuracy and entirety in the system and the system of adjacent Interfacing Contractor(s) and shall be properly maintained at the Site. The closing error of loop closure shall not exceed 12 (K)0.5 [mm], where K is the circuit length in kilometres, where K shall not exceed 5 kilometres. In case the accuracy of loop closure exceeds the limit defined herein, the entire loop shall be repeated until the desired accuracy is achieved.

d) The Contractor shall summarize the established coordinates (z) of all HORC Benchmarks with necessary adjustments along with raw observation data, calculation sheets and descriptions of all control marks in spreadsheet (MS Office Excel) format and submit to the Engineer for review.

10.21 Topographic Survey

a) The Contractor shall be responsible for carrying out validation of any Site data provided by the Employer and any additional surveys considered necessary by the Contractor for the execution of the Works, and shall ensure that the topography of the Site has been accurately recorded so that he can be fully satisfied to commence and proceed with the Works. The HORC Benchmarks as established by the Contractor shall be consistently used for surveys.

b) The Contractor shall confirm and locate all the Right of Way (ROW) marks given by the Employer at the Site and provide them with coordinates (x, y, z) so that both the Alignment and ROW are located based on the same horizontal control system.

c) The Contractor shall develop the documents including all reports, drawings, and maps. The Contractor shall summarise the results of Validation of Data, Additional Survey and Setting Out in the Survey Report. The submittals to be developed by the Contractor shall include but not be limited to the following:

a) the HORC Benchmark Establishing Plan;

b) the Survey Plan;

c) the HORC Benchmark Establishing Report;

d) the Survey Report;

e) the Site Location Map;

f) the Structure Setting-out Map;

g) the As-Built Alignment Plan and Profile Drawings; and

h) the Cross-Section Alignment Drawings (as required).

d) During the traversing of peripheral areas, the Contractor shall survey and record the broad alignment of important geographical and other features such as roads, watercourses and the locations of important buildings and facilities, etc., whenever considered necessary for development of the design.

10.22 Horizontal Alignment Staking

a) The Horizontal Alignment defined by the coordinates (x, y) of the centerline of the track shall be staked at an interval of twenty (20) meters in addition to TPTC, TP, TPCC points along the proposed alignment. While staking the Horizontal alignment at Site, the Contractor shall confirm the Right of Way (ROW) staking already done by the Employer at Site and provide and install any missing stakes. The Contractor shall ensure that staking of the ROW is carried out as per the relevant provisions of Indian Railways Engineering Code.

b) The Contractor shall use the TBMs provided by the Employer *only after revalidation is done as per Sub-Clause 10.20.1 (b) of Appendix 10, Section VII-9: Appendices*, in addition to the benchmarks established by the Contractor for staking the alignment.

c) Upon completing the Horizontal Alignment staking and providing all the ROW marks with coordinates (x, y, z), the Contractor shall submit to the Engineer the final coordinates (x, y, z) data of the Vertical Alignment at an interval of twenty (20) meters, the ROW coordinates (x, y, z) at an interval approximately twenty (20) meters, horizontal alignment calculation report including curve details at every twenty (20) meters (transition curves, circular curves, IP coordinates (x, y, z) and direction).

d) The Contractor shall summarize the survey results of the Right of Way marks given to the Contractor by the Employer and the Centre Line Survey and the Right of Way staking and submit to the Engineer for his consent.

e) Upon the consent of the Engineer to the report, the confirmed Alignment and Right of Way marks, including maps and drawings which confirm the ROW as well as any control points established by the Centre Line and Right of Way staking, shall become the responsibility of the Contractor. The Contractor shall ensure that these marks and control points are protected and maintained and remain consistent throughout the Time for Completion.

10.23 Setting Out

a) The Contractor shall set out the Works at the Site. The Contractor shall ensure that all the

b) Permanent Works are accurately set out.

c) The setting-out of the Works shall be carried out based upon the Drawings which have been issued with a approval and have been issued to the site ''For Construction''

d) The Contractor shall consistently apply the HORC Benchmarks to the setting-out.

10.24 Auxiliary Works

In addition to the requirements specified elsewhere in the Works Requirements and the Conditions of Contract, the Contractor shall follow good industry practice when carrying out surveying, setting out and associated activities, which includes but is not limited to the following:

a) performing all necessary calculations accurately and presenting all computations and results clearly in order to facilitate verification by the Contractor and Engineer;

b) removing machinery and obstructions from required sight-lines;

c) prior to carrying out surveys, setting out or similar works, stopping or relocating any operating machinery, drilling, blasting, pile driving or the like which may cause ground or structure vibration; and stopping any activity which could generate smoke,

dust, gas, etc., thereby obscuring clear views or causing refraction, which would thereby interfere with such survey works;

d) restricting or stopping pedestrian and/or vehicular traffic near instruments or in sight-lines during instrument observations, as required;

e) providing adequate equipment, labour and materials as deemed necessary and suitable to carry out control and any other surveys required.

10.25 Geotechnical/Geological Survey

10.25.1 Contractor's Surveys

The Contractor shall be responsible for carrying out validation of any Site data provided by the Employer and any additional geotechnical/geological or other surveys which, in the Contractor's opinion, are considered necessary for the execution of the Works.

10.25.2 Geotechnical Interpretative Report

The Contractor shall prepare and submit to the Engineer for review a Geotechnical Interpretative Report which includes site investigation results and the geotechnical interpretation of site investigation work including that undertaken by the Contractor in sufficient detail to confirm and justify parameters used in the design of temporary works. The report shall include full borehole logs, geological profile and descriptions of confirmatory boreholes drilled by the Contractor. The requirements for this Report are described in the Works Requirements.

10.26 Other Related Surveys

The Contractor shall be responsible for carrying out validation of any Site data provided by the Employer and any other surveys considered necessary by the Contractor for the execution of the Works. Such surveys may include, but are not limited to, the following:

a) Topographic Survey

b) Utilities Survey including Adjacent Structures and Works with Works Areas

c) Environmental Survey

d) Hydrological/ Hydro-Meteorological Survey

10.27 Temporary Facilities

10.27.1 General

a) The Contractor shall be entirely responsible for the provision, erection, maintenance and removal on completion of all required temporary facilities, as part of the Temporary Works, which are required for the proper execution and completion of the Permanent Works. Such temporary facilities shall include the Contractor's offices, laboratories, workshops, stores, utilities, services, accommodation, canteens, recreational and welfare facilities, health, safety, security and environmental protection facilities and the like, whether on or off the Site.

b) The Contractor's Personnel shall not be allowed to live on the Site. A limited number of security personnel designated to secure the Contractor's facilities will be permitted to stay after working hours subject to the approval of the Engineer. The Contractor shall make all necessary arrangements for suitable off-Site accommodation and transportation for the Contractor's Personnel.

c) All of the Contractor's temporary facilities on the Site or elsewhere within the Project site shall be designed, provided, erected, maintained and removed to the satisfaction of the Engineer and in strict accordance with applicable Laws. The Contractor shall obtain all necessary approvals and permits from the relevant authorities having jurisdiction for the provision, erection, operation, maintenance and removal of the Contractor's temporary facilities.

d) All of the Contractor's temporary facilities, other than those designated to remain, are to be removed on the completion of the Works and the ground surfaces reinstated to the satisfaction of the Engineer.

e) When deemed essential for the preservation or maintenance of health, safety, security and/or environmental protection, the Engineer may instruct the Contractor to modify the Contractor's temporary facilities, regardless of any approvals or consents previously given, and the Contractor shall promptly comply with such instructions. These instructions shall not constitute Variations.

10.28 Location of Area for Temporary Facilities

10.28.1 The Contractor shall be aware that the area for temporary facilities is not for the Contractor's exclusive use, and the Contractor shall cooperate fully with the Interfacing Contractors if it becomes necessary for the efficient use of a limited area among the said Interfacing Contractors.

10.28.2 The precise locations of the Contractor's Temporary Works including the temporary facilities within and outside the Site area shall be proposed by the Contractor and approved by the Engineer.

10.28.3 The Contractor shall submit drawings showing the proposed locations and outlines of the proposed temporary facilities. Drawings and details of the Temporary Works for a particular part of the Permanent Works may be submitted as part of the shop or working drawings and/or the work method statements forming part of the Contractor's Documents. These locations and outline drawings for the temporary facilities shall be submitted twenty-eight (28) days before commencing the construction of any temporary facility or twenty-eight (28) days after the Commencement Date. These drawings and outlines shall be updated whenever addition or removal of any facility is planned. Detailed drawings for any particular temporary facility, showing all necessary utilities and services, shall be submitted at least fourteen (14) days before the planned commencement date of construction thereof.

10.28.4 The areas for the Contractor's temporary facilities may also be used for temporary storage of excavated material suitable for reuse in embankment or fill for the Works, or for use by the Employer in future projects or on other works packages.

10.28.5 The Contractor shall dispose of all surplus topsoil and all subsoil materials arising from the Works in the designated area wherever available within the ROW of the Project as agreed by the Engineer. In case area for disposal of surplus soil is not available, the Contractor shall make his own arrangements outside the ROW and the Contractor shall bear all costs including royalty for using/disposing of excavated material unless otherwise specified in the Contract.

10.28.6 The Contractor is free to make his own arrangements for any additional areas required for the proper execution of the Works, and the costs of same shall be borne by the Contractor.

10.29 Site Offices

10.29.1 The Contractor shall be responsible for identifying and establishing suitable facilities for the Contractor's office facilities as approved by the Engineer.

10.29.2 The Contractor's Site offices and facilities shall be provided within or in the vicinity of the work site, with all necessary facilities including furniture, office equipment, office supplies, utility services, sanitary system and vehicle parking. The Engineer will have one (1) Sub-Site Office established for this Contract. The Contractor shall establish the same number of Sub-Site Office and Site Huts in close proximity to the Engineer's Offices.

10.30 Project Information Signboards

10.30.1 The Contractor shall provide project profile sign board at each of the Site Offices and at prominent public places along the alignment of the project as directed by the Engineer of a size, minimum 1.5 m x 2.5 m, and maintain them in good condition. All information on the signboards will be written in English and local language for separate signboard. The signboards will be positioned on a steel frame as directed by the Engineer. The Contractor shall submit proposals for the signboard materials, the text layout (in English and local language) and installation of the signboards at the Site Offices of the Engineer and the Contractor for Engineer' s approval. Each sign board shall show:

a) The name of the Project and the Works,
b) The Location Map,
c) The name of the Bank,
d) The name of the Employer,
e) The name of the Engineer,
f) The name of the Contractor,
g) Date of Commencement of the Works,
h) Time for Completion,
i) Cost of the Works and
j) All other details as required by the Engineer

10.30.2 The Contractor shall maintain the sign boards and remove them on completion of the Works or when instructed by the Engineer. The Contractor shall clean, update, maintain and replace the signboards if damaged, throughout the duration of the Contract. No additional payment shall be applicable for damaged signs which are required to be replaced.

10.30.3 Within twenty eight (28) days from the Commencement Date, the Contractor shall provide and install a Project information sign, as per the requirements for signboards at the Employer's/Engineer's Site Offices, at each of the entrance points to each Site Office location (both the Contractor's and Employer's/Engineer's offices) and the Site entrances, or, as directed by the Engineer.

10.30.4 The Contractor shall maintain the signboards and remove them on completion of the Works or when instructed by the Engineer, so as to inform the public of the implementation of the Works and the Project and to advise road users of on-going construction.

10.30.5 The Contractor shall clean, update, maintain and replace the signboards if damaged, throughout the duration of the Time for Completion. No additional payment shall be applicable for damaged signs which are required to be replaced.

10.31 First Aid Station

10.31.1 The Contractor shall construct, equip, and maintain First Aid stations at a sufficient number of appropriate locations on the Site and at each labour camp.

10.31.2 The Contractor shall comply with all requirements specified in the Works Requirements (including Appendix 13 [Environmental, Social, Health and Safety Management]) and the Conditions of Contract.

10.32 Labour Accommodation Camps

10.32.1 The Contractor shall supply, equip and maintain facilities as necessary for the living accommodation, feeding and welfare of its employees by providing, servicing, and maintaining a camp at appropriate location(s), as necessary.

10.32.2 The Contractor shall comply with all requirements specified in the Works Requirements (including Appendix 13 [Environmental, Social, Health and Safety Management]) and the Conditions of Contract.

10.33 Site Storage and Yards

10.33.1 The Contractor's Site storage areas and yards shall be utilized for, among other things, material and equipment storage, casting of precast structural elements, workshops, warehouses and secure storage.

10.33.2 The Contractor shall erect a 2.0 metres high chained security fence around the Site storage areas and yards, complete with suitable lighting and lockable gates.

10.33.3 The location of each Site storage area and yard shall be determined prior to the commencement of the works and the Contractor shall propose the locations and details of same and submit to the Engineer for consent.

10.34 Borrow Areas and Quarries

10.34.1 It shall be the responsibility of the Contractor to arrange for borrow areas (for fill material) and quarry sites (for ballast, aggregate and rock material) using his own resources. The Contractor shall be responsible for carrying out his own investigations to verify the availability, sufficiency, quality and quantity of materials from such sources. The Contractor may also arrange any additional borrow areas and quarry sites as required by him, all at his own discretion. No claim whatsoever shall be entertained by the Employer in this regard.

10.34.2 All costs and charges, including but not limited to permits, royalties, duties, taxes, rental or other costs associated with land or the temporary use of same, etc. as applicable, for

arranging borrow areas and quarry sites and access thereto, including for the extraction of material therefrom, shall be borne by the Contractor.

10.34.3 Before commencing operations in each of the borrow areas and quarry sites, the Contractor shall submit a detailed plan of his operations and demobilization/grading and finishing/reinstatement, etc. in respect of the same to the Engineer for his approval, together with relevant drawings.

10.34.4 The quality of fill material, aggregates, etc. extracted from borrow areas and quarry sites shall meet the Works Requirements and be subject to the consent of the Engineer.

10.34.5 Borrow areas, quarry sites and the installation of rock crushers shall not be permitted within the ROW.

10.34.6 On completion of the Works, the Contractor shall leave borrow areas in a safe and stable condition.

10.34.7 The Contractor shall indemnify the Employer against all claims in relation to borrow areas and quarry sites both during the Time for Completion and after the Works are completed and taken over.

10.35 Stockpile Areas

10.35.1 The land available, if any, within the ROW may be used by the Contractor for storage of materials required for the project, subject to the consent of the Engineer.

10.35.2 The Contractor may also arrange any additional stockpile areas as required by him at his own discretion and cost.

10.35.3 The location and size of stockpile areas proposed by the Contractor shall be subject to consent of the Engineer. The Engineer's consent may be withheld, if:

a) in the opinion of the Engineer, a stockpile area or access thereto may be such as:
   i. would have a detrimental effect on the natural and social environment;
   ii. would disturb drainage system(s) around the stockpile areas;
   iii. would constitute a danger to the public; or
b) at the Engineer's discretion, a stockpile would become too high.

10.35.4 Before commencing operations, the Contractor shall submit detail drawings of the proposed stockpile areas, together with the proposed method of operation, including stockpile heights, angles of repose, runoff / dust control measures, access road layouts, drainage, measures to be taken for restoration, all verified by appropriate calculations and analysis.

10.35.5 On completion of stockpiling operations, the Contractor shall reinstate stockpile area(s) to a safe and stable condition.

10.35.6 The Contractor shall indemnify the Employer against all claims in relation to stockpile area(s), both during the Time for Completion and after the Works are completed and taken over.

10.36 Contractor's Plants.

10.36.1 The Contractor shall plan, install, erect, maintain, dismantle and remove all plants required for the Works, including but not limited to major items such as concrete batching/mixing plants, rock crushers, casting yard, curing yard, stacking yard etc. of sufficient number and capacity to meet planned peak requirements during construction. The capacity of such plants shall be subject to consent by the Engineer. The location of concrete batching plants is subject to environmental approval from the appropriate authorities and shall not able to operate until such approval is obtained. All control and

measuring equipment shall be regularly checked and calibrated and the Contractor shall regularly submit calibration certificates for same to the Engineer.

10.36.2 The land available, if any, within the ROW may be used by the Contractor for storage of materials, concrete batching/mixing plants, casting yards, curing yard and stacking yards subject to the consent of the Engineer. The Contractor shall arrange any additional areas as required by him at his own discretion and cost.

10.37 Material Testing Laboratories

10.37.1 The Contractor shall design, construct, equip, maintain, dismantle and remove all required material testing laboratories and associated facilities on the Site and / or at work areas as are required for the sampling and testing of materials as required in the Works Requirements. The Engineer's consent shall be obtained to the location of material testing laboratories.

10.37.2 Laboratory buildings shall be supplied with adequate electricity, water, air-conditioning, etc., and shall have sufficient area(s) for storing samples.

10.37.3 The laboratory equipment to be supplied and the methods of testing shall be in accordance with relevant International, Indian and/or other standards and codes as detailed in the Works' Requirements. All apparatus and equipment shall be brand new and of the latest design and manufactured by a reputable manufacturer. The proposed type and number of items of laboratory equipment shall be submitted to the Engineer for review and consent prior to purchase.

10.37.4 The laboratory equipment and apparatus shall be checked and calibrated before testing starts and thereafter at regular intervals as specified by the manufacturer and as directed by the Engineer. The Contractor shall regularly submit calibration certificates for same to the Engineer.

10.37.5 The Contractor shall complete the design, construction and installation of the laboratory facilities for operation within one hundred and forty (140) days after the Commencement Date and operate and maintain the facilities until the issue of Taking-Over Certificate, unless otherwise authorized by the Engineer. The Contractor shall also make all facilities and services available to the Engineer as required. All sampling and testing to be undertaken shall be under the direct supervision of the Engineer. The material testing laboratory shall be staffed by Contractor's personnel fully experienced in the sampling and testing of materials, and quality control.

10.37.6 Any testing which may be required in accordance with the Works Requirements and which cannot be performed in the Contractor's laboratory due to lack of time or equipment shall be assigned to an independent organization having NABL accreditation and as duly consented to by the Engineer. The Contractor shall accept all results, instructions or restrictions stipulated by the Engineer based on such tests.

10.38 Wheel Washing Facilities

10.38.1 In and around residential and commercial area, the Contractor is required to install wheel washing area within ROW at the "Exit" points/gates of the construction area to ensure the removal of wheel/band dirt from construction vehicles and machines. Wheel washing area design shall be proposed in CEMP. As a part of the Contractor's method statement for the site preparation plans, wheel washing area shall be proposed and approved by the Engineer before the commencement of the work. The facilities are required to have access for cleaning out the sludge which collects together with provision for 2 high pressure hose connections and adequate water supply.

10.39 Temporary Roads

10.39.1 The Contractor at his own discretion construct and dismantle/alter/dispose of the temporary roads after the completion of Contract as directed by the Engineer.

10.39.2 Before constructing any temporary roads outside the ROW, the Contractor shall make all necessary arrangements, including payment if required, with the public authorities or landowners concerned, for the use of the required land and shall obtain the consent of the Engineer. Such consent will be dependent on the Engineer being satisfied with the Contractor's proposals for items such as capacity, signage, lighting and surface quality of the temporary road, together with proposed maintenance arrangements. Such consent shall not relieve the Contractor from any of its responsibilities under the Contract.

10.39.3 The Contractor shall note that temporary road shall not be for the Contractor's exclusive use and shall be subject to relocation or restrictions at his cost during the execution of the Works as and when such relocation or restriction is inevitable. Except in an emergency, the Contractor will be given a prior notice of any such relocation or restriction. The road layout and design proposal shall be revised and re-submitted to the Engineer for consent whenever road arrangements are to be modified for whatsoever reasons.

10.39.4 Within forty-two (42) days after the Commencement Date and consequent to the surveys performed by the Contractor, the Contractor shall submit for the Engineer's review and approval of the proposed design, including layout, and details of the temporary road, fences, protection to underground pipes and culverts at road-crossing points and all additional temporary pipes and culverts that shall be provided by the Contractor, to sustain road traffic, irrigation and drainage flow in all existing streams, irrigation canals and ditches, drainage canals and ditches, and utilities or services, whether buried or exposed, all of which, in the opinion of the Engineer, are necessary for the proper execution of the Works.

10.39.5 During the transportation of Goods and Contractor's Personnel, the Contractor shall be responsible for keeping all railways, roads, bridges, watercourses, utilities services, etc. free from damage and from spillage of construction materials, detritus, oils, etc. and shall repair any damage howsoever caused to any such structure or property (whether on or off the Site) by Contractor's Equipment (including that of any Subcontractor). In that respect the Contractor will be required to carry out a condition survey of all roads and other facilities in and adjacent to the works area which will show in detail the state of those items prior to the commencement of construction. The full records shall be submitted to the Engineer and the status monitored throughout the course of construction with further records maintained.

10.39.6 At the junction of temporary roads with existing roads, the Contractor shall provide suitable traffic marshals to warn and regulate the traffic as per the requirements.

10.39.7 The Contractor shall be responsible for upholding and protecting all slopes at the boundaries of the Site against slippage into adjacent properties. As adjacent areas may be irrigated, this requirement will also therefore include the provision of temporary coffering as appropriate.

10.39.8 All temporary roads, culverts, ditches and the like required for the Contractor's or Subcontractors' or any other Contractor's operations shall be provided and maintained by the Contractor, kept in good condition by cleaning, watering, rolling, grading, repairing and maintaining, all to the approval of the Engineer.

10.39.9 If the Engineer has provided drawings or details of any temporary works, then such drawings or details shall be understood to be indicative of the minimum required standard only. The Contractor shall remain responsible for the design of Temporary Works.

10.39.10 Unless otherwise approved by the Engineer, the demolition of any existing roads, culverts, etc. shall not commence until the replacement facilities therefore have been completed by the Contractor.

10.39.11 When any of the temporary approach roads are no longer required, or earlier if so directed by the Engineer, the Contractor shall carefully dismantle the temporary bridge or road, and remove and dispose of all surplus materials in compliance with the applicable Laws, and reinstate the area to its original condition to the approval of the Engineer.

10.40 Vehicles

10.40.1 The Contractor shall provide all necessary vehicles required for the transportation and movement of Goods and Contractor's Personnel, including but not limited to trucks, cranes, trailers, cars, motorcycles, etc.

10.40.2 The Contractor shall provide competent and licensed drivers and operators for all such vehicles. Vehicles shall be licensed and insured in accordance with the applicable Laws and the Contractor shall be responsible for all servicing, repairs and maintenance required.

10.41 Contractor's Equipment

10.41.1 The Contractor shall ensure that all Contractor's Equipment whether on or in the vicinity of the Site, including apparatus, machinery, vehicles and other similar things to be operated by him or his Sub-Contractors for the execution and testing of the Works, are maintained and operated in a good and safe condition.

10.41.2 All lifting and hoisting equipment shall be regularly certified in accordance with the applicable Laws, and the safe working load limits shall not be exceeded.

10.41.3 The Contractor shall operate and maintain an equipment repair facility within or in the vicinity of the Site, so that downtime of Contractor's Equipment can be minimized. Temporary fuel and lubricant stores shall be properly designed, constructed, secured, fire- and spill-guarded, and be well ventilated so as to comply with the relevant applicable Laws.

10.42 Utilities for Temporary Facilities

10.42.1 Power Supply and Lighting:

i. Electric power supplies for the Contractor's temporary facilities, including but not limited to Contractor's camps, offices, Site, work areas and other facilities as described herein, shall be arranged by the Contractor.
ii. The Contractor shall install, operate and maintain its own electrical distribution systems for the electrical supply required for his temporary facilities as described in paragraph (1) above.
iii. The Contractor shall also furnish, install and keep operational the diesel power generating facilities of such capacity as the Contractor considers necessary to prevent any interruption to the progress of the Works.
iv. The Contractor shall ensure adequate lighting is provided for all his operations at the Site and the temporary facilities and camp according to the National Building Code of India (2016).

10.42.2 Water Supply

i. The Contractor shall design, install, operate and maintain water supply systems including pumps, piping systems, valves, storage tanks etc., at the Site with respect to:

a) Industrial water supply system
For construction use the water quality shall meet the quality requirements in the Works Requirements.

b) Potable water supply system
For supply to all the Contractor's temporary facilities including but not limited to Contractor's camps, offices, Site, work areas and other facilities for human consumption and use.

ii. In case the Contractor plans to install bore well(s) for water supply, he shall thoroughly investigate the relevant legislation and regulations imposed by the competent authorities and the installation shall be subject to approval by the said competent authorities and/or consent of the Engineer.

iii. Throughout the Time for Completion the Contractor shall take samples from all water supplies at regular intervals and test it for suitability for the intended use.

10.42.3 Sanitation and Sewerage

i. All operational parts of the Site, offices, workshops, fabrication yards, laboratory, camp and other facilities, etc. shall be provided with sanitation and sewage handling and disposal systems complying with the statutory requirements and applicable Laws, codes and standards.

ii. If required, portable sanitary facilities including chemical toilets shall be provided and maintained by the Contractor for the use of all personnel at all work locations.

iii. All the requirements of the Works Requirements (including Appendix 13 [Environmental, Social, Health and Safety Management] of the General Specifications) and the Conditions of Contract shall also be complied with.

10.42.4 Waste and Garbage Disposal

i. The Site and the work areas shall be kept clean and free of detritus at all times.

ii. The Contractor shall collect waste material and garbage from Site, camp, offices, yards, workshops, etc. on a daily basis and dispose of same in an approved disposal area(s) and as per guidelines prescribed by local and governmental authorities having jurisdiction. No waste of any kind shall be deposited in any watercourses.

iii. All the requirements of the Works Requirements (including Appendix 13 [Environmental, Social, Health and Safety Management Management] of the General Specifications) and the Conditions of Contract shall also be complied with.

10.42.5 Fencing, Site Security and Safety

i. The Contractor shall be responsible for the security and safety of the Site. Accordingly, the Contractor's temporary facilities including offices, workshops, fabrication yards and storage compounds, campsites, all construction areas, storage areas shall be adequately fenced, gated, lighted and guarded on a twenty-four hour, seven days a week basis. Firefighting equipment shall be provided in accordance with the applicable Codes and the requirements of local authorities.

ii. Any storage facilities for explosives shall comply with the relevant Laws and regulations of India and shall be situated at locations approved by the competent authorities. Detonators and fuses shall be stored in facilities separate from explosives. In no case shall detonators and fuses be transported in the same vehicle as explosives. Storage facilities for explosives, detonators, fuses, etc. shall be secure, kept locked and the keys shall be accounted for at all times.

iii. All the requirements of the Works Requirements (including Appendix 13 [Environmental, Social, Health and Safety Management Management] of the General Specifications) and the Conditions of Contract shall also be complied with.

iv. The Contractor shall be responsible for any losses occurring within the Site premises.

10.42.6 Inspection by the Employer or Engineer

The Employer and the Engineer have the right at any time to inspect any part of the Contractor's temporary facilities and to require immediate rectification to comply with the specified requirements.

10.42.7 Final Clean-Up

i. Upon the completion of Works, or when any of the Contractor's Equipment and/or temporary facilities have fulfilled or completed their function, the Contractor shall dismantle and demobilize such Contractor's Equipment and/or temporary facilities and remove all equipment, machinery, materials, refuse, debris, objectionable material, and reinstate, including filling, grading and dressing all areas to their original condition prior to completion of the Works.

ii. The Contractor shall not proceed with any demobilization and/or removal of temporary facilities and equipment without the prior consent of the Engineer.

10.43 Maintenance of Temporary Facilities

10.43.1 The Contractor shall provide all necessary maintenance requirements and shall keep the temporary facilities and other areas established for the Works, clean, tidy and litter-free.

10.43.2 The Contractor shall be responsible throughout the Time for Completion for keeping the Site and temporary facilities to the satisfaction of the Engineer.

10.43.3 The Contractor shall maintain all existing security fences required for the Works until completion of the Works. Existing fences which interfere with construction operations, shall not be relocated or dismantled, until written permission has been obtained from the fence owner.

10.44 Damage to Existing Property

10.44.1 The Contractor shall be responsible for any and all damage that may occur to any existing structures, works, materials, or equipment that is due to any operation(s) for which the Contractor is responsible, including any operation(s) of any Subcontractor.

10.44.2 The Contractor shall repair or replace any damaged structures, works, materials, or equipment to the satisfaction of the Engineer.

10.44.3 The Contractor shall be responsible for all damage to roads, railway infrastructure, curbs, sidewalks, highways, shoulders, embankment, ditches, drains, culverts, bridges, or other public or private property, which may be caused by their construction activities and shall indemnify for losses due to such damages.

10.45 UTILITIES

10.45.1 General

a) The Contractor shall at all times work with due diligence to ensure the safety of all personnel and property from injury and damage from known ("Charted Utilities") and unknown utilities ("Uncharted Utilities").

b) The Contractor shall always take care of concerning buried Charted and Uncharted Utilities and if any such Utilities infringe the work, the Contractor shall make the area affected safe and ensure that no unauthorised member of the workforce or members of the public shall enter such area.

c) Contractor shall be responsible for relocation/diversion/shifting/modification of all charted *(except specified otherwise) and* uncharted utilities infringing the Works.

d) Contractor shall indemnify the Employer against any losses/claim/damage cost to any damage to utility/services during execution of Works.

10.46 Utilities, Services and Facilities

10.46.1 The Utilities are categorised as (i) Charted Utilities, which have been identified by the Employer and may be affected during the execution of the Works. and, (ii) Uncharted Utilities, which are not known and would get identified during the execution of the Works.

10.46.2 Charted Utility

The Charted Utilities identified by the Employer are enclosed in Part 2, Section VII-8-Employer's Requirements, Tender Drawings and Documents. These are further categorised as discussed under:

i. Type A –Overhead Electrical Crossings

a. These are Overhead Electrical Crossings, traversing the proposed HORC alignment and likely to infringe during execution of the work primarily due to inadequate ground clearance. The Employer has already taken action to remove these infringements by either raising or laying underground cables. The infringements due to LT and HT (up to 33 KV) utilities shall be removed by the Employer within 90 days of the award of Contract. The Crossings shifted underground shall normally be laid within ten (10) metres of the chainages given in the list of Overhead Electrical Crossings except at locations where stations and buildings of HORC are proposed. At the stations and HORC buildings, the utility will be shifted beyond the structure area. For cables crossing the HORC alignment, extra length of 3m to 5m is being provided on both sides, so that cable can be slewed if required during construction. The Contractor shall consider the effect of these shifted utilities in his work planning and price. The coordinates of the new locations where utilities have been shifted will be shared with the Contractor once the shifting is completed. Electrical utilities which have been laid underground, will be considered as charted utilities. The Contractor shall design the span in such a way that further utility shifting is avoided unless inescapable.

b. The infringements due to EHT (above 33 KV) Utilities will be progressively removed and is likely to be completed within 12 months of the award of the Contract. However, these utilities will not infringe the working of Contractor. The Contractor shall plan his works taking this aspect into consideration.

ii. *Deleted.*

iii. *Deleted*.

10.46.3 Uncharted Utility

The Uncharted Utilities will be those unknown utilities which get identified during execution of the Works. These may be identified during Ground Penetration Survey or anytime during execution of the Works.

10.46.4 The Contractor shall do a general survey and Ground Penetrating Radar (GPR) Survey of the Site after possession and notify the Engineer of Charted & Uncharted Utilities, which may obstruct the works and need to be relocated.

10.46.5 For all Charted & Uncharted Utilities requiring relocation identified by the Contractor in the Utilities survey, the Contractor shall inform the Engineer and provide relevant details, including but not limited to, the following:

i. location of the Utility;

ii. date on which Utility was encountered;

iii. nature and size of the Utility;

iv. condition of the Utility

v. type of the Utility & its owner:

a) Electrical cables;

b) OFC & Telecom cables;

c) Gas pipelines;

d) Water/sewerage/drainage/storm water/hume pipelines;

e) Irrigation pipelines/channels;

f) Telecom towers;

g) Overhead Water tanks and others overhead tanks;

h) Others, if any

vi. Reasonable estimate of time required for shifting of Unchartered Utilities.

vii. The information shall also cover the details of the agency/department carrying out the utility shifting.

10.46.6 The trial trenching, arrangements and working methods to be employed in respect of such Charted & Uncharted Utilities which warrants removal/relocation, including proposed protection measures, diversions, reinstatements in consultation with utility owner shall be done within 56 days after Handing Over of the Site by the Employer. The Contractor shall provide relevant justification for the identified utilities (Charted & Uncharted) which require removal/diversion for proceeding with the works.

10.46.7 The Engineer will accord approval within 21 days to the Contractor for initiating required action for the utilities warranting removal/relocation/modification.

10.46.8 The Contactor shall be responsible for taking prompt necessary action for such identified utilities (Charted & Uncharted) including the following but not limited to:

i. Identification of the extent of the utility to be relocated

ii. Coordinate and get permissions from utility owner & all relevant authorities.

iii. Preparation and submission of relevant documentation to the authorities.

iv. Mitigate the situation and re-arrange the work to minimise the effect on the timeline of the Works

v. Continue with other related works in as much as possible to maintain the timeline of the Works.

Any relocation/removal/diversion of Charted Utility shall be entirely the Contractor's responsibility and any cost on this account shall be borne by the Contractor.

10.46.9 The relocation/removal/diversion of identified Uncharted Utilities shall be assigned to the Contractor to be carried out through the utility agencies, or their specified contractor or by the Contractor himself. The cost of relocation/removal/diversion of Uncharted Utility shall be paid by the Employer as mentioned below:

i. If Uncharted Utility relocation/removal/diversion is carried out by Utility agency or theirspecified contractor, the Contractor shall make the payment to such agency or specified contractor. The Employer shall reimburse such amount as Specified Provisional Sum based on invoices.

ii. If Uncharted Utility relocation/removal/diversion is carried out by Contractor himself, then he shall be paid under Specified Provisional Sum.

10.46.10 The Contractor shall not divert, remove or relocate any such identified Charted & Uncharted Utilities without having first received the Engineer's consent to such diversion, removal or relocation.

10.46.11 The Contractor shall liaise and co-ordinate with the relevant Utilities Companies to ensure that all the above-mentioned works of relocation/diversion, support and protection are executed satisfactorily. Contractor shall obtain necessary clearances from the Utility company/owner prior to the start of any relocation/removal/diversion works of the utilities. The same shall be submitted to the Engineer prior to start of the works.

10.46.12 Throughout the execution of the Contract, the Contractor shall reasonably comply, in all respects, with the requirements of all the utility owners and authorities regarding the handling, protection and maintenance of the utility facilities. The responsibility in respect of diversion/ modification/ relocation/ protection etc. of the Utilities (Charted or Uncharted) to facilitate safe construction lies with the Contractor. If required, the employer shall provide support to facilitate approvals/permits from utility owner/concerned department for the proposed diversion/relocation of utilities.

10.47 Prevention of Damage and Interference

10.47.1 Temporary supports and protection methods proposed by the Contractor and agreed by the utility owner shall be provided to the utilities. The permanent supports and protection shall be provided wherever required for the safety and security of the utility service.

10.47.2 The Contractor shall not interfere in any manner with the Utility lines and services without prior approval of the Utility owner and Engineer. Whenever the interfering necessity arises, the Contractor shall submit a proposal to the Engineer for his approval. Any unintentional interference caused shall be immediately corrected without causing danger and trouble to any on-going operations or the existing utility lines or services. The Contractor shall immediately inform the Engineer and the utility agencies of:

i. damage to utilities;

ii. leakage of utilities;

iii. discovery of utilities not previously identified; and

iv. Any hazardous material found during the excavation.

a) location of utility

b) date on which the utilities were encountered;

c) nature and sizes of the utilities;

d) condition of utility;

e) temporary or permanent supports provided; and

f) diversions made –temporary or permanent

The Contractor shall include the details (plan, location, ownership, size and material) of all suchutilities in the As-built Drawings.

10.48 Drainage Systems

10.48.1 All existing drainage systems that are affected by the Temporary and the Permanent Works shall be protected, relocated and/or diverted as required for the Works, by the Contractor.

10.48.2 Such protection, relocation or diversion works shall be carried out by the Contractor, and his designs shall be approved by the utility owners / relevant authorities and the Engineer.

10.48.3 Upon completion of the works, all the diverted or temporarily diverted drains/box culverts and canals shall be fully reconstructed to their original size or to a revised size as required by the utility owners /relevant authorities. However, if the utility owner or relevant authority requires to keep the Utility at the original location, the same shall be reconstructed at the original location.

10.49 Building Service Connections

10.49.1 Building service connections shall be maintained and protected or if required to be shifted, shall be informed to the Engineer during the execution of the works. The Contractor shall take necessary steps to ensure these services with the approval of utility owner and the Engineer.

10.49.2 Building service connections shall include the branch pipes from the main water pipe, water meter chambers/bulk meter, sewer and drainage discharge pipes, grease traps, etc.

10.49.3 Building service connections shall be identified by trial trenches or other methods approved by the relevant Utility Companies. Where these service connections interfere with the works, the Contractor shall follow the methodology as approved by the relevant Utility Companies and the Engineer.

10.50 Street Furniture and Minor Service

Where street furniture, including lamp posts, traffic lights, fire hydrants, signage, minor electrical cables, water services, etc. are required to be dismantled and stored or relocated temporarily or permanently, the Contractor shall propose such works to the Engineer and Utility Companies or relevant authorities for their approval.

10.51 TRAFFIC MANAGEMENT PLANS

10.51.1 General

a) The Contractor shall thoroughly acquaint itself with existing traffic conditions and understand the importance of maintaining traffic safety and the avoidance of excessive traffic delay. The Contractor shall co-operate with the relevant agencies regarding traffic control and all details shall be subject to the Engineer's approval.

b) The requirements concerning temporary road works shall include, but not be limited to, construction of detours, temporary bridge approach roads, traffic control devices and services for the control and protection of traffic through areas of construction.

c) The Contractor shall be responsible for investigating and establishing the requirements for traffic control and ensuring safety at each site and shall submit such details in the form of a Temporary Traffic Control Plan for the Engineer's review and consent.

d) All temporary roadworks and traffic management shall be as specified in this appendix, unless specified otherwise elsewhere in the Contract or local Indian regulations and standards, and the more onerous provision shall apply.

10.52 Temporary Traffic Control Plan (TCP)

10.52.1 Submission, Consent and Change

a) Within twenty-eight (28) days after the Commencement Date, the Contractor shall submit a Temporary Traffic Control Plan (TCP) to the Engineer for review and consent. The Engineer's consent shall be obtained prior to the start of Works on Site.

b) The Contractor shall comply with the TCP which has received the Engineer's approval and any Engineer's instructions issued concerning traffic control.

c) Should the Contractor propose any to change to the TCP which has received the Engineer's approval, the Engineer shall be notified in writing at least seven (7) calendar days prior to the date planned for the implementation of any such proposed change. Changes proposed are subject to receipt of the Engineer's consent. If the Engineer makes any subsequent recommendations or issues instructions concerning the TCP in writing, the Contractor shall revise the TCP accordingly.

10.52.2 Contents of Temporary Traffic Control Plan

a) The main contents of the Temporary Traffic Control Plan shall include, but not be limited to,the following:

i. Type and main specifications of traffic control devices and facilities;

ii. A scale plan of the location(s), clearly identifying existing road(s), proposed diversions ofpedestrian and road traffic, locations of warning signs and traffic control measures;

iii. Details of all lane widths, temporary surfaces, etc.;

iv. Construction details of any proposed diversion(s);

v. Safety measures including signage and staffing;

vi. Program for installation and erection of traffic control devices and facilities;

vii. Traffic control means during non-working time and during night time;

viii. Protection/diversion of any existing utilities;

i. Environmental measures to be implemented, e.g. dust suppression, noise abatement,

ix. watercourse diversion and the like; and

x. Person responsible for overseeing implementation of all aspects of the TCP.

b) In addition to the above and prior to the implementation of any Site-specific traffic control schemes, the Contractor shall obtain any necessary approval letters from relevant authorities who have jurisdiction over or ownership of the existing traffic way including the Traffic Police,NHAI, PWD and any other local government/authorities and other related parties having jurisdiction, as applicable and as required.

10.52.3 Number of Lanes for Traffic Control

a) The existing traffic on roads at the Site must be maintained at all times during the execution of the Works and if diversions are required these must be of the same traffic capacity as the original road. Notwithstanding the above, the Engineer may give consent to reductions in traffic capacity if the Contractor can demonstrate that such will not cause excessive delays to traffic flow. If such consent is given, the Engineer may specify the hours during the day when the reduction in capacity may be applied and it should be anticipated by the Contractor that these hours will not include any peak periods for the traffic movement.

b) The Contractor shall cooperate with relevant authorities having jurisdiction regarding traffic control and all details will be subject to receipt of the Engineer's consent.

10.52.4 Temporary Traffic Ramps and Speed Breakers

a) In locations where it is necessary (for example, pipeline crossing a road above ground), the Contractor shall construct and maintain temporary traffic ramps.

b) In cases where it is necessary (for example, requirement by an agency having jurisdiction) or required by the Engineer, the Contractor shall provide and maintain temporary speed breakers.

10.52.5 Traffic Control for Public Roads

a) The Contractor shall maintain close liaison with the Traffic Police, NHAI, PWD and any other local government/authorities and other related parties having jurisdiction, as applicable to traffic control requirements and shall comply with all approval and permit requirements from such authorities.

b) In order to facilitate traffic through or around the Works, or wherever ordered by the Engineer, the Contractor shall erect and maintain at prescribed points on Site roads and at approaches to the Works, a temporary fence made of corrugated metal sheet supported by hard posts with foundations and horizontal bars, traffic signs, lights, barricades, traffic cones with traffic warning lamps and other facilities for the direction and control of traffic. The fence is to be painted and maintained in good condition. Drawings and details of the fence are to be prepared and submitted to the Engineer for review and issue of a approval.

c) Where required, or as directed by the Engineer, the Contractor shall provide competent flagmen whose sole duties shall consist of directing the movement of traffic through or around the Works.

d) In addition to the requirements as described above, the Contractor shall furnish and erect, within or near Works areas, such warning and guide signs as may be ordered by the Engineer.

e) For all traffic safety precautions, the Contractor shall refer to Traffic Management and Site Barricading. The Contractor shall refer to Section VII-8, Tender Drawings and Documents for details of barricading.

f) The repair of any existing roads that have been damaged by the Contractor during the execution of the Works (including any damage caused by Contractor's Equipment) shall be at the risk and cost of the Contractor.

10.53 Extraordinary Traffic

The Contractor shall be responsible for carrying out any necessary investigations and the obtaining of approvals, licenses, escorts and any other necessary facilities in order to enable extraordinary traffic to be moved on the roads in the Works area.

10.54 Maintenance and Protection of Traffic

10.54.1 During the execution of the Works the Contractor shall keep open to traffic existing roads, provided that where required or as directed by the Engineer, the Contractor shall arrange detours subject to the consent of the Engineer. The Contractor shall at all times keep roads and footpaths affected by its operations, free from obstruction and nuisance and suitable for public use.

10.54.2 The Contractor shall take necessary care at all times during the execution of the Works to ensure the convenience and safety of residents along and adjacent to public roads and highways that may be affected by the Works. Street lighting shall be relocated as necessary to maintain the same standard of lighting during the course of the Works, until new lighting facilities are brought into operation.

10.54.3 Any failure of the Contractor to meet these requirements will entitle the Engineer to carry out such works as he deems to be necessary and to charge the Contractor with the full cost thereof plus ten percent of such cost, which sum will be deducted from any money due or which may become due to the Contractor under the Contract.

10.55 Vertical Clearance

In general, any Temporary Works placed over roads or diversions used by public traffic shall maintain a vertical clearance of at least 5.5 metres unless otherwise directed by the Engineer. Where required by the Engineer the Contractor shall erect and maintain suitable check-gates, fitted with warning signs indicating the vertical clearance.

10.56 Materials

Materials and other specifications related to traffic control devices shall conform to IRC Standards unless otherwise specified elsewhere in the Contract.

10.56.1 Retro-reflective Material

Unless otherwise specified in the Contract, sign panels, barricades, traffic cones, vertical panels, and flagmans' paddles shall have retro-reflective sheeting, as consented to by the Engineer.

10.56.2 Sign Panels

Sign panels shall be yellow with black legend unless otherwise specified in the Contract or local Indian regulations and standards.

10.56.3 Sign Posts

Sign posts shall be fabricated from materials as acceptable to the Engineer. Signs shall be provided with suitable foundations and be designed so as to be capable of remaining in position during normal traffic flow and wind conditions.

10.56.4 Barricades

The Contractor shall erect barricades demarketing public areas to ensure safety of pubic and vehicular traffic in accordance with the Tender drawings.

10.56.5 Traffic Cones

a) Traffic cones shall be capable of withstanding impact without damage to the cones or vehicles. All cones shall be orange with highly reflective white bands which is easily visible both in daylight and darkness. Traffic cones shall be capable of remaining visible and in position during normal traffic flow and wind conditions in the area where they are used. Lamps for cones shall be suitable for purpose.

b) Where traffic cones are used for the diversion of pedestrians the cones shall be fitted with yellow/black reflective cone bars to prevent pedestrians walking outside the protected walk area.

c) All cones shall be as above unless otherwise specified in the Contract or local Indian regulations and standards, whichever is more onerous.

10.56.6 Warning Lights (flashing or steady-burn)

High visibility traffic warning lights shall be provided and used at all locations where Works are being carried out and visible warnings are required, i.e. road works, excavations, pedestrian diversions, etc. The requirements for warning lights shall be:

i. Lens colour shall be amber;

ii. Lens diameter shall be not less than 185mm;

iii. Flashing shall be 110 per minute;

iv. Suitable for fitting to traffic cones;

v. Battery operated; and

vi. Continuous operation of more than 600 hours.

10.57 Construction Requirements

10.57.1 The Contractor shall keep the length of construction areas to manageable lengths such that traffic will be accommodated safely. Traffic control devices and services shall be provided and maintained both inside and outside the limits of work as required to facilitate traffic guidance, should this be necessary. The provision of traffic control devices and services shall comply with the provisions of the Works Requirements and the Conditions of Contract and local Indian regulations and standards.

10.57.2 Prior to the start of construction operations, the Contractor shall erect such signs, barricades, and other traffic control devices as may be required by the Works Requirements and the Conditions of Contract or as directed by the Engineer. Traffic control devices shall be operated only when required and only those devices that apply to conditions actually in existence shall be operable.

10.57.3 Wherever required or directed by the Engineer, temporary fences shall be placed to provide a visual barrier between the work area and adjacent traffic or buildings.

10.57.4 Any devices provided under this clause that are lost, stolen, destroyed, or deemed unacceptable while in use on the Works shall be replaced by the Contractor at the Contractor's risk and cost.

10.57.5 During non-working hours and following completion of a particular construction operation, all warning signs, except those necessary for the safety of the public, shall be removed or entirely covered with either metal or plywood sheeting so that the sign panel will not be visible.

10.57.6 Retro-reflective sheeting on signs, barricades, and other devices shall be kept clean. Stretches, rips, and tears in the sheeting shall be promptly corrected by the Contractor. Retro-reflective sheeting shall have a maintained retro-reflection.

10.57.7 Nighttime operations shall be illuminated by a lighting system which has received the Engineer' s consent. The lighting system shall be positioned and operated to avoid glare to road users.The heat produced by any lighting system shall be considered and allowed for. The use of lights with flames (such as gas-powered lighting) will not be permitted.

10.57.8 The Contractor shall ensure that no Contractor's Equipment leaves the work sites with mud, debris or rock that may drop or be deposited on a public highway or private right-of-way, and the roads in the vicinity of the Site shall be kept clean. Suitable vehicle washing facilities shall be provided by the Contractor.

10.58 PACKAGING STORAGE SHIPPING AND DELIVERY

10.58.1General

a) Unless otherwise required by the Particular Conditions, Plant and the Materials shall be delivered to the Site at the most suitable time(s) in accordance with the Works Programme and Procurement Work Segment Programme, so as to avoid undue damage and/or deterioration due to a storage period of excessive duration.

b) All Plant and the Materials, if manufactured or assembled off-Site, shall be properly and securely packed at the point of origin, in order to prevent damage during transport to the Site and due to storage in the weather conditions to be encountered at the Site.

c) The Contractor shall securely crate or box all consignments for ocean shipment in a manner suitable to protect them from damage in transit and shall be responsible for and rectify any and all damage due to any improper packing. Crates shall have external markings identifying the Contract reference number, origin, destination, contents and consignee.

d) The Contractor may be required to furnish the Employer, by courier or other approved means with advance copies of shipping documents, invoices and other pertinent papers showing the date and origin of shipment, a description of the Goods, the shipping weight of each item, destination, name of the vessel and other pertinent information.

e) The Contractor shall also be responsible for the trans-shipment up till the delivery to the installation sites.

f) The Contractor shall ensure, prior to delivery of Plant or Material, that adequate storage facilities and/or areas are available on Site to properly store and protect the Plant or the Material so as to prevent any damage or deterioration. Air-conditioned or other controlled-environment storage shall be provided for Plant items sensitive to high humidity and/or temperature.

g) Materials of an inflammable, explosive, toxic or similarly hazardous nature shall be securely stored separately at approved locations. The Contractor shall provide adequate security and safety control at such locations throughout the storage period. Before delivery of such Materials to Site, all necessary permits and licenses shall have been obtained from the authorities having jurisdiction, all in accordance with the applicable Laws.

h) When Plant or Materials arrive on Site it shall as soon as practicable be inspected by the Contractor in the presence of the Engineer, for damage or deterioration. The Contractor shall be responsible for unpacking and re-packing in an appropriate manner and for provision of all necessary equipment, tools, materials and labour at his own expense. If damage or deterioration has occurred as determined by the Engineer, payment for shall not be made for such damaged or deteriorated Plant or Materials, and such shall be removed from the Site and repaired or replaced according to the instructions of the Engineer, at the Contractor's risk and cost.

i) For the Plant or the material which is subject to deterioration after opening the packing, appropriate alternative inspection measures shall be determined on Site between the Engineer and the Contractor. No payment shall become due to the Contractor for those uninspected Plant or Material, unless otherwise determined by the Employer.

j) Packing materials shall remain the property of the Contractor and shall be removed from the Site immediately when no longer required on the Site, as determined by the Engineer.

k) The Contractor shall be responsible for the safe and secure storage and handling of Plant and Materials on Site until the issuance of the Taking-Over Certificate for the relevant part of the Works, regardless of any transfer of ownership thereof to the Employer.

l) Any action taken by the Engineer in inspecting Plant or Materials upon arrival on Site or any determination subsequently made by the Engineer shall not relieve the Contractor of any of his responsibilities under the Contract.

10.59 Storage of Plant and Materials

10.59.1 The Contractor shall provide and maintain storage facilities at acceptable locations in consultation with the Engineer, for the equipment and materials of all kinds intended for use in carrying out the Permanent Works or for incorporation into the Permanent Works.

10.59.2 The Contractor shall prepare, protect, provide security and store in an agreed manner for all Works, Contractor's Equipment, equipment and materials until the Project completion so as to safeguard them against any loss, damage and any other hazards arising during shipment, storage on/off the Site or climatic influences.

10.60 Crating

The Contractor shall provide all packing, crates and markings. In doing so, it shall comply with the following requirements:

a) Each case, crate or package shall be waterproof, rot, insect and rodent proof. It shall be of robust construction and fit for its intended purpose. The Contractor shall, in determining the packaging materials to be used, take into consideration the climatic conditions likely to occur during the period of transport, shipment and storage.

b) Each case, crate or package shall be legibly and indelibly marked in large letters with the Site address, Contract number, "right way up", opening points and other markings as necessary to permit materials to be readily identified and handled during transit and when received at the Site.

c) Each case, crate or package shall contain a comprehensive packing list showing the number, mark, size, weight and contents, together with any relevant drawings. A second copy of the packing list shall be enclosed in a watertight enclosure on the outside of each case, crate or package. Distribution of additional copies of each packing list shall be in accordance with the Engineer's instructions.

d) All items heavier than 100 kg shall be marked on the outside of the case, crate or package, indicating the gross and net weights, the points for slinging, and where the weight is bearing.

e) Care shall be taken to prevent movement of items within cases, crates or packages by the provision of bracing, straps and securing bolts as necessary. Bags of loose items shall be packed in cases and shall be clearly identified by well-secured metal labels on which the quantity and name of the parts and their index or catalogue number have been stamped.

f) All packing shall be free from sharp edges to prevent injury to persons or other objects.

g) Each bulky/heavy case, crate or package shall include wedge(s) for easy loading and unloading by mechanical handling equipment such as forklift truck.

h) Electronic circuit boards, integrated circuits and the like shall be well protected by using appropriate packing, e.g. anti-static bubble wrap or similar.

i) Rubber products and the like shall be suitably packed to avoid damage including but not limited to hardening, deformation and peel-off.

10.61 General Precautions

10.61.1 Spare parts shall be tropicalized in their packing for prolonged storage in accordance with appropriate international/ Indian standards and shall be suitably and individually labelled to indicate:

a) Name of parts;

b) Shelf life and date of manufacture;

c) Type or condition(s) of storage and special handling information;

d) Description of item and relevant part number;

e) Serial number, if applicable;

f) Inspection/test certificate number and batch number; and g) Contract number, order number and item number.

10.61.2 Tubes, cable, conductor and other similar openings shall be properly sealed and blanked off to prevent ingress of dirt or moisture.

10.61.3 Spare ball and roller bearings and similarly protected items shall not be removed from the manufacturer's wrappings or packing.

10.61.4 Fragile materials shall be packed in such a way that they shall not be damaged during transit and when they are properly unpacked for quality inspection. Glass items shall be capable of being easily re-packed without removing the original wrappings or packing for long- term storage within the same packing case.

10.61.5 Appropriate precautions in accordance with the Contractor's safety regulations, the regulations of the Employer, Appendix 13 [Environmental, Social, Health and Safety Manual] and statutory regulations in respect of all hazardous, toxic, inflammable, etc. materials.

10.62 Packaging Procedures

10.62.1 All required inspection/test certificates shall be supplied and packed together with individual materials. All packaging materials and procedures shall be subject to review by the Engineer.

10.62.2 All empty cases, crates or packages, whether or not returnable, shall be removed from the Site by the Contractor or stored by the Contractor in such a way that they do not interfere with the progress of the Works.

10.63 Shipping

10.63.1 The Contractor shall notify the Engineer at least fifteen (15) days in advance of any expected shipment date and give further notification of the actual shipment date and routing when such information is subsequently established. This shall complement the inspection requirements prior to delivery as specified herein.

10.63.2 Two (2) copies of packing lists and quality certificates shall be attached with each case or package to be shipped. One copy shall be placed inside the package and the second copy shall be enclosed in a watertight enclosure on the outside of each case or package. A copy of packing lists and quality certificates shall be sent to the Engineer after each package of the Works, the equipment, spare parts and other items have been shipped.

10.63.3 Without prejudice to any other provisions of the Contract, the Contractor shall be responsible for all legal requirements, insurance, customs, duties, dues, taxes and other such requirements and expenditures required for the plant, equipment, spare parts and other items to be supplied under the Contract.

10.64 Delivery

10.64.1 The Contractor shall deliver Plant and Materials required for the Works and all items to be supplied under the Contract to the Site.

10.64.2 The Contractor shall unload all items to be supplied under the Contract at the designated delivery point and place them in position or store them.

10.64.3 Any part of the Works or any item to be supplied under the Contract that is damaged in transit shall not be considered as delivered until repairs or replacements have been made and all necessary spare parts or items have been delivered to the Site.

10.64.4 All documents, manuals, drawings and other deliverables shall be delivered to an address to be designated by the Engineer in writing.

10.64.5 The Contractor shall store and secure Plant and Materials until the same have been inspected by the Engineer and are considered delivered at the designated point.

10.64.6 The Contractor shall remove temporary fittings required for shipment and re-assembly of Plant and Materials and shall complete this prior to the inspection of same and before they are considered delivered.

10.64.7 An item shall be considered delivered when all damage has been repaired and all documentation and post-delivery preparation has been completed.

APPENDIX 11

WORKS QUALITY MANAGEMENT PLAN

11.1. General

The Contractor shall implement a Project Quality Management Plan in accordance with ISO-9001 "Quality System - Model for Quality Assurance in Design/Development, Production, Installation and Servicing" to ensure that all materials, workmanship, plant and equipment supplied and work done under the contract meets the requirements of the contract. This plan shall apply to all activities related to the quality of items, including designing, purchasing, inspecting, handling, assembling, testing, storing, and shipping of materials and equipment and different elements of construction work and installations of system components.

The Quality Plan to be prepared by the Contractor and submitted to the Engineer shall follow the requirements of ISO 9000 and address each element therein.

Registration of the Contractor's organisation, or subcontractors or subconsultants is not required for this Project but the Project Quality Management Plan as submitted shall meet the intent of the ISO 9000 requirement in that there is a comprehensive and documented approach to achieving the project quality requirements.

11.2. Works Quality Management Plan

The Works Quality Management Plan (WQMP) shall as a minimum address the quality system elements as required by ISO 9001, generally noting the applicability to the Contractor's Works Programme for the Project. Procedures or Quality Plans to be prepared by others (Suppliers, Subcontractors, Subconsultants) and their incorporation in the overall WQMP shall be identified.

The Contractor shall provide and maintain a Quality Assurance Plan (QA) to regulate methods, procedures, and processes to ensure compliance with the Contract requirements. The QA Plan, including QA written procedures, shall be submitted to the Engineer for his review.

Adequate records shall be maintained in a readily retrievable manner to provide documented evidence of quality monitoring and accountability. These records shall be available to Employer at all times during the term of the Contract and during the Defects Liability Period and for a five-year period thereafter.

The Plan shall identify:

- Design Process: that control, check and verify the accuracy, completeness and integration of the design shall be performed by certified personnel and in accordance with documented procedure that have the written consent of the Engineer.
- Special Processes: that control or verify quality shall be performed by certified personnel and in accordance with documented procedures that have the written consent of the Engineer;
- Inspection and Test: Inspection and testing instructions shall provide for reporting nonconformances or questionable conditions to the Engineer; Inspection shall occur at appropriate points in the installation sequence to ensure compliance with drawings, test specifications, process specifications, and quality standards. The Engineer shall designate, if necessary, inspection hold points into installation or inspection planning procedures;
- Receiving Inspection: These procedures shall be used to preclude the use of nonconforming materials and to ensure that only correct and accepted items are used and installed;
- Identification and Inspection Status: a system for identifying the progressive inspection status of equipment, materials, components, subassemblies, and assemblies as to their acceptance, rejection, or non-inspection shall be maintained;

- Identification and Control of Items: an item identification and traceability control shall be provided;
- Handling, Storage, and Delivery: provide for adequate work, surveillance and inspection instructions.

The Plan shall ensure that conditions adverse to quality such as failures, malfunctions, deficiencies, deviations, and defects in materials and equipment shall be promptly identified and corrected.

The Plan shall provide for establishing, and maintaining an effective and positive system for controlling non-conforming material including procedures for the identification, segregation, and disposal of all non-conforming material. Dispositions for the use or repair of non-conforming materials shall require the Engineers consent.

11.3. Plan Implementation and Verification

The Plan shall clearly define the QA Organisation. Management responsibility for the QA shall be set forth on the Contractor's policy and organisation chart. The Plan shall define the requirements for QA personnel, their skills and training. Records of personnel certifications shall be maintained and monitored by the QA personnel. These records shall be made available to the Engineer for review, upon request.

The QA operations shall be subject to the Engineers, Employer or Employer's authorised representative's verification at any time, including: surveillance of the operations to determine that practices, methods and procedures of the plan are being properly applied; inspection to measure quality of items to be offered for acceptance; and audits to ensure compliance with the Contract documents.

Monthly Quality Report (MQR): The contractor shall submit the Monthly Quality Report to the Engineer. MQR will contain, apart from the Material Testing Reports, the following major items:

a) Status of Approval of Method Statements: The Contractor shall submit Method Statements including check lists & ITP (Inspection & Test Plan) for execution of each and every item of work including temporary works at least four weeks before their execution, conforming to the outline construction specifications given in the contract document for review and approval by the Engineer. (copies of sample Method Statements are available with the Engineer).

b) Quality Walk: Quality Walk of the project site shall be held once in a week by the employer/Employer's authorized representative.

c) Weekly Quality Report (WQR): The contractor shall submit the Weekly Quality Report for review of the quality by the Engineer in weekly progress review meeting. The WQR will be based on the lines of MQR.

d) Internal Quality Audit (IQA): The contractor shall conduct an internal audit of the quality of the project by the quality team of their HQ every month and shall submit the report to the Engineer.

e) External Quality Audit (EQA): The contractor shall get conducted the External Quality Audit quarterly by the reputed agency approved by the Engineer and shall submit the report to the Engineer.

f) Calibration of Batching Plant: The contractor shall be done the calibration of batching plant, immediately after installation of the batching plant and at an interval of six months thereafter, by a reputed external agency approved by the Engineer. However, the contractor shall check the calibration in presence of Engineer's authorized representative on regular basis at least once in a month.

g) Laboratory at Site: The contractor shall get calibrated the Laboratory equipment and their dial gauges from the reputed agency/laboratory accredited by NABL and approved by the Engineer. The calibration certificate including their validity shall be displayed near each and every equipment of the Lab.

h) External Laboratory for Conducting Tests: The contractor shall get conducted the tests of materials and elements of the work for which testing facility is not available in the field Lab, from the external laboratories having valid accreditation of NABL approved by the Engineer. In addition to this, the contractor shall get conducted 5% of the tests, for which testing facility is available in field Lab also, in the external Lab, to facilitate independent review.

i) Water: The contractor shall get the water tested, from the reputed external laboratory approved by the Engineer, at the start of the work and at an interval of three months thereafter. The contractor shall also conduct the testing of the water at least once in a month in the field laboratory.

j) Status of deployment of Machinery and other T&P (Tools & Plants): The contractor shall deploy machinery and other T&P as per the provisions of the contract. Method statements approved by the Engineer and as per the requirement of the site. The contractor shall indicate the schedule of deployment of the machinery and other T&P in the Monthly Quality Report. The fitness of the machinery and other T&P shall be regularly got checked by the contractor by external inspection/Audit Team.

k) NCNs (Non-Conformity Notice) of quality issued by Engineer/Employer & NCR's (Non-Conformity Report) of quality raised by the Contractor: The status of NCNs and NCRs of quality shall be included by the contractor in the Monthly Quality Report.

The Contractor shall provide all necessary access, assistance and facilities to enable the Engineer to carry out on-site and off-site surveillance of Quality Assurance Audits to verify that the quality system which has the consent of the Engineer is being implemented fully and properly.

APPENDIX 12

CONTRACTOR'S SITE LABORATORY

12. SITE LABORATORY

12.1 The Site Laboratory shall be approximately 250m^2 in area. It shall consist of the following accommodation:

1 concrete laboratory	60m2 floor area
1 Soil laboratory	30m2 floor area
2 office	each15m2 floor area
1 store room	10m2 floor area
1 kitchen	10m2 floor area
Male& female toilets, changing room & shower	sufficient for 6 persons

12.2 The remainder of the 250m2 shall consist of storage area for concrete cube curing tanks. The laboratory, office etc. shall be in one building; the curing tank storage building may be in a separate building, but if so, it shall be adjacent to the laboratory building & connected to it by a level, weatherproof passageway. In addition, an area of covered hard standing of 50m2 for motor vehicles shall be provided adjacent to the laboratory.

12.3 STANDARD OF CONSTRUCTION

12.3.1 The laboratory shall be constructed to the best Engineering practice and as approved by the Engineer. Two independent telephone lines with two extensions each shall be provided for the laboratory. Telephones shall be located in areas as agreed with the Engineer.

12.3.2 A water tank with minimum capacity of 2000 litres shall be installed, as a source of constant water pressure (15 kPa minimum) for each laboratory.

12.3.3 In the case of sinks used for washing samples, adequate trapping and/or separating devices shall be provided to ensure the proper functioning of the facility.

12.4 FURNISHINGS AND FIXTURES

The contractor's site laboratory shall be provided with required furnishings and fixtures.

12.5 LABORATORY EQUIPMENT

12.5.1 The laboratory equipment, as listed below, shall be approved by the Engineer. The Contractor shall submit for the Engineer's approval within 2 weeks of the order to commence work the name of the supplier it intends to use for each piece of apparatus together with the relevant catalogue number. All the equipment shall be ISI marked. The list of equipment for earthwork shall be as per Annexure-VIII and Appendix -N of RDSO Specification No. RDSO/2020/GE:IRS-0004, September 2020. Equipment for concreting shall conform to specification given in relevant IS codes.

12.5.2 The layout of the equipment in the testing laboratory shall be instructed by the Engineer. The equipment shall be maintained to an accuracy appropriate to the required testing methods with routine calibration by an accredited organisation as recommended by the appropriate Authority. Equipment shall also be calibrated after maintenance or relocation.

12.5.3 The Contractor's site laboratory shall be equipped with the following material testing equipment as a minimum given in the below Table. The nature and quantity of equipment required for testing may be varied by the Engineer depending on the detail of the Contractor's Design and Construction methods or for any other reason which he deems to be valid and necessary for the proper control of quality:

S. No.	Description	Unit
1	Determining Liquid Limit	1 Set.
2	Liquid limit device (Casagrande type)	2 Set.
3	Cone penetrometer	2 Nos.
4	Grooving tools	3 Nos.
5	Evaporating dish	2 Nos.
6	Spatula 100mm blade	2 Nos.
7	Laboratory balance, capacity 500 gm, (Sensitivity 0.01 gms.)	1Nos.
8	Wash bottle, capacity 500 ml.	3 Nos.
9	Wash bottle, capacity 1 lit.	2 Nos.
10	Moisture cans, capacity 50 ml.	36 Nos.
11	Determining Plastic Limit (1 complete set) Glass plate 50cm x50cm x10 mm	3 Nos.
12	Stainless steel rods, 3 mm dia.	2 Nos.
13	Determining Moisture Content	1 Set.
14	Micro Oven- thermostatically controlled to maintain atemperature105 to 110 °c.	1 Nos.
15	Electronic weighing machine capacity 200 gm., sensitivity 0.01 gm.	2 Set.
16	Lab. Tongs	1 Nos.
17	Moisture cans 75ml. with lid	36 Nos.
18	Compaction Characteristics	1 Set.
19	Standard compaction mould 100mm dia.	6 Nos.
20	Modified compaction mould 150mm dia.	6 Nos.
21	Standard compaction Rammer, 2.6 kg.	2 Nos.
22	Modified compaction Rammer, 4.89 kg.	2 Nos.
23	Straight edge 300mm long	2 Nos.
24	Sample ejector for 100mm and 150mm mould	2 Nos.
25	Sample tray 60 x 60 x 8 cm	10 Nos.
26	Wash bottle, 500 ml.	2 Nos.
27	Moisture cans 250 ml.	80 Nos.
28	Density of soil in-place by sand cone method	2 Set.
29	Sand density cone apparatus, 150mm	2 Nos.
30	Plate, 300mmx300mm with center hold 150mm	2 Nos.
31	Glass jug for sand cone	2 Nos.
32	Chisel 25mmx 150mm	6 Nos.
33	Hammer	6 Nos.
34	One-gallon field cans	24 Nos.
35	Sampling spoon	3 Nos.
36	Soft hairbrush	3 Nos.
37	Sieve Analysis	
38	Electric Sieve shaker (portable)	1 Unit
39	Coarse sieves In Sizes from 100mm to 10mm (As per IS 383 table no. 2)	1 Set.
40	Fine Sieves 10mm, 4.75mm, 2.63mm, 1.18mm, .600mm, .300mm, .150mm,each)Pans & Covers Specific Gravity and Absorption of Coarse AggregateWire basket, 200mm dia.Heavy duty suspension balance, 20 kg x 1 gm. with accessory for weight in water.	2 Set.
41	Suitable water container	1 Nos.
42	Unit Weight of Aggregate Balance, 100 kg. capacity with 10 gm precision	1 Nos.
43	Tamping rod 16mm diameter x 600mm long	3 Nos.
44	Measuring containers (3,10,15,30 liters) Flakiness and Elongation	1 each
45	Flakiness gauge, elongation index	2 Set.
46	Soundness Test	

S. No.	Description	Unit
47	Sodium sulphate	25 Kg.
48	Soaking tank	1 Nos.
49	Balance, Capacity 3 kg., Sensitivity 0.1 gm.	1 Set.
50	Sieves: Coarse	1 Set.
51	Fine	1 Set.
52	Concrete	
53	Buckets for concrete sampling	12 Nos.
54	Slump cone	12 Nos.
55	Tamping rod	12 Nos.
56	Base plate	12 Nos.
57	Mixing pan for concrete	2 Nos.
58	Scoop for general purpose	6 Nos.
59	Concrete thermometer	6 Nos.
60	Concrete cylinder mould, 150 mm * 300 mm;	30 each
61	150 mm * 200 mm	30 each
62	Concrete cube mould, 100 mm cube & 150 mm cube	10+100 each
63	Adjustable spanners for dismantling cube moulds	6 Nos.
64	Capping set	2 Nos.
65	Capping compound	As per requirement
66	Riffle	1 No.
67	Concrete curing tank with capacity for 270 cubes,	
68	temperature controlled, with circulation system drain and lockable cover	2 Nos.
69	Schmidt test hammer	1 Nos.
70	Compression testing machine (Fully automated)	1 Nos
71	Mould oil	
72	Temperature chart recorder	1 Nos.
73	Miscellaneous Vernier calipers to measure up to 200mm, with elongated jaws	5 Nos.
74	Steel rule, 300 mm long graduated	2 Nos.
75	Rubber gloves	10 pr.
76	Cotton working gloves	20 pr.
77	First aid kit	1 Set.
78	Wire brush	6 Nos.
79	Steel tape, 3m, 5m, 30m	3 each.
80	Ball peen hammer, 1 kg	2 Nos.
81	Paint scraper. Approx. 100mm wide	8 Nos.
82	Float, steel Approx.280 x 120 mm	8 Nos.
83	Sack barrow	1 Nos.
84	Shovel: Square Mouthed	2 Nos.
85	Round Mouthed	2 Nos.
86	24- wheel trolley, heavy duty, approx. 0.7m x 1.0m long pneumatic tyred type	2 Nos.
87	Wheelbarrow, rubber tyred	1 Nos.
88	Comprehensive tool kit. To include screwdrivers, pliers, claw hammer, multi-grips, spanners (adjustable)	1 Nos.
89	Type NR Schmidt Hammer and tester with recording device	1 Nos.
90	Testing Anvil for Schmidt Hammer test (SHT)	1 Nos.
91	Chart recording paper for SHT	10 pkts.
92	Cover meter for detecting metal objects to depth of 100mm below the surface of non-magnetic objects	3 Nos.
93	Noise meter	1 Nos.

S. No.	Description	Unit
94	RCPT Testing Machine with mould	1 Nos.
95	Permeability Testing Machine	1 Nos.
96	RAIN GAUGE	1 Set.
97	Loss angle abrasion machine	1 Set.
98	Mortar cube casting machine	1 Set.
99	Cement testing kit as per Is-4031	1 Set.
100	Nuclear Moisture Density Gauge (NMDG) Apparatus	2 Set.
101	Core cutter with dolly and hammer (as per appendix D of RDSO-004)	4 Set.
102	Torque wrench (500 N-m)	4 Nos.
103	SDA/SN bolt pull out testing equipment	2 Nos.
104	Swellex pull out equipment	1 Nos.
105	Anemometer	2 Nos.
106	Multi gas detector	2 Nos.
107	Lux meter	2 Nos.
108	Noise detector	2 Nos.
109	Alcohol detector	2 Nos.
110	Panels for shotcrete testing	2 Nos.
111	Shotcrete slab moulds (150x150x450)	12 Nos.
112	Penetrometer	1 Nos.

S. No	Consumable Item	Unit
1	Sieve brush Wire brush	
2	Sodium carbonate	
3	Sodium hexa meta phosphate.	
4	Kerosene Mercury	

S. No.	Additional Equipment	Unit
1	Hand auger 150mm dia with extension rod	
2	Sampling tube 100mm dia. And 450mm length	

Note: All machines and equipment should have Calibration Certificate.

Appendix 13

Environment, Social, Health and Safety Management Manual

Table of Contents

1. ESHS FRAMEWORK

1.1. General

1.1.1. The Contractor shall be responsible for Environment, Social, Health and Safety (ESHS) on the Site and any other areas being used by him for the purposes of the Contract. Each Contractor shall develop his own contract specific ESHS Management Plan, which will represent his approach to the management of ESHS activities on his work, sites under the Contract with the Employer. The ESHS Management Plan should contain all the measures in the project Environmental and Social Management Plan (ESMP) which is part of the EIA.

1.1.2. The Contractor shall ensure that all appropriate ESHS measures are implemented throughout the execution of the Works.

1.2. Scope

1.2.1. The Environment, Social, Health and Safety Management Manual defines the principal requirement of the Employer and forms an essential part of the overall Environment, Social, Health and Safety Management System proposed to be employed by the Employer for the construction of the Project.

1.3. Definition

a) HEALTH & SAFETY – Conditions and factors that affect the well-being of employees, temporary workers, Contractor personnel, visitors and any other person at the workplace;

b) ENVIRONMENT – Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interaction;

c) ENVIRONMENT ASPECT – Element of an organization's activities or products or services that can interact with the environment;

d) ENVIRONMENT IMPACT – Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects;

e) HAZARD – Source, situation, or act with a potential for harm in terms of human injury or ill health or a combination of these;

f) Ill Health – Identifiable, adverse physical or mental condition arising from and/or made worse by a work activity and/or work-related situation;

g) Incident – Work related event (s) in which an injury or ill health (regardless of severity) or fatality occurred, or could have occurred:

- "Accident" is an incident which has given rise to injury, ill health or fatality;
- "Emergency" is an incident having potential to affect many persons orsevere property damage;
- "Near Miss" is an incident or a situation with clear potential for an undesirable outcome to occur, even though no actual negative consequenceshappened. In other words, it is an event with potential to cause injury, property damage, environmental release or an adverse community reaction; and
- "Dangerous Occurrence" is an unplanned and undesired occurrence(incident) which

has the potential to cause injury, and which may or maynot cause damage to property, equipment or the environment.

h) AUDIT – Systematic examination to determine whether activities planned areimplemented effectively and related results are suitable for achieving theorganization policy and objectives;

i) INTERESTED PARTIES – Individual or group concerned with or affected by the ESHS Management Performance of an Organization;

j) NON-CONFORMITY – Any deviation from work standards, practices, procedures, regulations, management system performance, etc. that could either directly or indirectly lead to injury or illness, property damage, damage to workplace environment, or a combination of these;

k) OBJECTIVES – Goals in terms of ESHS Management Performance that an organization sets itself to achieve;

l) ESHS MANAGEMENT SYSTEM – Parts of overall management system that facilitates the management of the ESHS risks associated with the business of the organization. This includes the organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the organization's ESHS Management Policy;

m) ORGANIZATION – Company, operation, firm enterprise, institution or association, or part thereof, whether incorporated or not, public or private, that has its own functions and administration;

n) PERFORMANCE – Measurable results of the ESHS Management System, related to the organization's control on environment, health and safety risks, based on its ESHS Management Policy and objectives;

o) RISK – Combination of the likelihood and consequences of a hazardous event occurring;

p) RISK ASSESSMENT – Overall process of establishing the magnitude of risk and deciding whether the risk is tolerable;

q) ACCEPTABLE RISK – Risk that has been reduced to a level that can be tolerated by the organization having regard to its legal obligations and its own ESHS Policy;

r) DEVIATION – Is defined as something not in compliance with quality standard, specification or measuring requirements, or as deviations from specified procedures or way of working within production, environment, working environment (safety) or security;

s) CORRECTIVE ACTION – Action taken to eliminate the causes of an existing non-conformity, defect or other undesirable situation;

t) PREVENTIVE ACTION – Action taken to eliminate the causes of a potential non-conformity, defect or other undesirable situation to prevent occurrence or recurrences;

u) ENGINEER – Employer's Representative

v) Abbreviation

- "Ministry of Environment, Forest and Climate Change, Government of India" is abbreviated as MoEFCC;

- "Central Pollution Control Board" is abbreviated as CPCB;
- "State Pollution Control Board" is abbreviated as SPCB;
- "Haryana Pollution Control Board" is abbreviated as HPCB;
- "National Green Tribunal" is abbreviated as NGT;
- The use of "shall" indicates a mandatory requirement. "ESHS" means Environment, Social, Health and Safety;
- "Haryana Rail Infrastructure Development Corporation Limited" is the Employer abbreviated as HRIDC;
- "ESHS Manager" is an officer approved by the Engineer who is overall responsible for monitoring all ESHS functions prescribed in this document on behalf of the Contractor;
- "BOCWA" Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and amendment done thereafter;
- "BOCWR" Haryana Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Rules, 2005 and amendment done thereafter;
- "BOCWWCA" Building and Other Construction Workers' Welfare Cess Act, 1996;
- "BOCWWCR" Building and Other Construction Workers' Welfare Cess Rules, 1998;
- "CHIEF INSPECTOR" is the Chief Inspector of Inspection of Building and Other Constructions of Government of Haryana;
- "HIRA" is Hazard Identification and Risk Assessment; and

1.4. Application of This Document

1.4.1. This document applies to all aspects of the Contractor's Scope of Work including Subcontractors and all other agencies. There shall be no activity associated to the Contract, which is exempted from the purview of this document.

1.5. Purpose of This Document

1.5.1. The objective of these guidelines is to ensure that adequate precautions are taken for incident/occupational illness free safe work execution as well as to avoid harmful effects on the environment and social during construction.

1.5.2. This document:

a) Describes the Environment, Social, Health and Safety interfaces between theEngineer and the Contractor;

b) Details the processes by which the Contractor shall manage Environment, SocialHealth and Safety issues while carrying out the work under the contract.

1.5.3. These requirements shall be read together with, ISO 45001: 2018 Occupational Health and Safety Management System and ISO 14001: 2015 Environmental Management Systems.

2. ESHS MANAGEMENT

2.1. General

2.1.1. This document defines the principal requirements to be practiced at the Site at all times.

2.2. ESHS Targets and Goals

2.2.1. Following ESHS targets and goals shall be set and achieved by the Contractor/Subcontractor based on time bound work plan:

a) Zero total recordable injuries;

b) Zero non-conformances in respect of statutory laws related to Environment, Health, Social and Welfare measures, living conditions and Safety regulations.

c) Total compliance of recording and reporting of all types of incidents.

d) 100% compliance on Safety Induction of all personnel

e) Total compliance of conducting inspections and audits as per approved ESHSManagement Plan;

f) 100% incident recording and reporting;

g) 100% adherence to usage of appropriate PPEs at work;

h) Executing construction work with least disturbance to the environment, adjoiningroad users and traffic;

i) Minimize waste generated at sites and maximize reuse of materials;

j) Maintaining environment conditions of site as per statutory requirement of HPCB,NGT etc. to avoid penalty;

k) To achieve construction site as zero discharge site as far as possible.

2.3. Contractor's Obligation to Abide by Mandatory Legislations and Standards

2.3.1. The construction works shall be undertaken in accordance with the Employer's ESHS Management Policy and Management Systems as amended from time to time provided in ESHS Management Manual.

2.3.2. The construction works shall be undertaken in accordance with all updated applicable legislation listed below, but not limiting to:

a) Indian Electricity Act 2003 and Electricity Rules, 2005;

b) National Building Code, 2016;

c) Factories Act, 1948 and state respective factory Rules;

d) Motor Vehicles Act as amended in 1994 and The Central Motor Vehicles Rules,1989;

e) Indian Road Congress Code IRC: SP: 55-2014 'Guidelines on Safety in Road Construction Zones';

f) The Petroleum Act, 1934 and Rules, 1976;

g) Gas Cylinder Rules, 2003;

h) Indian Explosives Act, 1884, along with the Explosives Substance Act, 1908 andthe Explosives Rules, 1983;

i) Environmental and Social Legislations as listed in Clause 6.0 of this document.

2.4. Contractor's Environmental, Social, Health and Safety Management Policy and Plan

2.4.1. The Contractor as per Rule 39 of the BOCW Central Rules shall formulate an Environment, Social, Health & Safety policy and display it at conspicuous places at work sites in English and Hindi so that the policy shall be understood by majority of the construction workers. The policy shall contain the following as minimum coverage:

a) The intention and commitments of the Contractor regarding Environment, Social, Health & Safety protection of the workers;

b) Organizational arrangement made to carry out the policy specifying the responsibilities at different levels of hierarchy;

c) Responsibilities of the Contractors, Subcontractor, transporter or other agencies involved in the construction work ;

d) Techniques and methods for assessment of Aspects/Impact and risk to safety and health and remedial measures;

e) Arrangement for training of workers, supervisors or other persons engaged in the construction work;

f) Other arrangements for making the policy more effective.

2.4.2. The Contractor shall revise the policy whenever any modification having implication on the Environment, Social, Health and Safety of the workers is made or any new construction work, substances, or technique are introduced which have implication on environment, health and safety of workers.

2.4.3. The contractor shall submit ESHS Management plan for review by the engineer within 28 days after the commencement date.

2.4.4. The Contractor shall revise and submit the ESHS Management Plan if at any time the ESHS Management Plan is insufficient in the Engineer's opinion. The Contractor shall within 7 days submit the revised ESHS Management Plan to the Engineer for review.

2.4.5. Any omissions, inconsistencies, and errors in the ESHS Management Plan or the Engineer's acceptance or rejection of the ESHS Management Plan and/or supplements thereto shall be without prejudice to the Contractor's obligations with respect to site safety, industrial health and environment and shall not be excused for any failure by the Contractor to adopt proper and recognized safety practices throughout the execution of the Works. The Contractor shall adhere to the ESHS Management Plan and shall ensure, as far as practically possible, that all supervisors and subcontractors of all tiers each have a copy of the ESHS Management Plan on the Site and comply with its provisions.

2.4.6. The details of contents to be covered in the ESHS Management Plans are given in Attachment - 1[Contents of ESHS Management Plan] of this document.

2.4.7. Contractor will inform AIIB of any significant ES events such as accidents, near misses, fatalities. AIIB is to be informed within two days of the event.

2.5. Designer's Role

2.5.1. The Designer's primary role includes to minimize the risk to environment, safety and health of those who are going to construct, maintain, clean, repair, dismantle or demolish the structures and anyone else like adjoining road users/public, who might be affected by the work.

2.5.2. Every temporary structure like scaffold, temporary deck, earth retaining structures etc. shall be properly designed.

2.6. Site ESHS Organisation

2.6.1. The Contractor shall appoint the required ESHS Management Personnel as prescribed in the Contract.

In order to effectively implement labour welfare provisions and to interact on such provisions with the Employer and the statutory authorities enforcing the labour welfare legislations, every Contractor shall employ fulltime, qualified, and experienced Labour Welfare Officer.

2.6.2. **Conduct and Competency**

The Contractor shall ensure that all personnel are competent to perform the job assigned to them. In the event that the Contractor is unable to demonstrate the competency of any person whose activities can directly impact the Works' Environment, Social, Health & Safety performance, the Engineer shall remove that person from the Site without any procedural formalities.

Labor Code of Conduct: The Contractor shall have a Code of Conduct for the Contractor's Personnel. The Contractor shall ensure that each Contractor's Personnel is provided a copy of this Code of Conduct, written in a language comprehensible to that person, and shall seek to obtain that person's signature acknowledging receipt of the same.

2.6.3. **Approval from The Engineer**

The name, address, educational qualification, work experience and health condition of each ESHS personnel deployed shall be submitted to the Engineer for approval well before the start of the Works or before deployment whichever is earlier. These personnel are authorised to work only after approval of the Engineer. In case any ESHS personnel leaves the Contractor, the same shall be intimated to the Engineer within a week. Non-informing the employer will attract penalty. The Contractor shall recruit new personnel and fill up the vacancy before relieving a person. Proper handing over of all the documents shall be ensured before relieving a person.

2.6.4. The Contractor shall provide all ESHS Management Personnel with such facilities, equipment and information that are necessary to enable them to discharge their duties effectively. The minimum requirements of such facilities/equipment to be provided for ESHS Management Personnel are given in Attachment-4 [General Instruction:ESHS/GI/001].

2.7. Responsibility of ESHS Personnel

2.7.1. PICOW (Person In-Charge of Work)

a) "Person in Charge of Work" under whose supervision, the Workers operate as per approved method statement and ESHS Management Manual.

b) PICOW shall lead/supervise and direct the Workers to undertake the work in a safe manner.

c) Each Request for Inspection (RFI) must indicate the name of PICOW for that work.

2.7.2. Responsibility of a PICOW

PICOW should ensure that:

a) A safe system of work is adopted;

b) Everyone in the group is briefed and understand the system of work before work starts;

c) The current system of work is altered whenever there is any change in conditions or circumstances make it necessary and ensure that everyone understands the new arrangements; and

d) The work is stopped and everyone moved to a position of safety immediately, should there be any doubt whether the work may safely continue.

2.7.3. All ESHS Management Personnel are to report to the ESHS Manager who shall always report

directly to the Contractor's Project Manager. Their primary role is to oversee environment, social, health and safety aspects at work site. The Engineer shall always monitor adherence to this procedure. In case of non-adherence penalty shall be levied.

2.8. ESHS Committee

2.8.1. The Contractor shall form Site ESHS Committee within 60 days of award of the Contract and notification regarding the same shall be communicated to the members.

2.8.2. The Terms of Reference for the Site ESHS Committees shall be as follows:

a) To oversee implementation of the Contractor's Environment, Social, Health and Safety policies and practices;

b) To monitor the adequacy of the Contractor's ESHS Management Plan and ensure its implementation;

c) To review ESHS training;

d) To review the Contractor's ESHS monthly reports;

e) To identify probable causes of accident and unsafe practices in construction work and to suggest remedial measures;

f) To stimulate interest of the Workers in environment, health and safety by organizing environment/safety week, safety competition, talks and film-shows on environment/safety, preparing posters or taking similar other measures as and when required or as necessary;

g) To go around the Site with a view to check unsafe practices and detect unsafe conditions and to recommend remedial measures for their rectifications including first-aid medical and welfare facilities;

h) Committee team members should perform a site inspection before every committee meeting and to monitor ESHS inspection reports;

i) To bring to the Notice of the Engineer hazards associated with use, handling and maintenance of the equipment used during the course of construction work;

j) To suggest measures for improving environment, social, health and safety in construction work at the Site;

k) To investigate the health hazards associated with handling different types of explosives, chemicals, and other construction materials and to suggest remedial measures including personal protective equipment; and

l) To review the last ESHS committee meeting minutes and the remedial measures taken for Non-Compliance.

Chairman	Project Manager
Secretary	ESHS Manager (Will be nominated by Project Manager)
Members	i) Contractor's ESHS staff. ii) Labour Welfare Officer; iii) In -charge of Plant and Machinery & Site Electricals; iv) In-charge of Special Work Operations (e.g. bridge, viaduct, and tunnel, etc.); v) In-charge of Stores; vi) Subcontractor's representative; and vii) Workers' representatives;
Engineer's Representatives	To be nominated by the Engineer

2.8.3. **Minimum time between two monthly ESHS Committee meetings**

A minimum period of 21 days shall be maintained between any two ESHS monthly committee meetings.

2.8.4. **Agenda**

The Secretary shall circulate the agenda of the meeting at least seven working days in advance of the scheduled date of the meeting to all members as well as to the Employer.

2.8.5. The agenda should broadly cover the following:

a) Chairman's overview of ESHS Management Performance;
b) Confirmation of minutes of last meeting;
c) Previous month ESHS statistics;
d) Incident and accident investigation/Dangerous occurrence/Near miss report;
e) Site ESHS inspection and compliance report;
f) The Contractors' ESHS issues;
g) Report from the Employer and Engineer;
h) Non-compliances raised by Engineer/Statutory Authorities;
i) Report and compliance of GRC; and
j) Any other concern.

2.8.6. In case of station and other contiguous areas where more than one main Contractor is working together, the Engineer shall instruct the other Contractors/ Sub-contractors to join for the monthly ESHS committee meeting of the main civil Contractor, to discuss and decide about the common provision of safety, security, lighting, toilet, drinking water etc. and sharing the maintenance cost of the same etc.

2.8.7. The Minutes of the Meeting shall be prepared as per the format provided and sent to all members within 2 working days by mail. Minutes of ESHS Committee Meeting shall also be displayed on the notice board for wider publicity to all concerned.

2.8.8. The chairman shall inform the members of any outstanding issues in the meeting and in case of repeated offence/ non-compliance by some members or other Subcontractors shall impose suitable disciplinary action including provisions of monetary penalty as per Clause 7. [Financial Deduction/Withholding].

2.8.9. In addition, there shall be a Project ESHS Committee whose composition shall be as follows:

Chairman	Project Director
Secretary	ESHS Manager (Will be nominated by PD)
Members	i) Deputy Project Director/Civil ii) Project Manager along with ESHS manager from each Contract Package iii) ESHS experts of GC
Employer's Representatives	Chief Project Manager

2.8.10. Project ESHS Committee shall also meet once a month after the meeting of Site ESHS Committee. Project ESHS Committee shall oversee the implementation of ESHS Policy and ESHS Management Plan of the Contractor in execution of the Project. This Committee shall also redress the grievances/complaints/representations received from public, other stakeholders and employees of the Contractor and Subcontractors. The agenda of the meeting shall be circulated by the Secretary of the Committee after taking approval from the Project Director.

2.9. ID Card and ESHS Induction

2.9.1. The Contractor shall ensure that all personnel working at the Site receive an induction ESHS training immediately on the first day of joining explaining the nature of the work, the hazards that may be encountered during the site work. Personnel shall only be deployed at site once he/she has completed ESHS induction. The training shall cover the contents as given in Clause 8, Attachment-4[General Instruction: ESHS/GI/002].

2.9.2. All personnel shall be issued a photo identity card as per the format given in Clause 8, Attachment-4[General Instruction: ESHS/GI/003].

2.9.3. The Contractor shall also issue a Personnel pocket ESHS Booklet in a language known to the Workers, which provides information on ESHS and emergency procedures

2.10. Other ESHS Training

2.10.1. The Contractor shall organize the ESHS training to engage managers, supervisors and other personnel in behavioural change and improve safety performance. The contents of ESHS training to managers/supervisors as given in Attachment-4[General Instruction: GI/005].

2.10.2. The Contractor shall provide a training/workshop on ESHS to all its workers/staff/employees/subcontractors of at least 2 days. It shall be completed in various modules and each employee/worker shall have a record of completing all modules.

2.10.3. On-the spot practical skill development training on height safety including scaffold safety, crane safety, welding safety, electrical safety, and traffic safety for marshals shall also be conducted.

2.10.4. Every employee including workman shall take a safety oath followed by toolbox talk every day.

2.10.5. All vehicles and machine drivers including heavy work vehicle and machine operators shall be trained on defensive driving with necessary certificate or license.

2.11. ESHS Inspection

2.11.1. The Contractor shall evolve and administer a system of conducting ESHS inspection and other risk management analysis on a periodical basis.

2.11.2. The purpose of ESHS inspection is to identify any deviation in construction activities and operations, machinery, plant and equipment and processes against the ESHS Management Plan and its supplementary procedures and programs.

2.11.3. The Contractor shall initiate a monthly joint site ESHS Management inspection with the Engineer and report shall be generated on the same day with the corrective action and accepted target date (within a week) by the Engineer.

2.11.4. The Compliance of the joint inspection "Non-Conformance" shall be witnessed/accepted by the Engineer.

2.11.5. The Contractor shall submit follow up compliance report of the weekly ESHS inspection report within six days of the date of Inspection.

2.11.6. The Contractor shall evolve and administer a system of conducting ESHS inspection and other risk management analysis on a periodical basis.

2.11.7. Following ESHS inspections program shall be adopted:

a) Planned general inspection;

b) Routine inspection;

c) Specific inspection; and

d) Other inspection.

2.11.8. Planned general inspections are performed at predetermined intervals. Inspections that will be classified under this inspection program are:

a) Monthly Contractor and subcontractor's site safety committee inspection;

b) Weekly safety inspection by construction supervisors (the Contractor and the Subcontractor); and

c) Daily safety inspection by the Contractor site ESHS team.

2.11.9. Routine inspections are often referring to the inspection of the Site, equipment and temporary structures performed by the Site and equipment operators and temporary structure erectors.

Inspections that will be classified under this inspection program are:

a) Daily inspection of plant and equipment by operators;

b) Weekly inspection of scaffold by scaffolding supervisors;

c) Monthly Inspection of electrical hand tools by competent electrical supervisors;

d) Quarterly inspection of temporary electrical systems by competent electrical supervisors; and

e) Half-yearly inspection of lifting machinery, lifting appliances, equipment and gears by Govt. approved competent persons.

f) Quarterly inspection of lifting gears, tools tackles and appliances.

g) Quarterly colour coding of lifting gears, tools & tackles. The recommended colour coding for the 4 quarters of the years shall be as under

i) January – March: GREEN

ii) April – June: YELLOW

iii) July – September: BLUE

iv) October – December: WHITE

2.11.10. The list mentioned above is not exhaustive. The Contractor may add additional categories. The ESHS Manager will ensure that a system of routine inspections is carried out periodically to all plants, equipment, powered tools and any other temporary structures that will pose a hazard to operators and workmen.

2.11.11. **Specific Inspection**

Specific inspections are performed on activities without a predetermined date. Competent supervisors usually perform inspections for ensuring an activity whether it is executed in accordance to a general set of rules; Method Statement submitted or developed procedures.

The following are examples that will be commonly performed as required on the Site:

a) Inspection performed before a heavy lifting operation;

b) Inspection performed before and after the entry of person into a confined space;

c) Inspection performed before and after a welding and gas cutting operation;

d) Inspection of formwork before concreting by formwork erector.

The list mentioned above is not exhaustive. The Contractor shall ensure that a competent supervisor inspects all high-risk processes and activities.

2.11.12. Other inspections include the following:

a) Mandatory inspections by Labour Department of Government of Haryana; and

b) HRIDC site ESHS management team.

c) Inspections by Central Pollution Control Board, Haryana Pollution Control Board, Ministry of Environment and Forest and Climate Change, National Green Tribunal etc.

2.11.13. The Contractor shall prepare all required safety inspection checklist for all activity operations and equipment. Checklists will be prepared based on the Indian SafetyStandards, Rules and Regulations and the Works requirements.

2.11.14. All inspection records and reports will be properly kept and filed for audit purpose. Inspection reports of planned general inspection and routine inspection will be used for discussion during safety committee meetings.

2.11.15. The contractor project manager & ESHS expert with site team shall be participating in the ESHS inspection.

2.12. ESHS Audit

2.12.1. The purpose and scope of ESHS Audit is to assess potential risk, liabilities and the degree of

compliance of the ESHS Management Plan and its supplementary procedures and programs against applicable and current ESHS legislation regulations and the Works requirements.

2.12.2. The Contactor's project manager shall hold the ultimate responsibility in ensuring implementation of ESHS audit program during the construction work.

2.12.3. Monthly Audit Rating Score (MARS)

2.12.4. Monthly Audit Rating Score (MARS) will be performed once in a month. A team consisting of the Contractor's project manager and the Engineer's representative based on the pre-designed score-rating format will conduct it.

2.12.5. This Monthly ESHS Audit Rating Score (MARS) report will enable the Engineer to evaluate the general compliance by the Contractor with the Conditions of Contract, and the ESHS Management Plan. A Minimum Compliance level to achieve 75% overall Audit Rating is essentially required. Falling this, the Engineer will take punitive action which includes non-processing of running account bills.

2.12.6. The Contractor's project manager accompanied by the Engineer's representatives shall carry out the Audit. The Contractor's senior manager and the ESHS in-charge should also be invited to attend.

2.12.7. **Timing**

The Monthly Audit Rating Score (MARS) should be conducted at least 7 days prior to the scheduled date of monthly ESHS Committee Meeting.

2.12.8. **Evaluation**

The numerical scoring has been weighed on a 1-10 scale. The audit team will use their observations noted in evaluating the points to be awarded against each of the elements of the audited section. Wherever some topics and sub-topics are not applicable the score rating need not be given. The overall audit ratings shall be achieved by:

$$\text{Overall Audit rating} = \frac{\text{Actual Score Achieved}}{\text{Maximum Possible Score}} \times 100$$

The criticality of the required actions for the respective sections of the Audit will be classified as:

S.No.	Score	Description	Action
1	< 60%	Immediate	Require the Contractor to rectify within 24 hours
2	< 75%	Improvement Necessary	The Contractor rectification within 7 days and confirmed in writing to the Engineer
3	< 90%	Improvement Desirable	The Contractor rectification within 1 month and confirmed in writing to the Engineer

2.12.9. **Report**

A copy of each Audit Report will be sent to the Engineer and to all subcontractors, with whom it will then be discussed in detail at the monthly ESHS Committee Meeting to ensure that any corrective actions are agreed upon.

2.12.10. **External ESHS Audit**

External ESHS Audit is to be conducted by the external agencies that are competent with ISO

qualified auditors with the prior approval of the Engineer.

a) Areas of Competence of Audit Team

i) The Audit team shall have practical understanding of BOCWR/A statutory requirements on health/medical and welfare of workmen, construction hazardsand its prevention and control, traffic management, electrical safety, rigging, safety of construction equipment and environment and social management.

ii) Audit shall be conducted as per the guidelines of ISO, ILO and national standards. Audit report shall also be presented as per the formats given in thestandards; and

iii) External ESHS Audit shall be conducted on a quarterly basis throughout the currency of the Contract.

b) Targets of ESHS Audit:

The contents and coverage of the audit shall include the following items:

i) ESHS Management:

- ESHS Organization;
- ESHS Policy and Plan;
- ESHS committee;
- ESHS orientation;
- ESHS training;
- ESHS communication and motivation;
- ESHS submittals to the Employer;
- ESHS promotional and awareness program;
- Incident reporting &investigation;
- Onsite/offsite emergency preparedness plan;
- Hazard identification and risk assessment;
- Implementations of work permit system.

ii) Technical:

- Work Method Statement;
- Operational control procedures/ Safe operating procedures;
- Working at height;
- Hand tools and power tools;
- Electrical safety;
- Fire prevention and control;
- Housekeeping;
- Overhead protection;
- Slipping, tripping, cutting, drowning and falling hazards;
- Lifting appliances and gear, tools and tackles;
- Lifting and launching operation;
- Construction plant and machinery;

- Machine and area guarding;
- Material handling;
- Hot work;
- Demolition;
- Excavation and tunnelling;
- Work permit system;
- Traffic management;
- Chemical handling;
- Dangerous and harmful Environments;
- Maintenance matrix of mechanical and electrical machines / equipment;
- Working on or under water;
- Working near or under high tension line;
- Personal protective equipment;
- Visitors at Site;
- Occupational health and welfare measures;
- All statutory forms, returns under various statutes;
- First-aid and medical facilities;
- Welfare measures; and
- Environmental and Social management.

c) Audit Documents:

The Contractor shall make the below itemized documents available for review by the Audit team;

a) ESHS Policy;

a) ESHS Management Manual;

b) ESHS Rules and Regulation;

c) ESHS Organization chart;

d) Annual ESHS objectives/programs;

e) Accident/near miss statistics and analysis;

f) ESHS training program/records for all personnel;

g) Operating manuals and maintenance manual of all equipment;

h) Safe worthiness certificates of all lifting appliances and gears;

i) Medical fitness record for all personnel;

j) Risk identification, assessment and control details;

k) Environmental and Social management reports;

l) Emergency management records including mock drill;

m) Housekeeping inspection records;

n) Minutes of ESHS committee meetings;

o) Calibration and testing records;

p) Safety budgets;

q) Records of previous audits;

r) Safety inspection records;

s) First Aid, medical facilities and other welfares measures;

t) Maintenance procedure of plant &machinery;

u) Records of Industrial hygiene surveys (noise, ventilation, and illumination level, airborne and toxic substances, explosive gases).

d) Reporting

Audit report shall be prepared and directly sent to the Engineer within 7 days of conducting the audit.

e) Report Contents:

a) Executing Summary - Based on the finalized checklists as written the findings to the Engineer by the audit team members, the audit leader will compile a concise and accurate summary of observations and findings;

b) Introduction- This will contain basic information regarding the facilities or organization audited, the specific audit dates (inclusion of those for preparation and post-audit activities);

c) Principal Positive Findings - This will contain the summary of positive aspects as observed by the auditors. It will also contain highlights of those issue, which may warrant dissemination as best practice regarding methodology used or achievement;

d) Audit Findings - All audit findings as detailed in the audit checklists shall be grouped together as priority 1 and 2 as detailed below in a separate listing:

i. Priority 1: Actions to rectify gaps or weakness should generally beimplemented within two-weeks' time if risk potential is high or unacceptable; and

ii. Priority 2: Actions should be generally implemented or rectified with a maximum of 3- 4 weeks, if not rectified would create a likelihood of minor injury or business loss.

f) Conformity Report Action to the Engineer:

a) The auditor shall inspect the Site after 14 days of conducting initial audit for checking the adequacy of implementation of items maintained under priority 1 by the Contractor and shall submit a Conformity/Non-conformity Report to the Engineer;

b) The auditor shall again inspect after 28 days of conducting initial audit for checking the adequacy of implementation of items mentioned under priority 2 by the Contractor and shall submit a Conformity/Non-conformity Report to the Engineer; and

c) In case of non-conformity of items mentioned by auditor, the Engineer shall take necessary steps including stoppage of work and or imposing any penalty for getting the item implemented.

d) If the Contractor fails to conduct the External ESHS Audit in time, the Engineer shall get it done. All expenses related to the external ESHS audits shall be borne bythe Contractor.

2.13. ESHS Communication

2.13.1. The Contractor shall make every effort to communicate the ESHS Management measures through posters campaigns/billboards/banners/glow signs being displayed around the Site as part of the effort to raise ESHS awareness amongst the work force. Posters should be in Hindi, English and other suitable language deemed appropriate. Posters/billboards/ banners/glow signs should be changed at least once in a month to maintain the impact.

2.13.2. The Contractor shall also observe important days as listed in Attachment-4[General Instruction: ESHS/GI/006] and printing and displaying safety signage and posters as listed in Attachment-4[General Instruction: ESHS/GI/007].

2.14. ESHS Submittals

2.14.1. The Contractor's ESHS Management shall send the following reports to the Engineer periodically in soft copy:

a) Daily reporting of total number of workmen;

b) Monthly ESHS Reports;

c) Minutes of ESHS Committee meeting;

d) ESHS inspection and compliance reports; and

e) ESHS audits reports;

- Monthly Audit Rating Score (MARS) reports;
- External ESHS audits;

2.14.2. The Contractor shall prepare a Monthly ESHS Report consisting of the following within 7th of next month to the Engineer:

a) Monthly man-hour details as specified in the ESHS Management Plan;

b) Monthly accident/incident details as specified in the ESHS Management Plan;

c) ESHS committee details;

d) ESHS inspection and compliance report;

e) ESHS internal audit details.;

f) ESHS communication activities undertaken in the month indicating the number of posters displayed and balance availability in stock;

g) Monthly Environment (including air, noise, water and soil testing results) and Social Report;

h) Graphical representation of monitored results over past four reporting periods;

i) Details of interactions with regulators (e.g. Pollution Control Board, Forest Department etc.) including dates, subjects, outcomes (report the negative if none);

j) Details of Clearance/ Permission//Permit obtained;

k) Compliance status for conditions of all relevant clearances /permissions / consents/permits for the Work, including quarries, etc.;

l) Tree felling, transplanting and compensatory planation details;

m) Details of consumption of construction material, energy and water;

n) Details of different types of waste and scrap generated during the month and sold to authorised recyclers;

o) Summary of complaints, results of investigations and follow-up actions;

p) Gender: Number of female workers, percentage of female workforce, gender issue raised and dealt with;

q) HIV/AIDS: Provider of health services, information& training;

r) GBV/SEA: Details of training conducted;

s) Grievances: List of grievances received in the reporting period and unresolved past grievances by date received, complaint how received, to whom referred to for action, resolution and date (if completed), date of resolution of community grievances if any.

t) Toolbox talks details;

u) PPE details: Quantity purchased, issued to the workmen and stock available;

v) Details on IP 44 panel boards, lighting poles, welding and cutting equipment, Ladders, Hoists, Tools & Tackles;

w) Monthly lux meter study results;

x) Housekeeping;

y) Barricade maintenance details;

z) No of critical excavations;

aa) Health and welfare activities;

bb) ESHS activities planned for next month.

Formats in which information to be given for monthly Environment and Social aspects are given in Attachment 4 [General Instruction: ESHS/GI/008]

2.15. Accident Reporting and Investigation

2.15.1. All accidents and dangerous occurrences shall immediately be informed through message to the Engineer and the Employer. AIIB is to be informed within two days of the event. This will enable the Engineer to reach to the scene of accident/dangerous occurrences to monitor/assist any rescue work and/or start conducting the investigation process so that the evidences are not lost.

2.15.2. Reports of all accidents (fatal/injury) and dangerous occurrences shall also be sent within 24 hours by the Contractor.

2.15.3. No accident/dangerous occurrences are exempted from reporting to the Employer.

2.15.4. Any wilful delay in verbal and written reporting to the Employer and Engineer shall be penalized as per Clause 7. [Financial Deduction/Withholding].

2.15.5. In addition to the above verbal and written reporting to the Employer and Engineer, as per Rule 276 of HBOCWR, notice of any accident to a worker at the Site that:

a) Causes loss of life; or;

b) Disables a worker from working for a period of 48 hours or more immediately following the accident; shall forthwith be sent by telegram, telephone, fax, orsimilar other means including special messenger within 4 hours in case of fatal accidents and 72 hours in case of other accidents, to:

i) The Assistant Director, Industrial Safety and Health having jurisdiction in the area in which the establishment in which such accident or dangerous occurrence took place is located. The Assistant Director, Industrial Safety and Health shall be the authority appointed under section 39 of the Act;

ii) Board with which the building worker involved in accident was registered as a

beneficiary;

iii) Chief inspector; and

iv) The next of kin or other relative of the Worker involved in the accident.

2.15.6. Further, notice of any accident shall be sent in respect of an accident which:

a) Causes loss of life; or;

b) Disables the injured worker from work (for a period of more than 10 days) to;

i) The Officer-in-charge of the nearest police station;

ii) The District Magistrate or, if the District Magistrate by order so desires to;

iii) The Sub-Divisional Magistrate.

2.15.7. In case of an accident-causing minor injury, first-aid shall be administered, and the injured worker shall be immediately transferred to a hospital or other place for medical treatment.

2.15.8. Where any accident-causing disablement that subsequently results in death, notice in writing of such death, shall be sent to the authorities within 72 hours of such death.

2.15.9. The following classes of dangerous occurrences shall be reported to the inspector having jurisdiction, whether any disablement or death caused to the Worker, namely:

a) Collapse or failure of lifting appliances, or hoist, or conveyors, or similar equipment for handling of building or construction material or breakage orfailure of rope, chain or loose gears; or overturning of cranes used in construction work;

b) Falling of objects from height;

c) Collapse or subsidence of soil, tunnel, pipelines, any wall, floor, gallery, roof or any other part of any structure, launching girder, platform, staging, scaffolding or means of access including formwork;

d) Explosion of receiver or vessel used for storage of pressure greater than atmospheric pressure of any gas or any liquid or solid used as building material;

e) Fire and explosion causing damage to any place on the site where the Workers are employed;

f) Spillage or leakage of any hazardous substance and damage to their container;

g) Collapse, capsizing, toppling or collision of transport equipment; and

h) Leakage or release of harmful toxic gases at the Site.

2.15.10. In case of failure of launching girder, lifting appliance, loose gear, hoist machinery and transport equipment at the site, such appliances, gear, hoist, machinery or equipment and the site of such occurrence shall, as far as practicable, be kept undisturbed until inspected by the authorities.

2.15.11. Every notice given for fatal accidents or dangerous occurrences shall be followed by a written report to the concerned Authorities under Section 39 of BOCWA and the Chief Inspector of Government of Haryana in the specified Form **XLVI** of the **HBOCWR.**

2.15.12. Actions to be taken post incident/accident:

a) In case any incident/accident happens at site leading to injury to the worker, the worker/s is/are required to be taken to the nearest hospital immediately;

b) Project Manager/ESHS Manager/Labour Welfare Officer of the Contractor

c) needs to report the incident to the Engineer immediately without fail for all the death cases including natural deaths;

d) In case of fatal accident, doctor from the nominated hospital is the only authorized person to declare the death of the worker. It is not to be decided suo-moto by any other person. FIR should be registered for all the fatal cases which happen at the Site/labour camp;

e) Post Mortem of the dead body is mandatory in all the death cases i.e. whether it is natural or due to any incident / accident;

f) Family members of the injured / deceased worker are to be informed immediately;

g) In case of fatal accident, the dead body is to be handed over to the family members. Arrangement of sending the dead body to the native place shall be made by the contractor including cash payment for meeting out last rites expenses as per Rules;

h) Fatal accident report is to be sent to State Labour Authority in Form EE (as per workmen's compensations act) within seven days and to the Licensing Authority in Form XLVI within 24 hours of the incident/accident;

i) Workmen's Compensation dues are to be deposited with the Employee's Compensation Commissioner within 30 days of the death or the period of notice served by the Employee's Compensation Commissioner;

j) Copy of all the documents deposited with any labour authority, FIR, Post Mortem, Medical Reports etc. shall be submitted to the Engineer in duly approved Labour Welfare Fund (LWF) Form;

k) The Contractor shall be liable for getting disbursement of Provident Fund benefits, compensation under Employee compensation Act, benefits of ESI Act to the workman/dependents of the deceased workman. The Contractor shall also provide accommodation and transportation to dependents of the deceased workman or to the disabled workman who come for settlement ofterminal claims.

2.15.13. **Accident Investigation:**

a) Investigations shall be conducted in an open and positive atmosphere that encourages the witnesses to talk freely. The primary objective is to ascertain the facts with a view to prevent future and possibly more serious occurrences;

b) Accidents and dangerous occurrences which result in death, serious injury or serious damage must be investigated by the Contractor immediately to find out the cause of the accident/occurrence so that measures can be formulated to prevent any recurrence; and

c) Near misses and minor accidents should also be investigated by the Contractor as soon as possible as they are signals that there are inadequacies in the ESHS Management System.

2.15.14. Procedure of Incident Investigation

It is important after any accident or dangerous occurrence that information relating to the incident is gathered in an organized way. The following steps shall be followed:

a) Take photographs and make sketches;

b) Examine involved equipment, work piece or material and the environmentalconditions;

c) Interview the injured, eye-witnesses and other involved parties;

d) Consult expert opinion where necessary; and

e) Identify the specific Contractor or subcontractor involved.

2.15.15. Having gathered information, it is then necessary to make an analysis of incident:

a) Establish the chain of events leading to the accident or incident;

b) Find out at what stage the accident took place;

c) Considering all possible causes and the interaction of different factors that led up to the accident and identify the most probable cause, the cause of an accident should never be classified as carelessness; and

d) The specific act or omission that caused the accident must be identified.

2.15.16. The next stage is to proceed with the follow-up action:

a) Report on the findings and conclusions;

b) Formulate preventive measures to avoid recurrence; and

c) Publicize the findings and the remedial actions taken.

2.15.17. The Engineer's Independent Incident Investigation

In case of fatal/dangerous occurrence, the Engineer shall also conduct independent investigation. The Contractor and his staff shall extend necessary co-operation and testify about the accident.

2.15.18. The Contractor shall take every effort to preserve the scene of accident till the Engineer completes the investigation.

2.15.19. All persons summoned by the Engineer in connection to witness recording shall obey the instructions without delay. Any wilful suppression of information by any person shall be removed from the site immediately and/or punished as per Clause 7. [Financial Deduction/Withholding].

2.16. Emergency Preparedness Plan

2.16.1. The Contractor shall prepare as required under BOCWR, an Emergency Response Plan for the Site as a part of the Contractor ESHS Management Plan. The plan shall integrate the emergency response plans of the Contractor and all other Subcontractors. The Emergency Response Plan shall detail the Contractor's procedures, including detailed communication arrangements, for dealing with all emergencies that could affect the Site. The plan shall address items such as injury, sickness, evacuation, fire, chemical spillage, severe weather and rescue.

2.16.2. The Contractor shall ensure that the Emergency Response Plan is prepared to deal with emergencies arising out of, but not limited to:

a) Fire and explosion;

b) Collapse of lifting appliances and transport equipment.

c) Collapse of building, sheds or structure etc.

d) Gas leakage or spillage of dangerous goods or chemicals;

e) Bomb threatening, Criminal or Terrorist attack;

f) Drowning of workers; and

g) Landslides getting workers buried, floods, earthquake, storms and other natural calamities etc.

The above list is not exhaustive and other emergencies can also be included.

2.16.3. Arrangement shall be made for emergency medical treatment and evacuation of the victim in the event of an accident or dangerous incident occurring, the chain of command and the responsible persons of the Contractor with their telephone numbers and addresses for quick communication shall be adequately publicized and conspicuously displayed in the workplace.

2.16.4. The Contractor shall require to tie-up with the hospitals and fire stations located in the neighbourhood for attending to the casualties promptly and emergency vehicle kept on standby

duty during the working hours for the purpose.

2.16.5. The Contractor shall conduct an onsite emergency mock drill once in every month for all his workers and his sub-Contractor's workers.

2.16.6. It shall be the responsibility of the Contractor to keep the Local Law and Order Authorities informed and seek urgent help to mitigate the consequences of an emergency. Prompt communication to the Employer and Engineer, through telephonically initially and followed by a written report, shall be made by the Contractor.

2.17. Experts/Agencies for Environment, Social, Health & Safety Services

2.17.1. The Contractors may utilise the services of experts/agencies empanelled for the purpose of training, audit and any other ESHS services with prior approval of the Engineer. This approval can be withdrawn by the Engineer at any time if the quality of output of the agency is found not satisfactory.

3. LABOUR PROTECTION

3.1. General

3.1.1. The Contractor shall comply in full of the project Workplace Policy as described in Attachment-2 [Work Place Policy on HIV/AIDS, Prevention & Control] and Attachment -3 [Covid 19 policy].

3.2. Engagement of Staff and Labour

3.2.1. The Contractor shall ensure that the employees deployed by him in the premises of the Employer are physically and mentally fit and do not have any criminal record.

3.3. Payment of Minimum Wages

3.3.1. The Contractor shall ensure payment of at least the minimum wages as prescribed and applicable from time to time under the Minimum Wages Act, 1948 in the presence of an authorised representative of the Engineer and shall maintain proper records of their timely disbursement. These records shall be preserved for a period of at least 3 years and made available even after the Contract is over for any verification by the statutory authorities.

3.4. Conditions of Labour

3.4.1. The Contractor shall observe conditions of labour that are no less favourable than those established for the relevant trade or industry.

3.4.2. During the work, the Contractor shall afford all employees all basic rights enumerated in the conventions of the International Labour Organisation, including freedom of association, right to freedom from forced labour, and right to freedom from discrimination based on race, colour, sex, religion, political opinion and social origin.

3.4.3. The Contractor shall ensure coverage of his employees under the Employees Provident Fund and Miscellaneous Provisions Act, 1952 and the Employees State Insurance Act, 1948 via independent code numbers allotted to them by the Central Provident Fund Organisation and Employees State Insurance Corporation respectively.

3.4.4. The Contractor shall insure all his employees under Group Personal Accident Insurance scheme through a recognised and registered insurance company.

3.5. Labour Laws

3.5.1. The Contractor shall ensure that all his employees and the Subcontractors obey applicable following laws and regulations, including those concerning safety at work.

a) Minimum Wages Act, 1948;
b) Payment of Wages Act, 1936;
c) Equal Remuneration Act, 1976;
d) Employees Provident Fund and Miscellaneous Provisions Act, 1952;
e) Payment of Gratuity Act, 1972;
f) Employees State Insurance Act, 1948;
g) Payment of Bonus Act, 1965;
h) Maternity Benefit Act, 1951;

i) Industrial Disputes Act, 1947;

j) Trade Unions Act, 1926;

k) Child Labour (Prohibition and Regulation) Act, 1986;

l) Building and Other Construction Workers (Regulation of Employment of Service) Act, 1996;

m) Haryana Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Rules, 2005;

n) Building and Other Construction Workers Welfare Cess Act, 1996;

o) Building and Other Construction Workers Welfare Cess Rules, 1998;

p) The Contract Labour (Regulation and Abolition) Act, 1970;

q) Inter State Migrant Workmen's (Regulation of Employment and Conditions of Service) Act, 1979;

r) Haryana Major Accident, Hazard Control Rules, 2009;

s) Workmen's Compensation Act. 1923;

t) Factories Act, 1948;

u) Mines Act, 1952; and

3.5.2. The Contractor shall comply with all other statutory requirements, rules, regulations and notifications in relation to employment of his staff and workers that may be issued from time to time by the concerned government authorities.

3.6. Working Hours

3.6.1. No work shall be carried out beyond the statutory limit given under BOCWA, 1996.

3.6.2. No work shall be carried out outside the normal working hours stated in the Contract unless otherwise:

a) The Engineer gives his consent in writing for additional work; and

b) The work is unavoidable or necessary for the protection of life or property or forthe safety of the Works, in which case the Contractor shall immediately inform the Engineer.

4. SAFETY GENERAL

4.1. General

4.1.1. The following standards whichever is more stringent shall be applicable:

a) The BOCW Acts 1996 and the Haryana BOCW Rules 2005 framed there under;

b) Other relevant National Legislations & IS Codes.

4.2. Housekeeping

4.2.1. General Housekeeping shall be carried out by the Contractor and ensured always at the Site, Construction Depot, Batching Plant, Labour Camp, Stores, Offices and Toilets/Urinals.

4.2.2. Full height fence, barriers, barricades etc. shall be erected around the Site to prevent the surrounding from excavated soil, rubbish etc., which may cause inconvenience to and endanger the public. The barricade especially those exposed to public shall be aesthetically maintained by regular cleaning and painting as directed by the Engineer. These shall be maintained in one line and level.

4.2.3. The Contractor shall ensure that all his sub-contractors maintain the site reasonably clean through provisions related to housekeeping. All surplus earth and debris are removed/disposed of from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. to avoid dust or odour impact shall be covered while moving. The tyres of the trucks leaving the site shall be cleaned with water, wherever the possibility of spillage on carriageways meant for regular road traffic exists

4.2.4. Water logging or bentonite/polymer spillage on roads shall not be allowed. If bentonite/polymer spillage is observed on road endangering the safety of road users, the Contractor shall be penalized as per Clause 7. [Financial Deduction/Withholding].

4.2.5. No parking of trucks/trolleys, cranes and trailers etc. shall be allowed on roads, which may obstruct the traffic movement.

4.2.6. Roads shall be kept clear and materials like pipes, steel, sand, boulders, concrete, chips and brick etc. shall not be allowed on the roads to obstruct free movement of road traffic.

4.2.7. Proper and safe stacking of material are of paramount importance at yards, stores and such locations where material would be unloaded for future use. The storage area shall be well laid out with easy access and material stored/stacked in an orderly and safe manner. Lumber with protruding nails shall be bent/removed and properly stacked.

4.3. Working at Height

4.3.1. Working at height means work in any place, including a place at or below ground level.

4.3.2. The Contractor shall ensure that work at height is properly planned, appropriately supervised, and carried out in a safe manner and without any appreciable risk. Appropriate care shall be taken during bad weather.

4.3.3. Adequate protection in the form of working platform with railing, toe board, safe access, safety net, roof ladder etc. shall be provided. Where fall hazards cannot be eliminated, use fall-arrest systems while erecting, modifying, and dismantling scaffolds.

4.3.4. A trained and certified person shall check working platform, railing, toe board, safe access, safety

net, roof ladder etc. after erection and once in a week. A certificate shall be tagged on this equipment.

4.3.5. Employees involved in the erection, dismantling, moving, repairing, etc., of scaffolding and also workers who perform work on a scaffold shall receive training from a competent person. The purpose of the training is to recognize any hazards associated with the work.

4.3.6. When the height of a scaffold exceeds three times of the smallest width of the base, secure it to the building or structure at every other lift and every 9.0 m horizontally. The scaffold and scaffold working platform with handrails approximately 1.0 m high, mid rails, and toe boards, all secured rigidly by both ties and braces to prevent movement. Working platforms should be completely decked with safety planks, manufactured scaffold decking, or metallic planks.

4.3.7. Only metal frame working scaffold is permitted. Steel stairs are used as a means of raising and lowering the metal frame working scaffold, except for special cases. It is prohibited to directly raise and lower the framework with limbs or to use only ladder.

4.3.8. The Contractor shall ensure that following areas are clearly indicated:

a) where a workplace contains an area in which, owing to the nature of the work, there is a risk of any person at work;

b) Falling a distance; or

c) Being struck by a falling object:

4.3.9. The Contractor shall ensure that work equipment exposed to conditions causing deterioration, which is liable to result in dangerous situations, is inspected at suitable intervals and after any exception occurrence jeopardizing the safety of work/equipment.

4.3.10. In relation to work at height involved in construction work;

a) The top guard-rail or other similar means of protection shall be at least 1100 mm above the edge from which any person is liable to fall;

b) Toe-boards shall be suitable and sufficient to prevent the fall of any person, or any material or object, from any place of work; and

c) Any intermediate guardrail or similar means of protection shall be positioned sothat any gap between it and other means of protection does not exceed 550 mm.

4.3.11. Requirements for all Working Platforms:

a) Every working platform requires a firm & stable supporting structure for holding it;

b) A working platform shall possess a suitable surface and be so constructed that the surface of the working platform has no gap through which a person/material/object could fall;

c) A working platform and any supporting structure shall not be loaded to give rise to a risk of collapse or to any deformation, which could affect its safe use;

d) When altered or modified, it should be so altered or modified as to ensure that it

e) remains stable;

f) A working platform shall be of sufficient dimension to permit the safe passage of persons and the safe use of any plant or materials required to be used and to provide a safe working area having regard to the work being carried out there;

g) Depending on the complexity of the scaffolding selected, a responsible person shall draw up an assembly, use and dismantling plan;

h) A copy of the plan, including any instructions it may contain, shall be kept available for the use of persons concerned in the assembly, use, dismantling or alteration of scaffolding until

it has been dismantled; and

i) While a scaffold is not available for use, including during its assembly, dismantling or alteration, it shall be marked with general warning signs in accordance with and be suitably delineated by physical means preventing access to the danger zone.

4.3.12. Requirements for collective safeguards for arresting falls:

a) Collective safeguard is a safety net, airbag or other collective safeguard for arresting falls;

b) A safeguard shall be used only if:

i) A risk assessment has demonstrated that the work activity can (so far as is reasonably practicable) be performed safely while using it and without affecting its effectiveness;

ii) The use of other safer work equipment is not reasonably practicable; and

iii) A sufficient number of available persons have received adequate training specific to the safeguard, including rescue procedures.

4.3.13. Requirements for personal fall protection systems:

a) A personal fall protection system shall be used only if a risk assessment hasdemonstrated that;

i) The work can (so far as be reasonably practicable) be performed safely while using that system; and

ii) The use of other safer work equipment is not reasonably practicable.

The user and a sufficient number of available persons have received adequate training specific to the operations envisaged, including rescue procedures; and

b) A personal fall protection system designed for use with an anchor shall be securely attached to at least one anchor, and each anchor and the means of attachment thereto shall be suitable and of sufficient strength and stability to supporting any foreseeable loading.

4.3.14. Requirements for Ladders:

a) Every Contractor shall ensure that a ladder is used for work at height only if a risk assessment has demonstrated that the use of more suitable work equipment is not justified because of the low risk;

b) The short duration of use;

c) Existing features on the Site, which he cannot alter;

d) Only metal ladders shall be allowed. Bamboo ladders are prohibited;

e) Any surface upon which a ladder rests shall be stable, firm, of sufficient strength and of suitable composition safely to support the ladder so that its rungs or steps remain horizontal, and any loading intended to be placed on it;

f) A ladder shall be so positioned as to ensure its stability during use;

g) No interlocking or extension ladder shall be used unless its sections are prevented from moving relative to each other while in use;

h) Where a ladder or run of ladders raises a vertical distance of 9.0 m or more above its base, there shall, where reasonably practicable, be provided at suitable intervals sufficient safe landing areas or rest platforms;

4.4. Overhead Protection

4.4.1. All contractors shall provide overhead protections as per BOCW Act & Haryana BOCW Rules.

4.5. Slipping, Tripping, Cutting, and Falling Hazards

As Per Rule 98 of HBOCWR:

a) All places should be free from dust, debris or similar materials;

b) Sharp projections or any protruding nails or similar objects shall be suitably guarded or shall even be avoided to make the place safe to work;

c) Contractor shall not allow workmen to work or use platforms, scaffolds/passageways or any walkways, which has water, or oil or similar substances spilt and has a slipping hazard, unless it is cleaned off or covered or sanded or saw dusted or make it safe with any suitable material;

d) Open side or opening where worker, equipment, vehicle or lifting appliance may fall at a building or outside shall be guarded suitably except in places of free access by reasons of nature of work;

e) Suitable safety net shall be provided at places of material / man falling is possible in accordance with national standards;

f) Reinforcement of Pier and columns shall be secured from the risk of tilting through provisioning of minimum three guy wires ropes anchored to any concrete block/counter weight of sufficient capacity.

4.6. Lifting Appliances including Cranes

4.6.1. Lifting appliances means a crane, hoist hydra, derrick, winch, gin pole, sheer legs, jack, hoist drum, slewing machinery, slewing bearing fasteners, lifting machinery sheaves, pulley blocks, hooks or other equipment used for lifting materials, objects or the Workers and lifting gears means ropes, chain slings, shackles, hooks, lifting lugs, wire ropes, lifting eyebolts and eye nuts and other accessories of a lifting appliance.

4.6.2. Each of the lifting appliances and lifting gear including all parts thereof, whether fixed or moveable shall be thoroughly tested and examined by a competent person once at least in every 6 months or after it has undergone any alterations or repairs liable to affect its strength or stability. Within the validity, if the lifting appliances are shifted to a new site, re-examination by the competent person for ensuring its safety shall also be done.

4.6.3. The Contractors shall utilize the services of any competent person as defined in Factories Act, 1948 with the permission of the Engineer.

4.6.4. No machine shall be selected to do any lifting on a specific job until its size and characteristics are considered adequate:

a) The weights, dimensions and lift radii of the heaviest and largest loads;

b) The maximum lift height, the maximum lift radius and the weight of the loads that must be handled at each;

c) The number and frequency of lifts to be made;

d) How long the crane will be required on site;

e) The type of lifting to be done (for example, is precision placement of loads important;

f) The type of carrier required (this depends on ground conditions and machine capacity In its operating quadrants: capacity is normally greatest over the rear, less over the side, and non-existent over the front;

g) Whether loads will have to be walked or carried;

h) Whether loads will have to be suspended for lengthy periods;

i) The site conditions, including the ground where the machine will be set up, access roads and ramps it must travel, space for erection and any obstacles that might impede access or operation.

4.6.5. The Contractor shall ensure that a valid certificate of fitness issued is available for all lifting appliances including synchronized mobile jacks, pre-stressing hydraulic jacks, jacks fitted with launching girders etc. and the Engineer approval is obtained before inducting to the site. Only after obtaining the approval from the Engineer any lifting appliances and gear shall be used.

4.6.6. The laminated photocopies of fitness certificate issued by competent person, the Engineers approval letter, the operators photo, manufactures load chart and competency certificate shall always be either kept in the operator cabin or pasted on the visible surface of the lifting appliances.

4.6.7. All lifting appliances and loose gears shall be clearly marked for its safe working load and identification by stamping or other suitable means.

4.6.8. The Contractor shall also maintain a register containing a system of identification of all tools and tackles, its date of purchase, safe working load, competent person date of examination etc.

4.6.9. Sufficient lighting arrangement shall be ensured at all lifting operations.

4.6.10. **Qualification of operator of lifting appliances etc.:** The Contractor shall not employ any person to drive or operate a lifting machine-like crane, hydra etc. whether driven by mechanical power or otherwise or to give signals to work as an operator of a rigger or derricks unless he:

a) Is above 21 years of age and possesses a valid heavy transport vehicle driving license as per Motor Vehicle Act and Rules;

b) Is competent and reliable;

c) Possesses the knowledge of the inherent risks involved in the operation of lifting appliances by undergoing a formal training at any institution of national importance acceptable to the Engineer; and

d) Is medically examined periodically as specified in schedule VII of BOCW Rules.

4.6.11. All hydraulic piping and fittings shall be maintained leak proof.

4.6.12. Only four legged slings shall be allowed which includes master link (ring), intermediate master link (ring) if necessary, chain / wire rope sling, sling hook or other terminal fitting.

4.6.13. Hand spliced slings up to 32mm diameter shall not be used at site for any lifting purpose. The slings used shall confirm to IS 2762: 2009 Wire rope slings and sling leg specification.

4.6.14. No load shall be slewed over public areas without stopping the road traffic first.

4.6.15. Failure to do any of the above shall attract penalty from the Employer as per Clause 7. [Financial Deduction/Withholding].

4.6.16. Automatic safe load indicator (ASLI) to be provided in crane with audible and visible warning system and made functional and calibrated by the manufacturer or its authorized representative every 6 months or after repair of the lifting equipment.

4.6.17. **Automatic safe load indicators and data logger in lifting appliances**

As stipulated in Rule 123 of HBOCW Rules, every lifting appliances and gears like cranes, hydras etc., if so constructed that the safe working load may be varied by raising or lowering of the jib or otherwise, shall be attached with an automatic indicator of safe working loads approved by Bureau of Indian standards/International certifying bodies which gives a warning to the operator whenever the load being handled exceeds the safe working limit.

a) Provision of functional data logger with alert facility through SMS and web in all cranes shall

be mandatory;

b) Cut-out shall be provided which automatically arrests the movements of thelifting parts of every crane if the load exceeds the safe working limit.

4.6.18. The crane should have a substantial/durable safe working load chart which has clearly legible characters in English and Hindi and figures displayed inside the crane and is easily visible to the crane operator.

4.6.19. General Requirements

The sweep area (work area) of the construction machinery shall be always free from obstructions. All hydraulic piping and fittings shall be maintained leak proof. The operator cab shall posses good and safe:

a) Structure, windows and windshield wipers;

b) Drivers chair and footrest;

c) Control handles;

d) Cab instrumentation;

e) Telecommunication;

f) Cab outfitting;

g) Wind indicator with an adjustable set point shall be in a position representative for the wind on the crane. The indicator shall give continuous information regarding constant speeds and gusts.

4.6.20. Mandatory Rigging requirement

a) Rigging shall be done under experienced and qualified rigger only. All Load shall be adequately and safely rigged to prevent any danger;

b) The primary requirement in rigging shall be to assess the weight of load before attempting any lift;

c) All hooks shall be fitted with Master Rings having certificate of fitness from the competent person, so that the hooks are subjected to balanced vertical loading only;

d) Only four legged slings shall be allowed which includes master link (ring), intermediate master link (ring) if necessary, chain / wire rope sling, sling hook or other terminal fitting;

e) Requirements of outriggers

i) All outriggers shall be fully extended and at all tyres are clear of theground;

ii) Heavy duty blocking having large bearing area shall be necessary to prevent sinking of floats;

iii) Provision of heavy steel plates/ high density interconnected wooden logs of required dimension shall be used to uniformly distribute the load;

iv) The crane shall be setup on fully compacted ground;

4.6.21. Pick & carry operation

Prohibition on Use of "Tractor transmission type Pick and Carry Hydra Crane": Tractor transmission type Pick and Carry-1st Generation model is prohibited at HRIDC works. Contractor shall mobilize "Truck transmission type" Pick and Carry (Hydra)Crane– minimum 2nd Generation model only or higher model.

Pick and Carry operation is prohibited at all HRIDC construction sites except for the tailing purpose for lowering of pile cage, erection of radio tower, electrical poles, exhaust structures etc.

4.6.22. Operation of lifting appliances

Every Contractor shall ensure that:

a) The complete lifting operation shall be governed by signals as per established standards;

b) Adequate measures to be taken to ensure that no workers is allowed to stand, pass, rides or sit under the suspended load;

c) No lifting appliances shall be left by the operator while power is on or load is suspended;

d) After completion of the lifting operation, all doors of the appliances shall be closed by the operator and ignition/operation key should be handed over to competent reliever operator or site In-charge;

e) All loads are provided with minimum two tag lines to ensure that the load can be controlled at all times;

f) No close working to any live over head power line is permitted without system of a 'Permit to Work' and prior permission of the engineer shall be obtained before performing such operation;

g) Danger zone shall be identified and cordoned off for all lifting appliances during their operation;

h) All lifting gears & slings shall be stamped or appropriate tags for their identification no & SWL;

i) Knotting/wrapping of chains & slings shall not be allowed at site;

j) Lifting appliances shall not be used for any dragging or pulling purposes. Contract shall refer to 75% capacity load chart for ascertaining the suitability of crane for safe lifting of load;

k) During tandem lift, available capacity of crane in respect of SWL shall be considered after reduction of 15% for 75% (DIN) load chart respectively. In addition, additional de rating as advised by third party testing and certified agency shall also apply;

l) During hoisting of long material, use of suitable lifting beam is recommended;

m) Only original equipment manufacturer (OEM) supplied/provided load chart shall be used during lifting operation;

n) Before performing any lifting operation, all electronic devices, control levers, hydraulic oil, wind pressure etc. shall be checked and necessary spare parts to be kept in stock to handle any breakdown during time bound lifting operation;

o) Lifting point shall be considered on the I-Girders/U Girder/C Girder/Steel girder/parapet etc. during the casting of the same. Design load calculation for the same should be conducted;

p) All lifting activities shall be stopped in case of high speed wind and similar adverse whether condition or as prescribed by the crane manufacturer; and

q) All cranes shall be provided with fail safe devices to avoid any hoist free fall in case of brake failure.

4.7. Launching Operation

4.7.1. As launching operation is one of the riskiest jobs, the Contractor shall take utmost precaution at all stages like; planning, establishing casing yard, casting segments, transporting segments, fabrication and erection of launching girders, launching of segments, pre-stressing, auto launching of girders and dismantling of launching girders.

4.7.2. The Contractor shall prepare a comprehensive Method Statement for the launching operation, adhering to the ESHS conditions laid down in conditions of contract on the ESHS Management

Manual. Reference shall be made to the provisions on working at height. As the entire process of launching must be undertaken at an elevated level the safety of workers and the girder is paramount important. In addition to general precautions, such as trained personnel, PPE, etc. listed in earlier clauses, the following general guidelines shall be adhered to throughout the launching operation:

a) The segments shall rigidly secure to the truck with necessary wooden wedges and necessary red indicators/safety tapes provided so that the vehicle is clearly seen by other road users both in day/night time;

b) Every launching operation shall have a responsible engineer on duty all the time;

c) All the time from erection to dismantling the area between the two piers wherein launching is in progress shall always be barricaded;

d) Auto launching shall be done only after approval from the Engineer. After every auto launching the stability of launching girder shall be ensured;

e) The vertical deflection of launching girder shall be monitored at all critical stages like with/without loads and after every auto launching;

f) A register containing all important operational details from erection to dismantling of launching girders shall be maintained and made available to the Engineer whenever called for;

g) Driver shall also have undergone proper medical examination as per sub-Clause-5.2 (Medical Facilities) and checked for influence of alcohol before any kind of lifting operation;

h) Test certificate for all lifting gears including Macalloy Bars shall be maintained at a

i) location closer to the launching girder itself so that it can be referred during all inspections;

j) Proper & safe access stairways shall be maintained for safe ascending /descending of workmen /engineers to or from launchers;

k) Adequate collective and personnel fall protection measures like provision of safety nets while working over live roads/railways, lifeline for anchoring of safety harness, safe means of access on main box girder shall be ensured;

l) Before starting of the launching, valid third party test certificate of the launcher hoist shall be available;

m) Safe and fully deck working platform duly covered from all side shall be ensured for stressing work at front support;

n) Safety checklist for all activities of launching cycle shall be prepared, got approved & implemented;

o) Use of nonstandard locking pins shall attract penalty;

4.8. Construction Machinery

4.8.1. Construction machineries may include dumpers and dump trucks, lift trucks and telescopic handlers, piling rigs, vibration hammers, rail welding equipment, mobile elevating work platforms, cranes, tipper lorries, lorry loaders, skip wagons, 360° excavators, 180° backhoe loaders, crawler tractors, scrapers, graders, loading shovels, trenchers, side booms, pavers, planers, chippers, road rollers, locomotives, tankers and bowsers, trailers, hydraulic and mechanical breakers etc.

4.8.2. Every construction equipment shall be in sound mechanical working condition and certified by either competent person under Factories Act or manufacturers' warranty in case of brand new equipment or authorized persons/firms approved by the Engineer before induction to any site.

4.8.3. Fitness of the machine shall be carried out on regular basis or after every maintenance work excluding any minor service/oil or filter change and be documented properly. The certificate shall

be available in operator/driver cabin.

4.8.4. All vehicles shall be fitted with audible reverse alarms and maintained in good working condition. Reversing shall be done only when there is adequate rear-view visibility or under the directions of a banksman.

4.8.5. **General operating procedures:** Drivers entering site shall be instructed to follow the safe system of work adopted on site. These shall be verbal instructions or, preferably, written instructions showing the relevant site rules, the site layout, delivery areas, speed limits, etc.

a) No passengers shall be carried, unless specific seating has been provided in accordance with the manufacturer's recommendations;

b) Working on gradients beyond any equipment's capability shall not be allowed.

c) Prevention of dumper and dump truck accidents should be managed by providing for adequate lateral clearances, wheel stops at a sufficient distance from the edgesof excavations, spoil heaps, pits, markers, etc.;

d) No construction material, other than soil shall be carried in excavator buckets;

e) When two or more scrapers are working on the same job, a minimum distance of at least 25m shall be kept between them;

f) Every contractor shall ensure that Competency certificate for driver/operatorsshall be issued by their Plant and Machinery In-charge. The certificate shall be pasted on the machine body in such a way that drivers/operator vision is nothindered;

g) Checklist shall be prepared for all construction machinery and be filled on daily basis by the operator and be counter signed by plant & machinery person;

h) Provision of helper is mandatory for each construction appliances and vehicles during their movement inside and outside of site; and

i) All wood working machines shall be fitted with suitable guards and devices such astop guard, riving knife, push stick, guards for drive belts and chains, and emergency stop switch easily accessible by the operator.

4.8.6. Failure to do any of the above shall attract penalty as per Clause 7. [Financial Deduction/Withholding].

4.9. Machine Guarding

4.9.1. The Contractor shall ensure at the site all motors, cog wheels, chains and friction gearing, fly wheels, shafting, dangerous and moving parts of machinery are securely fenced or legged.

4.9.2. Fencing of dangerous parts of machinery shall not be removed while the machinery is in use or in motion and when removed, it shall be replaced as soon as practicable and in any case before the machinery is again brought into use.

4.10. Site Electricity

4.10.1. The Contractor shall refer to the applicable guideline "Indian Electricity Rules, 1956" and any amendment thereafter. ESHS requirements are:

a) Graduate Electrical Engineer having Electrical Supervisory CompetencyCertificate;

b) Diploma Electrical Engineer having Electrical Supervisory Competency Certificate;

c) ITI Certificate Holder Electrician with Wiremen Permit; and

d) Assessment of Electrical Load and properly designed power distribution system;

4.10.2. The Contractor shall assess the size and location of the electrical loads and the manner in which they vary with time during the currency of the Contract.

4.10.3. The Contractor shall elaborate as to how the total supply is to be obtained/generated. The details of the source of electricity, earthing requirement, substation/panel boards, distribution system shall be prepared and necessary approval from the Engineer obtained before proceeding of the execution of the job.

4.10.4. The main Contractor shall take consideration, the requirements of the Subcontractors' electric power supply and arrive at the capacity of main source of power supply from diesel generators.

4.10.5. No electrical equipment shall be put into use where its strength and capability may be exceeded in such a way as may give rise to danger.

4.10.6. Adverse or Hazardous Environments:

a) Power supply from public utility service provider is preferable;

b) The Contractor shall provide sufficient ELCBs (maintain sensitivity 30 mA)/ Residual Current Circuit Breakers (RCCBs) for all the equipment (including Potable equipment), electrical switchboards, distribution panels etc. to prevent electrical shocks to the Workers;

c) Lightening Protection for all structures, gantry, metal portable cabins, silos etc; Lighting ought not to introduce the risk of electric shock. Therefore, 230V supplies should be used for those fittings, which are robustly installed, and well out of reach e.g. flood lighting or high-pressure discharge lamps;

d) No single insulation cable shall be used;

e) Cables shall be selected after full consideration of the condition to which they shall be exposed and the duties for which they are required. Supply cable up to 3.3 kV shall be in accordance with BS 6346:1997;

f) Cables buried directly in the ground shall be of a type incorporating Armor or metal sheath or both;

g) Cabling passing under the walk way and across way for transport and mobile equipment shall be laid in ducts at a minimum depth of 0.6 m;

h) The Contractor shall ensure plugs, socket-outlets, and couplers available in the Site as "splash EM proof" type. The minimum degree of Ingress Protection should be of IP44 in accordance with BS EN 60529;

i) Only plugs and fittings of the weather proof type shall be used and they should be colour coded in accordance with the Internationally recognised standards for example as detailed as follows:

    i) 110 volts: Yellow;

    ii) 240 volts: Blue;

    iii) 415 volts: Red.

j) No loose connections or tapped joints shall be allowed anywhere in the Site, office area, stores and other areas. Penalty as per Clause 7. [Financial Deduction/Withholding] shall be put in case of observation of any tapped joints;

k) All equipment shall have the provision for major switch/cut-off switch in the equipment itself;

l) Isolate exposed high-voltage (over 415 Volts) equipment, such as transformer banks, open switches, and similar equipment with exposed energized parts and prevent unauthorised access;

m) All temporary metal structures like barricade boards, temporary metal containers/shed etc. shall be adequately earthed through suitable means;

n) All the earth pits shall be properly numbered along with display of resistance value and inspection records of the same shall be maintained

4.10.7. Work on or near live conductors

No person shall be engaged in any work activity on or so near any live conductor (other than one suitably covered with insulating material so as to prevent danger) that danger may arise unless-

a) It is unreasonable in all the circumstances for it to be dead;

b) It is reasonable in all the circumstances for him to be at work on or near it while it is live; and

c) Suitable precautions (including where necessary the provision of suitable protective equipment) are taken to prevent injury.

4.10.8. Whenever pilling work is undertaken manually through tripod in the influence zone of live OHE, method statement shall be prepared, submitted and got approved before start of work.

4.10.9. All electrical equipment should be permanently numbered, and a record kept of the date of issue, date of last inspection and recommended inspection period.

4.10.10. Appropriate electrical protection shall be provided for all circuits, against over load, short circuit and earth fault current.

4.10.11. For supplies to mobile or transportable equipment where operating of the equipment subjects the cable to flexing, the cable shall conform to any of these codes BS 6007/BS 6500/BS 7375.

4.10.12. Flexible cords with a conductor cross sectional area smaller than 1.5 mm2 shall not be used and insulated flexible cable shall conform to BS 6500 and BS 7375.

4.10.13. Power Tools:

The Contractor shall ensure that:

a) Electric tools are properly grounded or/and double insulated;

b) Ground Fault Circuit Interrupters (GFCIs)/Residual Current Circuit Breakers (RCCBs) shall be used with all portable electric tool operated especially outdoors or in wet condition;

c) Only trained employees shall use explosive actuated tools and the tool shall also be

d) unloaded when not in use;

e) Usage of such explosive actuated tools shall be avoided in case of places where explosive/flammable vapours or gases may be present;

f) Explosive actuated tools and their explosives shall be stored separately and be taken out and loaded only before the time of immediate use; and

g) Misfired cartridges of explosive actuated tools must be placed in a container of water and be removed safely from the project.

4.11. Illumination

4.11.1. The Contractor shall provide sufficient site lighting, of the right type and at the right place for it to be properly effective as per the relevant national standards & guidelines.

4.12. Welding and Cutting

4.12.1. Gas cylinders in use shall be kept upright on a custom-built stand or trolley fitted with a bracket to accommodate the hoses and equipment or otherwise secured. The metal cap shall be kept in place to protect the valve when the cylinder is not connected for use.

4.12.2. Test Certificate for cylinders and Vendor license shall be obtained. Gas Cylinder Act & Rules shall always be followed at workplace.

4.12.3. All gas cylinders shall be fixed with pressure regulator and dial gauges. clamp or clip shall be used to connect hoses firmly in both sides of cylinders and torches.

4.12.4. Non-return valve and flashback arrester shall be fixed at both end of cylinder and torch.

4.12.5. Domestic LPG cylinders shall not be used for gas welding and cutting purpose.

4.12.6. Dry Chemical Pressure (DCP) or CO2 type Fire Extinguisher not less than 5 kg shall be fixed at or near to welding process zone in an easily accessible location. Fire extinguisher should confirm to IS 2190:1992.

4.12.7. Oxygen cylinders and flammable gas cylinders shall be stored separately, at least 6.6 m (20 feet) apart or separated by a fireproof, 1.5 m (5 feet) high partition. Flammable substances shall not be stored within 15m of cylinder storage areas.

4.12.8. Welding grounds and returns should be securely attached to the work by cable lugs, by clamps in the case of stranded conductors, or by bolts for strip conductors. The ground cable will not be attached to equipment or existing installations or apparatus.

4.12.9. All electrical installations shall meet the IS: 5571: 1997 and NFPA 70 for gas cylinder storage area and other hazardous areas.

4.12.10. Use firewatchers if there is a possibility of ignition unobserved by the operator (e.g. on the other side of bulkheads).

4.12.11. Transformer used for electrical arc welding shall be fixed with ammeter and voltmeter and fixed with separate main power switch.

4.12.12. Use a low voltage open circuit relay device if welding with alternating current in constricted or damp places.

4.12.13. The current for Electric arc welding shall not exceed 300 A on a hand welding operation.

4.13. Excavation General

4.13.1. References:

a) The Haryana Building and other construction workers (Regulation of Employment of conditions of Service) Rules, 2005;

b) IS: 3764 -1992 (Re-affirmed 1996): Code of Safety for Excavation Work;

c) IS: 4756 -1978 (Reaffirmed 1996): Safety Code for Tunnelling Work;

d) BS 6164: 2011 (Code of practice for health and safety in tunnelling in the construction industry);

e) BS EN 16191: 2014 (Tunnelling Machinery-Safety requirements);

f) IS 4081:2013 Blasting and related drilling operations-code of safety.

4.13.2. The Contractor shall ensure:

a) Where any construction & building worker engaged in excavation is exposed to hazard of falling or sliding material or article from any bank or side of such excavation which is more than 1.5 m above his footing, such worker shall be protected by adequate piling and bracing against such bank or side;

b) Undercutting during excavation shall be avoided. Whenever it is inescapable and banks of an excavation are undercut, adequate shoring is provided to support the material or article overhanging such bank;

c) Excavated material is not stored at least 0.65 m from the edge of an open excavation or trench and banks of such excavation or trench are stripped of loose rocks and the banks of such excavation or trench are stripped of loose rocks and other materials which may slide, roll or

fall upon a construction building worker working below such bank;

d) Metal ladders and staircases or ramps are provided, as the case may be, for safe access to and egress from excavation where, the depth of such excavation exceeds 1.5 m and such ladders, staircases or ramps comply with the IS 3696 Part 1&2 and other relevant national standards;

e) Trench and excavation is protected "against falling on a person by suitable measures if the depth of such trench or excavation exceeds 1.5m and such protection is an improved protection in accordance with the design and drawing ofa professional engineer, where such depth exceeds 4.0m;

4.13.3. Warning Signs and Notices:

The Contractor shall ensure that suitable warning signs or notices, required for the safety of workers carrying out the work of an excavation, shall be displayed or erected at conspicuous places in Hindi and in a language understood by most of such workers at such excavation work.

4.14. Tunnelling Works

4.14.1. The Contractor shall inform in writing to the Chief Inspector of Government of Haryana within 30 days, prior to the commencement of any tunnelling work.

4.14.2. The Contractor shall appoint a responsible person for safe operation for tunnelling work as per BOCWR.

4.14.3. In addition to general precaution such as display of warning sign/notices, deployment of trained staff, housekeeping, etc., the Contractor shall ensure that:

a) All portable electrical hand tools and inspection lamp used in underground and confined space at an excavation or tunnelling work is operated at a voltage not exceeding 24V;

b) Every compressed air system in a tunnel is provided with emergency power supply for maintained continued supply of compressed air ad per Rule 155 of BOCWR.

c) Only flame proof equipment of appropriate type as per IS: 5571:2000 and or another relevant national standard is used inside the tunnel;

d) Petrol or LPG of any other flammable substances are not used, stored inside the tunnel except with prior approval from the Engineer, and no oxy-acetylene gas is used in a compressed air environment in excavation or tunnelling;

e) Adequate number of water outlets provided for fire fighting purpose, an audible fire alarm and adequate number and types of fire extinguishers are provided and maintained;

f) Temperature in any working chamber in an excavation or tunnelling work where workers employed does not exceed 29°C as per Rule 165 of BOCWR;

g) All working areas in a free air tunnel are provided with ventilation system as approved by the Chief Inspector of Government of Haryana and the fresh air supplied in such tunnel is not less than 6 m3/min for each worker employed in tunnel and the free air flow movement inside such tunnel is not less than 9.0 m/min as per Rule 153 of BOCWR;

h) The oxygen level shall not be less than 19.5% in the working environment;

i) The excavated areas are made safe by use of suitably designed and installed steel sets, rock bolts or similar other means;

j) The responsible person referred to in BOCWR examines and inspects the workplaces in a tunnel before the commencement of work in such tunnel, and at regular intervals thereafter, to ensure safety of the Workers in such tunnel;

k) The portal areas of a tunnel with loose soil, or rock, likely to cause injury to a person are adequately protected with supports;

l) The Contractor shall ensure safe means of access to enter into tunnel.

m) The Contractor shall establish controlled Access/Egress system for the tunnel entry. Tally board system shall be adopted where any person entering the tunnel shall register his/her details before entering.

n) All life saving and fire fighting facilities shall be arranged in accordance with BS 6164 latest version.

o) The Contractor shall ensure continuous gas monitoring inside the tunnel before and after the blasting. Monitoring of the gas shall also be conducted with the help of hand held gas monitors. Such instrument shall be calibrated on regular basis.

p) The Contractor shall install emergency illumination (with battery backup) at an interval of not less than 15 m.

4.14.4. Means of Communication

The Contractor shall ensure that: reliable and effective means of communication such as telephone or walkie-talkie is provided and are maintained in working order for arranging better and effective communication at an excavation as per Rule 136 of BOCWR.

4.14.5. Permissible Limit of Exposure of Chemicals

The Contractor shall ensure that the responsible person referred to in BOCWR conducts necessary test before the commencement of a tunnelling work for the day and at suitable intervals as fixed by Chief Inspector to ensure that the permissible limits of exposure are not exceeded, and a record of such test is maintained and is made available for inspection to Chief Inspector, on demand.

4.14.6. Rock Fall Prevention (NATM)

The Contractor shall:

a) Draw up a method statement that includes preventive measure to fall of rock, tunnel face watching, evacuation methods from the face, and the construction sequence etc. to ensure that workers are informed.

4.14.7. Evacuation and Training

The Contractor shall ensure that:

a) Implementation of the training for evacuation and fire fighting immediately before the distance reaches about 100m from the portal to the tunnel face; and

b) Implementation of evacuation training by a responsible person appointed in terms of dealing with technical matters.

4.15. Blasting and Drilling

4.15.1. The following standards whichever is more stringent shall be applicable:

a) Safety Code for Blasting and Drilling operation IS 4081:2013;

b) Safety Code for tunnelling Work IS 4756-1978;

c) Code of practice for construction of tunnels IS 5878;

d) The Haryana BOCWR ; 2005 and Other Relevant National Legislations & ISCodes; and

e) Code of Practice for the safe use of explosives in the construction industryBS 5607:1988.

4.15.2. The Contractor shall ensure that all blasting operations will only be permitted following consultations with the relevant authorities and subsequent issuing of the permission to blast permits.

The Engineer must also give his consent in writing before any blasting operations take place.

4.15.3. The Contractor shall:

a) appoint the manager, the deputy manager and officer in charge of handling explosives to prevent handling accidents;

b) when doing blasting work, the Contractor shall appoint a work supervisor from among those who can take on the blasting work;

c) All blasting shall be conducted under the direct supervision of a Licensed Shot firer.

4.15.4. Handling of explosives- as per Rule 278 HBOCWR;

The Contractor shall ensure at a construction site of a building or other construction work that-

a) All explosives are handled, used or stored in accordance with the instructions and the material data sheet supplied by the manufacturer of such explosives;

b) The use of explosives is carried out in safe manner to avoid injury to any person and under the direct supervision of a responsible person;

c) Before using any explosive, necessary warning and danger signals are erected, at conspicuous places of such use to warn the building workers and the general public of the danger involved in such use.

d) Safety Precautions- as per Rule 279 of HBOCWR;

The Contactor shall ensure at a construction site of a building or other construction work that-

i) Notwithstanding the provisions of rule 278, the following precautions are observed at the places of transporting, handling, storage and use of such explosives, namely-

ii) Prohibition of smoking, naked lights and other sources of ignition in the vicinity where explosives are handled, stored and used;

iii) To keep safe distance and to use non-sparking tools while opening packages containing explosives;

iv) To stop the use of explosives and handling thereof while the weather conditions are not suitable for such use or handling.

v) In addition to the provisions of this chapter, all measures, and precautions

vi) required to be observed for use, handling, storing or transportation of explosives under the rule framed under the Explosives Act, 1884(4 of 1884), are observed.

4.15.5. Risk Assessment and Method Statements

The Contractor shall produce a detailed hazard and risk assessment and an in depth method statement for amongst others the following elements:

a) Type of explosives to be used;

b) Anticipated effects of vibration on nearby structures;

c) Blasting patterns;

d) Delivery of the explosives;

e) Transportation and storage of explosives on site;

f) Drilling and charging of holes;

g) Warning sirens;

h) Measurement of Vibration;

i) Use of blast screens;

j) Ventilation following blasting;

k) Atmosphere monitoring;

l) Procedure for miss-fires;

4.16. Material Transportation

4.16.1. The Contractor shall develop the System Procedure/Methods Statement for heavy/big material/machinery transportation such as Rolling Stock, Transformer, and Bridge Main Girder, etc.

4.16.2. The Contractor shall ensure that the person in charge should inspects the safety implementation like properly fixing of wire with vehicle slab bed, condition of vehicle breaks etc. before starting the job and record the accidents and records.

4.16.3. The Contractor shall ensure that every vehicle/moving machinery should have a signal man who has a whistle, a flag or a signal light (in the night) with striking clothes and stands at a safe visible place from a machine operator by means of the proper signal and way determined.

4.16.4. The induction related to moving and parking safely should be given to driver/operator like parking construction vehicles at a specified place with a parking brake and making sure to put a drag.

4.17. Foundation Works

4.17.1. The Contractor is required to evaluate the risk in each activity and suggest a control measures of piling works:

a) Covering of bore holes with adequate warning signs;

b) Cage to be lowered by using crane;

c) The auxiliary hook of the rig shall not be used to pull or lower the cage in bore hole;

d) The tremie pipe lowering and lifting after concreting shall be done by using crane;

e) Control measure to arrest polymer spillage from the Site to avoid contaminating the surface drains;

f) An entry restraining fence shall be provided around the pier excavation completion;

g) No man suffering from any chronic disease, alcoholic excess, ear or heart troubles or having a sluggish blood circulation or who has excess of fat should be employed as a diver;

4.18. Batching Plant and Casting Yard

4.18.1. The Contractor is required to evaluate the risk in each activity and suggest Control Measures:

a) Adequate space between the casting bed, segment storage area and the adjoining road shall be maintained so that a steel railing could be installed to segregate the gantry crane movement area from the road;

b) All safety precautions stated in Sub-Clause4.8[Construction Machinery], Automatic Safe Load Indicator (ASLI) for crane and gantry shall be complied during erection of gantry crane and other equipment;

c) The aggregate/sand storage area shall be kept under the full coverage of effective water sprinkler to avoid dust generation;

d) The entire batching plant/aggregate storage Area shall be adequately walled of sufficient height, above which the Contractor is required to erect green dust protective net. This is a mandatory requirement to avoid dust in surrounding environment;

e) The batching plant and casting yard required to obtain ''Consent to Establish'' and

f) ''Consent to Operate'' certificate from State Pollution Control Board;

g) The batching plant/casting yard shall be barricaded and made as a compulsory Personal Protective Equipment (PPE) zone;

h) Time office, canteen, drinking water, toilet and rest place shall be suitably located for the easy access to workers. All the facilities shall be properly cleaned and maintained during the entire period of operation;

i) Drainage shall be effectively provided, and waste water shall be disposed after proper treatment; and

j) Manual handling of cement shall be avoided. Whenever it is necessary the workmen shall be given full body protection, hand protection and respiratory protection as a basic measure of ensuring better health.

4.19. Form Works

Ensure no attaching equipment to the formwork assembly unless specifically designed for this purpose; and not using a stripping process which may cause damage to the permanent structure.

4.20. Concrete Works

a) Concrete pumping equipment, trucks etc. are not to be washed down on site and any waste-water, concrete slurry or other contaminants are to be contained; and

b) These contaminants are not to be discharged into or onto roadways, footpaths, gutters, drainage systems, watercourses or any other surface area that will result in damage to the environment or contravenes environmental legislation.

4.21. Pier Casting Works

a) Using crane to hold the pier reinforcement during the time gap between de-staging and placement of shutter; and

b) Location and pier height specific securing arrangement and specific Method Statement for pier more than 9.0 m shall be submitted and approved by the Engineer.

4.22. Bridge Erection Works

4.22.1. References:

a) The BOCW Acts and Rules;

b) The Haryana BOCW Rules 2005;

c) Indian Railways Bridge Manual; and

d) Safety Assessment with regard to Steel Bridge Erection Works 1985, Ministry of Health, Labour and Welfare;

4.22.2. General

As bridge erection works are one of the riskiest jobs, the Contractor shall take utmost precaution at all stages like; planning, establishing temporary yard, casting segments, transporting segments, fabrication and operation of erection machinery, if any, launching of segments/lifting of segments, pre-stressing, cutting and welding, auto (or manual) launching and dismantling of erection machineries. For pre-stressed concrete bridges, the Contractor shall further ensure that:

a) a responsible person should be appointed for post-tensioning works testing and inspection of tendon tensioning devices and using material;

b) installation of protective board behind a tensioning jack and keep out behind a jack during

tensioning;

c) use of protective glasses, laver gloves, and masks during grouting for safety of the Workers; and

d) fall prevention installation of overall boarding at the bottom of a bridge and installation of funnel type boarding at the side of a bridge during construction in case of RFO (Railway Flyover) or ROB (Road over Bridge) for preventing the flying and fall of materials and tools by safety net, should be ensured.

4.22.3. The Contractors Obligation

The Contractor shall prepare a comprehensive method statement for the bridge erection works, adhering to the ESHS conditions laid down herein. Particular reference shall be made to the provisions on working at height. As the entire process of launching/lifting has to be undertaken at the Site especially during night time, the safety of workers is of paramount important. Daily inspection of scaffold structure and mechanical equipment for the traveller crane should be done.

4.22.4. Basic Consideration under Site Condition:

Erection works over or adjacent roads or highways:

a) The work area should be demarcated properly, and route map and traffic management plan should be developed and implemented with proper signages and

b) caution;

c) The Contractor shall ensure the implementation of proper stop traffic and detour plan;

d) The Contractor shall arrange the proper guide and signs to be followed while working on highway or adjacent roads, railways; and

e) The Contractor should plan and establish all the required measures for the protection of overhead wires and buried utilities.

i) The regular inspection is done for all the installed protection equipment;

ii) The movement restriction site plan to be developed with defined operation path for safe working at site;

iii) watchmen should be appointed who are given training related to all type of traffic management and all signals used for smooth traffic flow and site transportation and works;

iv) The railway schedule is taken in consideration while planning the site works and ensures the safe management system with the details given regarding the kind of works suspended while a train is passing and clarifying the way of opening or closing railway in case of track closure works. For steel truss bridges;

v) The Contractor must install the protective net just after erecting truss upper chord material;

vi) The Contractor must install safety operation path to an end of erected member and a cross point of lateral bracing;

The Contractor may use any of the erection methods. However, following general points will be kept in view and ensured as applicable-

A. The Contractor should develop and confirm the Engineer his Method Statement with details of position of bearing, jacking operation, roller passing etc.;

B. Detailed inspection report related to the movement and condition of superstructure from the place of launching equipment and rollers should be given to the Engineer;

C. The Contractor shall give confirmation of binding situation such as a bolting erection member;

D. The Contractor shall give confirmation of displacement per every erection phase;

E. The Contractor shall give confirmation of fixing situation for bearings;

F. The Contractor must take measures to avoid a fall and lateral buckling of member; and

G. The Contractor shall take measures of fall prevention for main superstructure.

4.23. Building and Roof Erection Works

4.23.1. The Contractor shall plan erection sequence and work procedures properly under competent and experienced personnel to ensure the safety of workers and prevent structure failure during erection:

a) Contractor shall develop and confirm with the Engineer his method statement with details;

b) The stability of structural members is to be ensured by means of ties, braces, anchor/fixing bolts, or other suitable means before releasing lifting gear, slings, chains etc;

c) Tag lines must be attached to the ends of components/loads to maintain control during crane lifting operations;

d) Structure stability is to be ensured always. Unattended and incomplete buildings/structures are NOT to be left in an unsafe and hazardous condition, to pose a risk to the safety and health of site personnel or the public;

e) The Workers placing and securing roof battens are to be protected and are to work from an enclosed environment (e.g. scaffolding, deck guardrail or equivalent) and work up from the bottom of the truss/rafter towards and finish at the ridge /peak of the roof framing; and

f) When the spacing of trusses and roof battens exceed 600mm the appropriate procedures are to be considered and applied after conducting a risk assessment to provide the optimum fall protection.

4.24. Overhead Contact Wire Works

4.24.1. During starting of works using rack vehicle/moving scaffold/ladder/insulation tower/step ladder, etc., the Contractor's operation in charge shall confirm as follows:

a) The work sequence shall be determined while using Ariel Track vehicle. Communication system between drivers and conductors shall be developed and adopted;

b) A deck which must be used by workers, shall have enough capacity of carry necessary loads for work at a high place with a pre-operation inspection;

c) The workers shall be given the safety protection equipment which has enough capacity to hold necessary loads to prevent any accidental fall with a pre-operation inspection;

d) State of electrical equipment installation and a route of going up and down from ground;

e) The Worker is given required training for electrical works at height and the Worker must use a safety rope, an auxiliary rope, a fall prevention equipment such as a rolip which is a fall arrest device for a fixed rope when they work at high place;

f) The Worker shall fix the grip of an auxiliary ropes at the upper position of their safety ropes and uses special wires or a lift when delivering materials and tools from ground to high place;

g) The Contractor shall ensure that no one lean out of the rail of the track vehicles, or take a foot on the rail; and Shall take all the precautions for self-propellant or roll prevention when bringing the track vehicle to a stop;

h) The installation of medium rail at the place where handrail is more than 85cm high;

i) The training is given to all, for putting on a foot brake when bringing the rolling tower to a stop or working on the deck of the rolling tower suspended;

j) Putting on a foot brake and fixing the insulation tower by an assistant when bringing the insulation tower to a stop or working on its suspension;

4.24.2. While going up and down along an Electric Pole, Power Pylon or a High Steel Structure or working above it, the Contractor shall ensure the safety precautions mentioned below:

a) Use of a safety rope, an auxiliary rope and a fall prevention equipment with using an exclusive scaffold when going up and down along the electric pole;

b) Use of an escort rail, or both a Full Body Harness and an auxiliary rope when going up and down along the power pylon or the high steel structure;

c) While working on a Beam, the Contractor shall ensure the safety precautions mentioned below:

i. Use of a horizontal rope on working consecutively on the beam or painting the beam surface without an auxiliary rope; and

ii. Use of a safety rope and an auxiliary rope when moving on the beam under unavoidable circumstances.

4.25. Locomotives and Wagons

4.25.1. Speed limit is determined, and traffic signs of speed limits, lights and related hazards signage and cautions shall be installed at work place.

4.25.2. Person in charge shall be nominated as maintenance officer to inspect and repair temporary rails or track surface situation regularly.

4.25.3. Ensure the installation of an alarm device such as a horn and a buzzer, a head light, and a flood light for the driver's seat.

4.25.4. Training and education shall be given to the driver and the signal man regarding how to send standard signal and operate vehicle diagram and turning off and putting on the brakes while the driver leaves his seat. And making sure to set wheel stoppers when stopping or parking at the slope track.

4.25.5. Each locomotive shall carry an extinguisher for fires

4.26. Confined Space Entry

4.26.1. The Contractor must ensure all confined spaces are identified and managed using documented site confined space management methods.

4.26.2. When internal combustion engines are to be used into confined space or excavation or any other workplace where natural or artificial ventilation system is inadequate to keep carbon monoxide below 50ppm, exposure of workers shall be avoided unless suitable measures are taken and provided by the Contractor.

4.26.3. No worker shall be allowed into any confined space or tank or trench or excavation wherein there is given off any dust, fumes/vapours or other impurities which is likely to be injurious or offensive, explosive or poisonous or noxious or gaseous material or other harmful articles unless steps are carried out by the Contractor and certified by the responsible person to be safe.

4.27. Fire Protection

4.27.1. The contractor shall ensure that the construction site is provided with—

a) Fire extinguishing equipment sufficient to extinguish any probable fire at such construction site;

b) An adequate water supply at ample pressure as per national standards;

c) Number of trained persons required to operate the fire extinguishing equipment provided; and

d) Is properly maintained and inspected at regular intervals of not less than once in a year by the responsible person and a record of such inspections is maintained.

4.27.2. The extinguishers shall be chosen as per type of fire load and surrounding location.

4.27.3. All construction machinery including crane shall carry a portable fire extinguisher in operator's cabin.

4.27.4. Emergency plan and Fire Evacuation plan in ESHS Management Plan shall be prepared and issued by the Contractor. Mock drills should be held on a monthly basis to ensure the effectiveness of the arrangements and as a part of the programme, the telephone number of the local fire brigade should be prominently displayed near each telephone on site.

4.27.5. Recharging of fire extinguishers and their proper maintenance should be ensured and as a minimum should meet Indian National Standards.

4.27.6. All drivers of vehicles, foreman, supervisors and managers shall be trained on operating the fire extinguishers and firefighting equipment.

4.28. Corrosive Substance

As per Rule 100 of HBOCWR, The contractor shall ensure that corrosive substances, including alkalis and acids, shall be stored and used by a person dealing with such substances at a building or other construction work in such a manner that it does not endanger the building worker and suitable protective equipment shall be provided by the contractor to a building worker during handling or use of such substances at a building or other construction work and in case of spillage of such substances on the building worker, immediate remedial measures shall be taken by the contractor.

4.29. Demolition

4.29.1. All demolition works be carried out in a controlled manner under the management of experienced and competent supervision.

4.29.2. The concerned department of the Government or local authority is informed, and permission obtained wherever required. Media shall also be informed regarding this concern.

4.29.3. All glass or similar materials or articles in exterior openings are removed before commencing any demolition work and all water, steam, electric; gas and other similar supply lines are disconnected.

4.29.4. No demolition work be performed if the adjacent structure seems to be unsafe unless and until remedial measures life sheet piling, shoring, bracing or similar means be ensured for safety and stability for adjacent structure from collapsing.

4.29.5. Debris/bricks and other materials or articles shall be removed by means of chute, bucket or other safe method.

4.29.6. No person other than the Workers or other persons essential to the operation of demolition work shall be permitted to enter a zone of demolition and the area be provided with substantial barricades.

4.30. Permit to Work

4.30.1. The Contractor shall develop work permit system, which is formal written system used to control certain types of work that are potentially hazardous. A work permit is a document, which specifies the work to be done, and the precautions to be taken.

4.30.2. Work Permits form an essential part of safe systems of work for many construction activities. They allow work to start only after safe procedures have been defined and they provide a clear record that all foreseeable hazards have been considered. Permits to Work are usually required in high-risk areas as identified by the Risk Assessments.

4.30.3. A permit is needed when construction work can only be carried out if normal safeguards are dropped or when new hazards are introduced by the work.

4.30.4. Examples of high-risk activities include but are not limited to:

a) Entry into confined spaces;

b) Hot work;

c) To dig where underground services may be located;

d) Work with heavy moving machinery;

e) Work with radioactive isotopes;

f) Heavy lifting operations and lifting operations closer to live electric power line;

g) Work with using track motor vehicles etc.; and

h) Work under electric facility and overhead electric (OHE) line energized.

4.30.5. The Contractor shall prepare operation manuals above mention and implement training course at any time based on such manuals to the Workers given completion of certificates before the commencement of works.

4.30.6. The permit-to-work system should be fully documented, laying down:

a) How the system works;

b) The jobs it is to be used for;

c) The responsibilities and training of those involved; and

d) How to check its operation.

4.30.7. A work permit authorization form shall be completed with the maximum duration period not exceeding 12 hours or end of shift, which is earlier.

4.30.8. A copy of each permit to work shall be displayed at work place. during its validity, in a conspicuous location in close proximity to the actual works location to which it applies.

4.31. Traffic Management and Site Barricading

4.31.1. The basic objective of the following guiding principles is to lay down procedures to be adopted by the Contractor to ensure the safe and efficient movement of traffic and also to ensure the safety of workmen in the all work areas.

4.31.2. The guiding principles to be adopted for safety in construction zone are to:

a) Warn the road user clearly and sufficiently in advance;

b) Provide safe and clearly marked lanes for guiding road users;

c) Provide adequate traffic marshals to regulate the movement of traffic;

d) Provide safe and clearly marked buffer and work zones; and

e) Provide adequate measures that control driver behaviour through construction zones.

4.31.3. In all cases, the Contractor shall employ proper precautions. Wherever operations undertaken are likely to interfere with public traffic, Specific Traffic Management Plans shall be drawn up and implemented by the Contractor in consultation with the approval of Local Police Authorities and/or the concerned politburo/Civil Authorities and followed to the IRC:SP;55- 2014 (Guidelines on Traffic Management in work zones) & IRC: 67 (Code of Practice for Road Signs).

4.32. Working near Railway

4.32.1. The details of Safe work procedure for work near Railway Track is given in **Attachment -5** of this document.

4.33. Other Works to be Scrutinized

4.33.1. Other works including, but not be limited to, the works in the Site (the ROW), the works in the Borrow Pit, the works in the Quarry and Works on road shall be included to be scrutinised with

respect to the accident prevention.

4.33.2. If blasting is anticipated in excavation in rock, preventive measures against accidents and protective measures against environmental/social impacts shall be of paramount importance.

4.33.3. The Contractor shall include all those items as well as work elements to formulate the preventive and protective measures considering envisaged conditions, situations, and activities of the works which may induce accidents or hazard to environment and/or society.

4.34. Personal Protective Equipment

4.34.1. The Contractor shall provide required PPEs to workmen to protect against safety and/or health hazards. Primarily PPEs are required for the following protection:

a) Head protection (Safety helmet with a chin strap);

b) Foot protection (Safety footwear, Gumboot, etc.);

c) Body protection (High visibility clothing (Waistcoat/Jacket), Apron, etc.);

d) Personal fall protection (Full body harness, Rope-grip fall arrester, etc.);

e) Eye protection (Goggles, Welders Glasses, etc.);

f) Hand protection (Gloves, Finger coat, etc.);

g) Respiratory protection. (Nose mask, Self-contained breathing apparatus, etc.); and

h) Hearing protection (Ear plugs, Ear muffs, etc.).

4.34.2. The PPEs and safety appliances provided by the Contractor shall be of the standard as prescribed by Bureau of Indian Standards (BIS). If materials conforming to BIS standards are not available, the Contractor as approved by the Engineer shall procure PPE and safety appliances.

4.34.3. The Contractor shall provide the PPEs which the Contractor deems necessary including; but not be limited to, safety helmets, safety shoes to all the Contractor's Employees including workmen (including those of its sub-contractors). When and Where the Contractor thinks that he needs to provide the Contractor's Employees including workmen' (including those of its sub-contractors) with high visibility clothing as per the following requirement.

a) Hi-visibility jacket covering upper body and meeting the following requirements as per BS EN 471:1994;

b) Background in fluorescent orange-red in colour;

c) Jackets with full-length sleeves with two bands of retro reflective material, which shall be placed at the same height on the garment as those of the torso. The upper band shall encircle the upper part of the sleeves between the elbow and the shoulder; the bottom of the lower band shall not be less than 5cm from the bottom of the sleeve;

d) Two vertical green strips of 5cm wide on front side, covering the torso at least 500 cm2;

e) Two diagonal strips of 5 cm wide on back in an 'X' pattern covering at least 570cm2;

f) Horizontal strips not less than 5cm wide running around the bottom of the vertical strip in front and 'X' pattern at back;

g) The bottom strip shall be at a distance of 5cm from the bottom of the vest; and

h) viii) Strips shall be retro reflective and fluorescent.

Safety Helmet Colour Code (Every Helmet should have the LOGO*affixed/painted)	Person to use
Hard hat with company Logo (Employees)	Hard hat with reflective tape (Marshals)
White	Employer/Engineer
Grey	All designers, Architect, Consultants, etc.
Violet	Main Contractors (Engineers/Supervisors)
Blue	All subcontractors (Engineers/Supervisors)
Red	Electricians (Both Contractor andSubcontractor)
Green	Safety professionals (Both Contractor and Subcontractor)
Orange	Security guards/Traffic marshals
Yellow	All workmen
White (with "VISITOR" sticker)	Visitors
Safety Shoes (Anyone at the Site incl. Marshals)	
All employees of the contractor including workmen	Traffic marshals

Note: LOGO·

a) Logo shall have its outer dimension 2"X2" and shall be conspicuous
ii) Logo shall be either painted or affixed
iii) No words shall come either on Top / Bottom of Logo

Logo of the corresponding main contracting company for their employees and sub-contracting company for their employees shall only be used.

4.34.4. In addition to the above any other PPEs required for any specific jobs like, welding and cutting, working at height, tunnelling etc. shall also be provided to all workmen and also ensure that all workmen use the PPEs properly while on the job.

4.34.5. The Contactor shall not pay any cash amount in lieu of PPEs to the workers/sub- contractors and expect them to buy and use during work.

4.34.6. The Contactor shall at all-time maintain a minimum of 10% spare PPEs and safety appliances and properly record and show to the Engineer during the inspections. Failing to do so shall invite penalty as per Clause 7. [Financial Deduction/Withholding].

4.34.7. It is always the duty of the Contactor to provide required PPEs for all visitors. Towards this required quantity of PPEs shall be kept always at the security post.

4.34.8. The Contractor shall ensure that safety equipment and protective clothing is available and used on the site at all material times and those measures for the effective enforcement of proper utilisation and necessary replacement of such equipment and clothing shall be incorporated into the Site ESHS Plan.

4.35. Visitor at Site

4.35.1. No visitor can enter the Site without the permission. All authorised visitors should report at the site office. The Contractor shall provide visitor's helmet (White helmet with visitor sticker) and other PPEs like Safety Shoe, reflective jacket, respiratory protection etc. as per requirement of the Site. Entry of visitors in underground shall be suitably controlled.

4.35.2. The Contractor shall be fully responsible for safety and health of all visitors within the Site.

4.36. Site Security

4.36.1. The Contractor shall be wholly responsible for security on the Site and any other areas being used by him or the Subcontractor's for the purposes of the Contract. The Contractor shall implement and cause the Subcontractor's to implement proper security management procedures in accordance with the approved ESHS Management Plan.

4.36.2. The Contractor shall assign on the Site a security officer (adequately trained person,) and his alternate(s), who shall be primarily responsible for the Contractor's security services and fully cooperate with the Engineer's security organization throughout the Time for Completion. Necessary approval of agency shall be obtained from the Engineer.

4.36.3. The security plan covered by the ESHS Management Plan shall contain the following:

a) Security policy statement and objectives;

b) The Contractor's security organization;

c) Role, responsibility and authority of each member of the security organization;

d) Procedure for enforcement of security regulations;

e) Daily, weekly and monthly security meeting procedures;

f) Sample forms for security reports;

g) Personnel security control procedures;

h) Goods security control procedures;

i) On-site security patrol procedures;

j) Liaison and coordination procedure with local fire/police and other authorities;

k) Liaison and coordination procedure with the Employer and relevant other authorities; and

l) Liaison, coordination and joint security inspection procedure with other Contractors.

4.36.4. Where necessary, the Contractor shall install, modify, maintain and remove the temporary security fences, gates, posts, security lightings and other facilities required for proper security control, in addition to those to be constructed as part of the Works. The Contractor shall operate these facilities to properly control ingress to and egress from the areas under his control throughout the Time for Completion. This control shall apply to every person including the Employer's Personnel.

5. OCCUPATIONAL HEALTH AND WELFARE

5.1. Physical Fitness of Workmen

5.1.1. The Contractor shall ensure that his employees/workers subject themselves to such medical examination as required under the law or under the contract provision and keep a record of the same.

5.1.2. The Contractor shall not permit any employee/workers to enter the work area under the influence of alcohol or any drugs.

5.1.3. The Contractor shall maintain the confidential records of medical examination or the physician authorized by the Engineer.

5.1.4. No worker is charged for the medical examination and the cost of such examination is borne by the Contactor employing such worker.

5.1.5. If the Contractor fails to get the medical examination conducted as mentioned above, the Engineer will have the right to get the same conducted through an agency with intimation to the Contractor and deduct the cost and overhead charges from his dues.

5.2. Medical Facilities

5.2.1. Occupational Health Centre (First Aid Station)

The Contractor shall ensure at a construction site an occupational health centre, mobile or static is provided and maintained in good order. Services and facilities as per the scale lay down in Schedule IV of HBOCWR. A construction medical officer appointed in an occupational health centre, possess the qualification as laid down in Schedule V Rule no 113 of HBOCWR:

5.2.2. The Contractor shall appoint appropriate full-time staff including one nurse, one dresser- cum-compounder, one sweeper-cum-ward boy with each construction medical officer.

5.2.3. The Contractor shall communicate the complete details including name, qualification and experience of the construction medical officer, to the inspector having jurisdiction under HBOCWR.

5.2.4. Ambulance Room, Ambulance Van and Stretchers:

The Contractor shall ensure at a construction site of a building or other construction work that an ambulance van and room are provided at such construction site or an arrangement is made with a nearby hospital for providing such ambulance van for

transportation of serious cases of accident or sickness of workers to hospital promptly and such ambulance van and room are maintained in good repair and is equipped with standard facilities specified in Schedule VI of Rule 114 & Schedule VII of Rule 115 of HBOCWR.

5.2.5. The Contractor shall provide enough stretchers at each site for use in an emergency.

5.2.6. First Aid Boxes and Emergency Care:

The Contractor shall ensure at construction site one First-aid box for 100 workers for providing first-aid to the workers. Every First-Aid box is distinctly marked "First-Aid" and is equipped with the articles specified in Schedule IX of Rule 119 of HBOCWR. Adequate no. of trained first aid persons shall be available at each work site in each shift.

5.2.7. HIV/AIDS Prevention and Control:

a) The Contractor shall adopt the Employer's "Workplace Policy on HIV/AIDS Prevention and Control for Workers Engaged by Contractors" and implement it. A copy of the policy is given in **Attachment-2 [Workplace Policy on HIV/AIDS Prevention & Control]**; and

b) The Contractor shall prepare and submit the Manual for HIV/AIDS Prevention and Control for his workers in terms of the aforesaid Employer's Policy within 28 days of the date of notification of the Contract.

c) The Contractor shall organize awareness program for labourers on the risks of AIDS and STDs in coordination with Haryana State AIDS Control society.

5.2.8. COVID -19 Prevention and Control

The Contractor shall ensure that the latest guidelines issued by Ministry of Health and Family Welfare (MoHFW), local government and the district administration are strictly followed at the construction works site. The Workplace Policy on COVID-19 Prevention and Control is given in **Attachment-3 [Workplace Policy on COVID-19 Response].** The Contractor shall undertake a COVID-19 risk assessment of project area and prepare and submit COVID-19 Response and Management Plan.

5.2.9. Prevention of Mosquito Breeding

Measures shall be taken to prevent mosquito breeding on the Site. The measures to be taken shall include:

a) Empty cans, oil drums, packing and other receptacles, which may retain water, shall be deposited at a central collection point and shall be removed from the site regularly;

b) Stagnant water shall be treated at least once every week with oil to prevent mosquito breeding;

c) The Contractor's equipment and other items on the site, which may retain water, shall be stored, covered, or treated in such a manner that water could not be retained; and

d) Water storage tanks shall be provided.

5.2.10. Posters in local language, Hindi and English, which draw attention to the dangers of permitting mosquito breeding, shall be displayed prominently on the Site.

5.2.11. The Contactor at periodic interval shall arrange to prevent mosquito breeding by fumigation/spraying of insecticides, and the ideal larvicide etc.

5.2.12. Alcohol, Smoking and Drugs

The Contactor shall always ensure that no employee is working under the influence of alcohol/drugs which are punishable under BOCWR;

Smoking at public places by any employee is also prohibited as per Government Regulations. The Contractor shall comply with the legal provisions in this regard, such as; Prohibition of Smoking in Public Places Rules, 2008. He shall be solely responsible for any penalty or punitive action by the government authorities because violations of the provisions contained in these rules by him or his representatives or his employees or his Subcontractors. Requisite notice boards, posters, etc., shall be put by him, as per the Rules.

5.3. Occupational Noise

5.3.1. The Contractor shall comply with the codes, regulations and standards regarding noise pollution and control as notified and amended by Central Government and State Government from time to time on the Site including but not necessarily limited to:

a) Chapter VII, Part -I, Schedule-I of Haryana BOCWR 2005;

b) Noise Pollution (Regulation and Control) Rules, 2000;

c) Environment (Protection) Act, 1986;

d) Environment (Protection) Amendment Rules, 2000; and

e) Central Motor Vehicles Rules, 1989;

f) Notification on Control of Noise from DG Sets, 2002.

5.4. Welfare Measures for Workers

5.4.1. Latrine and Urinal Accommodation:

a) Latrine and urinals shall be provided as per Chapter VI, Part – II of Rule 80 of Haryana BOCWR and shall also comply with the requirements of public health authorities; and

b) When women are employed, separate latrine and urinals accommodation shall be provided.

5.4.2. Moving Sites:

a) In case of works like track laying, the zone of work is constantly moving. In such cases, mobile toilets with proper facility to drain the sludge shall be provided at reasonably accessible distance; and

b) In case the Contactor fails to provide required number of urinals and latrines or fails to maintain it as per the requirements of Public Health Laws, the Engineer shall have the right to provide/maintain through renowned external agencies at the cost of the Contactor.

5.4.3. **Canteen**

In every workplace wherein not less than 250 workers are employed, the Contractor shall provide an adequate canteen conforming to Chapter VI, Part – II of Rule 81 of Haryana BOCWR

5.4.4. **Drinking Water.**

As per Section 32 of BOCWA, the Contractor shall make in every site, effective arrangements to provide sufficient supply of wholesome drinking water. Quality of the drinking water shall conform to the requirements of national standards on Public Health Laws. While locating these drinking water facilities due care shall be taken so that these are easily accessible from the place of work for all workers at all location of the Site. All such points shall be legible marked "Drinking Water" in a language understood by most of the workmen employed.

5.4.5. **Crèche**

In every workplace where in more than 50 female workers are ordinarily employed, there shall be provided and maintained a suitable room for use of children under age of 6 years, conforming to the provisions of Section 35 of BOCWA.

5.4.6. Labour Accommodation Camps

Labour camp management plan shall be prepared and approved by Engineer. Where workers are based some distance from their normal place of residence, the Contractor shall provide them with suitable and safe accommodation free of charge and shall take all necessary precautions to protect their health and welfare. The accommodation shall conform to the requirements of Section 34 of BOCWA and include but not be limited to the further measures specified hereunder.

5.4.7. All accommodation camps shall be provided always with a sufficient supply of clean drinking water (of potable quality according to national legal standards), in suitable and easily accessible locations:

5.4.8. The quality of drinking water shall be tested once a fortnight as prescribed in IS 10500:2012and immediate remedial action shall be taken if quality falls below the standard. Test results shall be provided to the Engineer at least monthly.

5.4.9. The Contractor shall provide all accommodation camps with clean and properly equipped and staffed kitchen and canteen facilities to supply meals for workers.

5.4.10. The Contractor shall provide sufficient toilet and bathroom facilities for the numbers of workers accommodated in each camp. Separate accommodation and toilet/bathroom facilities shall be provided for men and women and all facilities shall be kept in full working order always and cleaned and re-equipped daily.

5.4.11. The Contractor shall provide a laundry facility at the Labour Accommodation Camps.

6. ENVIRONMENT AND SOCIAL MANAGEMENT

6.1. General Conduct of the Works

6.1.1. The purpose and objective of these guidelines is to outline how the project will avoid, minimise or mitigate effects on the environment and surrounding area. These guidelines detail the implementation of measures in accordance with environmental and social commitments of HRIDC. These guidelines will be 'live' guidelines that will be reviewed and updated at regular intervals throughout the project life cycle. These guidelines will ensure that the development is compliant with current Environmental and Social legislations and will guide and assist the Contractor in exploring all reasonable and feasible means for reducing construction related Environmental and Social impacts.

6.1.2. The Contractor shall comply with the Environment and Social Management Plan (ESMP) given in the Environmental and Social Impact Assessment (ESIA) report available on HRIDC portal for information disclosure and will note and implement any requirements therein, in addition to those found in this specification.

6.1.3. The Contractor is required to build good public relations before the commencement of the Works particularly with the local level representatives such as the Gram Panchayat, by informing the expected impacts by the Works and their schedule and dispute resolution mechanism known as GRM set by the Employer.

6.2. Environmental Legislation

6.2.1. The Contractor shall always comply with all relevant National and State legislations regarding environmental protection, pollution prevention and control, waste management and other relevant environmental matters, including but not necessarily limited to, the following with their latest amendments:

a) The Environment (Protection) Act, 1986 and Rules 1986

b) The Indian Wildlife (Protection) Act, 1972;

c) The Forest (Conservation) Act, 1980 &Rules;

d) Punjab Land Preservation Act, 1900;

e) The Noise Pollution (Regulation and Control) Rules, 2000;

f) Notification on Control of Noise from Diesel Generator (DG) sets, 2002;

g) The Air (Prevention and Control of Pollution) Act, 1981and Rules 1981;

h) The Water (Prevention and Control of Pollution) Act, 1974 and Rules 1974;

i) Guidelines to control and regulate ground water extraction in India, 24th September2020, Central Ground Water Authority;

j) The Solid Management Rules, 2016;

k) The Construction and Demolition Waste Management Rules, 2016;

l) The Hazardous and Other Wastes (Management and Transboundary Movement)Rules, 2016;

m) The Bio-medical Waste Management Rules, 2016;

n) Plastic Waste Management Rules, 2016;

o) E-Waste (Management) Rules 2016;

p) The Batteries (Management and Handling) Rules, 2001;

q) Manufacture, Storage, and Import of Hazardous Chemical (Amendment) Rules,1989;

r) Ancient Monuments and Archaeological Sites and Remains (Amendment andValidation) Act 2010;

s) Fly ash utilization notification, Sept 1999;

t) Applicable NGT Guidelines issued time to time; and

u) Provisions of Graded Response Action Plan notified by the MoEFCC.

6.2.2. The Contractor shall comply the Environmental and Social Framework (ESF) of Asian Infrastructure Investment Bank (AIIB) February 2016.

6.2.3. If the requirements stated in this document are in conflict or inconsistent with the requirements of applicable laws, the more stringent requirements shall apply.

6.2.4. It is also the Contractor's responsibility to obtain all environment clearances, official approvals, consents, or other authorizations as may be necessary to comply with the relevant statutes, and to pay all related fees and other costs. The Contractor shall obtain all authorizations in a timely manner and submit to the Engineer as the evidence for the regulatory obligations before commencement of any related construction activity. The indicative clearances/permission/permit are presented in Table below and Contractor is required to take any other clearance as required for its construction activities.

Clearance/ Permission/Permit	**Relevant Acts/Rules**	**Concerned Agency**
Consent to Establish and Consent to Operate batching plants and casting yards	• The Water (Prevention and Control of Pollution) Act, 1974, and its amendments; • The Air (Prevention and Control of Pollution) Act 1981 and its amendments	Haryana Pollution Control Board
Authorization for generation, handling, storage, and transportation of hazardous waste	Hazardous and other Wastes (Management & Transboundary Movement) Rules, 2016	Haryana Pollution Control Board
Permission for extraction of ground water	Central Ground Water Authority guidelines to regulate and control ground water extraction in India, 24th September, 2020	Central Ground Water Authority
Pollution Under Control Certificate	Central Motor and Vehicle Act 1998 Vehicular Exhaust Norms, CPCB 2007	Department of Transport, Government of Haryana
Construction and Demolition Waste Management Plan	Construction & Demolition Waste Management Rules, 2016	Local Authority (Municipal Corporation)
Deleted	*Deleted*	*Deleted*

6.3. Environmentally Friendly Construction Practices

6.3.1. Containment of Air Pollution

a) All construction equipment's should be cleaned of visible dirt/mud before exiting the construction sites and streets shall be promptly cleaned by manual sweeping, or by deploying electro – mechanical devices if such material has been dropped;

b) The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction depots and batching plants. This facility will be provided with efficient drainage, water re-circulation apparatus and silt traps to prevent any excessive buildup of water. Where wheel-washing facility is not possible, the Contractor shall ensure manual cleaning of wheels by wire brushes or similar suitable means;

c) The Contractor shall ensure that vehicles shall have properly fitted side and tailboards. No open load carrying vehicle shall be used for moving potentially dust-producing materials and dust potential material shall not be loaded to a level higher than the side and tail boards, and shall be fitted with cover lids or tarpaulin covers;

d) The Contractor shall place excavated materials in the dumping/disposal areas with suitable slopes designated in the drawings;

e) The Contractor shall place material in a manner that will minimise dust production. Material shall be stabilized each day by watering or other accepted dust suppression techniques;

f) Materials should not be dropped from more than 1.5 m to limit fugitive dust generation;

g) During dry weather especially on windy, water sprinkling must be used daily at every two hours intervals or at any time that it is required for dust control to prevent any dust from blowing and causing nuisance.

h) The Contractor shall provide storage facilities at each construction site in the form of closed containers/bins or wind protected shelters or mat covering or walled or any combination of the above to the satisfaction of the Engineer.;

i) Stockpiles of sand and aggregate greater than 20m3 for use in concrete manufacture shall be enclosed on three sides, with walls extending above the stockpile and two (2) metres beyond the front of the stockpile;

j) Areas within the Site such as construction depots and batching plants, where there is a regular movement of vehicles shall have an approved hard surface that is kept clear of loose surface material;

k) Unless the Engineer has given notice otherwise, the Contractor shall restrict all motorised vehicles on the Site to a maximum speed of 15 kilometers per hour and confine haulage and delivery vehicles to the designated roadways inside the site;

l) The Contractor shall erect hoardings as specified in Engineer requirements securely around all construction work sites during the main construction activity, to contain dust within the site area and also to reduce air turbulence caused by passing traffic. The hoarding shall be safely secured to the ground to prevent from toppling with minimum gap between the base of hoarding and ground surface.

m) Water spray should be used to control dust during breaking of rock/concrete;

n) During tunnel construction the Contractor shall monitor dusts concentration, wind velocity, air capacity of ventilation system every month and will keep monitoring record including date, method, location, condition, results, and evaluation of results.

o) The contractor shall take all necessary actions to control air pollution as per guidelines issued by the commission for Air Quality Management in National Capital Region time to time.

p) The contractor shall take necessary actions as per the provisions of Graded Response Action Plan (GRAP) issued time to time.

6.3.2. **Containment of Water Pollution**

a) List of sources (surface/ground) to be provided for approval from Engineer;

b) Prior to use of source, written permission to be obtained from authority to use the water in construction activity, and submit a copy to Engineer;

c) During construction only permitted quantity (permission taken) from approved sources to be used in construction activity;

d) A Drainage system should be constructed during the commencement of the works, drain off all surface water at the site into suitable drains;

e) At construction depots and batching plants temporary drainage works should be maintained, removed, and reinstated as necessary and all other necessary precautions should be taken for avoidance of damage by flooding and silt;

f) The Contractor shall provide a hard surface with suitable drainage system for Transit Mixture washing at Casting Yard and/or Batching plant. The slurry water from Transit Mixture washing area shall go to sedimentation tank of suitable capacity to treat the slurry water. The contractor shall ensure the facility remains functional till the end of the contract;

g) The Contractor shall take measures to prevent discharge of oil on land and in water bodies. Oil separator/interceptors shall be provided at Batching Plant and Construction Depot location for vehicle maintenance to prevent the release of oils and grease into the drainage system. These shall be cleaned on a regular basis;

h) Open stockpiles of construction materials (e.g. aggregates, sand and fill material) should be covered with tarpaulin or similar fabric during rainy season or at any time of the year when rainstorms are likely. Washout of construction or excavated materials should be diverted to drainage system through appropriate sediment traps;

i) Rainwater pumped out from trenches or foundation excavation should be discharged into storm water drains after obtaining notice of no objection from the Agency controlling the system;

j) The Contractor shall prevent soil particles and debris from entering the wells or water discharge points by use of filters and sedimentation basins as required;

k) The Contractor shall always ensure that all existing stream courses and drains within, and adjacent to the site are kept safe and free from any debris and any excavated materials arising from the Works;

l) The Contractor shall discharge wastewater arising from site offices, canteens or toilet facilities constructed by him into sewers after obtaining prior notice of no objection of agency controlling the system;

m) The volume of oil spill should be calculated as well as storage volume to contain spill within the materials storage containment areas. The procedure shall include measures to contain and mitigate transportation of oil, grease or hazardous materials to the drainage system or any water body;

n) The Contractor shall ensure that earth, bentonite, chemicals and concrete agitator washings etc. are not deposited/drained in the watercourses but are suitably treated and effluents and residue disposed off in a manner approved by local Regulatory Authorities;

o) Construction works should be programmed to minimize soil excavation works in rainy season. If carried out during rains, temporarily exposed slope surfaces should be covered by tarpaulin, and temporary access roads should be protected by crushed stone or gravel, as

excavation proceeds.

p) Wastewater from Concrete Batching & Precast Concrete Casting and that generated from the washing down of mixer trucks and drum mixers and similar equipment should wherever practicable be recycled. The discharge of wastewater should be kept to a minimum;

q) The road between the vehicle washing bay and the public road should be paved to reduce vehicle tracking of soil and to prevent site run-off from entering public road drains;

r) Surface run-off should be segregated from the concrete batching plant and casting yard area as much as possible and diverted to the storm water drainage system. Surface run-off contaminated by materials in a concrete batching plant or casting yard must be treated to, within the discharge norms before disposal into storm water drains;

6.3.3. **Containment of Noise and Vibration**

a) Contractor shall minimize the use of impact devices, such as jackhammers, and pavement breakers and instead use concrete crushers or pavement saws;

b) Equip noise producing equipment such as jackhammers and pavement breakers with acoustically attenuating shields or shrouds recommended by the manufacturers thereof, to meet relevant noise limitations;

c) Use hydraulic tools instead of pneumatic impact tools. If pneumatic impact tools and equipment are used, they shall have intake and exhaust mufflers recommended by the manufacturers thereof, to meet relevant noise limitations;

d) Provide mufflers or shield panelling for other equipment, including internal combustion engines, recommended by manufacturers thereof;

e) Employ prefabricated structures instead of assembling on-site;

f) Use electric instead of diesel-powered equipment;

g) Provide enclosures for stationary equipment and barriers around noisy areas;

h) Locate stationary equipment in such a way, so as to minimize noise and vibration impact on community.

i) Keep noisier equipment and activities as far as possible away from noise sensitive locations and nearby buildings.

j) Plant and equipment known to emit noise strongly in one direction should where possible, be oriented in a direction away from noise sensitive receptor.

k) Reduce the number of plant and equipment operating in critical areas close to noise sensitive receptors.

l) Schedule truck loading, unloading, and hauling operations in such a way so as to minimize noise impact near noise sensitive locations and surrounding communities;

m) Plan noisier operations during times of highest ambient noise level, keep noise levels relatively uniform and avoid excessive and impulse noises;

n) Use only well-maintained, regular serviced plant/equipment, and not to be kept idling when not in use;

o) Maintain equipment such that parts of vehicles and loads are secure against vibrations and rattling;

p) Grading of surface irregularities on construction sites to prevent the generation of impact noise and ground vibrations by passing vehicles;

q) If back-up alarms are used on construction equipment, their noise emission level near noise

sensitive receptors such as residences, schools, hospitals and similar areas where calmness is essential, should be regulated, especially at night time;

r) Select truck routes for muck disposal so that noise from heavy-duty trucks will have minimal impact on sensitive areas (e.g., residential);

s) Conduct truck loading, unloading and hauling operations in a manner such that noise and vibration are kept to a minimum;

t) Avoid operating truck on streets that pass by schools during school hours;

u) Efforts to be made to bring down the noise levels due to the DG set, outside the premises, within the ambient noise requirements by proper setting and control measures;

v) The Contractor shall ensure that all necessary permissions/ approvals/consent is obtained from relevant authorities before installation and operation of Generator set;

w) A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacture;

x) At all times noise levels of DG sets shall comply the standards set out by CPCB/SPCB;

y) During tunnel operation following measures to be taken:

i) Blasting activities to be so schedule that local people are not disturbed and notify them prior to undertaking such activity;

ii) Operations to be scheduled to coincide when people are busy with their daily tasks so that they would be least likely to be affected. Blasting operation shall not be carried out in night.

iii) Charge mass per delay should be decreased by minimizing the number of blastholes firing on each delay.

iv) Smaller blasthole patterns and longer delays shall be used between dependent charges.

v) A preconstruction survey of nearby structure likely to be adversely affected by the construction activities to be performed and threshold or limiting values to be established that take into account each structure or use's ability to withstand the loads and displacements due to construction vibrations;

vi) An extensive outreach to be conducted in advance in the surrounding villages that could be affected;

vii) Vibration levels shall be monitored in the foundations of nearby buildings during all blasting activities. Blasting activities resulting in peak particle velocity (vibration) levels in excess of appropriate damage criteria as measured in the foundations of nearby structures would be immediately stopped until further precautionary measures are taken to reduce blasting-related vibration impacts.

viii) Work shall not begin again until the steps proposed to stabilize and/or prevent further damage to the designated buildings are approved.

6.3.4. **Containment of Waste**

a) The Contractor is required to develop, institute and maintain a Waste Management Plan (WMP) during the construction of the project for his works, which may include:

ix) Identification of disposal sites;

x) Identification of quantities to be excavated and disposed off;

xi) Identification of split between waste and inert material;

xii) Identification of amounts intended to be stored temporarily on site and location of such storage;

xiii) Identification of intended transport means and route;

xiv) Obtaining permission, where required, for disposal;

b) Such mechanism is intended to ensure that the designated area for the segregation and temporary storage of reusable and recyclable materials are incorporated in the WMP. The WMP shall be prepared and submitted to Engineer for approval.

c) Construction activities are expected to generate a variety of waste such as:

i) General refuse;

ii) Construction and Demolition waste including waste from excavated material;

iii) Chemical waste;

iv) Hazardous waste; and

v) Biomedical waste.

All wastes shall be stored at a designated areas and not to be mixed with each other.

General Refuse

a) Each worksite would generate general refuse including paper and food waste which shall be stored in enclosed bins or units.

b) The Contractor shall not burn debris or vegetation or construction waste on the site;

c) The refuse shall be stored and transported in accordance with good practice and disposed at licensed landfills;

d) An authorised waste collector shall be employed by the Contractor to remove general refuse from the site, on a daily basis to minimise odour, pest and litter impacts.

Construction and Demolition (C&D) Waste

a) C&D Waste would mainly arise from the project construction activities and from the demolition of existing structures where necessitated. It will include: material and equipment wrapping packaging material, unusable/surplus concrete/grouting mixes, damaged/contaminated/surplus construction materials, wood from formwork and false work, concrete rubble, plastics, metal, glass, asphalt, wood and refuse obtained from demolition of houses.

b) The Contractor shall be responsible for collection, segregation, storage and disposal of C&D waste as directed or notified by the concerned local authority in consonance with the Construction & Demolition Waste Management Rules, 2016;

c) The Contractor shall ensure that there is no littering or deposition of C&D waste and disposal of C&D waste along the riverbed, natural drainage and wet land is strictly prohibited;

d) The requirement of concrete/RCC/PCC waste disposal, generated from the entire contract shall be either when 15 Tons of C&D waste which has been generated or such C&D waste has been stored for 15 days (irrespective of quantity), of the two whichever is earlier;

e) A proper arrangement for record keeping has to be maintained to ensure disposal of C&D waste to C&D waste recycling plant. Contractor shall submit the record of C&D waste disposal to recycling facility, in his Monthly Environment Report;

Hazardous Waste

f) Hazardous waste would mainly arise from the maintenance of equipment. These may include, but not be limited to: Used engine oils, hydraulic fluids, waste fuel, spent

mineral oils/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spent solvents/solutions, some of which may be derived, from equipment cleaning activities which shall be disposed off in a manner in compliance with the procedure given in "Hazardous Waste (management, handling and trans-boundary movement) rules, 2016" only to authorized recyclers under intimation to the Employer's Representative ;

g) Chemicals classified as hazardous chemicals under "Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 of Environment (Protection) Act, 1986 shall be disposed off in a manner in compliance with the procedure given in the rules under the aforesaid act;

h) The hazardous waste shall be stored on an impermeable surface with containment bunding to retain leaks, spills and ruptures;

i) All waste collection containers shall be of appropriate size with a closed lid. Each container will be clearly labelled with a colour code system in local language and English. Original labels of empty containers should be completely covered and the contents of the type of waste stored in the used containers clearly indicated.

j) Drip pans of suitable size and numbers shall be used to collect oil leakage and spills. The area shall be cleaned after completion of maintenances/repair and generated waste disposed off in approved manner.

Bio medical waste

k) Collection, segregation, storage and disposal of Bio Medical waste shall be in accordance with The Bio-medical Waste Management Rules, 2016;

l) Storage time of waste shall be as less as possible so that waste storage, transportation and disposal is done within 48 hours;

m) The contactor shall ensure Posters/ placards for bio-medical waste segregation shall be installed at the point of generation;

n) Disposal of biomedical waste shall be through a licensed waste collector, duly authorized by MoEFCC or Haryana Pollution Control Board as the case may be. License of the waste collector shall be shown to the Employer's Representative on demand. Staff handling the biomedical waste shall be provided with PPEs;

Storage and Segregation of Waste

a) Collection and storage points of appropriate size containers shall be established around all construction work sites, with a 'display board' showing quantity and nature of waste;

b) All waste shall be stored in different coloured bins as per table below:

Colour coding of Waste storage bins

Type of Waste	**Colour**
Wet/Organic/ Bio-Degradable Waste	Green Bins with lids
Dry/Recyclable waste (excluding Bio-medical waste/ hazardous waste)	Blue
Bio-Medical waste	Red with lids

E-Waste	Black
Hazardous Waste	Brown
COVID Waste	Yellow

6.3.5. **Housekeeping**

a) The Contractor along with his sub-Contractors shall maintain the site, labour camps, stores and offices reasonably clean, keep free from obstruction and properly store any construction equipment, tools, and materials.

b) Full height fence, barriers etc. will be installed at the site in order to preserve the surrounding area from excavated soil, rubbish etc. which may cause inconvenience to public.

c) The Contractor's through daily pre-work meeting (tool box talk), safety meeting etc. will impart the necessary education to labour on housekeeping. Other staff such as supervisors and engineers working at the site will also be educated on the necessity of good housekeeping;

d) The Contractor shall ensure the availability of dustbins in Labour Camps at required place and ensue regular cleaning of rooms, kitchens, toilet blocks and dustbins.

e) Proper access and stacking shall be ensured at the Stores. A list will display daily stock of materials.

f) Everyone shall be responsible to maintain housekeeping of their work station.

g) To keep the area free of litter and garbage, specific locations shall be designated for consuming food and snacks to prevent random disposal of waste.

h) Drip pans of suitable size shall be used to collect oil leakages and spills while plants/equipment/machinery maintenance.

i) The Contractor shall make available Material Supply Data sheet (MSDS) for material/chemicals/substances used, for which these are available to the Engineer when requested;

j) Such material/chemicals/substances used shall be treated, handled, stored, transported and disposed off, by the Contractor, in a manner specified in the MSDS.

6.3.6. **Landscape, Greenery and Aesthetics**

a) As far as is reasonably practicable, the Contractor shall maintain ecological balance by preventing deforestation and defacing of natural landscape. In respect of ecological balance, the Contractor shall observe the following instructions.

   i) Prevent any avoidable destruction, scarring or defacing of natural surroundings in the vicinity of work;

   ii) Any damage shall be repaired, replanted or otherwise corrected at Contractor's expense.

   iii) Directional shielding for light used for illumination shall be used to prevent from striking adjacent areas, where feasible;

b) Tree Felling

   i) All trees and shrubs, which are not specifically required to be cleared or removed for construction purposes, shall be preserved and protected from any damage by use of protective barriers or other methods approved by Engineer;.

   ii) The Contractor shall not fell, remove or dispose of any tree or forest produce in any land handed over to him for the construction of works and facilities related to project except

with the previous permission obtained from the Forest Department;

iii) Trees shall not be used for anchorage.

6.3.7. **Energy Management**

a) The Contractor shall use energy efficient pumps and motors. The efficiency shall be measured during installation and also periodically;

b) The Contractor should rigorously follow the maintenance regime of his DG sets;

c) The Contractor shall maximize the use of energy efficient luminaries such as LED's, metal halide lamps and ensure optimum illumination levels to save energy.

d) The Contractor shall make provision of Earth Leakage Circuit Breakers (ELCBS) to prevent loss of excessive earth currents which are unsafe;

e) The Contractor shall plan in advance and select locations to receive and store material such that these are at the least distance from place of use;

f) The Contractor shall design site offices for maximum daylight and minimum heat gain.

6.3.8. **Archaeological And Historic Resources**

a) If any archeological and historic structure is likely to be affected, a resource protection plan shall be prepared by the Contractor in consultation with the Archaeological Survey of India (ASI) to identify and assess construction effects and seeks ways to avoid, minimize or mitigate adverse effects on such monuments;

b) The Contractor shall stop work immediately and notify the Engineer if, during construction, an archaeological or burial site is discovered. The work will not recommence until approval of the Engineer is obtained for the same.

6.3.9. **Fly Ash**

MoEFCC fly ash notification dated September 1999 and its subsequent amendments makes it mandatory for use of fly ash-based products in construction activities located within 300Km from coal or lignite based thermal power plants. The Contractor shall use fly ash as a percentage substitution of cement, in concrete for certain structures and works as prescribed in the latest amendment. The Contractor shall provide details of usage of such products to Engineer and shall maintain a detailed record of usage of Fly Ash.

6.4. Environmental Monitoring

6.4.1. **Baseline Study:** Before commencement of actual construction work, all items and parameters as specified in ESHS manual shall be monitored once as the baseline of the environmental condition prior to the construction and compared with the monitored values during the construction period;

6.4.2. **Qualification of Monitoring Agency:** Monitoring shall be conducted by MoEFCC approved or NABL accredited laboratory and approved by the Engineer;

6.4.3. **Enforcement of the Monitoring**: Monitoring plan shall be proposed in the Contractor's ESHS Management Plan and must be approved by the Engineer before commencement of the monitoring. If the monitoring results are more than baseline and standards, cause analyses and necessary counter measures shall beproposed to the Engineer in the monitoring reports;

6.4.4. **Parameters, Location and Frequency of the Monitoring:** Environmental Monitoring parameters, locations and frequency is given in following table.

Parameters, Standards, Location and Frequency of Monitoring

Parameters	Sampling Standards	Location	Frequency
Air (PM_{10}, $PM_{2.5}$)	CPCB (2011) Guidelines for the Measurement of Ambient Air Pollutants, Manual Sampling & Analyses	One representative location within each construction yard and batching plant	Monthly
		Closest residential or commercial area (one location) within 100m from each active construction site or representative locations approved by theEngineer	Monthly
		$PM_{2.5}$ In Tunnel portion	Bi weekly
Noise **Day Time** (6 AM – 10PM) L_{max}, L_{min}, L_{eq}, L_{10}, L_{90}, L_{50} **Night Time** (10PM – 6AM) L_{max}, L_{min}, L_{eq}, L_{10}, L_{90},L_{50}	CPCB (2015) Protocol for Ambient Level Noise Monitoring	One representative location within each construction yard and batching plant	Weekly
		Closest residential or commercial area (one location) within 100m from each active construction site or representative locations approved by the Engineer	Weekly
Vibration (in mm/s orVdB)	IS 14884 (2000)	During complaints or as directed by employer.	
Drinking/GW (pH, Total Alkalinity, Electrical Conductivity, Total Dissolved Solids, Fluoride, Arsenic, Nitrate, Iron, Lead, Cadmium, E-coli)	IS 3025 (2008) & IS 10500 (2012)	**Drinking water**: construction yard, batching plant andlabour camps	Quarterly (April, July, October, January)
		Groundwater: one representative tube/bore well in the adjacent residential area or within 100m from each active construction site	Quarterly (April, July, October, January)

Parameters	Sampling Standards	Location	Frequency
Surface Water pH, Total Dissolved Solids, Fluoride, Arsenic, Iron, Lead, E-coli	IS 3025 (2008) & IS 2296 (1982) & CPCB (2012) Guide Manual Water and Wastewater Analysis	Upstream and downstream of the river/stream if any. Any natural water course (ex. Pond etc.) located or within 100 m of each a) construction yard, b) labour camp, and c) active construction site	Quarterly (April, July, October, January)
Waste	Not available but fully complying with monitoring the quantities of wastes specified by the Solid Management Rules2016 & the Construction and Demolition Waste Management Rules2016	Each construction yard and construction site	Quarterly (April, July, October, January)
Hazardous waste	Not available but typed reporting (not handwriting) fully complying with monitoring the quantities of wastes specified by the Hazardous and Other Wastes (Managementand Transboundary Movement) Rules2016,	Each construction yard and active construction site	Quarterly (April, July, October, January)
Complaints if any		All Works' related locations	Weekly

6.5. Complaint Response Process

6.5.1. Enquiries, complaints and requests for information can be expected from a wide range of individuals and organisations both private and government. Most complaints are likely to be received by HRIDC, although the site offices are also likely to be contacted;

6.5.2. The objective of complaint process is to ensure that public and agency complaints are addressed

and resolved consistently and expeditiously;

6.5.3. The Contractor's Project Manager will be notified immediately on receipt of complaint that may relate to environmental impacts. The Project Manager will immediately inform the Engineer;

6.5.4. Field investigation shall determine whether the complaint has merit, and if so, action shall be taken to address the complaint;

6.5.5. The outcome of the investigation and the action taken shall be documented on a complaint Performa prepared by the Contractor and submitted for notice by the Engineer in advance of the works;

6.5.6. Where possible, a formal response to each complaint received shall be prepared by the Contractor within seven days to notify the concerned person(s) that action has been taken.

6.6. Social Legal Requirement

6.6.1. The Contractor shall always comply with all relevant national and state legislations regarding social safeguard including but not necessarily limited to, the following with their latest amendments

a) National Policy for the Empowerment of Women, 2001;

b) The Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013;

c) The Protection of Children from Sexual Offences Act, 2012;

d) The Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (Prevention and Control) Act, 2017;

e) Child Labour (Prohibition & Regulation) Act 1986

Some of the key International instruments for the protection of women include the following:

a) United Nations General Assembly, Resolution 52/86 on Crime Prevention and Criminal Justice Measures to Eliminate Violence Against Women, 2 February1998;

b) United Nations Security Council Resolution 1325 on Women, Peace and Security, 31 October 2000;

c) Environmental and Social Framework (ESF) of Asian Infrastructure Investment Bank (AIIB) February 2016

6.7. Gender equality

6.7.1. The Contractor is responsible for providing equal opportunities to both genders and end gender related discrimination, if any. The ESHS Committee will proactively identify cases of gender discrimination with key focus on the following topics:

a) Gender based violence, including sexual harassment at the workplace;

b) Disparity in benefits provided;

c) Termination on account of pregnancy.

6.7.2. The Contractor shall enhance female workforce participation and maintain sex -disaggregated data for periodic reporting.

6.7.3. The Contractor shall ensure that women workers are paid at par with male workers

6.7.4. If women workers are deployed at site then day crèche facilities shall be provided to facilitate the women with infant working on site.

6.8. Labour Requirements

6.8.1. The contractor shall use unskilled labour drawn from local communities to avoid any additional stress on the existing facilities (medical services, power, water supply etc.)

6.8.2. The recruitment of women and members of vulnerable groups shall be prioritized

6.8.3. The Contractor shall provide training to build the skills of locally recruited labour.

6.8.4. All staff, skilled and unskilled labours employed on a site shall be required to sign Code of Conduct that shall ensure compliance with the ESHS provision of civil works and consultancy contracts.

6.9. Cultural and Religious Issues

6.9.1. Disturbance from construction works to the cultural and religious sites, and Contractors lack of knowledge on cultural issues cause social disturbances. The Contractor shall

a) Communicate to the public through community consultation, informing the peers and newspaper announcements regarding the scope and schedule of construction, as well as certain construction activities causing disruptions or access restriction;

b) Not block access to cultural and religious sites and sites of importance for livelihood activities, wherever possible;

c) Need to take mitigation measures while working near religious place/ educational institutions close to the construction sites;

d) Provide freedom to construction workers to observe their cultural and religious practices;

e) Monitor and be responsible for the behaviour of construction workers especially migrant workers towards the community. The workers must be debriefed well regarding local aspects and need to follow good behaviours, and informed regarding unexpected behaviours at the time of employing;

f) Provision of cultural sensitization training for migrant labours regarding engagement with local community;

g) Resolve cultural issues in consultation with local leaders and Project Manager;

h) Establish a mechanism that allows local people to raise grievances (directly and

i) indirectly) arising from the construction process;

j) Inform the local authorities responsible for health, religious and security duly informed before commencement of civil works so as to maintain effective surveillance over public health, social and security matters.

6.10. Guidelines for Addressing GBV in Projects

6.10.1. The Contractor's ESHS Plan shall include implementation of Gender Based Violence (GBV), Sexual Exploitation and Abuse (SEA) and Sexual Harassment (SH) Prevention and Response Action Plan. This action plan shall describe Code of Conduct (CoC), mechanism to address such incidents, assess the project scenario and potential risks of GBV/SEA/SH, training plan for workers on GBV/SEA/SH and awareness programme amongst workers regarding socially, culturally appropriate behaviour that would ensure that the project community and women in particular are safe, secured, and not vulnerable to abuse. A sample GVB/SEA/SH action plan is given in Table below.

Table - GBV/SEA/SH Prevention Action Plan

Objective	Activity	Responsibility
Assess Potential Risk of GBV	Rapid assessment of worksite, project footprint (e.g. community structure, local self-governance, national regulations, history of incidence), type of workers (local or migrant) for possible GBV risk.	As part of the social impact assessment (to be updatedat the time of construction).
Inclusive development	• Engage women in project planning and implementation • Incorporate women's feedback in project design and construction schedule • Organize systematic consultations with women to ensure continuous feedback on projects and identify any gender-sensitive adverse impacts	
Training – women	• Sensitization of women on GBV and women's rights to avoid/avert such incidents • Sensitization of women on actions to be taken in case of GBV	
Training – men	• Sensitization of male workers on GBV and women's rights to avoid/avert such incidents • Sensitization of male workers on actions to be taken in case of GBV • Sensitization of male workers on appropriate socially and culturally acceptable behaviour towards women • Training of managers on • methods of dealing with	

Objective	Activity	Responsibility
	cases of GBV	
Awareness generation	• Distribution of leaflets propagating gender-appropriate behaviour • Signing of self-declaration format on commitment towards gender-sensitive behaviour	

6.10.2. The Contractor shall constitute an appropriate Grievance Redress Mechanism (GRM) for addressing grievances at worksite. Grievances of workers will be first brought to the attention of supervisor at site. Grievances not redressed by the supervisor within 7 days will be brought to the Grievance Redress Committee (GRC). The composition of GRC will have representatives from workers, women representative, ESHS staff of the Contractor ESHS staff of GC. The main responsibilities of the GRC are to: (i) provide support to workers on problems arising at worksite, (ii) record workers grievances, categorise, prioritize grievances and resolve them, (iii) immediately inform the Engineer of serious cases and (iv) report to workers on development regarding their grievances and decisions of GRC. The panel of the GRC will function without any prejudice or fear of retaliation. The well-being of the panel members will be protected by HRIDC. A format for record of complaints is given in General Instruction: ESHS/GI/008. The GRC will redress the grievances within 14 days. The Contractor shall provide grievance box at Project Site Office.

6.10.3. This project has zero tolerance of any form of:

a) **Gender-based violence (GBV)**, that is perpetrated against a person's will and that is based on socially ascribed gender-related differences between people.

b) **Sexual exploitation and abuse (SEA**) which is attempted abuse of a position of vulnerability, differential power, or trust, for sexual purposes, including, but not limited to, profiting monetarily, socially or politically from the sexual exploitation of another.

c) **Sexual harassment (SH**) which is unwelcome sexual advances, requests for sexualfavors, and other unwanted verbal or physical conduct of a sexual nature.

6.10.4. Any incidence of GBV, SEA or SH should be reported to the Grievance Redress Committee (GRC). The panel of the GRC should take appropriate gender-sensitive actions to verify authenticity of the incident with due consideration to the safety, security, and dignity of the offended person. The investigation should be concluded within three days of receiving the report or as reasonably possible. Depending on the severity of the incident, the panel may report the case to appropriate authorities.

Following the investigation, the GRC shall recommend appropriate actions to the company which may include but not limited to:

a) Informal warning

b) Formal warning

c) Additional training

d) Loss of up to one week's salary

e) Suspension of employment (without payment of salary), for a minimum period of one month up to a maximum of six months

f) Termination of employment

6.10.5. The affected person will be provided with appropriate support (e.g. psychological counselling, medical support and any other support as needed).

6.10.6. A self-declaration format for adherence to gender-sensitive behaviour should be signed by all contractors, subcontractors, employees, and senior managers, engaged by the Project to avoid GBV/SEA/SH at worksite. A self-declaration format is given in below:

6.10.7. **Commitment Statement for all Project Workers**

(to be translated into local language or explained in a manner that is appropriate for general understanding of the signee)

I, (name of person), acknowledge that preventing Gender-Based Violence (GBV), Sexual exploitation and abuse (SEA) and Sexual harassment (SH) is essential, and that preventing it is my responsibility. At [Company], GBV activities constitute acts of gross misconduct and are therefore grounds for sanctions, penalties or potential termination of employment. All forms of GBV are unacceptable, be it on the worksite, the worksite surroundings, at workers' camps, or in the community. Prosecution of those who commit GBV may be pursued if appropriate.

I agree that while working on the [Project], I will:

- Cooperate with any relevant investigations.
- Treat women, children (definition of "child" shall be as specified in Child Labour (Prohibition and Regulation) Act, 1986) and men with respect regardless of race; color; language; religion; political or other opinion; national, ethnic or social origin; sexual orientation or gender identity; disability; birth or other status.
- Not use language or behaviour towards women, children or men that is inappropriate, harassing, abusive, sexually provocative, demeaning or culturally inappropriate.
- Not request or engage in sexual favors - for instance, making promises or favorable treatment dependent on sexual acts, in or outside the work site.
- Refrain from abusive and violent behaviour, in the workplace, labor camp or surrounding communities.
- Attend and actively partake in training courses related to HIV/AIDS, GBV, SEA and SH as requested by my employer.
- Report through the grievance redress mechanism or to my manager any suspected or actual GBV by a fellow worker, whether in my company or not, or any breaches of this Code of Conduct.

[Company] recognizes that false accusations of sexual harassment can have serious effects on innocent persons. If, after the investigation, it is found that the complainant has maliciously or recklessly made a false accusation, the complainant will be subject to appropriate sanctions. In such a case, the company will also take appropriate action to restore the reputation of the accused.

I understand that it is my responsibility to use common sense and avoid actions or behaviours

that could be construed as GBV or breach this Self-declaration format. I do hereby acknowledge that I have read the foregoing Self-declaration format, do agree to comply with the standards contained therein and understand my roles and responsibilities to prevent and respond to GBV. I understand that any action inconsistent with this Self-declaration format or failure to act, as mandated by this Self-declaration format may result in disciplinary action and may affect my ongoing employment.

I have familiarized myself with the contents of this Self-declaration format. By my signature below, I acknowledge, understand, accept and agree to comply with the information contained in

the Self-declaration format provided to me.

I hereby confirm I have read and understand the Self-declaration format.
Name (Employee)

Signature
Date

7. FINANCIAL DEDUCTION/WITHHOLDING

7.1. Financial deductions from Contractor on occurrences of an incident.

7.1.1. Table No. 1 below indicates ESHS incidents and the corresponding deductions to be made from the Contractor under Sub-Clauses 20.1 [Employer's Claims], Sub-Clauses 14.3 [Application for Interim Payment], Sub-Clauses 14.6 [Issue of Interim Payment Certificates] and Sub-Clauses 14.7 [Payment] of the General Conditions of Contract.

7.1.2. The affected part of the Works shall remain suspended until all necessary investigations are completed as prescribed in Clause 2. [ESHS Management], Sub-Clause 2.15 Accident Report and Investigation and as per the related local laws of the state.

7.1.3. Upon submission of the Contractor's Request for Inspection (RFI),a joint inspection of the affected part of the Works shall be carried out by the Engineer and the Contractor. On receipt of the Engineer's Consent (Notice of No Objection: NONO), the Contractor may resume the work.

7.1.4. The Contractor shall not be entitled to any extension of time or to the payment of any cost or profit due to any suspension in accordance with this Sub-Clause 8.5 [Extension of time for Completion]

7.1.5. The maximum amount of delay damages set out in Sub-Clause 8.8 [Delay Damages] of the General Conditions of Contract shall not be applicable where the cause of delay to completion is suspension of part of the Works due to the Contractor's non-compliance as described in this clause 7.1.

Table No. 1: Incidents

Sl. No.	Incident		Financial deductions from the Contractor in Indian Rupees
1.	Injury and Incidence reporting	i) Fatal accidents	i) Rs.1,000,000 for first fatality and Rs.1500,000 for every subsequent fatality.
		ii) Injury accident	ii) Rs.300,000 for first grievously injured person and Rs.500,000 for every subsequent grievously injured person (Grievous Injury as defined by Workmen's Compensation Act)
		iii) Abnormal delay in reporting accidents or willful suppression of information about any accidents / dangerous occurrence as per Sub-Clause 2.15.	iii) Rs.1,00,000 for first violation and Rs.2,00,000 for subsequent violations

7.2. Withholding and deduction of payments from Contractor

7.2.1. The Engineer may issue a notice to the Contractor in accordance with Sub-Clause 3.5 [Engineer's Instruction] of the General Conditions of Contract to rectify any unsafe act or condition (including but not limited to error, default or omission) upon discovery of same on the Site by the Engineer, in a form of Nonconformity Report.

7.2.2. Table No. 2 below indicates Contractor's non-conformances from the ESHS requirements of the Contract and the corresponding amounts to be withheld and deducted by the Engineer from payment due to the Contractor under Sub-Clause 14.3 [Application for Interim Payment], Sub-Clause14.6 [Issue of Interim Payment Certificates(IPC)] and Sub-Clause 14.7 [Payment] of the General Conditions of Contract.

7.2.3. The Engineer shall have the right to withhold and deduct charges for any other unsafe act and/or condition depending upon the gravity of the situation on a case-to-case basis. The charge shall be comparable to that, which is the closest to the unsafe act/condition, indicated in Table 2.

7.2.4. Except as may be required otherwise by the Laws of the Republic of India, upon receipt of the Engineer's notification concerning an unsafe act or condition as described in Table No. 2, the Contractor shall promptly comply with such notification, investigate the cause of the unsafe act or condition and as soon as possible (but no later than 7 days, or within such other period from receipt of the Engineer's notification as may be approved by the Engineer), submit to the Engineer for review full details of the proposed correction, prevention and any other measures (hereinafter referred to as the "measures") to be taken by the Contractor to rectify and close-out the matter and to prevent re-occurrence. Such measures shall be to the satisfaction of the Engineer.

7.2.5. The Engineer is entitled to withhold amounts from the Contractor's payment until the Engineer has verified the Contractor's measures, submitted to the Engineer for review as above, and accepted them after a joint inspection in response to the RFI for the same.

7.2.6. Should the Contractor default in implementing any measures within the time previously agreed between the Contractor and the Engineer or the Contractor makes subsequent violations as specified in Table No. 2, the Engineer shall be entitled to the deduction to be recovered from the Contractor under Sub-Clause 20.1 [Employer's Claims] of the General Conditions of Contract. Such deductions shall be made via the certification and payment process provided for in the Contract, including Sub-Clauses 14.3 [Application for Interim Payment], Sub-Clause 14.6 [Issue of Interim Payment Certificates] and Sub-Clause 14.7 [Payment] of the General Conditions of Contract without limiting to the unsafe acts and or conditions mentioned above in Table 2.

7.2.7. The release or deduction of amount shall happen in the next payment process.

7.3. Suspension of work

7.3.1. The Engineer may issue a notice to the Contractor in accordance with Sub-Clauses 3.5 [Engineer's Instruction] and Sub-Clause 8.9 [Suspension of Work] of the General Conditions of Contract to suspend the progress of part of the Works in a form of Nonconformity Report, if in the Engineer's opinion such work is non-compliant with the ESHS requirements of the Contract. Such notification shall include details of the cause of the suspension. During such suspension, the Contractor shall protect, store and secure such part of the Works against any deterioration, loss or damage.

7.3.2. The Contractor shall not proceed with the affected Works until its measures are accepted by the Engineer.

7.3.3. Suspension of part of the Works as described in Sub-Clause 7.3.1 above and withholding of the amount from the Contractor's payment Sub-Clause 7.2 above shall continue together or independently until the Engineer has verified the Contractor's correction and close-out of any such non-conformity.

7.3.4. The Contractor shall not be entitled to any extension of time or to the payment of any cost or profit due to any suspension in accordance with the Sub-Clause 7.2.

7.3.5. The maximum amount of delay damages set out in Sub-Clause 8.8 [Delay Damages] of the Conditions of Contract shall not be applicable where the cause of delay to completion is suspension of part of the Works due to the Contractor's non-complianceas described in this Clause 7.

Table No. 2: Unsafe Acts/Conditions

Sl. No	Unsafe Act/Condition		Deductible amount from the Contractor in Indian Rupees
1.	ESHS Management Policy & Plan	1) ESHS Policy Non-compliance of Sub-Clause 2.4.1	Rs.25,000 per month
		2) ESHS plan: a) Delay in submission (Sub-Clause 2.4.3.) b) Not updated as per employer's instruction as per Sub-Clause 2.4.4. c) Copies not provided to all required supervisors / engineers (Sub-Clause 2.4.5)	Rs.50,000 per month.
2.	ESHS Organization	i) Not filling up the vacancies created due to ESHS personnel before leaving the Contractor (Sub-Clause 2.6.3.) ii) ESHS organization not provided with required Audio-visual and other equipment as per General Instruction ESHS/GI/ 001 (Clause 8. Attachment-4) Sub-clause-2.6.4	i) Rs.200,000 per month. ii) Rs.50,000 per month
3.	ESHS Committee	i) Failed to formulate or conduct ESHS Committee meeting for any month (Sub-Clause 2.8.1) ii) The Contractor and Subcontractor representatives not attending ESHS Committee meetings (Sub-Clause 2.8.6.) iii) Failed to conduct Site inspection before conducting ESHS Committee meeting (Sub-Clause 2.8.2 (h). iv) Failed to send Agenda to Employer in time or ESHS	Deduction of amount i) Rs.100,000 per violation ii) Rs.5,000 per member not attending the meeting For item iii) & iv) Rs.25,000 per violation

Sl. No	Unsafe Act/Condition		Deductible amount from the Contractor in Indian Rupees
		Committee Minutes of Meeting (Sub-Clauses 2.8.4 & 2.8.7.)	
4.	ID Card	i) Non-adherence of Clause 2.9.	Rs. 1,000/- per ID card per month
5.	ESHS Training	i) Not complying to the requirements as mentioned in Sub-Clause 2.10.1, 2.10.2, 2.10.3 & 2.10.5.	Deduction of Rs.1,00,000 per violation
6.	ESHS Inspection	i) Not complying to the requirements as mentioned in Clause 2.11.	Rs.1,00,000 per violation
7.	ESHS Audit	Internal Audit, MARS & External Audit i) Not conducted as per ESHS Plan (Sub-Clauses 2.12.4) ii) Report not sent to Employer (Sub-Clause 2.12.9) iii) Corrective action not taken for any month (Sub-Clause 2.12.9) iv) Not conducted as per ESHS plan (Sub- Clauses 2.12.10)	Rs.1,00,000 per violation
8.	ESHS Communication	i) Important days to be observed for ESHS awareness as furnished by employer not observed (Sub-Clause 2.13.2) ii) Posters as directed by Employer not printed and displayed (Sub-Clause 2.13.2)	i) Rs.10,000 per violation and ii) 50,000 per month
9.	ESHS Submittals	Non-compliance of Clause 2.14	Rs.1,00,000 per month
10.	Traffic Management & Site Barricading	a) Non-compliance of Clause4.31	Rs.25,000 per single violation.
11.	Emergency Preparedness Plan	Non-compliance of Clause 2.16	Rs.1,00,000 per month

Sl. No	Unsafe Act/Condition		Deductible amount from the Contractor in Indian Rupees
12.	Permit to work	Non-compliance of Clause 4.30	Rs.1,00,000 per violation.
13.	OccupationalHealth	Non-compliance of Clause 5.1 & 5.2	Rs. 50,000 per month.
14.	Labour Welfare Measures	Non-compliance of Clause 5.4	Rs.50,000 per month .
15.	Environmental Management	i) Containment of air pollution (Sub-Clause 6.3.1) ii) Containment of water pollution (Sub-Clause 6.3.2) iii) Containment of noise pollution (Sub-Clause 6.3.3) iv) Containment of waste pollution (Sub-Clause 6.3.4) v) Preservation of trees (Sub-Clause 6.3.6 (b)) vi) Environment monitoring (Sub-Clause 6.4) vii) Non-adherence to statutory agencies (SPCB, CPCB NGT etc.) environment management guidelines	Rs.50,000 per violation Actual penalty imposed by statutory agency
16	Housekeeping (Clause 4.2)	i) Surrounding areas of drinking water tanks / taps not hygienically cleaned / maintained ii) Office, stores, toilet / urinals not properly cleaned and maintained. iii) Required garbage bins at appropriate places not provided / not cleaned. iv) Stairways, gangways, passageways blocked.	Rs.50,000 per violation.

Sl. No	Unsafe Act/Condition		Deductible amount from the Contractor in Indian Rupees
		v) Lumber with protruding nails left as such vi) Openings unprotected vii) Excavated earth not removed within a reasonable time. viii) Truck carrying excavated earth not covered/tyres not cleaned. ix) After close of work Vehicles / equipment not parked at designated place x) Unused surplus cables / steel scraps lying scattered xi) Wooden scraps, empty wooden cable drums lying scattered xii) Water stagnation leading to mosquito breeding	
17.	Working at Height / Ladders and Scaffolds	Non-compliance of Clause 4.3.	Rs.50,000 per violation
18.	Lifting Appliances and Gear	Non-compliance of Clause 4.6	Rs.50,000 per violation
19.	Launching Operation	Non-compliance of Clause 4.7	Rs.50,000 per violation
20.	Construction Machinery	Non-compliance of Clause 4.8	Rs.50,000 per violation
21.	Site Electricity	Non-compliance of Clause 4.10	Rs.10,000 per violation.
22.	Power Tools (Sub-Clause 4.10.13)		
23.	Welding and Cutting (Clause 4.12)	i) Wrong colour coding of cylinder. ii) Cylinders not stored in upright position. iii) Flash back arrester, non-return valve and regulator not present	Rs. 10,000 per violation.

Sl. No	Unsafe Act/Condition		Deductible amount from the Contractor in Indian Rupees
		or not in working condition. iv) Fail to put cylinders in a cylinder trolley. v) Damaged hose and fail to use hose clamps vi) Using domestic LPG cylinders vii) Fail to store cylinder 6.6m away from fire prone materials viii) Fire extinguisher not placed in the vicinity during operation Voltmeter and Ammeter not working. ix) Non-availability of separate switch in the transformer x) Improper grounding and return path. xi) Damaged and bare openings in the welding cable. xii) Damaged holder xiii) Fire extinguisher not placed in the vicinity during operation	
24.	Fire Precaution (Clause 4.27)	i) Smoking and open flames in fire prone area ii) Using more than 24V portable electrical appliances in the fire prone area iii) Not proper ventilation in cylinder storage area. iv) Absence of fire extinguishers v) Fire extinguishers not refilled once in a year. vi) Fire extinguisher placed in a not easily accessible location	Rs. 10,000 per violation.

Sl. No	Unsafe Act/Condition		Deductible amount from the Contractor in Indian Rupees
25.	Excavation, Tunneling and Confined Space	Non-compliance (Clauses 4.13, 4.14, 4.26)	Rs. 10,000 per violation
26.	Batching plant and Casting yard	Non-compliance of Clause 4.18	Rs. 10,000 per violation.
27.	Personal Protection Equipment	Non-compliance of Clause 4.34. Items of attention are as under – i) Not having ii) Not wearing (or) using and kept it elsewhere iii) Using damaged one iv) Using wrong type v) Using wrong colour helmet or helmet without logo vi) Using for other operation (e.g. Using safety helmet for storingmaterials or carrying water from one place to other)	Rs. 200 per person per violation.
28.	Working near Railway	Non-compliance of Clause 4.32.	Rs. 1,00,000 per violation

8. ATTACHMENT

Attachment -1 Contents of ESHS Management Plan

1.0 General

1.1 The Contractor shall prepare an Environment, Social, Health and Safety (ESHS) Management Plan, which provides measures to protect the Environment, Health and Safety of workers and the public.

1.2 The Contractor's ESHS Management Plan shall be based on Environment, Social, Health and Safety considerations submitted with the Tender and shall have the content shown in the following section [Contents of ESHS Management Plan].

1.3 The Contractor shall submit his ESHS Management Plan for review by the Engineer within 28 days after the Commencement Date and shall amend the ESHS Management Plan to address any comments made by the Engineer and submit a Final ESHS Management Plan within 14 days of receipt of comments.

1.4 The Final ESHS Management Plan shall be binding on the Contractor for the duration of the Contract.

2.0 Content of ESHS Management Plan

2.1 The Contractor's ESHS Management Plan shall cover the following aspects:

Site ESHS Management Plan	
Contract No.	
Contractor Name	
Project Name	
1	Project Highlights i) Title of the content; ii) Contract number; iii) Brief scope of work; iv) Location map/key plan; v) Period of the project;
2	ESHS Management Policy with senior management responsibility;
3	Site organization chart Chart indicating reporting of ESHS Management personnel, appointment, duties, and responsibilities
4	Roles &responsibility Individual responsibility of the i) The Contractor's representative

	ii) ESHS Manager iii) Environment manager iv) Social expert v) Chief accident prevention officer vi) Construction manager vii) Construction Supervisors viii) ESHS Committee members ix) ESHS in charge x) Site engineers xi) First line supervisors xii) Subcontractors
5	ESHS Site Committee xiii) Details - Chairman, secretary, members, and employer's representative xiv) Procedures for effective conduct of meeting
6	ESHS Training
7	Subcontractor Safety and Health procedures for Subcontractors;
8	ESHS Inspection and audit
10	Accident, diseases investigation reporting procedures
11	Health, First Aid, and emergencies measures
12	Staff and labour welfare measures at site
13	Policy for identifying hazards and risks with risk assessment and mitigation procedures
14	Safe Work Procedures e.g. i) Excavation ii) Structural steel erection iii) Form works iv) Concrete placement v) Work at height vi) Switch-over works vii) Floor, wall openings and stairways viii) Welding, cutting and bracing ix) Lifting appliances x) Electrical equipment

	xi) Mechanical equipment xii) Fire prevention xiii) Hazardous chemicals and solvent xiv) Lighting xv) Abrasive blasting
15	Work permit system
16	List of standard job specific PPEs to be used in the site
17	Maintenance of regime for construction equipment and machinery
18	Traffic management
19	Housekeeping
20	i) Environmental and Social Management ii) Applicable National and State legislation and regulations iii) Specific procedures for achieving environmental and social performance requirements as given in the Employer's requirements on Environment. iv) Details on air monitoring and noise monitoring control plan which details mitigation measures / corrective action / preventive action and monitoring schedule. v) The ESHS Management Plan must contain procedures on prevention and control of water pollution, storage, handling and disposal of waste, including municipal, C&D, plastic, bio-medical, chemical and hazardous wastes, reuse/recycle of waste, selling to authorised recyclers and records thereof, preservation of landscape disturbed due to construction, housekeeping/Environmental sanitation and traffic management as required under the contract. vi) Procedures for recording environmental complaints and response process. vii) HIV prevention and control plan viii) Gender Based Violence (GBV) and sexual Exploitation and Abuse (SEA) prevention and response plan ix) COVID-19 Response and management plan
21	Visitors and security arrangement
22	Disciplinary Procedures
23	Safety and Health promotion and awareness;
24	Safety and Health equipment and Safety and Health of the Contractor's construction and office equipment;

Note: -The Environment, Social, Health and Safety (ESHS) Management Plan shall beincorporated in the relevant sections.

3.0 Training

3.1 The Contractor shall describe the training program and content he will provide for workers and staff to:

a) Raise awareness of the role and importance of Environment, Social, Health and Safety matters; the potential negative impacts of construction work in general and the ways in which impacts can be prevented; and the expected constructionimpacts and long-term environmental and social benefits of the applicable project;

b) Disseminate the philosophy and approach of the ESHS Management Planthroughout the workforce, and explain the roles of all parties in implementing the ESHS Management Plan; and

c) Inform all employees of the Environment, Social, Health and Safety activitiesthey are required to comply with when conducting their work, and the penaltiesfor non-compliance.

3.2 Training to raise the awareness and capacity of the Subcontractors and their employees shall also be incorporated where necessary.

3.3 The Contractor shall prepare the following plans to supplement the ESHS Management Plan:

a) Emergency Response Plan; and

b) Fire Evacuation Plan.

Attachment -2 Workplace Policy (on HIV/AIDS Prevention & Control)

Haryana Rail Infrastructure Development Corporation Limited (HRIDC) recognizes HIV/AIDS as a developmental challenge and realizes the need to respond to it by implementing regular HIV/AIDS prevention programmes and creating a non- discriminatory work environment for HIV infected workmen engaged by Contractors. For the purpose of making conscientious, sensitive and compassionate decision in addressing the realities of HIV/AIDS, HRIDC has established these guidelines based on ILO code of practice on HIV/AIDS.

- Creating awareness through professional agency using IEC (Information, Education and Communication) package specially designed for migrant workers.
- Institutional capacity building by training the project implementation team, Environmental, Social, Health & Safety (ESHS) Managers, establishing linkages for deficient diagnosis and treatment of the affected workers, effective monitoring of implementation and documentation for further learning.
- Establishing peer educators by selecting them in consultation with Contractors and training them through professional agencies so that they become focal point for any information, education and awareness campaigns among the workmen throughout the contract period.
- Promotion of social marketing of condom

Attachment -3 Work Place Policy on COVID-19 Prevention and Control

It is likely that Corona virus Disease 2019 (COVID-19) will continue to occur in the community in the foreseeable future. It is therefore necessary to have a plan/policy in place to prevent the spread of this virus within the workplace. In order to reduce the risk of infection, Haryana Rail Infrastructure Development Corporation Limited (HRIDC) recommends to the Contractor to consider the following measures:

a) The Contractor shall ensure that the latest guidelines issued by Ministry of Health and Family Welfare (MoHFW), local government and the district administration are strictly followed at the construction works site.

b) On day 0, before resuming the work on sites post lockdown period, mandatory medical check-up will be arranged for all workers.

c) The workers coming from outside shall observe home-quarantine for at least 14 days as per the guidelines issued by MoHFW.

d) Only medically fit workers will be deployed at site and medical assistance will be arranged for unfit workers.

e) A unique photo identity card with serial number will be issued to all the workers and their family members staying at site.

f) All the essential items will be made available to them at site only. If necessary, they can go out wearing face masks, after informing the supervisor.

g) No outside worker will be allowed to stay at site without following proper procedure and instructions.

h) Start time on site will be staggered to avoid congestion at the entry gates.

i) As in most cases, workers reside at the Sites, hence no travel arrangements are required for them.

j) The workers staying outside (which are always nearby) shall reach the site either by walking or by their individual mode of transport (bicycle, two-wheeler etc.).

k) During attendance, training and other sessions, social distancing guidelines will be followed along with provision of no-touch attendance.

l) All workers may be advised to take care of their own health and look out for respiratory symptoms/fever and, if feeling unwell, shall leave the workplace immediately after informing their reporting officers.

m) They shall observe home-quarantine as per the guidelines issued by MoHFW and shall immediately inform the nearest health centre or call 011-23978046.

n) Workers shall not shake hands when greeting others and while working on the site.

o) Mandatorily wear face masks while working on site. While not wearing masks, cover your mouth and nose with tissues if you cough/sneeze or do so in the crook of your arm at your elbow.

p) Avoid large gatherings or meetings. Maintain at least 1 metre (3 feet) distance from persons, especially with those having flu-like symptoms, during interaction.

q) Not more than 2/4 persons (depending on size) shall be allowed to travel in lifts or hoists.

r) Use of the staircase for climbing shall be encouraged.

s) Workers shall clean hands frequently by washing them with soap and water for at least 40 seconds.

t) Workers shall not share their belongings like food, water bottles, utensils, mobile phones etc. with others.

u) The utensils shall be washed properly post use at designated places.

v) Post work, workers shall change their clothes before leaving the site and clothing shall not be shook out.

w) Avoid touching your eyes, nose, or mouth with unwashed hands.

Attachment -4 Reference for ESHS Activities

General Instruction: ESHS/GI/001

Minimum Requirements of ESHS Monitoring and Audio-Visual Equipment's

a) Every Contractor shall provide the following audio-visual aids for conducting weekly review, monthly safety committee and other post review meeting of all fatal and major incidences effectively. This audio-visual equipment is a must for conducting periodical in-house safety presentations in the training programs; and

b) In addition to the above, portable hand held Type I or Type II digital sound level meter (SLM) and portable hand held digital Lux meter are also to be provided.

c) The minimum requirement of the quantity to be provided in ESHS management Plan and approved by the Engineer.

Sl. No	ESHS Monitoring and Audio-Visual Equipment details
1.	Portable hand-held Type I or Type II Digital Sound Level Meter (SLM)
2.	Portable hand-held Digital Lux Meter
3.	Laptop computer with standard configuration including multimedia facilities
4.	Colour printer
5.	Computer projector with screen
6.	Overhead projector
7.	Smartphone for taking photos and recording of video
8.	Portable loudspeaker (for tool-box talk and emergency purpose)
9.	Communication facility like mobile phone, walky-talky etc.
10.	Accident investigation Kit containing the following:
a)	Chalk piece for marking
b)	Measuring tape for measuring Flexible tape – 2m length Metal Foot long scale and Metal tape – 30m
c)	Equipment tags
d)	Multipurpose Flash light
e)	Barrier tape
f)	Accident investigation Forms and checklists
g)	Enough Paper for witness recording and other noting
h)	Emergency Phone Numbers list

General Instruction: ESHS/GI/002

Topics for ESHS Orientation Trainings for Workmen for First Day at Work

1) **Hazard Identification Procedure**

Hazards on site:

- Falls;
- Earthing work;
- Electricity;
- Machinery;
- Handling materials;
- Transport;
- Site housekeeping;
- Fire;
- Safety of nearby located structures;
- Works close to railway tracks or roads.

2) **Personal Protective Equipment**

- What is available?
- How to obtain it?
- Correct use and care.

3) **Health**

- Site welfare facilities;
- Potential health hazards;
- First Aid/Cardiopulmonary Resuscitation (CPR). /Automated External defibrillator(AED)

4) **Duties of the Contractor**

- Brief outline of the responsibilities of the Contractor by law;
- Details of the Contractor's accident prevention policy;
- The Employer SHE Management Manual (if any);
- Building and other Constructions Welfare Law.

5) **Employee's Duties**

- Brief outline of responsibilities of employee under law
- Explanation of how new employees fit into the Contractor's plan for accident prevention (induction and orientation).

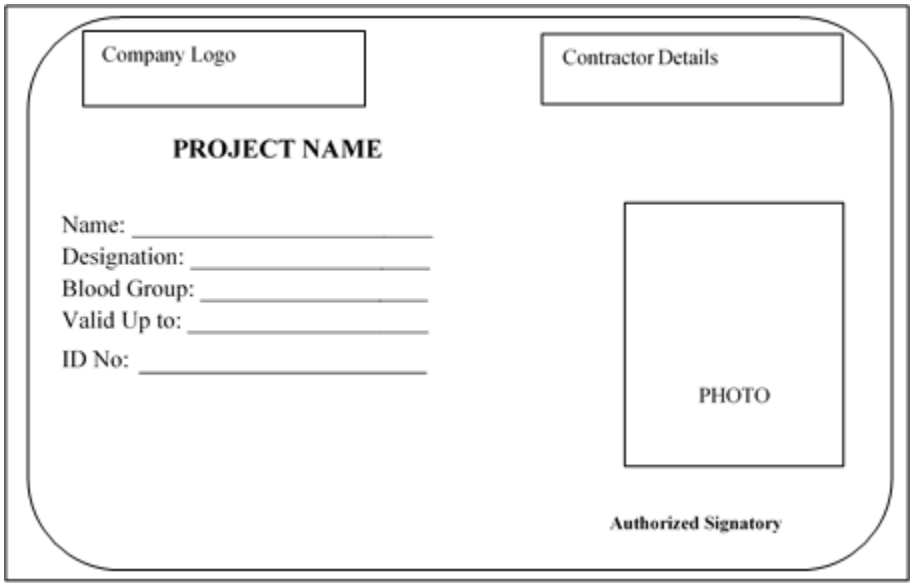
6) **Environment And Social**

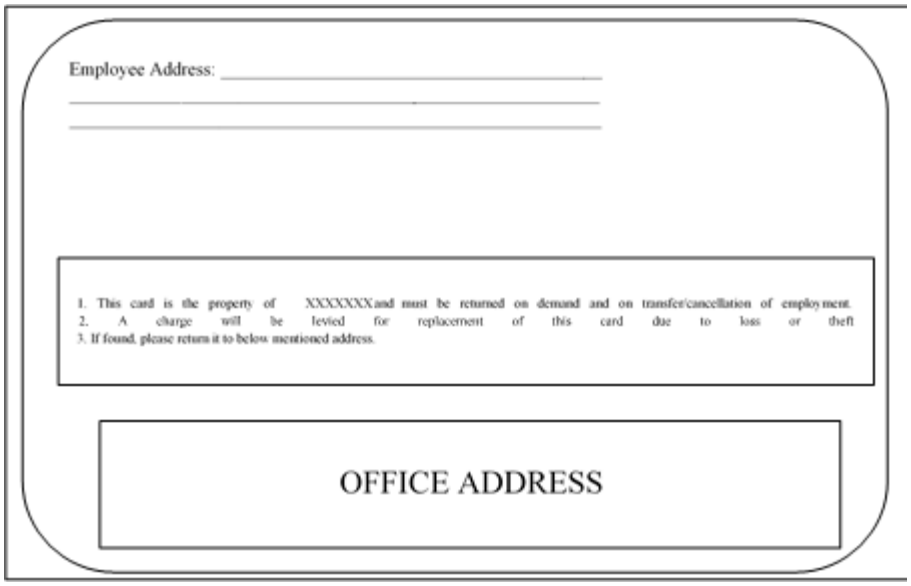
- Contractor's Environment Policy
- Key legal requirements
- Avoidance of Nuisance
- Environmental Sanitation

- Dust Control Measures
- Water Pollution and Control
- Occupational noise mitigation
- Waste Management and Disposal
- Gender Based Violence and Sexual Exploitation and abuse (GBV/SEA)
- HIV/AIDS prevention
- Grievance Redressal Mechanism for GBV/SEA

General Instruction: ESHS/GI/003

ID CARD FORMAT (85 mm x 55mm) FRONT SIDE OF ID CARD:





General Instruction: ESHS/GI/004 [ESHS Training Matrix]

ESHS Supervisors	ESHS Manager	Medical Officer	Clerical Staff	Security Officers	Transportation Drivers	Electrical workers	Mechanical Workers	Steel Workers	Station Building Workers	Material Handlers	Machinery Operators	Construction Foreman	Construction Supervisors	Construction Managers	Planning Engineer	Quality Manager	Sr. Construction Managers	Contractor Representative	Types of Training
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	ESHS orientation
		*												*	*	*	*	*	ESHS leadership
*	*	*										*	*	*	*	*	*	*	ESHS plan
*	*												*	*		*	*	*	ESHS improvement plan
*	*												*	*	*	*	*	*	Management of change
*	*												*	*	*		*	*	ESHS audit and inspection
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	ESHS emergency response & preparedness
*	*	*		*									*	*	*	*	*	*	Incident/Accident investigation & reporting
*	*											*	*	*	*	*	*	*	ESHS communication
*	*													*	*		*	*	ESHS promotion & incentives
*	*			*	*						*		*	*		*	*	*	Traffic management
*	*			*						*		*	*	*	*	*	*	*	Hazard identification & risk analysis & Aspect Impact
*	*			*				*	*	*		*	*	*		*	*	*	Permit to work system
*	*													*	*	*	*	*	Confined space entry
*	*	*		*				*	*	*				*		*	*	*	Scaffolding
*	*	*	*	*	*	*	*	*	*		*		*	*		*	*	*	Waste management
*	*											*	*	*			*	*	Environment monitoring
*	*	*										*	*	*		*	*	*	Labour welfare measures
*	*											*	*	*		*	*	*	Behavior Based Safety Management (BBSM)
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	Industrial First Aid and CPR
*	*		*	*	*	*	*	*	*	*	*	*	*						Fire fighting
*	*					*	*	*		*	*	*	*	*			*		Rigging
*	*											*	*	*					Wire rope inspection
*	*											*	*	*					Crane inspection
*	*											*	*	*					Electrical/Mechanical isolation
*	*											*	*						Explosive handling and control
*	*					*	*	*	*			*	*						Heavy lifting operation
*	*							*				*	*						Welding, cutting and bracing
*	*								*			*	*						Power actuated hand tool
*	*					*	*	*	*			*	*						Roofing work
*	*							*				*	*						Steel erection work
*	*					*	*	*	*			*	*						Scaffold erection/dismantling

General Instruction: ESHS/GI/005

ESHS Training Details for Managers and Supervisors

1. The Law and Safety	**2. Policy and Administration**
Statutory requirement Appropriate regulations Duties of employee	Effect of incentive on accident prevention ESHS Policy Industrial relations Safety Officer: duties, aims, objectives
3. Safety and the Supervisor	**4. Principles of Accident Prevention**
Safety and efficient production Accidents affect morale and public relations	Attitudes of management, supervision and operations Methods of achieving safe operations Accident and injury causes
5. Site Inspection	**6. Human Behaviour**
The role of management Hazard Identification Procedure Records results Follow-up procedures Feedback	Motivating agencies Individual behaviour Environmental effects Techniques of persuasion
7. Site housekeeping	**8. Health**
Site organization Relationship of site housekeeping to accident occurrence Site access Equipment storage Material stacking Materials handling	Medical examination Hazard to health on site Sanitation and welfare Protective clothing First Aid/CPR
9. Personal Protective Equipment	**10. Electricity**
Eye, face, hands, feet and legs Respiratory protective equipment Protection against ionizing radiation	Appreciation of electrical hazards Power tools Arc welding Low voltage system Lighting and power system on sites ELCB, RRCB, Grounding/Ground fault circuit interrupters (GFCIs)
11. Oxygen and Acetylene Equipment	**12. Equipment**

Cylinder storage and maintenance Condition and maintenance of valves, regulators, and gauges Condition and maintenance of hoses and fittings Pressures	Accidents related to moving parts of machinery Appreciation of principles of guarding Importance of regular maintenance
13. Transportation Transport to and from site Hazard connected with site transport Competent drivers Dumpers Tipping trucks Movement near excavations	**14. Excavations** Method of shoring Precautions while shoring Precautions at edge of excavations Removal of shoring Sheet steel piling
15. Working platforms, Ladders, and Scaffolding	**16. Cranes and other Lifting Machines**
Hazards connected with the use of ladders Maintenance and inspection Type of scaffold Overloading Work on roofs Fragile material Openings in walls and floors Use of Full Body Harness and nets	Licensing, certification and training required for operation of cranes Slinging Methods Signalling Access to crane(s) Maintenance and examination Ground conditions Hazards and accident prevention methods connected with the use of different types of cranes/heavy equipment Crane Lift Plan for all lifts
17. Lifting Tackle	**18. Fire Prevention and Control**
Slings - single and multi-legged Safe working loads (SWLs) Safety hooks and eyebolts Cause of failure Maintenance and examination	Principle causes determining fire Understanding fire chemistry Firefighting equipment Firefighting training
19. Communications	
Effective methods of communication (interest to non-English speaking workers) Method and preparation of reports Safety committees Safety meeting	

20. **Environment and Social**
Environment Policy Regulatory requirements • Central • State • Judicial • Environmental requirements of funding agency Overview of Environmental issues at construction sites and funding agency's requirements. Avoidance of nuisance Environmental sanitation Dust control measures Overview of impact of construction on Climate change Contractual requirements to reduce construction related impacts Monitoring of environmental parameters and their significance Waste Management Occupational Noise and its mitigation Health impacts of construction industry Resource minimization ISO requirement (as applicable) Gender Based Violence and Sexual Exploitation and abuse (GBV/SEA) HIV/AIDS prevention Grievance Redressal Mechanism for GBV/SEA

General Instruction: ESHS/GI/006

WEEK/DAYS TO BE OBSERVED FOR CREATING ESHS AWARENESS

1st Monday to Sunday of January	Road Safety Week (Subjected to confirmation from Ministry of Road Transport, Govt. of India every year.)
16th February	Kyoto Protocol Day
March	Red Cross Month
4th March	National Safety Day
22ndMarch	World Water Day
7th April	World Health Day
14th April	Fire Safety Day
18th to 22nd April	Earth Week
20th April	Earth Day
20th April	Noise Awareness Day
28th April	ILO World Day for Safety and Health at Work Day
1st to 7th May	Emergency Preparedness Week
5th June	World Environmental Day
12th June	World Day against Child Labours
21st June	World Yoga Day
9th July	Occupational Health Day
17th October	World Trauma Day
1st December	World AIDS Day

General Instruction: ESHS/GI/007

Minimum Requirements of ESHS Communication Posters/Signage/Video:

a) Every Contractor shall prepare a ESHS Communication Plan as a part of site specific ESHS Management Plan and shall include the following minimum requirement of Posters/Signage/Video as applicable. In case readymade posters are available in any of the category from National Safety Council or any other safety related organizations they may procure the same and display it. In case the same is not available, then the Contractors shall make necessary arrangements to get the posters designed and printed on their own. All posters shall each be in Hindi, English and the regional language; and

b) All the above is to be detailed in the Contractor's ESHS Management Plan and he shall obtain the Engineer's prior consent for the numbers, contents, locations, etc.

Table No.: 1 - Minimum No. of Posters

Sl. No	ESHS Poster Title	Minimum No. of concepts in each title	No. of Posters/Signage/Video
1.	Safety Culture	5	Each 10
2.	Daily Safety Oath	1English, 1 Hindi	Each 50
3. a)	Signage to display the messages like PPE ZONE, NO PPE ZONE, HARD HAT AREA etc.	2 types of sizes made up of metal sheet to be mounted at different locations	Each 25
b)	Helmet	5	Each 25
c)	Shoe	5	Each 25
d)	Goggles & Ear Protection	5	Each 25
e)	Full Body Harness	5	Each 25
f)	Hi-Vi Jacket	5	Each 25
4.	Emergency Management Plan	5	Each 25
5.	Working at Heights	10	Each 25
a)	Ladder, Stairway, Scaffold - Signage to display the messages like SAFE, UNSAFE, FIT FOR USE,	5 types of sizes made up of metal sheet to be mounted at different locations	Each 25

Sl. No	ESHS Poster Title	Minimum No. of concepts in each title	No. of Posters/Signage/Video

	AVOID USE etc.		
6.	Site Electricity	5	Each 25
7.	Crane Safety	5	Each 25
8.	Slings	5	Each 25
9.	Rigging Procedures	5	Each 25
10.	Excavation	5	Each 25
11.	Occupational Health (Mosquito Control, HIV/AIDS awareness, Dust Control, Noise Control, No Smoking/Spitting, etc.)	10	Each 25
12.	First – Aid	3	Each 25
13.	Labour Welfare Measures (Payment of Minimum Wages, Avoidance of Child labour, signing in the Muster Roll, in case of accidents- what to do? Etc.	5	Each 25
14.	Importance of "Safety Handbook"	1	25
15.	Traffic Safety (Speed limit, safe crossing and working within barricaded area etc.)	5	Each 25
16.	Environmental Monitoring (Spillage of Muck, hazardous material, Improper drainage, water spray for dust containment etc.)	5	Each 25
17.	Video in Hindi on PPE usage – 15 minutes duration	1	-

Note 1: Items mentioned under 17 is video. Items under 3 (a) and 5 (a) are metal signage boards and all other items are posters.

Note 2: The above minimum numbers are for guidance only. The actual number will depend on the project's specific requirements. The Contractor shall propose and obtain Engineer's prior consent to the final numbers, locations, etc.

Table No.: 2 – Size of Posters/Signage

Sl. No	Item	Size
1.	Posters – Standard	17"x22" –135 GSM 4 Colour Printing
2.	Posters – Special (Wherever required)	17"x22" card laminated FA Poster
3.	Posters - Mega size (Wherever required)	32"x40" Flex FA Poster
4.	First-Aid Booklet	6"x4"
5.	Safety Handbook	6"x4"
6.	Signage	Small: 12"x6" Big: 24"x12"
7.	Road Traffic Sign Boards	Strictly as per Indian Road Congress (IRC) specifications

Table No.: 3 – Safety Signage Colour (as per IS: 9457)

Sl. No	Type of signage	Colour
1	Mandatory	Blue
2	Danger	Yellow
3	Prohibitory	Red
4	Safe conditions	Green

General Instruction: ESHS/GI/008

Environment, Social Formats/Checklist

1. Weekly Environmental Inspection Summary

1.0 Major issues of non-conformity in the past week are:

	Issue	Reason
I.	Air (Specify)	
II.	Water (Specify)	
III.	Noise (Specify)	
IV.	Water (Specify)	
V.	Storage (Specify)	
VI.	Housekeeping (Specify)	
VII.	Roads (Specify)	

2.0 Over the last week have been able to implement environmental management requirement as per contract

Yes ☐ ☐ No if not yes reasons are:

(i)

(ii)

(iii)

3.0 Following issues have not been resolved for more than past two weeks

(i)

(ii)

(iii)

4.0 Support/Clarification from Employer's Representative required in the following:

(i)

(ii)

(iii)

5.0 Complaint received in the past week:

From	Action Taken	Reasons for Delay
(i) Public		
(ii) Client		
(iii)Statutory Agency		

Auditor: Project Manager

Contact Number: Contractor:

Environmental Manager	Project Manager	Document No.:

2. Weekly Environmental Inspection

Report No.:	Inspection Date:	Inspected by:
Inspection Area:		
Participants:		

S.No.	Item	Observation	Remarks	Action	
				By Date	By Whom
1.0	**Air Pollution**				
1.1	Dust (approach roads, adjacent road, working area, cement handling etc.)	☐ Satisfactory ☐ Site Dusty ☐ Sprinkling carried out as required ☐ Excavated soil removed within 2 days			
1.2	Generators	☐ Satisfactory ☐ Maintenance regime followed ☐ Black smoke ☐ Leaking oil ☐ Drip pans not available			
1.3	Vehicles	☐ Satisfactory ☐ PUC certificate available ☐ Black smoke ☐ Wheel washed/cleaned ☐ Leaking oil ☐ Side of vehicle clean of mud ☐ Material transported in closed manner			
1.4	Air monitoring	☐ Carried out as per contract ☐ Results reported as per contract			

S.No.	Item	Observation	Remarks	Action	
				By Date	By Whom
		☐ Remedial measures in place where required			
2.0	**Water Pollution**				
2.1	Site Drains	☐ Drainage system functional ☐ No Contamination ☐ Not blocked by debris/ garbage ☐ No indications of Oil spilled in drains ☐ Storage of chemical waste not nearby			
2.2	Adjacent Drains	☐ Not damaged ☐ No signs of pouring bentonite ☐ No signs of pouring Chemicals ☐ Signs of discharging Silt/ debris			
2.3	Separator Tanks	☐ Tank not full of silt ☐ Tank regularly emptied			
3.0	**NOISE POLLUTION**				
3.1	Noise control measures	☐ All powered mechanical equipment's are sound reduced ☐ Acoustic / enclosures constructed in areas of excessive noise ☐ Equipment located and directed away from noise receptors			
3.2	Generators provided with acoustic enclosures	☐ Effective ☐ Not effective ☐ Not provide			
3.3	Noise Monitoring	☐ Carried out as per contract ☐ Not exceeded baseline values ☐ Remedial measures in place ☐ Results evaluated statistically for inclusion in Monthly report			

S.No.	Item	Observation	Remarks	Action	
				By Date	By Whom
4.0	**WASTE MANAGEMENT**				
4.1	Waste Identified	☐ Chemical Flammable Corrosive Construction related/ oil/ Filters/ Batteries ☐ Hazardous ☐ Other (Specify)			
4.2	Storage Containers & Bins	☐ Adequate number and properly place ☐ Proper quality ☐ Emptied regularly ☐ Labelling proper ☐ No spillage on container ☐ surface noticed			
4.3	Storage Containers & Bins	☐ Pollutants (e.g. waste chemical), not dumped in bins ☐ Recyclable (e.g. metal) not dumped in garbage bins			
4.4	Oil Waste	☐ Drip pans available ☐ No oil stains on ground ☐ Spill absorption material available ☐ Waste oil poured in to designated waste drums ☐ Used oil filters not dumped in garbage bins			
4.5	Excavated soil	☐ Storage satisfactory/ properly secured ☐ Dumping in authorized areas ☐ No interference with nearby drainage			
5.0	**STORAGE**				
5.1	Diesel Storage	☐ Extensive diesel spillage on ground not visible ☐ Drip pans used when pumping diesel ☐ Pipes / connectors/ pumps not leaking			

S.No.	Item	Observation	Remarks	Action	
				By Date	By Whom
		☐ Not located close to storm water drains ☐ Transfer arrangement satisfactory			
6.0	**AESTHETICS & CLEANLINESS**				
6.1	Housekeeping & Hygiene	☐ Designated storage area for materials ☐ Scraps/brickbats/rubbish scattered at site ☐ Proper space for handling waste ☐ Area Clean and dry ☐ Stagnant water treated weekly ☐ Proper stacking of drums ☐ Barricades are clean, in line, firmly secured and proper earthling ☐ Water not allowed to accumulate in work area for any reason			
7.0	**Roads**				
7.1	Access Roads	☐ Satisfactory Maintenance ☐ In urgent need of Maintenance			
7.2	Public Roads used by Contractor	☐ Satisfactory maintenance ☐ Repair not carried out			

3. Air and Noise Monitoring Report Format

Air Monitoring Report

Parameter:
Unit :

CPCB Standard Value:

Location	Monitoring Date	Measured Value	Base line value if any

Noise Monitoring Report
Day Time

Location	Category of Area/Zone	National Standard (Day time) Leq dB(A)	Baseline value (Day time), Leq dB(A)	Noise levels (Day time) Leq dB(A)

Night Time

Location	Category of Area/Zone	National Standard (Night time) Leq dB(A)	Baseline value (Night time), Leq dB(A)	Noise levels (Night time) Leq dB(A)

4. Monthly Waste Management Record

S.No	Waste Type	Unit	Quantity Generated		Quantity Disposed off		Adopted/Proposed disposal method
			For the month	Till date	For the month	Till date	
1	**Construction and Demolition Waste**						
	a. Concrete waste	MT					
	b.Demolition Waste	MT					
	c. Bentonite/Polymer mixed soil	CUM					
	d. Good earth	CUM					
2	**Hazardous Waste**						
	a. Waste oil	Litres					
	b. Oil filters	Nos					
	c. Air filters,	Nos					
	d. Cartridges etc.	Nos					
	e. Other (if any)						
3	**Recyclable waste**						
	Paper, plastic, wood, bottles, rubber etc.	Kg					
4	**Bio-degradable waste**						
	Food waste, vegetable waste etc	Kg					
5	**Metal Scrap**	Ton					
6	**E -Waste**	Nos/ Ton					
7	**Miscellaneous (any other)**						

Prepared by:	**Reviewed by: (Environment Manager)**	**Approved by: (Project Manager)**

5. Water Consumption Details

S. No	Source of Water	Quantity Consumed for the month (KL)	Quantity Consumed till date (KL)
1	Ground Water Extracted		
2	Municipal Supply		
3	Water Tanker		
4	Water bottles		
Total (A)			
Breakup of Raw Water Consumption Detail			
S. No.	**Particular**	**Quantity Consumed for the month (KL)**	**Quantity Consumed till date (KL)**
1	**Raw Water**		
	a. Consumed in RO Plant		
	b. Sprinkling		
	c. Wheel washing		
	d. Domestic purpose like drinking, toilets, labour camps, office cleaning		
	e. Curing		
	f. Stone cutting		
	g. TM washing		
	h. Any other use		
	Total (B)		
2	**R O treated water**		
	Total (C)		
3	**R O Reject Water**		
	Total (D)		

Prepared by: **Reviewed by:** **Approved by:**
Environment Manager **Project Manager**

6. Details on Fly Ash (If Applicable)

The Employer shall give his consent to the civil Contractor for using Fly Ash in concrete or brick works. The Contractor shall record all relevant details on the consumption of Fly Ash from the data of initial consumption to date of final use.

Fly Ash utilization in tonnes in Building Materials and Products for the FY-
Contract No. :
Name of Contractor :
Details regarding utilization of fly ash in road/flyover construction projects:

S. No.	Item of work	Total quantity of material used (tonnes)	Quantity of Fly ash used (tones)	Quantity of Soil/Earth any other material used (tones)	% fly ash used against total quantity of material used	Source of fly ash
Remarks:						

Prepared by: **Reviewed by:** **Environment Manager** **Approved by:** **Project Manager**

7. Material Consumption Details

S.No.	Particular	Unit	Quantity Consumed	
			For the month	Till date
1	Concrete	CUM		
2	Cement	MT		
3	Sand	MT		
4	Coarse Aggregate	MT		
5	Reinforcement	MT		
6	Admixtures	Litres		
7	Diesel	Litres		
8	Electricity	kWh		

Prepared by:	Checked by: (Environment Manager)

8. Records of Complaints

S.No	Nature of Complaints	Date of Complaints Received	Impact Location	Name of Complainant	Address of Complainant	Remarks	Status		
							Solved	On going	Pending

General Instruction: ESHS/GI/009

MARS Audit Rating

Contractor No.:	Contractor:	
Audit No.:	Date:	
For the month of:		
Audit team	Contractor representatives	HRIDC/GC Representatives
Headed by:		
Assisted by:		

Contract No.:		**Contractor:**	
For the month of:			
Audit date:			
Sl. No.	**Section**	**% score attained By Contractor**	**% Score given By HRIDC-GC**
1	ESHS Administration		
2	ESHS Training and ESHS Communication		
3	ESHS Inspection and Audit		
4	Hazard Identification, Risk Assessment and Emergency Preparedness		
5	Reporting of Accidents and Dangerous Occurrences and investigations		
6	Housekeeping		
7	Working at Height		
8	Lifting Operations and Gears		
9	Construction Machinery / Hand tools and power tools		
10	Site Electricity		
11	Fire prevention		
12	Welding & Cutting		
13	Excavations and Trenching		
14	Tunnelling and Confined Space operations		
15	Traffic management		
16	Personal Protective Equipment		
17	Industrial Health & Hygiene and Lighting & Ventilation		
18	Welfare amenities		
19	Environmental management		
20	Batching Plant and Casting Yard		
Overall audited score attained			

Team Head / Contractor Name:	**Designation**	**Signature**	**Date**
Team Head / HRIDC/GC Name:	**Designation**	**Signature**	**Date**

MONTHLY AUDIT RATING SCORE (MARS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.							
Contract No.:	Contractor's Name:						
1.0 ESHS Administration							
1.1 ESHS Organisation	**A**	**B**	**C**	**1.1a ESHS Organisation**	**A**	**B**	**C**
Adequacy of ESHS personnel	10			ESHS manpower from outsourcing agency	10		
Is ESHS personal professionally qualified	10			ESHS personals reports to ESHS manager	10		
Employer's approval for each ESHS personal	10			ESHS manager reports to Project Manager	10		
Intimation of ESHS personals vacancy to Employer	10			Facilities and equipment gave to the ESHS personnel	10		
ESHS personal lies with the main contractor	10			ESHS personnel can stop any unsafe act	10		
Sub total	**50**			**Sub total**	**50**		
1.2 ESHS Committee	**A**	**B**	**C**	**1.3 Construction ESHS Committee**	**A**	**B**	**C**
Is site and construction ESHS Committee formed	10			Does construction ESHS committee meet at least weekly	10		
Does PM Chairman of ESHS Committee	10			Do all sub contractors attend	10		
Committee members under gone monthly inspection	10			Is agenda cover all the points	10		
Does site ESHS committee meet at least monthly with 21 days time gap	10			Minutes of the meeting send to all committee members	10		
Are Incident Reports discussed	10			Minutes displayed in the notice board	10		
Sub total	**50**			**Sub total**	**50**		
1.4 ID card and first day at work	**A**	**B**	**C**	**1.5 Designer's role**	**A**	**B**	**C**
Is ID card issued to all persons	10			Whether designers were informed about clause 5.0 of Conditions of Contract on ESHS	10		
Is ID card as per standard	10			Whether designers provide ESHS risk at the drawing itself.	10		
Authority signed all ID cards	10			Whether hierarchy of risk control is indicated by the designer	10		
All worker undergone orientation training	10			Participation of designer in monthly SCM	10		
ESHS hand book issued to all personnel	10			Detailed supplementary information about ESHS risk of the design given by designer.	10		
Sub total	**50**			**Sub total**	**50**		
1.6 ESHS submittals to Employer	**A**	**B**	**C**	**1.6a ESHS submittals to Employer**	**A**	**B**	**C**
Daily reporting of workmen	10			External ESHS audit report	10		
Monthly ESHS report	10			Electrical safety audit report	10		
ESHS committee meeting minutes	10			Air monitoring report	10		
ESHS inspection report	10			Noise monitoring report	10		
Monthly internal ESHS audit score report	10			Accident, Incident and dangerous occurrence reporting	10		
Sub total	**50**			**Sub total**	**50**		
1.7 Visitors to site	**A**	**B**	**C**		**A**	**B**	**C**
Visitor got the permission from Employer	10						
Contractor have visitor PPEs	10						
Responsible accompanied with visitor	10						
Does visitor entering hazardous area	10						
Visitor register maintain at site office	10						
Sub total	**50**			**Sub total**			
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**450**			**Section % Score**	**100**		

A – Total score B – To be Awarded by contractor C – To be awarded by Employer

MONTHLY AUDIT RATING SCORE (MARS)

	HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.							
Contract No.:	Contractor's Name:							
2.0 ESHS Training and ESHS Communication								
2.1 Training Policy	**A**	**B**	**C**	**2.2 Induction Training**	**A**	**B**	**C**
Is training policy in ESHS Plan	10			Does training take place in first week	10		
Is policy implemented	10			Induction Handout	10		
Does it includes sub contractors	10			Project related syllabus	10		
Is training policy published	10			Management participation	10		
Does PM understand training policy	10			Attendance records kept	10		
Sub total	**50**			**Sub total**	**50**		
2.3 Toolbox Talks	**A**	**B**	**C**	**2.4 Supervisor Training**	**A**	**B**	**C**
Are they held at least weekly	10			Is there a recognized programme	10		
Presented by supervisor/safety officer	10			Project related	10		
System monitored by management	10			Senior management participation	10		
Employee involvement	10			Achievement test	10		
Attendance records kept	10			Attendance records kept	10		
Sub total	**50**			**Sub total**	**50**		
2.5 Follow up training	**A**	**B**	**C**	**2.6 Driver/Plant Operator Training**	**A**	**B**	**C**
Is follow up training organized	10			Does Driver/PO training take place	10		
Does it take place after six months	10			Are all drivers undergone for defensive training at IDTR.	10		
Is syllabus project related	10			Are all Drivers and Operators certificated	10		
Attendance records kept	10			Are records kept	10		
Workers participation towards training	10			Are all Drivers Operators retained	10		
Sub total	**50**			**Sub total**	**50**		
2.7 Promotional activities	**A**	**B**	**C**	**2.8 ESHS posters**	**A**	**B**	**C**
Is there a safety promotional programme	10			Are posters adequate no's	10		
Are any incentive schemes used	10			Are posters separately numbered	10		
Are subcontractors included in promotion	10			Are posters cover all topics	10		
Had any worker rewarded so far.	10			Are safety posters visible on site	10		
Management's participation towards this	10			Are posters maintaining regularly	10		
Sub total	**50**			**Sub total**	**50**		
2.9 ESHS Signage	**A**	**B**	**C**	**2.10 Important days to be observed**	**A**	**B**	**C**
Is signage in correct colours	10						
Adequate number of signs	10						
Suitable positioning of signs	10						
Signs in Hindi and English	10						
Are signage maintaining regularly	10						
Sub total	**50**			**Sub total**			
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**450**			**Section % Score**	**100**		

MONTHLY AUDIT RATING SCORE (MARS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.							
Contract No.:	**Contractor's Name:**						
3.0 ESHS Inspection and Audit							
3.1 Planned General Inspection	**A**	**B**	**C**	**3.2 Routine Inspection**	**A**	**B**	**C**
Monthly contractor and subcontractors' site ESHS committee Inspection	10			Operator Daily Inspection of plant and equipment	10		
Weekly ESHS inspection by supervisors	10			Monthly Inspection of electrical hand tools	10		
Daily ESHS inspection by site ESHS team	10			Quarterly Inspection of temporary electrical systems	10		
Employer's and contractor's representative involved in this ESHS inspection	10			Weekly Inspection of scaffold by scaffolding supervisor	10		
Records maintenance	10			Half-yearly inspection of lifting appliances and gears by competent person	10		
Sub total	**50**			**Sub total**	**50**		
3.3 Specific Inspection	**A**	**B**	**C**	**3.4 ESHS Inspection**	**A**	**B**	**C**
Before a heavy lifting operation	10			Is Contractor prepare checklist for all activity	10		
Before & after entry into confined space	10			Checklist mentioned in contractor ESHS plan	10		
Before & after a welding & gas cutting	10			All inspection reports registered	10		
Before concreting formwork	10			Inspection reports sent to Employer	10		
All high-risk processes inspected by competent supervisor	10			Planned and Routine Inspection used for discussion in ESHS Committee Meeting	10		
Sub total	**50**			**Sub total**	**50**		
3.5 MARS	**A**	**B**	**C**	**3.6 Electrical safety audit**	**A**	**B**	**C**
Performed once in a month	10			Covered all areas	10		
Project Manager accompanied this audit	10			Performed once in a month	10		
Conducted at least 7 days prior to Monthly ESHS Committee meeting	10			Team comprising of senior ESHS (Elect) engineer	10		
Audit Report will be sent to Employer	10			Audit Report will be sent to Employer	10		
Corrective actions taken	10			Corrective actions taken	10		
Sub total	**50**			**Sub total**	**50**		
3.7 External Audit (General)	**A**	**B**	**C**	**3.8 External Audit**	**A**	**B**	**C**
Conducted by external agencies	10			Contents and coverage	10		
Auditors ISO qualified and competent	10			Available documents	10		
Approval of the Employer	10			Qualification of audit team members	10		
Audit report as per ISO/ILO standard	10			Had checklist prepared	10		
Conducted on a quarterly basis	10			Status of NCR of external audit	10		
Sub total	**50**			**Sub total**	**50**		
3.9 Audit Report	**A**	**B**	**C**		**A**	**B**	**C**
Audit report as per ISO/ILO standard	10						
Audit conformity / non-conformity report to the Employer	10						
Report contents and coverage	10						
Corrective action by contractors	10						
Initial audit for checking the adequacy of implementation	10						
Sub total	**50**			**Sub total**			
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**450**			**Section % Score**	**100**		

A – Total score B – To be Awarded by contractor C – To be awarded by Employer

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.								
Contract No.:	Contractor's Name:							
4.0 Hazard Identification, Risk Assessment and Emergency Preparedness								
4.1 Policy for Identifying Hazards	**A**	**B**	**C**	**4.2 Risk Assessment**	**A**	**B**	**C**
Procedure for identifying hazards	10			Are risk assessment carried out	10		
Is there a list of significant hazards	10			Is there a formal process	10		
Procedure for Risk Assessment	10			Are worksheets used	10		
Whether any schedule or hierarchy made	10			Are records kept in site office	10		
Ranking of hazards	10			Whether control measures are planned	10		
Sub total	**50**			**Sub total**	**50**		
4.3 Method Statements	**A**	**B**	**C**	**4.4 Permit to work in use**	**A**	**B**	**C**
Are Method Statements produced	10			Is there a procedure for Permits to work	10		
Dot hey contain clear instruction	10			Issued by Authorized person	10		
Are they given to work supervisors	10			Issued for defined period	10		
Is correct information given to workers	10			Workers instructed	10		
Step by step description of task	10			Are records kept of Permits issue	10		
Sub total	**50**			**Sub total**	**50**		
4.5 Emergency Preparedness Plan	**A**	**B**	**C**	**4.6 Emergency control centre**	**A**	**B**	**C**
Is there description within Safety Plan	10			Available of first-aid box	10		
Is it up to date	10			Public addressing system	10		
Is it well published	10			Emergency phone numbers	10		
Does Project Manager have copy	10			Emergency alarm	10		
Exercise within past three months	10			Employees name list	10		
Sub total	**50**			**Sub total**	**50**		
4.7 Communication system	**A**	**B**	**C**	**4.8 Plan Details**	**A**	**B**	**C**
Public addressing system	10			Details of emergency co-ordinator	10		
Emergency power supply	10			Designated personnel with Tel. Nos.	10		
Mobile phone in Emergency care centre	10			Are telephone numbers up to date	10		
Warning boards	10			Emergency response team identified	10		
Records maintained for usage and maintenance of communication systems	10			Functions of Team identified	10		
	50			**Sub total**	**50**		
4.9 Requirements	**A**	**B**	**C**	**4.10 First Aid**	**A**	**B**	**C**
Link to Police	10			Is First Aid included in Safety Plan	10		
Link to Fire Services	10			Are adequate no. of First aiders appointed	10		
Link to Ambulance and Hospital	10			Record keep of qualification	10		
Communication to employees	10			First aid boxes supplied	10		
Displayed on Notice Boards	10			First aid boxes properly equipped	10		
Sub total	**50**			**Sub total**	**50**		
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**500**			**Section % Score**	**100**		

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.							
Contract No.:	Contractor's Name:						
5.0 Reporting of Accidents and Dangerous Occurrences and Accident Investigations							
5.1 Reporting to Employer	**A**	**B**	**C**	**5.2 Reporting to Govt. organisation**	**A**	**B**	**C**
Verbal information	10			Reporting to Regional Labour Commissioner	10		
Written information within 24 hrs	10			Reporting to welfare board	10		
Delay in reporting	10			Reporting to director general	10		
Are all accidents identified and recorded	10			Reporting to police station	10		
Are AFR rates calculated	10			Reporting to District Magistrate	10		
Sub total	50			**Sub total**	50		
5.3 Incident Reporting	**A**	**B**	**C**	**5.4 Follow up Action**	**A**	**B**	**C**
Is there a proper reporting procedure	10			Does Senior Manger review all reports	10		
Is the procedure communicated to all	10			Is result of investigation published	10		
Are reports available for inspection	10			Are workers advised of remedial action	10		
Do reports accurately describe incident	10			Are failure in Management recognized	10		
Is standardised form used	10			Whether statistics report prepared	10		
Sub total	50			**Sub total**	50		
5.5 Procedure for investigation	**A**	**B**	**C**	**5.6 Incident Investigation**	**A**	**B**	**C**
Made Photographs and sketches	10			Are witness statement taken	10		
Examine involved equipment	10			Is the chain of events identified	10		
Interviewed the eye-witnesses	10			Is specific sub contractor identified	10		
Consulted expert opinion	10			Investigation kit available	10		
Environmental conditions	10			Investigation report made available to Employer	10		
Sub total	50			**Sub total**	50		
	A	**B**	**C**		**A**	**B**	**C**
Sub total				**Sub total**			
	A	**B**	**C**		**A**	**B**	**C**
Sub total				**Sub total**			
Contractor's Observations:				**Employer's Observations:**			
Section Scores	300			**Section % Score**	100		

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

Contract No.:	Contractor's Name:

6.0 Housekeeping

6.1 Procedure	A	B	C	6.2 Organisation	A	B	C
Is it mentioned in ESHS plan	10			Adequacy of housekeeping personnel	10		
Responsibility classified	10			Is housekeeping personnel trained	10		
Housekeeping round the clock	10			Employer's approval for housekeeping personnel	10		
Reporting of housekeeping personals to ESHS Manager	10			Intimation of vacancy to Employer	10		
Housekeeping persons provided no. / badge	10			Persons provided with suitable logistics / aid	10		
Sub total	50			**Sub total**	50		
6.3 Housekeeping squad	A	B	C	**6.4 Barricades**	A	B	C
Housekeeping plan	10			Dimension of the board	10		
Member list	10			HRIDC logo	10		
Job allocation and time allocation	10			Sequential Numbering	10		
Periodicity of housekeeping	10			Availability of protruding parts	10		
Documentation of housekeeping	10			Regular cleaning and painting	10		
Sub total	50			**Sub total**	50		
6.5 Access / Egress way	A	B	C	**6.6 Dustbins**	A	B	C
Free from debris	10			Lumbar with protruding nails	10		
Unprotected opening	10			Unprotected projection	10		
Free from obstructions	10			Scattered unused materials	10		
Slippery condition	10			Spill of bentonite	10		
Spillage of water or oil	10			Fencing and guarding of equipments	10		
Sub total	50			**Sub total**	50		
6.7 Housekeeping at worksites	A	B	C	**6.8 Housekeeping at roads**	A	B	C
Lumbar with protruding nails	10			Tyre cleaning of vehicles	10		
Unprotected projection	10			Parking of construction vehicles at road	10		
Scattered unused materials	10			Water logging or bentonite spill on road	10		
Fencing and guarding of equipments	10			Roads kept clean	10		
Stacking and storing of materials	10			Position of barricades lying at roads	10		
Sub total	50			**Sub total**	50		
6.9 Storage of cylinders	A	B	C		A	B	C
Full / empty separated	10						
Gases separated	10						
Protected from weather	10						
Contents labelled	10						
MSDS available for each gas	10						
Sub total	50			**Sub total**			

Contractor's Observations:	Employer's Observations:

Section Scores	450			Section % Score	100		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

Contract No.:	Contractor's Name:

7.0 Working at Height

7.1 Organisation and planning	A	B	C
Adequate number of trained personnel	10		
Supervision	10		
Planning emergency and rescue	10		
Work permit system	10		
Refresher training	10		
Sub total	50		

7.2 Fragile surface	A	B	C
Suitable working platform	10		
Guard rails	10		
Crawling boards	10		
Warning notice	10		
Work permit system to work	10		
Sub total	50		

7.3a Scaffolding	A	B	C
Is scaffolding included in ESHS Plan	10		
Are scaffolding erected and dismantled by competent workmen	10		
Are records kept of inspections	10		
Security fixed or buttressed	10		
Working platforms free from rubbish	10		
Sub total	50		

7.3b Scaffolding	A	B	C
Scaffolds constructed for correct use	10		
Are scaffolds constructed of sound material without patent defect	10		
No unsuitable material	10		
Working platforms fully boarded	10		
Guardrails and mid rails fitted	10		
Sub total	50		

7.3c Scaffolding	A	B	C
Secure ladder access provided	10		
Toe board provided	10		
'Safe for Use' board erected	10		
Availability of base plate	10		
Free from rust / corrosion / debris	10		
Sub total	50		

7.4a Ladders	A	B	C
Are ladders specified in Safety Plan	10		
Is there a system for checking ladders	10		
Are records kept of weekly checks	10		
Using of Bamboo ladders	10		
Painting of ladders	10		
Sub total	50		

7.4b Ladders	A	B	C
Safety procedure followed	10		
Rubber bush in aluminium ladder	10		
Landing properly	10		
Climbing procedure	10		
Rungs at proper intervals	10		
Sub total	50		

7.5 Guardrails	A	B	C
Present at all working platforms	10		
Securely attached	10		
Sound material	10		
Designed as per standard	10		
Maintained properly	10		
Sub total	50		

7.6 Harnesses	A	B	C
Is use of harnesses specified in ESHS Plan	10		
Are harnesses of full body type	10		
Are secure anchorage points used	10		
Has instruction on correct use been given	10		
Maintenance and inspection	10		
Sub total	50		

7.7 Safety net	A	B	C
Approved type	10		
Good construction	10		
Adequate number to issue	10		
Testing	10		
Maintenance	10		
Sub total	50		

Contractor's Observations:	Employer's Observations:

Section Scores	500			Section % Score	100		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.							
Contract No.:	Contractor's Name:						
8.0 Lifting Operations and Gears							
8.1 Certification	**A**	**B**	**C**	**8.2 ASLI / Other Indicators**	**A**	**B**	**C**
Procedure is available in ESHS Plan	10			Free from damage	10		
Fitness / Test Certificates available	10			In operable conditions	10		
Daily inspection records maintained	10			Overload device tested	10		
Load chart for lifting appliances	10			Overload device operable	10		
Employer's approval for lifting appliances	10			Bypass key made available to I/C	10		
Sub total	50			**Sub total**	50		
8.3 Wire Ropes	**A**	**B**	**C**	**8.4 Safety Hooks**	**A**	**B**	**C**
Free from damage	10			Free from damage	10		
Lubricated	10			Safety latch fitted	10		
Correctly anchored	10			Safety latch in operable condition	10		
Splicing method	10			Other form of hook closure	10		
Inspection & Testing	10			Test certificates	10		
Sub total	50			**Sub total**	50		
8.5 Slings, Chains & Shackles	**A**	**B**	**C**	**8.6 Outriggers (Mobile Cranes)**	**A**	**B**	**C**
Properly stored when not in use	10			Outriggers locked in position	10		
In good condition without defects	10			Jacks in good condition	10		
Market with safe working load	10			Jacks firmly supported	10		
Bulldog clips correct fit/number	10			Wheels clear/not supporting load	10		
Correctly used	10			Chassis level	10		
Sub total	50			**Sub total**	50		
8.7 Operator and Operator cabin	**A**	**B**	**C**	**8.8 Rigging requirement**	**A**	**B**	**C**
Licence for HMV	10			Rigger qualification & experience	10		
Competent & skilled	10			Load assessment	10		
Medical fitness certificate	10			Type of slings to be used	10		
Portable fire extinguisher	10			Hocks & lifting assessment	10		
Defensive driving at IDTR	10			Overhead power line	10		
Sub total	50			**Sub total**	50		
8.9 Alarms & signals	**A**	**B**	**C**	**8.10 Accessories & controls**	**A**	**B**	**C**
Overload alarm	10			Side & rear view mirror	10		
Over hoist alarm	10			Clutch & brake	10		
Reverse horn	10			Swing & Extension control	10		
Pressure indicators	10			Illumination	10		
Outrigger extension alarm	10			Maintenance	10		
Sub total	50			**Sub total**	50		
Contractor's Observations				**Employer's Observations:**			
Section Scores	500			**Section % Score**	100		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.								
Contract No.:	Contractor's Name:							
9.0 Construction Machinery / Hand tools and power tools								
9.1 Machinery Fencing	**A**	**B**	**C**	**9.2 Maintenance**	**A**	**B**	**C**
All moving parts effectively guarded	10			All maintenance properly maintained	10		
Fencing not removed	10			No maintenance whilst M/c in motion	10		
Is procedure in ESHS Plan	10			Records of maintenance kept	10		
Warning board	10			Work Permit System	10		
Emergency stop switch	10			Use of 'Lock Out and Tag Out' (LOTO)	10		
Sub total	**50**			**Sub total**	**50**		
9.3 Air Receivers	**A**	**B**	**C**	**9.4 Wood working machines**	**A**	**B**	**C**
Fitted with pressure relief valve	10			Top guard fitted	10		
Annual test carried out	10			Working space	10		
All couplers with safety chains/wired	10			Guards to protect all drive belts	10		
Condition of hoses	10			Emergency stop switch	10		
Noise level under permissible limit	10			Push stick used	10		
Sub total	**50**			**Sub total**	**50**		
9.5 Grinding machine	**A**	**B**	**C**	**9.6 General**	**A**	**B**	**C**
Appropriate guards fitted	10			Is procedure in ESHS plan	10		
Correct size wheel/disc fitted	10			All operator medically fir and above 21 yrs	10		
Spindle speed marked on M/s	10			Unauthorized riding on plant	10		
Name plate for equipment specification	10			Inspection and maintenance record	10		
Test and maintenance	10			Portable fire extinguisher	10		
Sub total	**50**			**Sub total**	**50**		
9.7 Safe Operating Procedure	**A**	**B**	**C**	**9.8 Requirements**	**A**	**B**	**C**
Available for all machines	10			Manufacturer specification	10		
Available in the working area	10			Control switch	10		
Operator trained	10			GFCI / RCCB and other safety devices	10		
Operator know the same	10			IP 44 plugs, sockets & connectors	10		
Updated regularly	10			Guarding	10		
Sub total	**50**			**Sub total**	**50**		
9.9 Maintenance and Inspection	**A**	**B**	**C**	**9.10 PPE**	**A**	**B**	**C**
Daily inspection	10			Ear protection	10		
Lubrication	10			Hand Protection	10		
Pneumatic and hydraulic pressure	10			Eye protection	10		
Record maintenance	10			Apron	10		
Label displayed in the equipment itself.	10			Nose / face mask	10		
Sub total	**50**			**Sub total**	**50**		
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**500**			**Section % Score**	**100**		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

Contract No.:	Contractor's Name:

10.0 Site Electricity

10.1 Power assessment	A	B	C
Load calculation for power requirement	10		
Employer's approval for execution of the job	10		
Is small capacity diesel generator present	10		
Noise from diesel generator	10		
Sub-contractor's power requirement by main contractor	10		
Sub total	50		

10.2 Distribution Panels	A	B	C
Panel secure box to IP 44	10		
All cables enter box through glands	10		
ELCB or RCCB/ GFCI fitted	10		
Proper earth connection and earth pit	10		
Warning signs in appropriate position	10		
Sub total	50		

10.3 Cables	A	B	C
All cables free from damage	10		
Cables lying on the ground / water	10		
Cable joints made by IP 44 connectors	10		
Correct storage when not in use	10		
Colour coding	10		
Sub total	50		

10.4 Work on site	A	B	C
Site electricity covered in the ESHS Plan	10		
Name posted on Main Distribution Board	10		
Single line & Schematic diagram submitted	10		
Employer's Approval for execution	10		
GFCI provided	10		
Sub total	50		

10.5 Electrical professional	A	B	C
Sufficient numbers	10		
Professionally qualified	10		
Roles and responsibilities defined	10		
Valid license to electrical persons	10		
Training	10		
Sub total	50		

10.6 Earth Pit	A	B	C
As per standard	10		
Wet condition	10		
Pouring 5 litre water per days	10		
Earth pipe free from corrosion	10		
Earth resistance	10		
Sub total	50		

10.7 Plugs, Sockets and outlets	A	B	C
Are all plugs, sockets and outlets IP 44 type	10		
Colour coding of plugs and sockets	10		
All cables fitted with IP 44 Plugs	10		
All equipments connected with plugs	10		
All equipments free from defects	10		
Sub total	50		

10.8 Voltage / Current	A	B	C
Check voltage / current limit	10		
Rating clearly marked on all equipments	10		
Monitored continuously	10		
Mismatch of cable and equipments ratings	10		
Properly earthed	10		
Sub total	50		

10.9 Maintenance	A	B	C
Regular inspections carried out	10		
Records kept	10		
Suitable guards/security fenced	10		
Faults actioned	10		
Record maintaining	10		
Sub total	50		

10.10 Correct Disc. / Revolutions	A	B	C
Information plate on tool	10		
Information on Disc/Cutter	10		
Compatibility between Tool and Disc	10		
Operator trained/competent to fit Disc	10		
Safety check on condition	10		
Sub total	50		

Contractor's Observations:	Employer's Observations:

Section Scores	500			Section % Score	100		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

Contract No.:	Contractor's Name:

11.0 Fire prevention

11.1 Fire fighting personnel	A	B	C
Adequacy of Fire fighting personnel	10		
Professionally qualified	10		
Employer's approval	10		
Intimation of vacancy to Employer	10		
Adequate no of trained persons	10		
Sub total	50		

11.2 Requirements	A	B	C
Emergency plan	10		
Fire excavation plan	10		
Mock drill	10		
Nearest fire brigade phone numbers	10		
Reporting of fire accident to Employer	10		
Sub total	50		

11.3 Combustible material	A	B	C
Used in site	10		
Handling of combustible material	10		
Stored in separate place	10		
Spillage of materials	10		
Location of burning site	10		
Sub total	50		

11.4 Fire Extinguisher	A	B	C
Adequate numbers	10		
Appropriate type	10		
Easily accessible	10		
Frequency of recharge	10		
Maintenance and inspection	10		
Sub total	50		

11.5 Fir fighting equipments	A	B	C
Sufficient quantity of water supply	10		
Fire hose and nozzle	10		
Fire alarm	10		
Condition of fire hydrants	10		
Sufficient no. available	10		
Sub total	50		

	A	B	C
Sub total			

	A	B	C
Sub total			

	A	B	C
Sub total			

	A	B	C
Sub total			

Contractor's Observations:	Employer's Observations:

Section Scores	250			Section % Score	100		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.								
Contract No.:	Contractor's Name:							
12.0 Welding & Cutting								
12.1 Gas Welding / Cutting	**A**	**B**	**C**	**12.2 storage of cylinders**	**A**	**B**	**C**
Is procedure in ESHS Plan	10			Is procedure in ESHS Plan	10		
Are cylinders in cylinder-trolley	10			Storage in upright position	10		
Are pressure gauges fitted and operable	10			Full/empty segregated	10		
Are flashback arresters fitted	10			Different gases separated	10		
Are non return valves fitted	10			Contents labelled	10		
Sub total	50			**Sub total**	50		
12.3 Condition of cylinders	**A**	**B**	**C**	**12.4 Hose**	**A**	**B**	**C**
No damage by misuse	10			Colour coding	10		
No rust/corrosion	10			Hose clip and clamp	10		
Protected from weather	10			Is it free from leak and damage	10		
Colour coding proper	10			Hose lying on the ground	10		
MSDS available	10			Joints if any	10		
Sub total	50			**Sub total**	50		
12.5 Electric Arc Welding	**A**	**B**	**C**	**12.6 Transformer**	**A**	**B**	**C**
Are welding machines in good order	10			Presence of voltmeter and ammeter	10		
Welding leads free form defect	10			Separate main power switch	10		
Welding return free from defect	10			Ground connection	10		
Electrode holder properly insulated	10			Specification plate or board	10		
Dipping electrode in water when it is hot	10			Protected from weather	10		
Sub total	50			**Sub total**	50		
12.7 Electrical Cable	**A**	**B**	**C**	**12.8 Work Area**	**A**	**B**	**C**
Cable lying on ground / water	10			Area clear of flammable substances	10		
IP 44 cable connectors instead of insulation tape	10			Smoking inside the work area	10		
Damaged and exposed wires	10			Fire extinguisher fitted	10		
Separate earthing connection from work piece to transformer	10			Welding screens available	10		
Electrical protection devices ELCB, RCCB,etc	10			Ventilation and fume extraction	10		
Sub total	50				50		
12.9 PPE for welder, cutter and helper	**A**	**B**	**C**		**A**	**B**	**C**
Face and eye protection	10						
Gauntlet gloves	10						
Safety footwear	10						
Nose mask	10						
Ear muff / plug	10						
Sub total	50						
Contractor's Observations:				**Employer's Observations:**			
Section Scores	450			**Section % Score**	100		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.								
Contract No.:	Contractor's Name:							
13.0 Excavations and Trenching								
13.1 Planning	**A**	**B**	**C**	**13.2 Access/Egress**	**A**	**B**	**C**
Are excavations covered in ESHS Plan	10			Suitable ladders provided	10		
Examined by competent person	10			Ladders properly secured	10		
Records of inspection maintained	10			Alternative ladders available	10		
Underground cable and pipelines	10			Staircase for excavation more 1.5 m depth	10		
Backfilling and removal of trench	10			Guardrail for staircase.	10		
Sub total	**50**			**Sub total**	**50**		
13.3 Shoring	**A**	**B**	**C**	**13.4 Barriers and Warnings**	**A**	**B**	**C**
Shoring as soon as earth is removed	10			Rigid barrier around excavation	10		
Suitable support	10			Suitable warning notices	10		
Regular monitoring	10			Regularly checked by supervisor	10		
Proper repair under taken	10			Warning light & signs	10		
Material stacked properly on removal	10			Emergency exit board	10		
Sub total	**50**			**Sub total**	**50**		
13.5 Soil	**A**	**B**	**C**	**13.6 Underground Services**	**A**	**B**	**C**
Not closer than 1 metre	10			Checks made with Utility providers	10		
Properly stacked	10			Safe digging procedures in use	10		
Excavator clear of personnel	10			Supervision has service plans	10		
Storage of Excavated materials	10			Dewatering procedures	10		
Logistics for excavated soil	10			Line of dewatering	10		
Sub total	**50**			**Sub total**	**50**		
13.7 Undermining Nearby Structures	**A**	**B**	**C**	**13.8 Portable Electrical Equipment**	**A**	**B**	**C**
Survey carried out	10			Are as per standard	10		
Temporary support provided if required	10			Proper repair and condition	10		
Vibration measured	10			Rating voltage more than 24 V	10		
Regular monitoring	10			Double insulation	10		
Sufficient clearance provided	10			Open bare wires	10		
Sub total	**50**			**Sub total**	**50**		
13.9 Ventilation and Illumination	**A**	**B**	**C**	**13.10 Signals & Communication**	**A**	**B**	**C**
Are as per standard	10			Audio, Video signals	10		
Exhaust fan arrangement	10			Walkie-talkie / radio /mobile phones	10		
Temperature management	10			Head protection	10		
Gas monitoring systems	10			Arm protection	10		
Lighting arrangement	10			Leg protection	10		
Sub total	**50**			**Sub total**	**50**		
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**500**			**Section % Score**	**100**		

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.							
Contract No.:	Contractor's Name:						
14.0 Tunnelling and Confined Space operations							
14.1 Procedure	**A**	**B**	**C**	**14.2 Equipments**	**A**	**B**	**C**
Procedure in ESHS Plan	10			Gas monitoring equipment	10		
Permit Work system in use	10			Rescue BA equipment	10		
Only properly trained operatives	10			Full body harness for each worker	10		
Existing underground cables and pipelines	10			Tripod and lifeline	10		
Refresher training	10			Resuscitation Equipment	10		
Sub total	**50**			**Sub total**	**50**		
14.3 Access and Egress	**A**	**B**	**C**	**14.4 Procedure**	**A**	**B**	**C**
Proper staircase and lift	10			Inform to Director General before 30 days	10		
Guardrail for staircase	10			Emergency power generator	10		
Staircase made of sound material	10			Watertight bulkhead doors at entrance	10		
Free from defects	10			Reflective jackets for workers	10		
Emergency exit	10			Dewatering procedures	10		
Sub total	**50**			**Sub total**	**50**		
14.5 Warning / Communication systems	**A**	**B**	**C**	**14.6 Electrical equipment**	**A**	**B**	**C**
Telephone / walkie-talkie	10			Flame proof electrical equipment	10		
Emergency Alarm	10			Portable tools more than 24 V	10		
Warning for Exit way and electrical panel boards	10			Double insulation / earthing condition of portable equipment	10		
High visibility waist	10			Transformer used in without compressed air	10		
Warning lights	10			Bare conductor or semi enclosed fuse	10		
Sub total	**50**			**Sub total**	**50**		
14.7 Illumination and Ventilation	**A**	**B**	**C**	**14.8 Compressed air**	**A**	**B**	**C**
Illumination / ventilation levels	10			Adequacy of air supply	10		
Air circulation	10			Emergency power supply	10		
Level of oxygen / other toxic gas	10			Flame proof equipment	10		
Temperature level (not more than 29° C)	10			Available in man-locks and medical-locks	10		
Emergency power supply for luminaries	10			Hoses free from damage	10		
Sub total	**50**			**Sub total**	**50**		
14.9 Fire Prevention	**A**	**B**	**C**	**14.10 Health and Welfare**	**A**	**B**	**C**
Adequate water supply	10			Man-lock and medical-lock	10		
Fire alarm	10			Drinking water	10		
Flammable materials inside work areas	10			Medical officer	10		
Water outlet points	10			First-aid room	10		
Inspection and maintenance	10			Shelter room	10		
Sub total	**50**			**Sub total**	**50**		
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**500**			**Section % Score**	**100**		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.								
Contract No.:	Contractor's Name:							
15.0 Traffic management								
15.1 Traffic marshals	**A**	**B**	**C**	**15.2 Vehicle operators**	**A**	**B**	**C**
Sufficient numbers	10			Driving licence	10		
Professionally qualified or trained	10			Medically fitness	10		
Medically fit	10			Defensive driving training	10		
Driving licence	10			Refresher training	10		
Familiar with traffic signs	10			Fire fighting training	10		
Sub total	**50**			**Sub total**	**50**		
15.3 Traffic control devices	**A**	**B**	**C**	**15.4 Barricades**	**A**	**B**	**C**
Cons	10			Erected around the construction site	10		
Drums	10			Free from defects and protruding parts	10		
Delineators	10			Numbered	10		
Traffic cylinders	10			Painted and maintained in good condition	10		
Traffic signs and barricades	10			Barricade register	10		
Sub total	**50**			**Sub total**	**50**		
15.5 Barricades	**A**	**B**	**C**	**15.6 Regulatory Signs**	**A**	**B**	**C**
Barricade inspector & supervisor appointed	10			Approval from police and traffic authorities	10		
Retro reflective strips shape and size	10			Warning signs	10		
Reflective strips placed at a angle at bottom	10			Red light / flag indicator	10		
Minimum gap between retro reflective strips 1000mm	10			Design as per employer's approval	10		
One red light / blinker per barricade	10			Material made of reflective type.	10		
Sub total	**50**			**Sub total**	**50**		
15.7a Vehicle	**A**	**B**	**C**	**15.7b Vehicle**	**A**	**B**	**C**
Vehicle number and company name	10			Brakes in good working order	10		
Inspection stickers & license plate	10			Are wiper blades in good condition	10		
Seat belts	10			Rear view mirrors	10		
Two reflective triangles on rear side	10			Speedometer	10		
Fog lights (front & rear)	10			Vehicle's horn and reverse alarm	10		
Sub total	**50**			**Sub total**	**50**		
15.8 Heavy motor vehicles	**A**	**B**	**C**	**15.9 Operator cabin**	**A**	**B**	**C**
Automatic safe load indicator	10			Made of fire resistance material	10		
Load chart of the vehicle	10			Protection from vibration	10		
Fitness certificate	10			Weather protection	10		
Manufacturer details	10			Adequate ventilation	10		
Marking of safe working load	10			Suitable fire extinguisher	10		
Sub total	**50**			**Sub total**	**50**		
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**500**			**Section % Score**	**100**		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.								
Contract No.:	Contractor's Name:							
16.0 Personal Protective Equipment								
16.1 Head Protection	**A**	**B**	**C**	**16.2 Foot Protection**	**A**	**B**	**C**
Use enforced	10			Use enforced	10		
As per standard	10			Suitable type	10		
In good condition	10			Toecaps effective	10		
Colour and company logo	10			Fair condition	10		
Available for issue	10			Available for issue	10		
Sub total	**50**			**Sub total**	**50**		
16.3 Eye protection	**A**	**B**	**C**	**16.4 Hearing Protection**	**A**	**B**	**C**
Use enforced	10			Use enforced	10		
As per standard	10			As per standard	10		
Suitable type	10			Suitable type	10		
Good condition	10			Available for issue	10		
Available for issue	10			Noise levels monitored	10		
Sub total	**50**			**Sub total**	**50**		
16.5 Respiratory Protection	**A**	**B**	**C**	**16.6 Protective Gloves**	**A**	**B**	**C**
Use enforced	10			Use enforced	10		
As per standard	10			As per standard	10		
Suitable type	10			Correct type for operation	10		
Good condition	10			Good condition	10		
Available for issue	10			Available for issue	10		
Sub total	**50**			**Sub total**	**50**		
16.7 High-Visible Waist	**A**	**B**	**C**	**16.8 Fall Protection**	**A**	**B**	**C**
Use enforced	10			Use enforced	10		
As per standard	10			As per standard	10		
In good condition	10			In good condition	10		
Warning signs displayed	10			Warning signs displayed	10		
Available for issue	10			Available for issue	10		
Sub total	**50**			**Sub total**	**50**		
16.9 PPE for visitors	**A**	**B**	**C**		**A**	**B**	**C**
Use enforced	10						
10% PPEs for visitors in site office	10						
In good condition	10						
Colour and company logo	10						
Available for issue	10						
Sub total	**50**			**Sub total**			
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**450**			**Section % Score**	**100**		

MONTHLY AUDIT RATING SCORE (MARKS)

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.

Contract No.:	Contractor's Name:

17.0 Industrial Health & Hygiene and Lighting & Ventilation

17.1 Medical examination	A	B	C
All worker under gone	10		
Covered all testes as per standard	10		
Conducted by qualified person	10		
Confidential report for all workers	10		
Frequency of medical test maintained	10		
Sub total	**50**		

17.2 Occupational Health Centre	A	B	C
Construction medical officer & qualification	10		
Availability nurse & sweeper	10		
Floor area minimum 15 m^2 with two rooms	10		
Adequate equipment	10		
Medical emergency equipments	10		
Sub total	**50**		

17.3 First-aid	A	B	C
Equipped with all items as per standard	10		
Sufficient numbers	10		
First-aid room facility	10		
First-aider & his qualification	10		
Register for first-aid	10		
Sub total	**50**		

17.4 Ambulance van and room	A	B	C
Equipped with all items as per standard	10		
Availability and numbers	10		
Maintained in good repair	10		
Equipped with standard facilities	10		
Record of all cases of accident & sickness	10		
Sub total	**50**		

17.5 Mosquito breeding	A	B	C
Water retain on the site	10		
Periodic interval	10		
Still waters	10		
Posters	10		
Usage of insecticides	10		
Sub total	**50**		

17.6 Alcohol and drugs & HIV / AIDS prevention	A	B	C
Employee working under the influence of alcohol / drugs	10		
Smoking at public worksites	10		
Smoking at public worksites	10		
HIV / AIDS awareness training provided	10		
Workers participation / co-operation	10		
Sub total	**50**		

17.7 Noises	A	B	C
Are procedures for noise evaluation in the Safety Plan	10		
Are noise assessments carried out	10		
Are noise zones identified	10		
Is correct PPE provided	10		
Usage of PPE	10		
Sub total	**50**		

17.8 Vibration	A	B	C
Monitoring method	10		
Frequency of monitoring	10		
Vibration limits	10		
Report maintenance	10		
Control plan	10		
Sub total	**50**		

17.9 Radiation	A	B	C
Method statement	10		
Approval from Employer	10		
Use and storage of radioactive substance	10		
Disposal of radioactive substance	10		
Appropriate PPE	10		
Sub total	**50**		

	A	B	C
Sub total			

Contractor's Observations:	Employer's Observations:

Section Scores	450			Section % Score	100		

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.							
Contract No.:	Contractor's Name:						
18.0 Welfare amenities							
18.1 Toilets / Urinals	**A**	**B**	**C**	**18.1a Toilets / Urinals**	**A**	**B**	**C**
Enough no available	10			Is it properly illuminated	10		
Separate for men and women	10			Is it having separate and ample water facility	10		
Access within 500m from worksite	10			Is it having proper drainage system	10		
Is it properly cleaned	10			Water leaking or spillage	10		
Is it washed regularly	10			Records kept and available	10		
Sub total	**50**			**Sub total**	**50**		
18.2 Drinking water	**A**	**B**	**C**	**18.3 Canteen**	**A**	**B**	**C**
Quantity is sufficient	10			Is canteen available	10		
Quality is good	10			Is it neat and clean	10		
Laboratory test done	10			Is the flooring dust free	10		
Access within 200m from worksite	10			Is the cost 'no loss and no gain' basis	10		
Is it 6m away from toilets and urinals	10			Lighting, ventilation and water facility	10		
Sub total	**50**			**Sub total**	**50**		
18.4 Labour Accommodation	**A**	**B**	**C**	**18.5 Creaches**	**A**	**B**	**C**
Cooking, bathing, washing and lavatory facilities	10			Is it free from mosquito and other biological agent	10		
Is it free from mosquito and biological agent	10			In-charge to keep the children.	10		
Is it properly illuminated and ventilated	10			Is it properly illuminated and ventilated	10		
Is it adequate for all	10			Is it adequate for all	10		
Is it neat, clean and hygiene	10			Is it neat, clean and hygiene	10		
Sub total	**50**			**Sub total**	**50**		
18.6 Shelter	**A**	**B**	**C**	**18.7 Illumination**	**A**	**B**	**C**
Adequate to all workers	10			Minimum illumination requirement	10		
Is it properly illuminated and ventilated	10			Minimum 50 lux at work place	10		
Is it neat, clean and hygiene	10			Minimum 30 lux on trolley tracks	10		
Is it free from mosquito and biological agent	10			Minimum 10 lux elsewhere	10		
Drinking water and Toilet facilities	10			Adequate Emergency lighting provided	10		
Sub total	**50**			**Sub total**	**50**		
18.8 Ventilation	**A**	**B**	**C**		**A**	**B**	**C**
Oxygen level less than 19.5	10						
Air circulation of $6m^3$/min for each building Worker employed underground	10						
Free air flow movement in work place	10						
Ventilation system in operation	10						
Maintenance records kept and available	10						
Sub total	**50**			**Sub total**			
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**450**			**Section % Score**	**100**		

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.							
Contract No.:	Contractor's Name:						
19.0 Environmental management							
19.1 Air quality	**A**	**B**	**C**	**19.2 Water quality**	**A**	**B**	**C**
Monitoring by competent person	10			Monitoring by competent person	10		
Monitoring equipment as per standard	10			Monitoring equipment as per standard	10		
Monitoring method	10			Monitoring method	10		
Report to Employer	10			Report to Employer	10		
Control plan	10			Control plan	10		
Sub total	**50**			**Sub total**	**50**		
19.3 Noise monitoring	**A**	**B**	**C**	**19.4 Illumination monitoring**	**A**	**B**	**C**
Monitoring by competent person	10			Monitoring by competent person	10		
Monitoring equipment as per standard	10			Monitoring equipment as per standard	10		
Monitoring method	10			Monitoring method	10		
Report to Employer	10			Report to Employer	10		
Control plan	10			Control plan	10		
Sub total	**50**			**Sub total**	**50**		
19.5 Temperature monitoring	**A**	**B**	**C**	**19.6 Dust control**	**A**	**B**	**C**
Monitoring by competent person	10			Water sprinkler arrangement	10		
Monitoring equipment as per standard	10			Frequency water sprinkler inside the site	10		
Monitoring method	10			Dust screens	10		
Report to Employer	10			Dust level under permissible limit	10		
Control plan	10			Environmental monitoring	10		
Sub total	**50**			**Sub total**	**50**		
19.7 Waste Management	**A**	**B**	**C**	**19.8 Felling of Trees**	**A**	**B**	**C**
Dustbin in construction site	10			Approval from forest department	10		
Temporary dumping area	10			Trees used for anchorage.	10		
Separate dumping pit for disposable and non-disposable wastes	10			Trees exposed or injured by construction equipment	10		
Frequency of removal of waste	10			Protective barriers around tree	10		
Burning of waste	10						
Sub total	**50**			**Sub total**	**40**		
19.10 Energy Management	**A**	**B**	**C**		**A**	**B**	**C**
Uniform illumination	10						
Size and length of cable and wires	10						
Efficient luminaries	10						
Efficient motors and pumps	10						
Efficient air-conditions	10						
Sub total	**50**			**Sub total**			
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**440**			**Section % Score**	**100**		

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD..								
Contract No.:	Contractor's Name:							
20.0 Batching Plant and Casting Yard								
20.1 General	**A**	**B**	**C**	**20.2 Layout**	**A**	**B**	**C**
Is procedure in ESHS Plan	10			Plan of layout	10		
All operators medically fit/over 21	10			Drainage system	10		
No unauthorized riding on plant	10			Welfare amenities	10		
Daily inspections / recorded	10			Plan for vehicle moving area	10		
Equipped with all	10			Barrication	10		
Sub total	**50**			**Sub total**	**50**		
20.3 Material Handling & dust protection	**A**	**B**	**C**	**20.4 PPE**	**A**	**B**	**C**
Handling of cement bag	10			Hand protection	10		
Loading and unloading cement	10			Respiratory protection	10		
Handling of launching segments	10			Head protection	10		
Is dust level under permissible limit	10			Foot protection	10		
Environmental monitoring	10			Ear protection	10		
Sub total	**50**			**Sub total**	**50**		
20.5 Traffic management	**A**	**B**	**C**	**20.6 Welfare facilities**	**A**	**B**	**C**
Barricades	10			Toilet	10		
Warning boards	10			Drinking water	10		
Traffic marshals	10			Canteen	10		
Delineators	10			Shelter	10		
Lane warning	10			Labour accommodation	10		
Sub total	**50**			**Sub total**	**50**		
20.7 Fitness certificate	**A**	**B**	**C**		**A**	**B**	**C**
Crane	10						
Hydra and all equipment	10						
Ropes and chains	10						
Hooks and shackles	10						
Rigger & Operator	10						
Sub total	**50**			**Sub total**			
	A	**B**	**C**		**A**	**B**	**C**
Sub total				**Sub total**			
Contractor's Observations:				**Employer's Observations:**			
Section Scores	**350**			**Section % Score**	**100**		

Attachment -5 Safe Work Procedure for Work Near Railway Track

1.0 Safety precautions and measures to be observed during execution of ROB/ RUB/ Viaduct/ any other works in Railway and adjoining areas:

1.1 The Contractor(s) shall not allow any road vehicle belonging to him or his suppliers, etc. to ply in HRIDC/railway land next to the running line. If for execution of certain works viz. earthwork for parallel railway line and supply of ballast for new or existing rail line gauge conversion, etc. road vehicles are necessary to be used in railway/HRIDC land next to the railway line, the Contractor(s) shall apply to the Engineer-in-Charge for permission giving the type and number of individual vehicles, names and license particulars of the drivers, location, duration and timings for such work/movement. The Engineer-in-Charge or his authorized representative will personally counsel, examine and certify the road vehicle drivers, Contractor(s)' flagmen and supervisors and will give written permission giving names of road vehicle drivers, Contractor(s)' flagmen and supervisors to be deployed on the work, location, period and timing of the work. This permission will be subject to be following obligatory conditions:

1.2 Construction Activities and Safety:

a) The 'Methodology of Working' shall be incorporated in GAD and Temporary Arrangement Drawings.

b) The activities of work to be taken up during the railway traffic block/under speedrestriction, etc. should be clearly mentioned in such drawings. If at any stage of execution, any discrepancy is found in the drawing with respect to the site condition affecting safety or some new activity of work is required to be done, the same should be brought to the notice of Railway & HRIDC Engineers and such works should be done only after approval by Railways & HRIDC representative. In such cases, scheme may be modified and, if required, fresh CRS sanction shall have to be obtained.

1.2.1 The works required to be done under traffic block protection, are to be carried out only in the presence of Railway & HRIDC Engineering Officials. The Railway's and HRIDC's Supervisor has to certify safe conditions for passage of trains before resumption of traffic. The works to be done under traffic shall be carried out under the provision of banner flag and protection by Engineering Flagman.

1.2.2 Following important activities of works shall be carried out under supervision of Railway/HRIDC Engineer or his nominated Supervisor:

a) Excavation at foundation/ground level near to railway track

b) Concrete casting and/or masonry work very close to railway track

c) Erection of temporary structures near to running lines.

d) Casting of structures like girder/slab over railway track

e) Stage-prestressing of girders when placed across railway tracks properly supported

f) Launching of precast/pre-assembled girders across railway tracks

g) Any work of lifting, side shifting and slewing of girders over the railway track

h) Dismantling of temporary structures, shuttering, scaffolding, etc. adjacent to and above the railway track. For carrying out activities of casting, erection, launching, handling, and dismantling as listed above, the Contractor's Engineer shall furnish the Construction Programme in advance to HRIDC Supervising Engineer & Engineer representative. No such work should be taken up in absence of the HRIDC Supervising Engineer & Engineer representative. For the activities which are to be done in presence

of the HRIDC Engineer and prior intimation shall be given in writing and acknowledgement obtained from HRIDC's representative.

1.2.3 To ensure 'Safety' during construction activities, HRIDC Site Engineer & Engineer representative may direct the Contractor's Supervisor/Engineer or their nominated representative for safe working procedures/ instructions, notwithstanding the contractual or MOU conditions prevailing between/ among Railways/other Departments like NHAI/Contractors/ Concessionaire.

1.2.4 All the records of Quality Assurance/Quality Control, testing of the materials and satisfactory completion of an activity shall be maintained at site by the Contractor's Engineer and Supervisor. On the basis of these records, HRIDC Site Engineer shall do stage-wise clearance of the works at following stages:

i) Completion of foundation

ii) Completion of substructure

iii) Completion of superstructure

Without such stage clearance, the work in next stage of construction shall not be allowed by the HRIDC Supervisor, unless proper system of check and exercise is followed at the site.

1.2.5 Normally, the high beam PSC girders are designed with wider top flange and shorter bottom flange with very high beam which makes the girder unsuitable during lowering, slewing and launching time.

1.2.6 During launching of girders and subsequent adjustments for placement of bearing, special attention and precautions are required at site to be followed rigorously without resorting to shortcut practice or leaving the work at site to untrained or inexperienced Engineers. Normally, end diaphragms are not cast for the extreme both side girders. These shall be cast minimum 300mm on both sides for all 'I' beam girders to provide temporary supports for ensuring stability.

"OR"

For side adjustments and bearing placements below 'I' section girders, end brackets made of steel angles should be provided for all 'I' beams sequentially to avoid side titling of individual girders. End brackets shall be removed only after placing girders on bearing and casting of diaphragms.

1.2.7 During lowering, the jacks shall be operated duly keeping wooden packing of various thicknesses fixing the amount of lowering to the barest minimum, so that even if the jack fails, the wooden packing will take load and further stability of girder is not endangered.

1.2.8 Temporary crib support staging shall be interlaced with clamps and angles. Adequate base width shall be maintained proportionate to the height of stage, which is very essential for avoiding the oblong effect during launching of girders. During launching by RH girder method, the movement of the PSC girders shall be controlled both from front and rear with sync mechanism having simultaneous operation, so that the speed of the launching is always under the control. Spare hydraulic jacks shall always be kept at site. Lowering of girder shall always be carried out at one end only. Further, other end should be adequately secured by wire ropes, end brackets, etc. Thereafter, the process shall be continued alternately.

1.2.9 As far as possible, launching of girders by temporary staging shall be avoided and launching by heavy capacity cranes, wherever feasible, shall be adopted.

1.2.10 Steel girder launcher if used for launching of PSC girders should be pre-tested for the

critical loading (likely to be encountered during actual launching) before deployment on the approaches regarding its strength as well as amount of permissible deflection using actual test PSC girder as a testing load. Connections at supports shall be inspected and certified prior to actual launching. It shall be adequately secured to the base support system on the pier cap.

1.3 General Construction Safety:

1.3.1 General safety precautions as applicable for civil works shall be adopted in field.

1.3.2 Working near running line: Safe practices at site and at all times non-infringement to moving trains shall be ensured. Road vehicles, material trolleys, dollies with any tendency to roll off towards the running lines to be checked by providing chains, locking arrangements, blocks, etc. shall be ensured and the Site-in-Charge of the Contractor shall be primarily responsible, secondary responsibility being of Contractor's Consultant.

1.3.3 Testing of cranes, lifting jacks and other equipment: All equipment like cranes, lifting jacks shall be tested, duly calibrated and certified prior to the use at construction site.

1.3.4 Routine safety checks, validity of test certificates for load bearing equipment especially for cranes outsourced from third party shall be ensured prior to deployment.

1.3.5 Construction workers at site shall be provided with personal safety gear like reflective vest, helmet, Safety shoes, gloves & eyewear approved as per construction industry standards. For persons working at pier top/girder level, temporary supports, hand railing, protection with help of ropes, slings and temporary railings shall be provided.

2.0 Safety Guidelines and Precautions for working close to Railway tracks

2.1 A large number of men and machinery are deployed by the contractors for track renewals, gauge conversions, doublings, bridge rebuilding etc. It is therefore essential that adequate safety measures are taken for safety of the trains as well as the work force. The following measures should invariably be adopted.

A. The contractor shall not start any work without the presence of HRIDC Engineer at site.

B. Wherever the road vehicles and/or machinery are required to work in the close vicinity of railway line, the work shall be so carried out that there is no infringement to the Railway's schedule of dimensions. For this purpose, the area where road vehicles and/or machinery are required to ply, shall be demarcated and acknowledged by the contractor. Special care shall be taken for turning/ reversal of road vehicles/machinery withoutinfringing the running track. Barricading shall be provided wherever justified and feasibleas per site conditions.

C. The look out and whistle caution orders shall be issued to the trains and speed restrictions imposed where considered necessary. Suitable flagmen/detonators shall be provided where necessary for protection of trains.

D. The supervisor/workmen should be counseled about safety measures. A competency certificate to the contractor's supervisor as per Performa annexed shall be issued by DGM/HRIDC, which will be valid only for the work for which it has been issued.

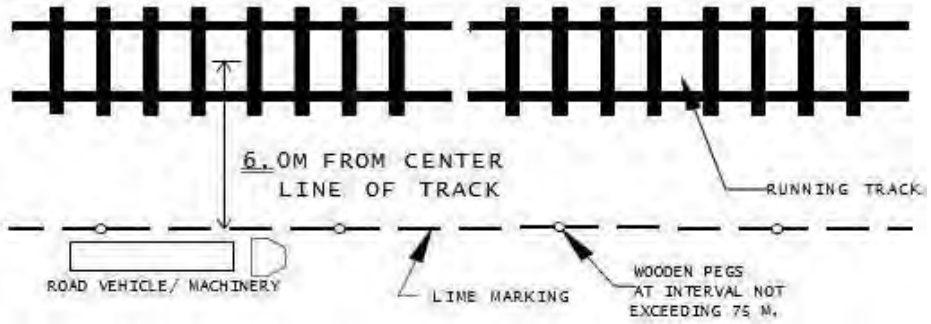
E. The unloaded ballast/rails/sleepers/other P-Way materials after unloading along track should be kept clear off moving dimensions and stacked as per the specified heights and distance from the running track.

F. Supplementary site-specific instructions, wherever considered necessary shall be issued by the HRIDC's representative.

2.2 PLYING OF ROAD VEHICLES AND WORKING OF MACHINERIES CLOSE TO RUNNING TRACKS

A. Normally, the road vehicles shall be run, or machinery shall be worked so as not to come closer than 6.0m from centre line of nearest running track.

B. The land strip adjacent to running tracks, where road vehicle is to ply or machinery is to work, shall be demarcated by lime in advance in consultation with the Railway's & HRIDC's Engineer. Wooden pegs at interval not exceeding 75mtr. shall be provided along the line marking as permanent marks. The road vehicles shall ply or machinery shall work so as not to infringe the line of demarcation.



C. If a road vehicle or machinery is to work closer to 6.0m due to site conditions or requirement of work, following precautions shall be observed:

a) In no case the road vehicle shall run or machinery shall work at distance less than 3.5m from centre line of track.

b) Demarcation of land shall be done by bright colored ribbon/nylon cord suspended on 120 cm high wooden/bamboo posts at distance of 3.5 m from centre line of nearest running track.

c) Presence of an authorized HRIDC's representative shall be ensured before plying of vehicle or working of machinery.

d) Railway's Supervisor shall issue suitable caution order to Drivers of approaching train about road vehicles plying or machineries working close to running tracks. The train drivers shall be advised to whistle freely to warn about the approaching train. Whistle boards shall be provided wherever considered necessary.

e) Lookout men shall be posted along the track at a distance of 800m from suchlocations who will carry red flag and whistles to warn the road vehicle/machinery users about the approaching trains.

f) On curves where visibility is poor, additional lookout men shall be posted.

D. If vehicle/machinery is to be worked closer to 3.5m from running track - Under unavoidable conditions, if road vehicles is to ply or machinery is to work closer to 3.5m due to site conditions or requirement of work, following precautions shall be observed:

a) Plying of vehicles or working of machinery closer to 3.5m of running track shall be done only under protection of track. Traffic block shall be imposed wherever considered necessary. The site shall be protected as per provisions of Para No. 806 & 807 of P-Way Manual as case may be.

b) Presence of a Railway's/, HRIDC's Supervisor shall be ensured at worksite.

c) Railway's& HRIDC's Supervisor shall issue suitable caution order to Drivers of approaching train about road vehicles plying or machineries working close to running tracks. The train drivers shall be advised to whistle freely to warn about the approaching train.

E. Precaution to be taken while reversing road vehicle alongside the track

The location where vehicle will take a turn shall be demarcated duly approved by Railway's/HRIDC's representative. The road vehicle driver shall always face the Railway track during the course of turning/reversing his vehicle. Presence of an authorized Railway/HRIDC representative shall be ensured at such location.

F. Road vehicle shall not be allowed to run along the track during night hours generally. In unavoidable situations, however, vehicles shall be allowed to work during night hours only in the presence of an authorized Railway's/HRIDC's representative and whereadequate lighting arrangements are made and where adequate precautions as mentioned earlier have been ensured.

G. Road vehicles/machinery/plant etc. when stabled near running tracks shall be properly secured against any possible roll off and always be manned even during off hours.

2.3 EXECUTION OF WORKS CLOSE TO OR ON RUNNING LINES

A. Any work close to or on running tracks shall be executed under the presence of a HRIDC's Supervisor only.

B. **Precaution to be taken to ensure safety of trains while execution of work close to the running line or on running lines**.

a) Such works shall be planned and necessary drawings particularly with regard to infringement to moving dimensions shall be finalized duly approved by competent authority before execution of work. The work shall be executed only as per approved procedure and drawings.

b) All temporary arrangements required to be made during execution of work shall be made in such a manner that moving dimension do not infringe.

c) Suitable speed restriction shall be imposed, or Traffic block shall be ensured as required. *The requirement of Traffic and Power Blocks shall be submitted by the Contractor to the Engineer for approval. The Traffic and Power Blocks will be finalized in consultation with the Delhi Division of Northern Railway. No cost shall be charged for Traffic and Power Blocks from the Contractor*.

d) Necessary equipment for safety of trains during emergency shall be kept ready at site.

C. Precaution to be taken to ensure safety of electrical/signal/ telephone cables while excavating near tracks.

a) Particular care shall be taken to mark the locations of buried electrical/signal/telephone cables on the plans jointly with S & T/Electric supervisor and also at site so that these are not damaged during excavation.

b) Copy of the cable plan should be given to the contractor's authorized representative before handing over the site to start the work.

c) Due care shall be taken to ensure that any part of the equipment or machinery or temporary arrangement does not come close to cables while working.

d) Joint procedure order No. 17/2013 issued by Railway Board vide letter No.2003/Tele/RCIL/1 Pt IX dated 24.06.2013 shall be followed for undertaking digging work in the vicinity of underground signaling, electrical and telecommunication cables.

D. Precaution to be taken during execution of works requiring traffic blocks.

a) Any work, which infringes the moving dimensions, shall be started only after the traffic block has been imposed.

b) Before closing the work, the track shall be left with the proper track geometry so that the trains run safely.

c) After completion of work the released sleeper and fittings should be properly stacked away from the track to be kept clear of moving dimensions.

d) Block shall be removed only when all the temporary arrangement, machineries, tools, plants etc. have been kept clear of moving dimensions.

E. Precaution to be taken during execution of works during night:

The work close to running line, generally, shall be carried out only during day hours. At locations, however, where night working is unavoidable, proper lighting arrangement should be made. The engineering indicator boards shall be lighted during night hours as per the provisions of IRPWM. The staff deputed for night working should have taken adequate rest before deploying them in night shift. We can specify duration of night shift from 20.00 hrs to 04.00 hrs. All other safety precautions applicable for daytime work should be strictly observed during night working.

F. Precautions to be taken to ensure safety of workers while working close to running lines:

a) Necessary lookout men with red flags and whistles shall be provided to warn the workmen about the approaching train.

b) Railway's/HRIDC's supervisor shall issue suitable caution order to Drivers of approaching train for whistling to warn the workers about the approaching train. Whistle boards shall be provided wherever considered necessary.

c) A "First aid kit" shall always be kept ready at site

G. Precaution shall be taken for safety of public or passengers, while executing works at locations, used by passengers and public

The worksite shall be suitably demarcated to keep public and passengers away from work area. Necessary signage boards such as "Work in progress. Inconvenience is regretted" etc. shall be provided at appropriate locations to warn the public/ passengers. Adequate lighting arrangement of worksite wherever required shall be done to ensure safety of public/passengers during night.

H. Precaution to be taken before stacking materials alongside the track to ensure that safety of trains is not affected –

The following precautions shall be taken before stacking the materials along the track for stacking of ballast, rails, sleepers etc.

a) The sites for material stacking should be selected in advance in such a manner as to ensure that no part of the material to be stacked is infringing the Standard Moving Dimensions. A plan of proposed stacking locations be made and signed jointly by an authorized HRIDC's/Railway's representative and contractor's representative.

b) The selected locations shall be marked by lime in advance.

c) Presence of an authorized HRIDC's/Railway's representative while unloading and stacking shall be ensured.

d) The material shall be stacked in such a height so as to not to infringe SOD in case of accidental roll off.

I. Precaution for handling of departmental material trains –

Instructions for working of material trains are contained in Chapter VIII of IRPWM which should be brought to the notice of the supervisors and other staff working on the material trains. In addition to this,following precautions should be taken:

a) Issue of 'fit to run' certificate:

As per Para 848 before a material train is allowed to work, the complete rake should be examined by the Carriage and Wagon staff and a 'fit to run' certificate issued tothe Guard.

b) As per Para 849 of IRPWM, a qualified Engineering official should be deputed on the train to ensure working of the material train as the Guard is not qualified to carry out such duties like Supervising of loading and unloading of materials.

c) As per Para 845 of IRPWM, the material train should not be permitted to work during the period of poor visibility due to fog, storm or any other cause except with the permission of the ADEN/DEN. Working of the material trains carrying labour should not be permitted between sunset and sunrise except in an emergency.

d) While unloading rail panels by the side of the running track, placement of the panels, clear of the maximum moving dimensions should be ensured.

e) Unloading of rail panels should be done by a team of trained staff under the active supervision of competent Supervisor/Officer.

f) Before unloading of rail panels, site should be prepared by way of leveling/removing extra ballast, if any, from the crib and shoulder with the objective to ensure requisite lateral and vertical clearances so as to prevent slippage of rail panels due to vibration during the passage of trains.

g) Reasonably adequate block should be asked and provided for unloading of the material and the work should be done preferably in day light to avoid shortcut in haste which may infringe the safety requirements.

J. Safety aspects to be observed while working in OHE area

a) No electrical work close to running track shall be carried out without permission of HRIDC representative.

b) A minimum distance of 2m has to be maintained between live OHE wire and body part of worker or tools or metallic supports etc.

c) No electric connection etc. can be tapped from OHE.

d) Authorized OHE staff should invariably be present when the relaying work or any major work is carried out.

e) Power block is correctly taken and 'permit to work' is issued.

f) The structure bonds, track bonds, cross bonds, longitudinal rail bonds are not disturbed and if disconnected for the work, they are reconnected properly when the work is completed.

g) The track level is not raised beyond the permissible limit during the work

2.4 PROTECTION OF TRACK DURING EMERGENCY

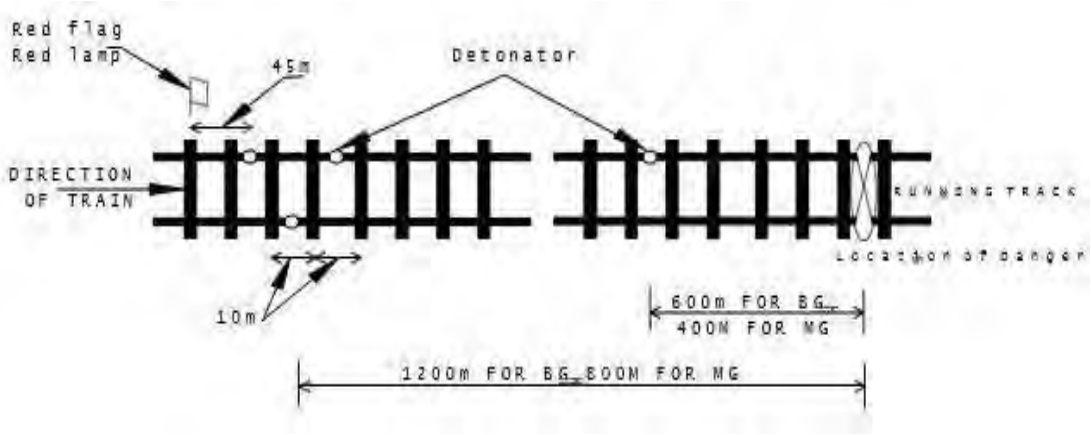
A. Action to be taken when a contractor's supervisor or vehicle operator apprehends any unusual circumstances likely to infringe the track and endanger safe running of trains.

a) At any time if a contractor's supervisor or vehicle operator observes any unusual circumstances likely to infringe the track and apprehend danger to safe running of track, he shall take immediate steps to advise a HRIDC official of such danger and assist him in protection of track.

b) The track shall be protected as under. One person shall immediately plant a red flag

(red lamp during night) at the spot and proceed with all haste in the direction of approaching train with a red flag in hand (red lamp during night) and plant a detonator on rail at a distance of 600m from the place of obstruction of BG track (400m for MG track) after which he shall further proceed for not less than 1200m from the place of obstruction from BG track (800m for MG track) and plant three detonators at 10m apart on rails. After this he shall display the red flag (red lamp during night) at a distance of 45m from the detonators.

c) Attempts shall also be made to send an advice to nearest Railway/HRIDC station about the incident immediately.



B. Action to be taken if train is seen approaching to site of danger and there is no time to protect the track as per guidelines mentioned above.

In such a case the detonators shall be planted on rails immediately at distance away from place of danger as far as possible and attention of driver of approaching train shall be invited by whistling, waving the red flag vigorously, gesticulating and shouting.

C. What action shall be taken if more than one track is obstructed.

a) In case of single line protection as above shall be done in both the directions from place of danger.

b) In case of double line or multiple lines, if other tracks are also obstructed, theprotection as above shall be done for other track also.

c) The protection shall be done in that direction and on that track first on which train is likely to arrive first.

d) The Contractor's Supervisors, Operators and lookout men shall be properly explained about the direction of trains on running tracks.

D. Equipment required for protection of track.

Minimum compliment of protection equipment i.e. 10 detonators, 4 red hand flags, 4 red hand lamps, 4 banner flags and whistles etc. shall always be kept ready at worksites for use in case of emergency. HRIDC will arrange to provide detonators, whereas Contractor shall arrange other equipment at his own cost.

E. Arrangement of lookout men and competency required for lookout man to warn labour about approaching train.

a) Contractor will provide lookout men.

b) The lookout men shall be properly trained in warning to staff at worksite about approaching train.

c) Only those lookout men shall be provided at site who have been issued with a competency certificate by the Railway's/HRIDC's Supervisor.

d) In case, it is felt necessary to provide lookout men by Contractor, the charges for the same as fixed by HRIDC Administration shall be recovered from Contractor.

2.5 Training to Supervisors and Operators of Contractor

The Supervisors and Operators of the contractor proposed to be deployed at wok site, which is close to the running track, shall be imparted mandatory training by the HRIDC at site free of cost about the safety measures to be adopted while working in the vicinity of running track. HRIDC's Engineer-in charge of the work shall decide the scale, extent & adequacy of training. In case training is imparted at a recognized Railway training institute, the charges for the same, as decided by HRIDC, shall be recovered from the Contractor. A competency certificate to this effect to the individual Supervisor/Operator shall be issued as given below,by a HRIDC Officer not below the rank of DGM/HRIDC. No Supervisor/Operator of the Contractor shall work or allowed to work in the vicinity of running track that is not in possession of valid competency certificate.

All the labour, materials, tools, plants etc. except detonators, required for ensuring safe running of trains shall be provided by Contractor at his own cost. Wherever lookout men are provided by HRIDC, charges at the rate of Rs. 1000/- per man day shall be recovered from Contractor.

A sample of training competency certificate is provided below for reference:

Competency Certificate

Certified that Shri …… Supervisor/Operator of M/s. ……has been trained and examined in safety measures to be followed while working in the vicinity of running railway track for the work. His knowledge has been found satisfactory and he is capable of supervising the work safely.

This certificate is valid only for the work mentioned in this certificate only.

Signature and designation of the officer

Final Tender Document for Works

(Two-Envelope Tendering Process Without Prequalification)

Procurement of:

C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00.

Summary

Specific Procurement Notice (SPN)

PART 1 – TENDERING PROCEDURES

Section I - Instructions to Tenderers (ITT)

Section II - Tender Data Sheet (TDS)

Section III - Evaluation and Qualification Criteria

Section IV - Tender Forms

Section V - Eligible Countries

Section VI - Prohibited Practices

PART 2 – EMPLOYER'S REQUIREMENTS

Section VII - Employer's Requirements

PART 3 – CONDITIONS OF CONTRACT AND CONTRACT FORMS

Section VIII - General Conditions of Contract (GCC)

Section IX - Particular Conditions of Contract (PCC)

Section X - Contract Forms

PART 3 – Conditions of Contract and Contract Forms

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Section VIII - General Conditions of Contract (GCC)

The General Conditions of Contract governing this Contract shall be the "Conditions of Contract for Plant & Design Build, ("Yellow book, Second Edition 2017", published by the Federation Internationale Des Ingenieurs – Conseils (FIDIC).

An original copy of the above FIDIC publication i.e. "*Conditions of Contract for Plant & Design Build* ", ("Yellow book , Second Edition 2017", (must be obtained from the following address of FIDIC:

International Federation of Consulting Engineers (FIDIC)
FIDIC Bookshop – Box- 311 – CH – 1215 Geneva 15 Switzerland
Fax: +41 22 799 49 054
Telephone: +41 22 799 49 01
E-mail: fidic@fidic.org
www.fidic.org
FIDIC code: ISBN13: 978-2-88432-084-9

Section IX - Particular Conditions of Contract (PCC)

The following Particular Conditions of Contract (PCC) shall supplement the GCC. Whenever there is a conflict, the provisions herein shall prevail over those in the GCC.

The PCC consists of three parts:

- Part A – Contract Data
- Part B – Specific Provisions
- Part C – Prohibited Practices

The references to Clauses and Sub-clauses provided in the PCC given below are applicable to the General Conditions of Contract i.e. "Conditions of Contract for Plant & Design Build, ("Yellow Book"), Second Edition 2017" published by the Federation Internationale Des Ingenieurs – Conseils (FIDIC).

Particular Conditions of Contract (PCC)

Part A - Contract Data

S. No.	Conditions	GCC Sub-Clause	Data
1.	Defects Notification Period	1.1.27	(i) 365 days calculated from the date of issue of Taking-Over Certificate for the Works or part of the Works other than BLT works (ii) 1095 days calculated from the date of issue of Taking-Over Certificate for BLT works
2.	Employer's name and address	1.1.30	Haryana Orbital Rail Corporation Limited (HORCL), Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram, Haryana-122003 E-mail: shivomd_irse@yahoo.com
3.	Engineer's name and address	1.1.35	RITES Limited in Consortium with SMEC International Pty Ltd, 4th Floor, Plot No.144, RITES Limited, Sector-44, Gurugram, Haryana-122003
4.	Sections	1.1.76	Nil
5.	Time for Completion	1.1.86	*1460 days*
6.	Bank's name	1.1.91	Asian Infrastructure Investment Bank (AIIB)
7.	Borrower/Recipient's name	1.1.92	Haryana Orbital Rail Corporation Limited (HORCL) through Government of Haryana
8.	Electronic transmission system	1.3 (a) (ii)	By e-mail
9.	Address of Employer for communications:	1.3(d)	Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram, Haryana-122003 E-mail: gmphridc@gmail.com
10.	Address of Engineer for communications:	1.3(d)	4th Floor, Plot No.144, RITES Limited, Sector-44, Gurugram, Haryana-122003
11.	Address of Contractor for communications:	1.3(d)	To be filled in at the time of preparation of Contract Agreement
12.	Governing Law	1.4	The laws of Republic of India
13.	Ruling language	1.4	English

<table>
<tr><th>S. No.</th><th>Conditions</th><th>GCC Sub-Clause</th><th>Data</th></tr>
<tr><td>14.</td><td>Language for communications</td><td>1.4</td><td>English</td></tr>
<tr><td>15.</td><td>Time for the Parties to sign a Contract Agreement</td><td>1.6</td><td>35 days after issue of the Letter of Acceptance</td></tr>
<tr><td>16.</td><td>Number of additional paper copies of Contractor's Documents</td><td>1.8</td><td>NIL</td></tr>
<tr><td>17.</td><td>Total liability of the Contractor to the Employer under or in connection with the Contract</td><td>1.15</td><td>Equal to the Accepted Contract Amount (Amount to be filled in at the time of preparation of contract agreement)</td></tr>
<tr><td>18.</td><td>Time for access to the Site</td><td>2.1</td><td>Land will be Handed over as per details given in Table below. The referred Sketches are available in Section VII-8: Tender drawings and Documents, Part 2-Employer's Requirements
<table>
<tr><th>S. No.</th><th>Location</th><th>Details regarding Handing Over of the Site</th></tr>
<tr><td>1.</td><td>km 12.00 to km. 18.00</td><td>Within 7 days of Commencement Date</td></tr>
<tr><td>2.</td><td>Portal 1</td><td>Part land within 7 days and balance land within 90 days of Commencement Date Refer Sketch No. HRIDC-C4-SK-LANDPLAN 001_A0</td></tr>
<tr><td>3.</td><td>Permanent Ventilation Shaft 1 & 2</td><td>Part land within 7 days and balance land within 90 days of Commencement Date Refer Sketch No. HRIDC-C4-SK-LANDPLAN-002_A0</td></tr>
<tr><td>4.</td><td>Construction cum Utility Shaft</td><td>Part land within 7 days and balance land within 90 days of Commencement Date Refer Sketch No. HRIDC-C4-SK-</td></tr>
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<tr><th>S. No.</th><th>Conditions</th><th>GCC Sub-Clause</th><th>Data</th></tr>
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<table>
<tr><td></td><td></td><td>LANDPLAN-003_A0</td></tr>
<tr><td>5.</td><td>Permanent Ventilation Shaft 3 & 4</td><td>Part land within 7 days and balance land within 90 days of Commencement Date Refer Sketch No. HRIDC-C4-SK-LANDPLAN-004_A0</td></tr>
<tr><td>6.</td><td>Km 28.341 to Km 29.680</td><td>Within 7 days of Commencement Date Refer Sketch No. HRIDC-C4-SK-LANDPLAN-005_A0</td></tr>
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</td></tr>
<tr><td>19.</td><td>Employer’s Financial Arrangements</td><td>2.4</td><td>A loan from AIIB Bank and counterpart funds through equity partners.</td></tr>
<tr><td>20.</td><td>Engineer’s Duties and Authority</td><td>3.2</td><td>Cumulative variations resulting in an increase of the Accepted Contract Amount in excess of 5% shall require written consent of the Employer.</td></tr>
<tr><td>21.</td><td>Performance Security</td><td>4.2</td><td>The Performance Security will be in the form of a “demand guarantee” in the amount(s) of 5% of the Accepted Contract Amount and in the same currency (ies) of the Accepted Contract Amount. Demand guarantee for the Performance Security shall be in the form as specified in Sub-Clause 4.2, Part B-Specific Provisions, PCC.</td></tr>
<tr><td>22.</td><td>Maximum allowable accumulated value of work subcontracted (as a percentage of the Accepted Contract Amount)</td><td>4.4(a)</td><td>30%</td></tr>
<tr><td>23.</td><td>Parts of the Works for which subcontracting is not permitted</td><td>4.4(b)</td><td>Construction of NATM Tunnel and Cut & Cover Tunnel</td></tr>
<tr><td>24.</td><td>Period for notification of errors in the items of reference</td><td>4.7.2 (a)</td><td>28 Days</td></tr>
</table>

S. No.	Conditions	GCC Sub-Clause	Data
25.	Number of additional paper copies of progress reports	4.20	One (1)
26.	Normal working hours	6.5	From 8:00 AM to 5:00 PM
27.	Number of additional paper copies of program	8.3	One (1)
28.	Delay Damages payable for each week of delay or part thereof	8.8	0.05% of the Accepted Contract Amount, less Provisional Sum in the currencies and proportions in which the Contract Price is payable for each week or part thereof which shall elapse between the Time for Completion and actual Date of Completion of the Works. Delay Damages for not achieving Key Dates shall be levied as given in Appendix 2, Section VII-12, Part 2- Employer's Requirements for each week or part thereof which shall elapse between the relevant Key Date and actual date of achieving Key Date.
29.	Maximum amount of Delay Damages	8.8	5% of the Accepted Contract Amount, less Provisional Sum.
30.	Percentage rate to be applied to Provisional Sums for overhead charges and profit	13.4(b)(ii)	5%

S. No.	Conditions	GCC Sub-Clause	Data
31.	Total advance payment	14.2	05% of the Accepted Contract Amount less Provisional Sum payable in the currencies and proportions in which the Accepted Contract Amount is payable. The advance payment shall be released against Advance Bank Guarantee in two equal instalments, each of two and half percent (2.5%), of the Accepted Contract Amount. i. The first instalment shall be paid against an Advance Payment Certificate, under Sub-Clause 14.2.2. ii. Upon satisfactory utilization of first instalment, the second instalment shall be paid after the Engineer's approval of the Programme (GCC Sub-Clause 8.3), mobilization of Contractor's Representative (GCC Sub_Clause 4.3) and Key Personnel (GCC Sub-Clause 6.12) as per the Employer's Requirements. The Contractor shall submit utilization statement mentioning detailed particulars of expenses made with supporting documents to demonstrate that such amounts are utilized in a purposeful manner in relation to the Works. This shall be supported or endorsed by certified Chartered Accountant under their seal and stamp. It shall be paid against an Advance Payment Certificate, under Sub-Clause 14.2.2.
32.	Number of additional paper copies of Statements	14.3(b)	One (1)
33.	Percentage of retention	14.3 (iii)	10%
34.	Limit of Retention Money (as a percentage of Accepted Contract Amount less Provisional Sum)	14.3 (iii)	5%
35.	Plant and Materials	14.5(b)(i)	Plant and Materials for payment when shipped - NIL

S. No.	Conditions	GCC Sub-Clause	Data
		14.5(c) (i)	Plant and Materials for payment when delivered to the Site: Reinforcement Steel
36.	Minimum Amount of Interim Payment Certificates	14.6.2	NIL
37.	Period of payment of Advance Payment to the Contractor	14.7(a)	07 days
38.	Delayed Payment	14.8	The financing charges shall be calculated at an interest rate equal to "State Bank of India's (SBI) Marginal Cost of fund-based Lending Rate (MCLR)" applicable for the tenure of 01year prevailing on the due date plus three percent.
39.	Number of additional paper copies of draft Final Statement	14.11.1(b)	Two (2)
40.	Forces of nature, the risks of which are allocated to the Contractor	17.2(d)	Earthquake, Floods, rain, wind/storm
41.	Periods for submission of evidence(s) and relevant policy (ies) of insurance (s)	19.2	**Evidence(s):** Within twenty-eight (28) days from the date of receipt of Letter of Acceptance. **Policy(ies):** Within forty-two (42) days from the date of receipt of the Letter of Acceptance.
42.	List of Exceptional Risks which shall not be excluded from the insurance cover for the Works	19.2.1 (iv)	Earthquake, Floods, Rain, wind/storm

S. No.	Conditions	GCC Sub-Clause	Data
43.	Liability for breach of professional duty	19.2.3	AOA (Any One Accident) limit equal to four percent (4%) of the total Contract value against Schedule 'A' of Price Schedule in respect of 'design and construct' with AOY (any one year) limit of 2 accidents in a year. In the Professional Indemnity Insurance Policy, the deductible amount shall not be more than five percent (5%) of the AOA limit. This PII policy shall be valid from the date of commencement of Works, until 5 years after the date of issue of Performance Certificate. Alternatively, the Contractor shall renew the insurance before the expiry of the Yearly Insurance in such a way that the entire validity period is covered. Wherever the Contractor submits policy for shorter period / annual renewable policy, the same shall be renewed before its expiry date. In such situation, the Performance Guarantee shall be retained till required validity period. The Contractor's submission of such shorter period / renewable policy shall be construed as their irrevocable consent for retention of the Performance Guarantee. The Engineer will not issue Final Payment Certificate until the Contractor has produced evidence that coverage of the professional indemnity insurance has been provided for the aforesaid period.
44.	Amount of insurance required for injury to persons and damage to property	19.2.4	INR 0.50 million for any one incident, with number of incidents unlimited
45.	Insurance required for injury to employees	19.2.5	INR 20,000,000/- (Twenty million)
46.	Time for appointment of DAAB	21.1	180 days after signature by both parties of the Contract Agreement
47.	The DAAB shall be comprised of	21.1	Three Members

S. No.	Conditions	GCC Sub-Clause	Data
48.	List of proposed members of DAAB	21.1	NIL
49.	Appointment (if not agreed) to be made by	21.2	(i) In case of Indian firms- President of Indian Council of Arbitration, New Delhi, India (ii) In case of foreign firm- Singapore International Arbitration Centre (SIAC).
50.	Rules of arbitration	21.6	Sub-Clause 21.6 of PART B – Specific Provisions shall apply.

Particular Conditions of Contract (PCC)

Part B - Specific Provisions

Sub-Clause 1.1.9 Contract	"the Contractor's Proposal" is deleted.
Sub-Clause 1.1.27 "Defects Notification Period" or "DNP"	Add the following at the end of **Sub-Clause 1.1.27 "Defects Notification Period" or "DNP" is synonymous with "Defects Liability Period" or "DLP"**
Sub-Clause 1.1.28 "Delay Damages"	Add the following at the end of **Sub-Clause 1.1.28 "Delay Damages"** is synonymous with **"Liquidated Damages".**
Sub-Clause 1.1.30 Employer	The following is added at the end of this Sub-Clause: Haryana Rail Infrastructure Development Corporation Limited (HRIDC) has been nominated as the implementing agency for Haryana Orbital Rail Corridor (HORC) Project by the Employer i.e. Haryana Orbital Rail Corporation Limited.
Sub-Clause 1.1.49 Laws	The Sub-Clause is replaced with: "**Laws**" means all national (or state) legislation, statutes, ordinances and other laws, and regulations and by-laws of any legally constituted public authority."
Sub-Clause 1.1.77 Site	The Sub-Clause is replaced with: "**Site**" means the places where the Permanent Works are to be executed, including storage and working area, and to which Plant and Materials are to be delivered, and any other places specified in the Contract as forming part of the Site."
Sub-Clause 1.1.79 Statement	On the second line after "Payment Certificate under…", add "Sub-Clause14.2.1 [Advance Payment Guarantee] (if applicable),".
Sub-Clause 1.1.83 Tender	"the Contractor's Proposal" is deleted.
Sub-Clause1.1.86 Time for Completion	Replace the entire Sub-Clause 1.1.84 with the following: "**Time for Completion**" means the time for completing the Works, a Section (as the case may be) or a Key Date (as the case may be) under Sub-Clause 8.2 [Time for Completion], as stated in the Contract Data (with any extension under Sub-Clause 8.5 [Extension of Time for Completion]), calculated from the Commencement Date

Sub-Clause1.1.88 "Variation"	***Add the following at the end of Sub-Clause 1.1.88*** *"Conceptual Tender drawings have been furnished in the Contract in good faith and to enable the Contractor to carry out design of the Works. The Contractor shall design the Works in accordance with Employer's Requirements based on which the Notice shall be issued by the Engineer. No claim shall be entertained from the Contractor for executing the Works as per drawings for which Notice has been given by the Engineer. If any additional opening is required due to agitation by land owners or due to demand by road authority or due to any other reason not attributable to the Contractor after award of the Contract, the same will constitute Variation and shall be dealt with as per the conditions of the Contract. If there is a change in the clear opening area of Road Under Bridges (RUBs) and canal crossings by more than (+/-) 10% over the opening area shown in conceptual Tender drawings due to agitation by land owners or due to demand by road authority or due to any other reason after award of the Contract, the same will constitute Variation and shall be dealt with as per conditions of the Contract"*
Sub-Clause 1.1.91 to 1.1.98 are added after Sub-Clause 1.1.90	
Sub-Clause 1.1.91 Bank	"**Bank**" means the financing institution (if any) named in the Contract Data.
Sub-Clause 1.1.92 Borrower	"**Borrower**" or "**Recipient**" means the person (if any) named as the borrower/recipient in the Contract Data.
Sub-Clause 1.1.93 ESHS	"**ESHS**" means Environmental, Social, Health and Safety.
Sub-Clause 1.1.94 **Sexual Exploitation and Assault (SEA)**	"Sexual Exploitation and Assault" "(SEA)" stands for the following: Sexual exploitation is defined as any actual or attempted abuse of position of vulnerability, differential power or trust, for sexual purposes, including, but not limited to, profiting monetarily, socially or politically from the sexual exploitation of another. In Bank financed operations/projects, sexual exploitation occurs when access to or benefit from a Bank financed Goods, Works, Non-consulting Services or Consulting Services is used to extract sexual gain. Sexual assault is defined as sexual activity with another person who does not consent. It is a violation of bodily integrity and sexual autonomy and is broader than narrower conceptions of "rape", especially because (a) it may be committed by other

	means than force or violence, and (b) it does not necessarily entail penetration.
Sub-Clause 1.1.95 **Milestone Certificate**	"Milestone Certificate" means the certificate issued by the Engineer under Sub-Clause 4.26 [Milestone].
Sub-Clause 1.1.96 **Milestone**	"Milestone" means stage of completion of works in a given Cost Centre based on which payment will be made to the Contractor.
Sub-Clause 1.1.97 **Key Date**	"Key Date" means the time for completion for a part of the Plant and/or a part of the Works as described in detail in the Appendix 2 of Part 2 of the Employer's Requirements.
Sub-Clause 1.1.98 **Principal Employer**	Principal Employer means 'Haryana Orbital Rail Corporation Limited".
Sub-Clause 1.2 **Interpretation**	Sub-paragraph (a) is replaced with the following: (a) "Words indicating one gender include all genders; "he/she" is replaced with "it"; "him/her" is replaced with "it"; "his" and "his/her" are replaced with "its"; "himself/herself" are replaced with "itself"." Further, "and" is deleted from the end of sub-paragraph (i) and added at the end of sub-paragraph (j). sub-paragraph (k) is added: (k) "The word "tender" is synonymous with "bid" or "proposal", the word tenderer with "bidder" or "proposer" and the words "tender documents" with "bidding documents" or "request for bids documents" or "request for proposal documents", as applicable."
Sub-Clause 1.5 **Priority of Documents**	Replace subparagraphs from (a) to (k) with the following: (a) the Contract Agreement (if any), (b) the Letter of Acceptance,

	(c) the Addenda & Corrigenda issued before opening of the Tender, (d) the Letter of Tender-Financial Part, (e) the Letter of Tender-Technical Part, (f) the Particular Conditions -Part A (Contract Data), (g) the Particular Conditions -Part B (Specific Provisions), (h) the Particular Conditions Part C- Prohibited Practices (i) these General Conditions, (j) the Employers' Requirements, (k) the Schedules, (l) the Reference Information/ Report, and (m) any other documents forming part of the Contract.
Sub-Clause 1.12 Confidentiality	The following is added at the end of the second paragraph: "The Contractor shall be permitted to disclose information required to establish its qualifications to compete for other projects." "or" at the end of (b) is deleted. "or" at the end of (c) is added. The following is then added as (d): "is being provided to the Bank ."
Sub-Clauses 1.17 and 1.18 are added after Sub-Clause 1.16	
Sub-Clause 1.17 Inspections & Audit by the Bank	"The Contractor shall permit and shall cause its agents (whether declared or not), subcontractors, subconsultants, service providers, suppliers, and their personnel, to permit the Bank and/or persons appointed by the Bank to inspect the site and/or the accounts, records and other documents relating to the procurement process, tender submission, proposal submission, and contract execution, and to have such accounts, records and other documents audited by auditors appointed by the Bank."
Sub-Clause 1.18 **Change in Control**	The Contractor or its constituents shall inform the Employer about any change in "Control" during the execution of the Contract.
Sub-Clause 2.4 Employer's Financial Arrangements	The first paragraph is replaced with: "The Employer shall submit, before the Commencement Date, reasonable evidence that financial arrangements have been made for financing the Employer's obligations under the Contract."

	The following sub-paragraph is added at the end of Sub-Clause 2.4: "In addition, if the Bank has notified to the Recipient that the Bank has suspended disbursements under its loan, which finances in whole or in part the execution of the Works, the Employer shall give notice of such suspension to the Contractor with detailed particulars, including the date of such notification, with a copy to the Engineer, within 7 days of the Recipient having received the suspension notification from the Bank. If alternative funds will be available in appropriate currencies to the Employer to continue making payments to the Contractor beyond a date 60 days after the date of Bank notification of the suspension, the Employer shall provide reasonable evidence in its notice of the extent to which such funds will be available."
Sub-Clause 3.1 The Engineer	The following is added at the end of the first sub-paragraph: "The Engineer's staff shall include suitably qualified engineers and other professionals who are competent to carry out these duties."
Sub-Clause 3.2 Engineer's Duties and Authority	The third paragraph of Sub-Clause 3.2 is replaced with: The Engineer may exercise the authority attributable to the Engineer as specified in or necessarily to be implied from the Contract. However, the Engineer shall obtain the consent in writing of the Employer before taking action under the following Sub-Clauses of these Conditions: (a) Sub-Clause 4.12 [Unforeseeable Physical Conditions]: agreeing or determining an extension of time and/or additional cost. (b) Sub-Clause 8.5 [Extension of Time for Completion]: agreeing or determining extension of time. (c) Sub-Clause 11.9 [Performance Certificate]: issue of Performance Certificate. (d) Clause 20.1: [Claims]: agreeing or determining extension of time and/or additional payment. Notwithstanding anything to the contrary contained in this Sub-Clause 3.2, as set out above, if in the opinion of the Engineer, an emergency occurs which adversely affects safety of, (a) life, (b) Works, or (c) any adjoining property, the Engineer may, without obtaining prior approval of the Employer and without

	relieving the Contractor of any of its duties and responsibilities under the Contract, instruct the Contractor to execute all such work or to do all such things as may, in the opinion of the Engineer, be necessary to abate or reduce the aforesaid risk(s). The Contractor shall forthwith comply with such directions of the Engineer despite the absence of Employer's specific approval in this regard. The Engineer shall determine an addition to the Contract Price, in respect of such instruction(s), in accordance with Clause 13 [Variations and Adjustments], and shall notify the Contractor accordingly, with a copy to the Employer. However, in case the concerned emergency as specified in the above para occurs on account of any failure by the Contractor to comply with the terms and conditions of the Contract, including but not limited to, (a) not adhering to the approved scheme of work (b) not taking adequate safety precautions, or (c) by any other reason attributable to the Contractor, no additional amounts shall be paid to the Contractor for attending to such emergencies and the Contractor shall be liable for Employer's claims in this regard".
Sub-Clause 3.3 Engineer's Representative	The following is added at the end of Sub-Clause 3.3: "The Engineer shall obtain the consent of the Employer before appointing or replacing an Engineer's Representative."
Sub-Clause 3.4 Delegation by the Engineer	The following is added at the end of the second paragraph: "If any assistants are not fluent in this language, the Engineer shall make competent interpreters available during all working hours, in a number sufficient for those assistants to properly perform their assigned duties and/or exercise their delegated authority."
Sub-Clause 3.6 Replacement of the Engineer	In the first paragraph, "42 days" is replaced with "21 days"; In the third para, "shall" is replaced with "should".
Sub-Clause 4.1 **Contractor's General Obligations**	The following is inserted after the second paragraph "The Contractor shall provide the Plant (and spare parts, if any)…": "All equipment, material, and services to be incorporated in or required for the Works shall have their origin in any eligible source country as defined by the Bank."

	The following is inserted after the fifth paragraph "The Contractor shall, whenever required by the Engineer...": The Contractor shall not carry out mobilization to Site (e.g. limited clearance for haul roads, site accesses and work site establishment, geotechnical investigations or investigations to select ancillary features such as quarries and borrow pits) unless the Engineer gives consent, a consent that shall not be unreasonably delayed, that appropriate measures are in place to address environmental and social risks and impacts, which at a minimum shall include applying the Management Strategies and Implementation Plans (MSIPs) and Code of Conduct for Contractor's Personnel as part of the Contract. The Contractor shall submit, to the Engineer for Review any additional MSIPs as are necessary to manage the ESHS risks and impacts of ongoing Works (e.g. Tunnelling, excavation, earth works, bridge, Ballastless Track construction and structure works, stream and road diversions, quarrying or extraction of materials, concrete batching and asphalt manufacture). These MSIPs shall be included in the Contractor's Environmental and Social Management Plan (C-ESMP). The Contractor shall review the C-ESMP, periodically (but not less than every six (6) months), and update it as required to ensure that it contains measures appropriate to the Works. The updated C-ESMP shall be submitted to the Engineer for Review. The C-ESMP shall be part of the Contractor's Documents. The procedures for Review of the C-ESMP and its updates shall be as described in Sub-Clause 5.2 .1 *[Preparation by Contractor]* and Sub-Clause 5.2.2 *[Review by Engineer]*. If so stated in the Employer's Requirements, the Contractor shall: (i) design structural elements of the Works taking into account climate change considerations; and (ii) apply the concept of universal access (the concept of universal access means unimpeded access for people of all ages and abilities in different situations and under various circumstances.

	"The Contractor shall provide relevant contract- related information, as the Employer and/or Engineer may reasonably request to conduct Stakeholder engagements. "Stakeholder" refers to individuals or groups who: (i) are affected or likely to be affected by the Contract; and (ii) may have an interest in the Contract. The Contractor may also directly participate in Stakeholder engagements, as the Employer and/or Engineer may reasonably request." "The Contractor shall require that it's subcontractors execute the Works in accordance with the Contract, including complying with the relevant ESHS requirements."
Sub-Clause 4.2 Performance Security	**Replace Sub-Clause 4.2.1 with the following:** The Contractor shall, within 28 days of the date of receiving the Letter of Acceptance, provide to the Employer, the Performance Security in a sum equal to the amount specified in the Contract Data, for the due observance and performance by the Contractor of the Contract. In the event the Contractor fails to provide the Performance Security within 28 days from the date of issue of the LOA, it may seek an extension of time for providing the performance security for a period not exceeding a further 14 days on payment of damages for such extended period in a sum calculated at the rate of 0.005% of the Accepted Contract Amount for each day until the Performance Security is provided. The Contractor shall maintain the said Performance Security at its own expense, so that it shall remain in full force and effect until the date/period set out in the Contract. In the event of a revision of the Contract Price, the value of the Performance Security shall be increased proportionately by the Contractor, if required by the Employer. The cost of obtaining the Performance Security shall be at the expense of the Contractor. The Contractor shall submit the Performance Security in any of the following forms: (a) Unconditional and irrevocable Bank Guarantee from the specified banks in the form appearing in Section X [Contract Forms] as under:

	(i) a scheduled bank (excluding co-operative banks) in India, or (ii) a Foreign Bank having arrangement with a nationalized bank or scheduled banks (excluding co-operative banks) in India; (b) Banker's Cheque or Demand Draft drawn on a scheduled bank (excluding co-operative banks) or nationalized bank in India. The scheduled bank issuing the bank guarantee shall be on "Structure Financial Messaging System (SFMS)" platform. A separate advice of the bank guarantee shall invariably be sent by the issuing bank to Employer's Bank through SFMS and only after receipt of the same by the Employer's Bank, the bank guarantee shall become operative and acceptable to the Employer. Further, the bank guarantees in original form along with a copy of "MT760COV (in case of bank guarantee message)/ MT767COV (in case of bank guarantee amendment message) Report" sent by the concerned issuing bank sealed in an envelope shall be submitted to the Employer. The Issuing Bank shall send the SFMS to: Beneficiary: *Haryana Orbital Rail Corporation Limited*, Bank Name: Account No. IFSC Code: Note: All the instruments mentioned in (a) & (b) above should be in favour of Haryana Rail Infrastructure Development Corporation Limited, Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram. The Contractor shall ensure that the Performance Security is valid and enforceable until the Contractor has executed and completed the Works and remedied defects, if any. If, (a) the Contractor does not complete the Works for any reasons

	whatsoever, and (b) the Contractor has not become entitled to receive the Performance Certificate by 28 days prior to the expiry date of the Performance Security, the Contractor shall be bound to extend the validity of the Performance Security until the Works have been completed and the defects have been remedied. If the Performance Security is or becomes invalid or unenforceable for any reason whatsoever, or if such security is withdrawn or expires, the Contractor must immediately notify the Employer and obtain within 3 days a replacement guarantee in the form appearing in Section X [Contract Forms] and which is acceptable to the Employer in its absolute discretion. The provision, maintenance and renewal by the Contractor of the Performance Security in accordance with this Sub-Clause 4.2 [Performance Security] shall be a condition precedent to any payment by the Employer to the Contractor under the Contract. If the Contractor fails to provide, maintain and renew the Performance Security in accordance with the Contract, the Employer shall, without prejudice to any other rights and remedies to which it may be entitled, shall have the right to invoke the Performance Security for the value equal to the damages to the Employer as a result of the Contractor's failure and/or by written notice terminate the Contract in accordance with Clause 15.
Sub-Clause 4.3 Contractor's Representative	The following is added at the end of the last paragraph: "If any of these persons is not fluent in this language, the Contractor shall make competent interpreters available during all working hours in a number deemed sufficient by the Engineer."
Sub-Clause 4.8 Health and Safety Obligations	The following are included after deleting "and" at the end of (f) and replacing "." with ";" at the end of (g): " (i) provide health and safety training of Contractor's Personnel as appropriate and maintain training records; (ii) actively engage the Contractor's Personnel in promoting understanding, and methods for, implementation of health and safety requirements, as well as in providing information to Contractor's Personnel, training on occupational safety and health, and provision of personal protective equipment without expense to the Contractor's Personnel;

	(iii) put in place workplace processes for Contractor's Personnel to report work situations that they believe are not safe or healthy, and to remove themselves from a work situation which they have reasonable justification to believe presents an imminent and serious danger to their life or health. (iv) Contractor's Personnel who remove themselves from such work situations shall not be required to return to work until necessary remedial action to correct the situation has been taken. Contractor's Personnel shall not be retaliated against or otherwise subject to reprisal or negative action for such reporting or removal; (v) subject to Sub-Clause 4.6, where the Employer's Personnel, any other contractors employed by the Employer, and/or personnel of any legally constituted public authorities and private utility companies are employed in carrying out, on or near the site, of any work not included in the Contract, collaborate in applying the health and safety requirements, without prejudice to the responsibility of the relevant entities for the health and safety of their own personnel; and (vi) establish and implement a system for regular (not less than six-monthly) review of health and safety performance and the working environment." The second and third paragraphs are replaced with the following: "Within 21 days of the Commencement Date and before commencing any construction on the Site, the Contractor shall submit to the Engineer for Review a health and safety manual which has been specifically prepared for the Works, the Site and other places (if any) where the Contractor intends to execute the Works. The procedures for Review of the health and safety manual and its updates shall be as described in Sub-Clause 5.2.1 *[Preparation by Contractor]* and Sub-Clause 5.2.2 *[Review by Engineer]*. The health and safety manual shall be in addition to any other similar document required under applicable health and safety regulations and Laws. The health and safety manual shall set out all the health and safety requirements under the Contract, a) which shall include at a minimum: (i) the procedures to establish and maintain a safe working environment without risk to health at

	all workplaces, machinery, equipment and processes under the control of the Contractor, including control measures for chemical, physical and biological substances and agents; (ii) details of the training to be provided, records to be kept; (iii) the procedures for prevention, preparedness and response activities to be implemented in the case of an emergency event (i.e. an unanticipated incident, arising from both natural and man-made hazards, typically in the form of fire, explosions, leaks or spills, which may occur for a variety of different reasons including failure to implement operating procedures that are designed to prevent their occurrence, extreme weather or lack of early warning); (iv) remedies for adverse impacts such as occupational injuries, deaths, disability and disease; (v) the measures to be taken to avoid or minimize the potential for community exposure to water-borne, water-based, water-related, and vector-borne diseases, (vi) the measures to be implemented to avoid or minimize the spread of communicable diseases (including transfer of Sexually Transmitted Diseases or Infections (STDs), such as HIV virus) and non-communicable diseases associated with the execution of the Works, taking into consideration differentiated exposure to and higher sensitivity of vulnerable groups. This includes taking measures to avoid or minimize the transmission of communicable diseases that may be associated with the influx of temporary or permanent Contract-related labour; (vii) the policies and procedures on the management and quality of accommodation and welfare facilities if such accommodation and welfare facilities are provided by the Contractor in accordance with Sub-Clause 6.6; and

	b) any other requirements stated in the Specification. The paragraph starting with: "In addition to the reporting requirement of…" is replaced with the following: "In addition to the reporting requirement of sub-paragraph (g) of Sub-Clause 4.20 [*Progress Reports*] the Contractor shall inform the Engineer immediately of any allegation, incident or accident in the Site, which has or is likely to have a significant adverse effect on the environment, the affected communities, the public, Employer's Personnel or Contractor's Personnel. This includes, but is not limited to, any incident or accident causing fatality or serious injury; significant adverse effects or damage to private property; or any allegation of SEA. In case of SEA, while maintaining confidentiality as appropriate, the type of allegation (sexual exploitation, or sexual assault), gender and age of the person who experienced the alleged incident should be included in the information. The Contractor, upon becoming aware of the allegation, incident or accident, shall also immediately inform the Engineer of any such incident or accident on the Subcontractors' or suppliers' premises relating to the Works which has or is likely to have a significant adverse effect on the environment, the affected communities, the public, Employer's Personnel or Contractor's, its Subcontractors' and suppliers' personnel. The notification shall provide sufficient detail regarding such incidents or accidents. The Contractor shall provide full details of such incidents or accidents to the Engineer within the timeframe agreed with the Engineer. The Contractor shall require its Subcontractors and suppliers (other than Subcontractors) to immediately notify the Contractor of any incidents or accidents referred to in this Sub-clause."
Sub-Clause 4.10 **Use of Site Data**	**Add at the end of paragraph** 1 **of Sub-Clause 4.10.** "Accordingly, the Contractor shall have no claim in this regard." **In paragraph 2 of Sub-Clause 4.10.** Delete the words "To the extent which was practicable (taking account of cost and time)". **Start** the word "the" with a capital letter. Delete "To the same extent" from the fourth line and **Start** the word "the" with a capital letter.

	Add following (f) after existing Sub-Clause 4.10 (e) as under: "(f) damage to property adjacent to the Site and the risk of injury to the occupiers of such property due to execution of the Works." The following is added at the end of the Sub-Clause: The Geotechnical and other related data provided by the Employer are based on the investigation conducted by the Employer/Engineer and are for reference purposes only. The Contractor shall conduct further investigations if considered necessary by him at his own cost and should satisfy himself with the data furnished and make his own investigations if required for submitting his offer. Financial cost incurred due to any change in design or construction methodology later during execution on account of change in Geotechnical and other related data provided by the Employer shall be borne by the Contractor.
Sub-Clause 4.15 Access Route	The following is added at the end of Sub-Clause 4.15: "The Contractor shall take all necessary safety measures to avoid the occurrence of incidents and injuries to any third party associated with the use of Contractor's Equipment on public roads or other public infrastructure. The Contractor shall monitor road safety incidents and accidents to identify negative safety issues and establish and implement necessary measures to resolve them.
Sub-Clause 4.18 Protection of the Environment	Sub-Clause 4.18 Protection of the Environment is replaced with: "The Contractor shall take all necessary measures to: (a) protect the environment (both on and off the Site); and (b) limit damage and nuisance to people and property resulting from pollution, noise and other results of the Contractor's operations and/ or activities. The Contractor shall ensure that emissions, surface discharges, effluent and any other pollutants from the Contractor's activities shall exceed neither the values indicated in the Employer's Requirements, nor those prescribed by applicable Laws. In the event of damage to the environment, property and/or nuisance to people, on or off Site as a result of the Contractor's operations, the Contractor shall agree with the Engineer the

	appropriate actions and time scale to remedy, as practicable, the damaged environment to its former condition. The Contractor shall implement such remedies at its cost to the satisfaction of the Engineer. The Contractor shall comply with the Environmental and Social Management Plan, the Code of Conduct, and the Guidelines on Gender Based Violence as given in Appendix13 (ESHS Manual), Section VII-9: Appendices, Part 2, Employer's Requirements."
Sub-Clause 4.20 Progress Reports	Replace "4.20 (g) with: "the Environmental, Social, Health and Safety (ESHS) metrics set out in Appendix 13 (ESHS Manual), Section VII-9: Appendices, Part 2, Employer's Requirements.

Sub-Clause 4.21 Security of the Site	Sub-Clause 4.21 Security of the Site is replaced with: "The Contractor shall be responsible for the security of the Site, and: (a) for keeping unauthorized persons off the Site; (b) authorized persons shall be limited to the Contractor's Personnel, the Employer's Personnel, and to any other personnel identified as authorized personnel (including the Employer's other contractors on the Site), by a Notice from the Employer or the Engineer to the Contractor. The Contractor shall, within 21 days of the Commencement Date, submit for the Engineer's No-objection a security management plan that sets out the security arrangements for the Site. The Contractor shall (i) conduct appropriate background checks on any personnel retained to provide security; (ii) train the security personnel adequately (or determine that they are properly trained) in the use of force (and where applicable, firearms), and appropriate conduct towards Contractor's Personnel, Employer's Personnel and affected communities; and (iii) require the security personnel to act within the applicable Laws and any requirements set out in the Employer's Requirements. The Contractor shall not permit any use of force by security personnel in providing security except when used for preventive and defensive purposes in proportion to the nature and extent of the threat. In making security arrangements, the Contractor shall also comply with any additional requirements stated in the Employer's Requirements."
Sub-Clause 4.22 **Contractor's Operations on Site**	On the third line of the second paragraph before "4.17", "Sub-Clause" is added.
Sub-Clause 4.23 Archaeological and Geological Findings	The first paragraph is replaced with the following: "All fossils, coins, articles of value or antiquity, structures, groups of structures, and other remains or items of geological,

	archaeological, paleontological, historical, architectural or religious interest found on the Site shall be placed under the care and custody of the Employer. The Contractor shall: (a) take all reasonable precautions, including fencing-off the area or site of the finding, to avoid further disturbance and prevent Contractor's Personnel or other persons from removing or damaging any of these findings; (b) train relevant Contractor's Personnel on appropriate actions to be taken in the event of such findings; and (c) implement any other action consistent with the requirements of the Employer's Requirements and relevant Laws."
Sub-Clause 4.24 to 4.26 are added after Sub-Clause 4.23	
Sub-Clause 4.24 Suppliers (other than Subcontractors)	**4.24.1 Forced Labour** The Contractor shall take measures to require its suppliers (other than Subcontractors) not to employ or engage forced labour including trafficked persons as described in Sub-Clause 6.21. If forced labour/trafficking cases are identified, the Contractor shall take measures to require the suppliers to take appropriate steps to remedy them. Where the supplier does not remedy the situation, the Contractor shall within a reasonable period substitute the supplier with a supplier that is able to manage such risks. **4.24.2 Child labour** The Contractor shall take measures to require its suppliers (other than Subcontractors) not to employ or engage child labour as described in Sub-Clause 6.22. If child labour cases are identified, the Contractor shall take measures to require the suppliers to take appropriate steps to remedy them. Where the supplier does not remedy the situation, the Contractor shall within a reasonable period substitute the supplier with a supplier that is able to manage such risks. **4.24.3 Serious Safety Issues** The Contractor, including its Subcontractors (if any), shall comply with all applicable safety obligations, including as stated in Sub-Clauses 4.8, 5.1 and 6.7. The Contractor shall also take measures to require its suppliers (other than Subcontractors) to introduce procedures and mitigation measures to address safety issues related to their personnel. If serious safety issues are identified, the Contractor shall take measures to require the suppliers to take appropriate steps to remedy them. Where the supplier does not remedy the situation,

	the Contractor shall within a reasonable period substitute the supplier with a supplier that is able to manage such risks. **4.24.4 Obtaining natural resource materials in relation to supplier** The Contractor shall obtain natural resource materials from suppliers that can demonstrate, through compliance with the applicable verification and/ or certification requirements, that obtaining such materials is not contributing to the risk of significant conversion or significant degradation of natural or critical habitats such as unsustainably harvested wood products, gravel or sand extraction from river beds or beaches. **If a supplier cannot continue to demonstrate that obtaining such materials is not contributing to the risk of significant conversion or significant degradation of natural or critical habitats, the Contractor shall within a reasonable period substitute the supplier with a supplier that is able to demonstrate that they are not significantly adversely impacting the habitats.**
Sub-Clause 4.25 **Code of Conduct**	The Contractor shall have a Code of Conduct for the Contractor's Personnel. The Contractor shall ensure that each Contractor's Personnel is provided a copy of this Code of Conduct, written in a language comprehensible to that person, and shall seek to obtain that person's signature acknowledging receipt of the same. The Contractor shall also ensure that the Code of Conduct is visibly displayed in multiple locations on the Site and any other place where the Works will be carried out, as well as in areas outside the Site accessible to the local community and project affected people. The posted Code of Conduct shall be provided in languages comprehensible to Contractor's Personnel, Employer's Personnel and the local community.

Sub-Clause 4.26 **Milestone**	**Sub-Clause 4.26 Milestone** If no Milestones are specified in the Contract, this Sub-Clause shall not apply. The Contractor shall complete the works of each Milestone (including all work which is stated in the Employer's Requirements as being required for the Milestone to be considered complete). The Contractor shall apply, by notice to the Engineer, for a Milestone Certificate not earlier than 14 days before the works of a Milestone will, in the Contractor's opinion, be complete. The Engineer shall within 28 days after receiving the Contractor's notice: (a) issue the Milestone Certificate to the Contractor, stating the date on which the works of the Milestone were completed in accordance with the Contract, except for any minor outstanding work and defects (as shall be listed in the Milestone Certificate); or (b) reject the application, giving reasons and specifying the work required to be done and defects required to be remedied by the Contractor to enable the Milestone Certificate to be issued. The Contractor shall then complete the work referred to in sub-paragraph (b) of this Sub-Clause before issuing a further notice of application under this Sub-Clause.
Sub-Clause 5.1 **General Design Obligations**	**Add the following at the end of Sub-Clause 5.1** The Contractor shall furnish Contractor's Warranty in the in the form included in Section X [Contract Forms]. "All subcontracts relating to the Works shall include provisions which entitle the Employer to require the subcontract to be assigned to the Employer under subparagraph (a) of Sub-Clause 15.2.3 [After Termination]
Sub-Clause 6.1 **Engagement of Staff and Labour**	**The following paragraphs are added at the end of the Sub-Clause:** The Contractor shall provide the Contractor's Personnel information and documentation that are clear and understandable regarding their terms and conditions of employment. The information and documentation shall set out their rights under relevant labour Laws applicable to the

	Contractor's Personnel (which will include any applicable collective agreements), including their rights related to hours of work, wages, overtime, compensation and benefits, as well as those arising from any requirements in the Employer's Requirements; and shall also include the Code of Conduct for Contractor's Personnel as set forth in Sub-Clause 4.25. The Contractor's Personnel shall be informed when any material changes to their terms or conditions of employment occur. "The Contractor is encouraged, to the extent practicable and reasonable, to employ staff and labour with appropriate qualifications and experience from sources within the Country."
Sub-Clause 6.2 Rates of Wages and Conditions of Labour	The following paragraphs are added at the end of the Sub-Clause: "The Contractor shall inform the Contractor's Personnel about: (a) any deduction to their payment and the conditions of such deductions in accordance with the applicable Laws or as stated in the Employer's Requirements; and (b) their liability to pay personal income taxes in the Country in respect of such of their salaries, wages, allowances and any benefits as are subject to tax under the Laws of the Country for the time being in force. The Contractor shall perform such duties in regard to such deductions thereof as may be imposed on him by such Laws. Where required by applicable Laws or as stated in the Employer's Requirements, the Contractor shall provide the Contractor's Personnel written notice of termination of employment and details of severance payments in a timely manner. The Contractor shall have paid the Contractor's Personnel (either directly or where appropriate for their benefit) all due wages and entitlements including, as applicable, social security benefits and pension contributions, on or before the end of their engagement/ employment. If any amenity required to be provided under any Section of Contract Labour (Regulation and Abolition) Act of 1970 for the benefit of the contract labour employed in an establishment, is not provided by the Contractor within the time prescribed therein, such amenity shall be provided by the Principal Employer within such time as may be prescribed. All expenses incurred by the Principal Employer in providing the

	amenities will be recovered from the amount payable under the Contract. In case the Contractor fails to make payment of wages within the prescribed period or makes short payment, then the Principal Employer will make payment of wages in full or the unpaid balance due, as the case may be, to the contract labour employed by the Contractor and recover the amount so paid from the amount payable under the Contract. The Contractor shall keep the Employer indemnified in case any action is taken against the Employer by the competent authority on account of contravention of any of the provisions of applicable Laws. If the Employer is caused to pay or reimburse, such amounts as may be necessary to cause or observe, or for non-observance of the provisions stipulated in the notifications/bye laws/Acts/Rules/Regulations including amendments, if any, on the part of the Contractor, the Employer shall have the right to deduct any money due to the Contractor including his amount of Performance Security. The Employer shall also have right to recover from the Contractor any sum required or estimated to be required for making good the loss or damage suffered by the Employer. For the avoidance of any doubt, the Contractor shall be responsible for payment of applicable cess and making timely filings under the Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996."
Sub-Clause 6.5 Working Hours	The following paras are inserted at the end of the Sub-Clause: The Contractor shall provide the Contractor's Personnel annual holiday and sick, maternity and family leave, as required by applicable Laws or as stated in the Employer's Requirements." The Contractor, if required, shall take approval of Engineer for carrying out work during night hours or in shifts subject to compliance with applicable Laws and shall be responsible for all necessary safety arrangements with respect to the work being undertaken. However, the Contractor shall not be entitled to any claim for increase in rates or any additional cost and the same shall be deemed to be included in the Contract Price.
Sub-Clause 6.7 Health and Safety of Personnel	In the second paragraph, "The Contractor" is replaced with: "Except as otherwise stated in the Employer's Requirements, the Contractor…"

Sub-Clause 6.9 Contractor's Personnel	The Sub-Clause is replaced with: "The Contractor's Personnel (including Key Personnel, if any) shall be appropriately qualified, skilled, experienced and competent in their respective trades or occupations. The Engineer may require the Contractor to remove (or cause to be removed) any person employed on the Site or Works, including the Contractor's Representative and Key Personnel (if any), who: (a) persists in any misconduct or lack of care; (b) carries out duties incompetently or negligently; (c) fails to comply with any provision of the Contract; (d) persists in any conduct which is prejudicial to safety, health, or the protection of the environment; (e) based on reasonable evidence, is determined to have engaged in Prohibited Practice during the execution of the Works; (f) has been recruited from the Employer's Personnel in breach of Sub-Clause 6.3 [Recruitment of Persons]; (g) undertakes behaviour which breaches the Code of Conduct for Contractor's Personnel (ESHS). If appropriate, the Contractor shall then promptly appoint (or cause to be appointed) a suitable replacement with equivalent skills and experience. In the case of replacement of the Contractor's Representative, Sub-Clause 4.3 [*Contractor's Representative*] shall apply. In the case of replacement of Key Personnel (if any), Sub-Clause 6.12 [*Key Personnel*] shall apply Subject to the requirements in Sub-Clause 4.3 [*Contractor's Representative*] and 6.12 [*Key Personnel*], and notwithstanding any requirement from the Engineer to remove or cause to remove any person, the Contractor shall take immediate action as appropriate in response to any violation of (a) through (g) above. Such immediate action shall include removing (or causing to be removed) from the Site or other places where the Works are being carried out, any Contractor's Personnel who engages in (a), (b), (c), (d), (e) or (g) above or has been recruited as stated in (f) above."
Sub-Clause 6.12 Key Personnel	The following is inserted at the end of the last paragraph: "If any of the Key Personnel are not fluent in this language, the Contractor shall make competent interpreters available during

	all working hours in a number deemed sufficient by the Engineer."
The following Sub-Clauses 6.13 to 6.27 are added after sub-clause 6.12	
Sub-Clause 6.13 Foreign Personnel	The Contractor may bring into the Country any foreign personnel who are necessary for the execution of the Works to the extent allowed by the applicable Laws. The Contractor shall ensure that these personnel are provided with the required residence visas and work permits. The Employer will, if requested by the Contractor, use its best endeavors in a timely and expeditious manner to assist the Contractor in obtaining any local, state, national, or government permission required for bringing in the Contractor's personnel. The Contractor shall be responsible for the return of these personnel to the place where they were recruited or to their domicile. In the event of the death in the Country of any of these personnel or members of their families, the Contractor shall similarly be responsible for making the appropriate arrangements for their return or burial.
Sub-Clause 6.14 Supply of Foodstuffs	The Contractor shall arrange for the provision of a sufficient supply of suitable food as may be stated in the Employer's Requirements at reasonable prices for the Contractor's Personnel for the purposes of or in connection with the Contract.
Sub-Clause 6.15 Supply of Water	The Contractor shall, having regard to local conditions, provide on the Site an adequate supply of drinking and other water for the use of the Contractor's Personnel.
Sub-Clause 6.16 Measures against Insect and Pest Nuisance	The Contractor shall at all times take the necessary precautions to protect the Contractor's Personnel employed on the Site from insect and pest nuisance, and to reduce the danger to their health. The Contractor shall comply with all the regulations of the local health authorities, including use of appropriate insecticide.
Sub-Clause 6.17 Alcoholic Liquor or Drugs	The Contractor shall not, otherwise than in accordance with the Laws of the Country, import, sell, give, barter or otherwise dispose of any alcoholic liquor or drugs, or permit or allow importation, sale, gift, barter or disposal thereto by Contractor's Personnel.
Sub-Clause 6.18 Arms and Ammunition	The Contractor shall not give, barter, or otherwise dispose of, to any person, any arms or ammunition of any kind, or allow Contractor's Personnel to do so.

Sub-Clause 6.19 Festivals and Religious Customs	The Contractor shall respect the Country's recognized festivals, days of rest and religious or other customs.
Sub-Clause 6.20 Funeral Arrangements	The Contractor shall be responsible, to the extent required by local regulations, for making any funeral arrangements for any of its local employees who may die while engaged upon the Works.
Sub-Clause 6.21 Forced Labour	The Contractor, including its Subcontractors, shall not employ or engage forced labour. Forced labour consists of any work or service, not voluntarily performed, that is exacted from an individual under threat of force or penalty, and includes any kind of involuntary or compulsory labour, such as indentured labour, bonded labour or similar labour-contracting arrangements. No persons shall be employed or engaged who have been subject to trafficking. Trafficking in persons is defined as the recruitment, transportation, transfer, harbouring or receipt of persons by means of the threat or use of force or other forms of coercion, abduction, fraud, deception, abuse of power, or of a position of vulnerability, or of the giving or receiving of payments or benefits to achieve the consent of a person having control over another person, for the purposes of exploitation.
Sub-Clause 6.22 Child Labour	The Contractor, including its Subcontractors, shall not employ or engage a child (as defined in Child Labour (Prohibition & Regulation) Act, 1986). The Contractor, including its Subcontractors, shall not employ or engage a child between the minimum age and the age of 18 in a manner that is likely to be hazardous, or to interfere with, the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. The Contractor including its Subcontractors, shall only employ or engage children between the minimum age and the age of 18 after an appropriate risk assessment has been conducted by the Contractor with the Engineer's consent. The Contractor shall be subject to regular monitoring by the Engineer that includes monitoring of health, working conditions and hours of work. Work considered hazardous for children is work that, by its nature or the circumstances in which it is carried out, is likely to jeopardize the health, safety, or morals of children. Such work activities prohibited for children include work:

	(a) with exposure to physical, psychological or sexual abuse; (b) underground, underwater, working at heights or in confined spaces; (c) with dangerous machinery, equipment or tools, or involving handling or transport of heavy loads; (d) in unhealthy environments exposing children to hazardous substances, agents, or processes, or to temperatures, noise or vibration damaging to health; or under difficult conditions such as work for long hours, during the night or in confinement on the premises of the employer.
Sub-Clause 6.23 Employment Records of Workers	The Contractor shall keep complete and accurate records of the employment of labour at the Site. The records shall include the names, ages, genders, hours worked, and wages paid to all workers. These records shall be summarised on a monthly basis and submitted to the Engineer. These records shall be included in the details to be submitted by the Contractor under Sub-Clause 6.10 [Records of Contractor's Personnel and Equipment].
Sub-Clause 6.24 Workers' Organisations	In countries where the relevant labour laws recognise workers' rights to form and to join workers' organisations of their choosing and to bargain collectively without interference, the Contractor shall comply with such laws. In such circumstances, the role of legally established workers' organizations and legitimate workers' representatives will be respected, and they will be provided with information needed for meaningful negotiation in a timely manner. Where the relevant labour laws substantially restrict workers' organisations, the Contractor shall enable alternative means for the Contractor's Personnel to express their grievances and protect their rights regarding working conditions and terms of employment. The Contractor shall not seek to influence or control these alternative means. The Contractor shall not discriminate or retaliate against the Contractor's Personnel who participate, or seek to participate, in such organisations and collective bargaining or alternative mechanisms. Workers' organisations are expected to fairly represent the workers in the workforce.
Sub-Clause 6.25 Non-Discrimination and Equal Opportunity	The Contractor shall not make decisions relating to the employment or treatment of Contractor's Personnel on the basis of personal characteristics unrelated to inherent job requirements. The Contractor shall base the employment of Contractor's Personnel on the principle of equal opportunity and fair treatment, and shall not discriminate with respect to

	any aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, job assignment, promotion, termination of employment or retirement, and disciplinary practices. Special measures of protection or assistance to remedy past discrimination or selection for a particular job based on the inherent requirements of the job shall not be deemed discrimination. The Contractor shall provide protection and assistance as necessary to ensure non-discrimination and equal opportunity, including for specific groups such as women, people with disabilities, migrant workers and children (of working age in accordance with Sub-Clause 6.22). The Contractor shall give preference to local people including Project Affected Persons (PAPs) for employment opportunity during construction and enhance female work force participation.
Sub-Clause 6.26 Contractor's Personnel Grievance Mechanism	The Contractor shall have a grievance mechanism for Contractor's Personnel, and where relevant the workers' organizations stated in Sub-Clause 6.24, to raise workplace concerns. The grievance mechanism shall be proportionate to the nature, scale, risks and impacts of the Contract. The mechanism shall address concerns promptly, using an understandable and transparent process that provides timely feedback to those concerned in a language they understand, without any retribution, and shall operate in an independent and objective manner. The Contractor's Personnel shall be informed of the grievance mechanism at the time of engagement for the Contract, and the measures put in place to protect them against any reprisal for its use. Measures will be put in place to make the grievance mechanism easily accessible to all Contractor's Personnel. The grievance mechanism shall not impede access to other judicial or administrative remedies that might be available, or substitute for grievance mechanisms provided through collective agreements. The grievance mechanism may utilize existing grievance mechanisms, providing that they are properly designed and implemented, address concerns promptly, and are readily accessible to such project workers. Existing grievance mechanisms may be supplemented as needed with Contract-specific arrangements.
Sub-Clause 6.27	The Contractor shall provide appropriate training to relevant Contractor's Personnel on ESHS aspects of the Contract,

Training of Contractor's Personnel	including appropriate sensitization on prohibition of SEA, Gender Based Violence (GBV) and health & safety training referred to in Sub-Clause 4.8. As stated in the Employer's Requirements or as instructed by the Engineer, the Contractor shall also allow appropriate opportunities for the relevant Contractor's Personnel to be trained on ESHS aspects of the Contract by the Employer's Personnel. The Contractor shall provide training on SEA, GBV including its prevention, to any of its personnel who has a role to supervise other Contractor's Personnel.
Sub-Clause 7.3 Inspection	The following is added in the first paragraph after "Employer's Personnel" "(including the Bank staff or consultants acting on the Bank's behalf, stakeholders and third parties, such as independent experts, local communities, or non-governmental organizations)" The following is added as (b) (iv): "(iv) carryout environmental and social audit, and"
Sub-Clause 7.7 Ownership of Plant and Materials	The following is added before the first paragraph: "Except as otherwise provided in the Contract,"

Sub-Clause 8.1 Commencement of Work	The Sub- Clause is replaced in its entirety with the following: "The Engineer shall give a Notice to the Contractor stating the Commencement Date, not less than 07 days before the Commencement Date. The Notice shall be issued promptly after the Engineer determines the fulfilment of the following conditions: (a) signature of the Contract Agreement by both Parties, and if required, approval of the Contract by relevant authorities of the Country; (b) delivery to the Contractor of reasonable evidence of the Employer's financial arrangements (under Sub-Clause 2.4 [Employer's Financial Arrangements]); (c) except if otherwise specified in the Contract Data, effective access to and possession of the Site given to the Contractor together with such permission(s) under (a) of Sub-Clause 1.13 [Compliance with Laws] as required for the commencement of the Works; Subject to Sub-Clause 4.1 on the Management Strategies and Implementation Plans and the C-ESMP and Sub-Clause 4.8 on the health and safety manual, the Contractor, shall commence the execution of the Works as soon as is reasonably practicable after the Commencement Date, and shall then proceed with the Works with due expedition and without delay."
Sub-Clause 8.2 Time for Completion	The following paragraph shall be added at the end of Sub-Clause 8.2: The Contractor shall complete each Key Date (if any) within the Time for Completion for the Key Date (as the case may be), including completing all work which is stated in the Contract as being required for the Key Date to be considered to be completed for the issuance of key date completion certificate. .
Sub-Clause 8.5 Extension of Time for Completion	Replace the entire first paragraph of Sub-Clause 8.5 with the following: The Contractor shall be entitled subject to Sub-Clause 20.1 [Claims] to an extension of the Time for Completion if and to the extent that completion for the purpose of Sub-Clause 10.1 [Taking Over of the Works and Sections] or for the completion

	of Key Date specified in Appendix 2, Section VII-9: Appendices of Part 2 Employer's requirements is or will be delayed by any of the following causes:"
Sub-Clause 8.8 Delay Damages	Replace the entire Sub-Clause 8.8 with the following: Time is the essence of the contract and if the Contractor fails to comply with Sub-Clause 8.2 [Time for Completion], the Contractor shall subject to notice under Sub-Clause 20.1 Claims] pay delay damages to the Employer for this default. These delay damages shall be the sum stated in the Contract Data, which shall be charged for every week of delay or part thereof which shall elapse between the Time for Completion and actual Date of Completion of the Works. Delay damages for not achieving Key Dates stated in Appendix 2 Section VII-9, Part 2 of the Employer's Requirements, shall be the sum stated in the Contract Data. However, the total amount due under this Sub-Clause shall not exceed the maximum amount of delay damages stated in the Contract Data. These delay damages shall be the only damages due from the Contractor for such default, other than in the event of termination under Sub-Clause 15.2 [Termination for Contractor's Default] prior to completion of the Works. These damages shall not relieve the Contractor from his obligation to complete the Works, or from any other duties, obligations or responsibilities which he may have under the Contract. Delay Damages may be recovered by the Employer from any amount of money due from the Contractor under the Contract. The Delay Damages may also be recovered from the amount of Performance Security Bank Guarantee and in that case the Contractor would be liable to replenish the amount of Performance Security Bank Guarantee. The Delay Damages recovered corresponding to any key date will be provisional and would be refunded by the Employer on achievement of subsequent key date on time.
Sub-Clause 11.7 Right of Access after Taking Over	In the second paragraph, "Whenever the Contractor intends to access any part of the Works during the relevant DNP:" is replaced with: "Whenever, until the date 28 days after issue of the Performance Certificate, the Contractor intends to access any part of the Works:"

Sub-Clause 13.2 Value Engineering	Not applicable
Sub-Clause 13.3.1 Variation by Instruction	Subparagraph 13.3.1 (a) is replaced with: "a description of the varied work performed or to be performed, including details of the resources and methods adopted or to be adopted by the Contractor, and sufficient ESHS information to enable an evaluation of ESHS risks and impacts;"
Sub-Clause 13.3.1 Variation by Instruction	**Following is added to GC Clause 13.3.1** **Variation in the accepted Contract Amount & deriving rates of new items** **A.** The quantities of items shown in Price Schedule 'B' and estimated cost shown in Price Schedule 'C' are approximate, and are liable to vary during the actual execution of the work. Some items may have to be added or deleted. The Contractor shall be bound to carry out and complete the stipulated Work as instructed by the Engineer, irrespective of the magnitude of variations including additions or deletion in the Price Schedule. Variations in Price Schedule 'A', Price Schedule 'B' and Price Schedule 'C' shall be paid as follows: **(I)Price Schedule 'A'** **a)** For Bridges involving pile foundations, the quoted price of Schedule 'A' shall include providing piles, upto a pile depth of 20 m (below bottom of pile cap). Any increase or decrease in pile depth above/below the value of 20 m shall be payable/recoverable at the accepted rate of relevant item in Schedule 'C'. **b**). *No other variation shall be paid under Schedule 'A' unless Scope of the Works under Schedule 'A' changes.* **c).** *In case, there is variation in Scope of the Works in Schedule 'A', the cost of variation shall be worked out based on the accepted rates of items provided in Schedule 'B' or Schedule 'C'.* **(II) Price Schedule 'B' having items rates with quantities:** a) At the accepted rates of the Contract for Positive variation in quantities of items to the extent of *50%*. In case of variation in quantities on minus side, Contract rates will be payable at the accepted rates of the Contract for the executed quantities. For the purpose of variation for quantity of items of all types of cement given in Schedule 'B' shall be considered as on item.

	b) In case the Variation in individual items (except for items under Para c), below) as stipulated above: is more than 50% on plus side, the rate for the varied quantity beyond 50% shall be negotiated between the Engineer and the Contractor and mutually agreed rates arrived at before execution of the extra quantity. **c)** Variation in the quantity of items individually costing upto 1% of Accepted Contract Amount (i.e. total of Schedule 'A' and Schedule 'B' and Schedule 'C') or Rs. 1 crore, whichever is less, shall be payable at the accepted rates of the Contract, till the value of such individual item on account of Variation reaches upto 2% of the Accepted Contract Amount or Rs. 2 crore, whichever is less. Negotiation of rates for such items shall be conducted only for the exceeded quantity beyond 2% of the Accepted Contract Amount or Rs. 2 crore, whichever is less. **d) Deriving Rates for New Items / Negotiation** In case Engineer introduces an item for which the Contract does not contain any rates or prices applicable to the varied Works, the rate of such items shall be derived, wherever possible, from rate for similar items available in the Price Schedules of the Accepted Contract Amount. In case this is not possible, the rate shall be decided on the following basis: i. Cost of Materials at current market price, as actually utilized in the final finished Permanent Works, including a reasonable percentage for wastage and transportation. ii. Cost of enabling works if any (unless provided for separately) worked out on the above basis but with less stringent quality. Specifications minus salvage value of serviceable material released after completion of Work and cost of material released as scrap. iii. Cost of labour actually used at the site of Work at rates under Payment of Minimum Wages Act for the area of Work for each category of worker, further enhanced by a percentage of 10% of the aforesaid rates to account for labour not directly utilized at Site and other ancillary and incidental expenses on labour.

iv. Hire charges for Plant & Machinery, scaffolding, shuttering, forms, etc., required to be used at the site of the work. The tools used by the various trades shall not be counted as Plant & Machinery for this purpose.

v. An amount of 15% of items d) (i), (ii), (iii) and (iv) above to allow for Contractor's overheads including water/electricity charges and labour cess etc., profits and corporate taxes etc. No such percentage shall be applicable to the estimated cost of Materials supplied free of cost to the Contractor.

vi. In all cases where extra items of Work are involved, for which there are no rates in the Accepted Contract Amount, the Contractor shall give a notice to the Engineer, of at least 7 days before the need for its execution arises.

(III) Price Schedule 'C' (containing only rates of items but without quantities) /:

a) At the accepted rates of the Contract for varied cost of Schedule 'C' upto INR 4 Cr. In case of Variation on minus side, Contract rates will be payable at the accepted rates of the Contract for the executed quantities.

b) In case the varied cost of Schedule 'C' is more than INR 4 Cr., the rates of individual items shall be negotiated between the Engineer and the Contractor and mutually agreed rates arrived at, before its execution.

B. Disagreement in Rates for New Items /

In the event of disagreement of rates of new items/negotiations in respect of items A (I) c) and A (II) d) above, the Engineer shall fix such rates of price as are, in his opinion appropriate and shall notify the Contractor accordingly, with a copy to the Employer. Until such time as rates or prices are agreed or fixed, the Engineer shall determine provisional rates or prices to enable on-account payments to the Contractor. Alternatively, in the event of disagreement, the Contractor shall have no claim to execute extra quantities/new items and the Engineer shall be free to get such additional quantities beyond 50% / new items executed through any other Agency. However, if the Engineer or the Employer so directs the Contractor shall be bound to carry out any such additional quantities beyond the limits stated

	above original quantities and/or new items and the disagreement or the difference regarding rates to be paid for the same shall be settled in the manner laid down under the conditions for the settlement of dispute.
Sub-Clause 13.4 Provisional Sums	The following is inserted as the penultimate paragraph: "The Provisional Sum shall be used to cover the Employer's share of the DAAB members' fees and expenses, in accordance with Clause 21. No prior instruction of the Engineer shall be required with respect to the work of the DAAB. The Contractor shall submit the DAAB members' invoices and satisfactory evidence of having paid 100% of such invoices as part of the substantiation of those Statements submitted under Sub-Clause 14.3.
Sub-Clause 13.6 Adjustments for Changes in Laws	The following paragraph is added at the end of the Sub-Clause: "Notwithstanding the foregoing, the Contractor shall not be entitled to an extension of time if the relevant delay has already been taken into account in the determination of a previous extension of time and such Cost shall not be separately paid if the same shall already have been taken into account in the indexing of any inputs to the Table of Adjustment Data in accordance with the provisions of Sub-Clause 13.7 [Adjustments for Changes in Cost]."
Sub-Clause 13.7 Adjustments for Changes in Cost	The following paragraph is added at the end of Sub-Clause 13.7 Price adjustment will also be applicable during the extended period of Time for Completion where such extension has been granted under Sub-Clause 8.5 [Extension of Time for Completion] or it is specifically mentioned that extension is with Price Adjustment.
Sub-Clause 14.2.1 Advance Payment Guarantee	**Replace the first para of Sub-Clause 14.2.1 with the following:** The Contractor shall obtain (at the Contractor's cost) an Advance Payment Guarantee or Security in amounts and currencies equal to the advance payment and shall submit it to the Employer with a copy to the Engineer. The Guarantee in accordance to the form attached to the Contract can be split up in four (4) Guarantees to be released on repayment. The Contractor shall submit the Advance Payment Guarantee in any of the following forms:

	(a) Unconditional and irrevocable Bank Guarantee from the specified banks in the form appearing in Section X [Contract Forms] as under: (i) a scheduled bank (excluding co-operative banks) in India, or (ii) a Foreign Bank having arrangement with a nationalized bank or scheduled banks (excluding co-operative banks) in India; (b) Banker's Cheque or Demand Draft drawn on a scheduled bank (excluding co-operative banks) or nationalized bank in India. The scheduled bank issuing the bank guarantee shall be on "Structure Financial Messaging System (SFMS)" platform. A separate advice of the bank guarantee shall invariably be sent by the issuing bank to Employer's Bank through SFMS at the address given below and only after receipt of the same by the Employer's Bank, the bank guarantee shall become operative and acceptable to the Employer. Further, the bank guarantees in original form along with a copy of "MT760COV (in case of bank guarantee message)/ MT767COV (in case of bank guarantee amendment message) Report" sent by the concerned issuing bank sealed in an envelope shall be submitted to the Employer. The Issuing Bank shall send the SFMS to: Beneficiary: Haryana Orbital Rail Corporation Limited Bank Name: Account No. IFSC Code: Note: All the instruments mentioned in (a) & (b) above should be in favour of Chief Project Manager, Haryana Rail Infrastructure Development Corporation Limited, Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram.

	Such Advance Payment guarantee shall remain effective until the Advance Payment has been repaid pursuant to provision of this Sub-Clause 14.2, but the amount thereof shall be progressively reduced by the amount repaid by the Contractor as indicated in the Interim Payment Certificate issued in accordance with this Clause 14.
Sub-Clause 14.2.3 Repayment of Advance Payment	**Replace the Sub-Clause 14.2.3 with the following:** **a.** The recovery of Advances shall commence when 30% of the Accepted Contract Amount of the Work has been paid and it will be completed by the time, 90% of the Accepted Contract Amount has been paid or the original completion date whichever is earlier. However, minimum recovery of advances shall be at the rate of 10% (ten percent) of on-account bill. **b.** The Contractor shall always have the option to have the recoveries commenced and/or completed earlier, and/or to have recoveries affected in installments of higher amount and also to repay part or whole of the Advance by direct payment rather than through on-account Bills. However, the recovery of Advances shall be limited to 30% of on-account bill. **c.** In case the Contract is terminated due to default of the Contractor or rescinded / foreclosed, due to any other reason, the Contractor shall return the unrecovered amount of all Advances within 15 days of issue of notice of termination / rescission / foreclosure of the Contract and if the Contractor fails to do so due to any reason whatsoever, then interest at rate equal to State Bank of India's Marginal Cost of fund based Lending Rate (MCLR) applicable for the tenure of 01 year prevailing on the date of issue of notice of termination / rescission / foreclosure plus 3% Penal Interest per annum shall be charged on the unrecovered amount of such Advances from 16th day onwards compounded quarterly till the same is returned by the Contractor. **Interest in case of Delay in repayment of Advances** Should there be delay in the progress and completion of Work, as a result of which it is not possible to recover the Advances and interest thereon, before the date of completion stipulated in the Contract, then the interest to be charged from the Contractor on the remaining portion of the Advances beyond the original completion date specified in the Contract, shall be equal to State Bank of India's Marginal Cost of fund based Lending Rate (MCLR) applicable for the tenure of 01 year prevailing on

	the original completion date specified in the Contract plus 3% Penal Interest per annum. **Advances to be used only for this work** The advances shall be used by the Contractor strictly for the purpose of the Contract, and for the purpose for which they are paid. Under no circumstances, shall the advances be diverted for other purposes. Any such diversion shall be construed as a breach of the Contract and the Contractor shall be asked to return the advance at once and pay interest at 15% per annum till the advance is recovered back from him. The Contractor shall return the advance and pay the interest in one go without demur. Employer retains the right for any other remedy prescribed for breach of Contract in this regard.
Sub-Clause 14.3 Application for Interim Payment	The following is inserted at the end of (vi) after: *[Agreement or Determination]*: "any reimbursement due to the Contractor under the Dispute Avoidance/ Adjudication Agreement. (Appendix General Conditions of Dispute Avoidance/ Adjudication Agreement)."
Sub-Clause 14.3 Application for Interim Payment	**Add the following at the end, below Sub paragraph '(x)'** (xi) an amount to be deducted for the payments demanded by relevant competent authorities of the Central Government and/or State Government and/or local bodies from the Employer as due payments/ liability of the Contractor as mandated by relevant laws. (xii)Stage Completion/Milestone Certificate issued by the Engineer.
Sub-Clause 14.6.1 The IPC	**Replace the Sub-Clause 14.6.1 with the following:** The Engineer shall, within 07 days after receiving a Statement and supporting documents, issue an IPC to the Employer, with a copy to the Contractor: (a) stating the amount which the Engineer fairly considers to be due; and (b) including any additions and/or deductions which have become due under Sub-Clause 3.7 [Agreement or Determination] or under the Contract or otherwise, with detailed supporting particulars (which shall identify any difference between a certified amount and the corresponding amount in the Statement and give the reasons for such difference).

Sub-Clause 14.6.2 Withholding (amounts in) an IPC	"and/or" from subparagraph (b) is deleted. The following is then added as subparagraph (c) and sub-paragraph (c) of the Sub-Clause is renumbered as (d): "(c) if the Contractor was, or is, failing to perform any ESHS obligations or work under the Contract, the value of this work or obligation, as determined by the Engineer, may be withheld until the work or obligation has been performed, and/or the cost of rectification or replacement, as determined by the Engineer, may be withheld until rectification or replacement has been completed. Failure to perform includes, but is not limited to the following: (i) failure to comply with any ESHS obligations or work described in the Works' Requirements which may include: working outside site boundaries, excessive dust, damage to offsite vegetation, pollution of water courses from oils or sedimentation, contamination of land e.g. from oils, human waste, damage to archaeology or cultural heritage features, air pollution as a result of unauthorized and/or inefficient combustion; (ii) failure to regularly review C-ESMP and/or update it in a timely manner to address emerging ESHS issues, or anticipated risks or impacts; (iii) failure to implement the C-ESMP e.g. failure to provide required training or sensitization; (iv) failing to have appropriate consents/permits prior to undertaking Works or related activities; (v) failure to submit ESHS report/s (as described in general specifications, or failure to submit such reports in a timely manner; (vi) failure to implement remediation as instructed by the Engineer within the specified timeframe (e.g. remediation addressing non-compliance/s)."
Sub-Clause 14.7 Payment	At the end of sub-paragraph (b): "and" is replaced with "or" and the following inserted as (iii):

	"(iii) at a time when the Bank's loan (from which part of the payments to the Contractor is being made) is suspended, the amount shown on any statement submitted by the Contractor within 14 days after such statement is submitted, any discrepancy being rectified in the next payment to the Contractor; and" At the end of sub-paragraph (c): "." is replaced with ";" and the following inserted: "or, at a time when the Bank's loan (from which part of the payments to the Contractor is being made) is suspended the undisputed amount shown in the Final Statement within 56 days after the date of notification of the suspension in accordance with Sub-Clause 16.2 [Termination by Contractor]."

Sub-Clause 14.7 Payment	After the sub-paragraphs (c), add (d) with the following: (d) Provisional amount against the Statement specified in Sub-Clause 14.3: i) The Employer shall pay 80% of such amount as provisional payment within 7 days from the receipt of evaluated statement from the Engineer. The balance 20% shall be paid within 28 days from the receipt of evaluated statement from the Engineer. Next 80% amount of provisional payment shall be made only after 100% payment of preceding interim payment certified has been completed. ii) It shall be the responsibility of the Contractor to claim an amount for the performed services as admissible as per the Contract. If at any time it is observed by the Engineer that the amount claimed in the Statement are higher than the actual admissible performance, the facility of provisional payment will be withheld until such time the excess payment paid is adjusted in the subsequent Interim Payment Certificate. In such a case, warning letter will be issued to the Contractor. iii) If at any time, the Engineer/Employer observes for the second time that the amount claimed in the Statement are higher than the actual admissible performance, the facility of provisional payment will be liable to be withdrawn. *(*e) Payment of GST: The Contractor is responsible for paying all the taxes [including Goods and Service Tax (GST)], duties, cess, etc. as per the Statutory requirements. However, GST levied on the invoices raised by the Contractor will be temporarily withheld at the time of making payment for the invoice. GST withheld will be released by HRIDC/ HORCL on submission of proof, i.e. copy of Form GSTR-1 (reflecting the particular invoice) after due verification from the GST portal by the Employer.

Sub-Clause 14.9 **Release of Retention Money**	The following is added at the end of Sub-Clause 14.9: "Unless otherwise stated in the Contract, when the Taking-Over Certificate has been issued for the Works and the first half of the Retention Money has been certified for payment by the Engineer, the Contractor shall be entitled to substitute a guarantee, in the form annexed to the Particular Conditions of Contract or in another form approved by the Employer for the second half of the Retention Money. The Contractor shall submit unconditional and irrevocable Bank Guarantee from the specified banks in the form appearing in Section X [Contract Forms] as under: (i) a scheduled bank (excluding co-operative banks) in India, or (ii) a Foreign Bank having arrangement with a nationalized bank or scheduled banks (excluding co-operative banks) in India; The scheduled bank issuing the bank guarantee shall be on "Structure Financial Messaging System (SFMS)" platform. A separate advice of the bank guarantee shall invariably be sent by the issuing bank to Employer's Bank through SFMS at the address given below and only after receipt of the same by the Employer's Bank, the bank guarantee shall become operative and acceptable to the Employer. Further, the bank guarantees in original form along with a copy of "MT760COV (in case of bank guarantee message)/ MT767COV (in case of bank guarantee amendment message) Report" sent by the concerned issuing bank sealed in an envelope shall be submitted to the Employer. The Issuing Bank shall send the SFMS to: Beneficiary: Haryana Orbital Rail Corporation Limited Bank Name: Account No. IFSC Code: Note: Bank Guarantee should be in favour of Chief Project Manager, Haryana Rail Infrastructure Development

	Corporation Limited, Plot No 143, 5th Floor, Railtel Tower, Sector-44, Gurugram. The Contractor shall ensure that the guarantee is in the amounts and currencies of the second half of the Retention Money and is valid and enforceable until the Contractor has executed and completed the Works and remedied any defects, as specified for the Performance Security in Sub-Clause 4.2. On receipt by the Employer of the required guarantee, the Engineer shall certify, and the Employer shall pay the second half of the Retention Money. The release of the second half of the Retention Money against a guarantee shall then be in lieu of the release after the latest of the expiry dates of the Defects Notification Periods. The Employer shall return the guarantee to the Contractor within 21 days after receiving a copy of the Performance Certificate. If the Performance Security required under Sub-Clause 4.2 is in the form of a demand guarantee, and the amount guaranteed under it when the Taking-Over Certificate is issued is more than half of the Retention Money, then the Retention Money guarantee will not be required. If the amount guaranteed under the Performance Security when the Taking-Over Certificate is issued is less than half of the Retention Money, the Retention Money guarantee will only be required for the difference between half of the Retention Money and the amount guaranteed under the Performance Security."
Sub-Clause 14.12 Discharge	On the seventh line of the first paragraph, "Sub-Clause 21.6 [*Arbitration]*" is replaced with: "Clause 21 *[Disputes and Arbitration]'.*
Sub-Clause 14.15 Currencies of Payment	Throughout Sub-Clause 14.15, "Contract Data" is replaced with: "Schedule of Payment Currencies".
Sub-Clause 15.1 Notice to Correct	"and" is deleted from (b) and "." is replaced by: "; and" in (c). The following is then added as (d) "(d) specify the time within which the Contractor shall respond to the Notice to Correct." In the third para., "shall immediately respond" is replaced with: "shall respond within the time specified in (d)". Further, in the

	third para., "to comply with the time specified in the Notice to Correct." is replaced with: "to comply with the time specified in (c)."
Sub-Clause 15.2.1 Notice	Sub-paragraph (h) is replaced with: "based on reasonable evidence, has engaged in Prohibited Practice as defined in paragraph 2 of the Particular Conditions - Part C –Prohibited Practices, in competing for or in executing the Contract."
Sub-Clause 15.8 Part(s) termination of the Contract	Add New Sub-Clause 15.8 "**Part(s) termination of the Contract**" after Sub-Clause 15.7; **For Part(s) termination of the Contract** If the Contractor fails to demonstrate to the satisfaction of Engineer that they will be able to achieve a specified Key Date(s)/Date of Completion/ remedying any notified defect under the contract, the Engineer may give the Contractor a notice to correct under Sub-Clause 15.1 in writing to expedite such identified work(s) immediately, so as to achieve the Key Date(s)/Date of Completion/ remedying any notified defect under the contract. If the Contractor fails to comply with such notice, the Employer, in his sole discretion, shall be entitled to carry out such identified part of works (Maximum upto 10% original Accepted Contract Amount) under Sub Clause 13.1 (Right to vary) as is necessary to achieve the key Date(s)/Date of completion by his own workmen or by other contractors without prejudice to any other right or remedy(ies). Engineer shall proceed in accordance with Sub clause 3.7.2 (Engineer's Determination) the value of the part work(s) decided to be part terminated. The Engineer shall as soon as practicable after taking such decision, notify the Contractor thereof in writing of the value of the identified Works for the encashment of Performance Security as specified in Sub clause 15.4
Sub-Clause 15.9 Prohibited Practices	Add New Sub-Clause 15.9 "Prohibited Practices" after Sub-Clause 15.8; " 15.9.1 The Bank requires compliance with the Bank's Policy on Prohibited Practices as set forth in Particular Conditions - Part C- Prohibited Practices.

	15.9.2 The Employer requires the Contractor to disclose any commissions or fees that may have been paid or are to be paid to agents or any other party with respect to the tendering process or execution of the Contract. The information disclosed must include at least the name and address of the agent or other party, the amount and currency, and the purpose of the commission, gratuity or fee."
Sub-Clause 16.1 Suspension by Contractor	The following paragraph is inserted after the first paragraph: "Notwithstanding the above, if the Bank has suspended disbursements under the loan from which payments to the Contractor are being made, in whole or in part, for the execution of the Works, and no alternative funds are available as provided for in Sub-Clause 2.4 [Employer's Financial Arrangements], the Contractor may by notice suspend work or reduce the rate of work at any time, but not less than 7 days after the Recipient having received the suspension notification from the Bank."
Sub-Clause 16.2.1 Notice	Sub-paragraph (j) is deleted in its entirety. At the end of sub-paragraph (i): "; or" is replaced with: "." sub-paragraph (f) is replaced with: "(f) the Contractor does not receive a Notice of the Commencement Date under Sub-Clause 8.1 [*Commencement of Works*] within 180 days after receiving the Letter of Acceptance, for reasons not attributable to the Contractor."
Sub-Clause 16.2.2 Termination	The following is added at the end of Sub-Clause 16.2.2: "In the event the Bank suspends the loan from which part or whole of the payments to the Contractor are being made, if the Contractor has not received the sums due to him upon expiration of the 14 days referred to in Sub-Clause 14.7 [Payment] for payments under Interim Payment Certificates, the Contractor may, without prejudice to the Contractor's entitlement to financing charges under Sub-Clause 14.8 [Delayed Payment], take one of the following actions, namely (i) suspend work or reduce the rate of work under Sub-Clause 16.1 above, or (ii) terminate the Contract by giving notice to the Employer, with a copy to the Engineer, such termination to take effect 14 days after the giving of the notice."

Sub-Clause 17.1 Responsibility for Care of the Works	On the fourth and fifth lines of the first paragraph, replace "Date of Completion of the Works" with "issue of the Taking-Over Certificate for the Works".
Sub-Clause 17.3 Intellectual and Industrial Property Rights	On the first line of the second paragraph, replace "notice" is replaced with "a Notice".
Sub-Clause 17.4 Indemnities by the Contractor	Replace the sub-paragraph 17.4(b) (i) of Sub-Clause 17.4 with the following: (i) arises out of or in the course of or by reason of the design, execution, completion and the remedying of any defects of the Works, and
Sub-Clause 17.7 Use of Employer's Accommodation/Facilities	The following Sub-Clause is added as 17.7: "The Contractor shall take full responsibility for the care of the Employer-provided accommodation and facilities, if any, as detailed in the Employer's Requirements, from the respective dates of hand-over to the Contractor until cessation of occupation (where hand-over or cessation of occupation may take place after the date stated in the Taking-Over Certificate for the Works) If any loss or damage happens to any of the above items while the Contractor is responsible for their care arising from any cause whatsoever other than those for which the Employer is liable, the Contractor shall, at its own cost, rectify the loss or damage to the satisfaction of the Engineer."
Sub-Clause 18.1 **Exceptional Events**	Sub-paragraph (c) is substituted with: "(c) riot, commotion, disorder or sabotage by persons other than the Contractor's Personnel and other employees of the Contractor and Subcontractors;"
Sub-Clause 18.4 Consequences of an Exceptional Event	The following is added at the end of sub-paragraph (b) after deleting the ".": ", including the costs of rectifying or replacing the Works and/or Goods damaged or destroyed by Exceptional Events, to the extent they are not indemnified through the insurance policy referred to in Sub-Clause 19.2 [Insurance to be provided by the Contractor]."
Sub-Clause 18.5 Optional Termination	In sub-paragraph (c), "and necessarily" is inserted after ""was reasonably".

Sub-Clause 19.1 **General Requirements**	The following paragraphs are added after the first: "Wherever the Employer is the insuring Party, each insurance shall be effected with insurers and in terms acceptable to the Contractor. These terms shall be consistent with terms (if any) agreed by both Parties before the date of the Letter of Acceptance. This agreement of terms shall take precedence over the provisions of this Clause."
Sub-Clause 19.2 **Insurance to be provided by the Contractor**	The following is inserted as the first sentence in Sub-Clause 19.2: "The Contractor shall be entitled to place all insurances relating to the Contract (including, but not limited to the insurance referred to Clause 19) with insurers from any eligible source country through an insurance provider that is authorized to provide such insurance coverage in India. The Contractor shall submit all evidence(s) of insurances and policies within the period stated in the Contract Data."
Sub-Clause 19.2.1 **The Works**	On the last line of the second paragraph, "Clause 12 *[Tests after completion]*" is deleted.
Sub-Clause 19.2.5 **Injury to employees**	The second paragraph is replaced with: "The Employer and the Engineer shall also be indemnified under the policy of insurance, against liability for claims, damages, losses and expenses (including legal fees and expenses) arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel, except that this insurance may exclude losses and claims to the extent that they arise from any act or neglect of the Employer or of the Employer's Personnel."
Sub-Clause 20.1 **Claims**	In a): "any additional payment" is replaced with "payment".
Sub-Clause 20.2 **Claims for Payment and/or EOT**	The first paragraph is replaced with: "If either Party considers that it is entitled to claim under 20.1 (a) or (b), the following claim procedure shall apply:"

Sub-Clause 21.1 **Constitution of the DAAB**	Replace the entire first paragraph of Sub-Clause 21.1 with the following: Dispute shall be referred to a DAAB for decision in accordance with Sub-Clause 21.4 [Obtaining DAAB's Decision]. The Parties shall appoint a DAAB by the date stated in the Contract Data. The date may be changed if both the Parties agree, in writing, to change the date, up to one hundred eighty (180) days after the Commencement Date. In the second paragraph, at the end of the first sentence after deleting: ".", the following is added: ", each of whom shall meet the criteria set forth in Sub-Clause 3.3 of Appendix- General Conditions of Dispute Avoidance/ Adjudication Agreement." After the second paragraph insert the following paragraph: "If the Contract is with a foreign Contractor, the DAAB members shall not have the same nationality as the Employer or the Contractor."
Sub-Clause 21.2 **Failure to Appoint DAAB Member(s)**	For both (a) and (b): "by the date stated in the first paragraph of Sub-Clause 21.1 [*Constitution of the DAAB*]" is replaced with: "within 42 days from the date the Contract is signed by both Parties"

Sub-Clause 21.6 Arbitration	**This clause stands amended and restated in its entirety as follows:** **21.6.1 Disputes shall be settled by arbitration in accordance with the following provisions:** **(A) In case of the Contractor or the Lead member of the Contractor (in the case of a Joint Venture or Consortium) being of foreign origin** If the efforts to resolve all or any of the disputes through amicable settlement fails, then such disputes or differences, whatsoever arising between the parties, arising out of the Contract or relating to effect of the Contract or the breach thereof shall be referred to Arbitration in accordance with the following provisions: **1. Selection of Arbitrators** -Each dispute submitted by a Party to arbitration shall be heard by a sole arbitrator or an arbitration panel comprising three (3) arbitrators, in accordance with the following provisions: (a) Where the Parties agree that the dispute concerns a technical matter, they may agree to appoint a sole arbitrator or, failing agreement on the identity of such sole arbitrator within thirty (30) days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, either Party may apply to Singapore International Arbitration Centre (SIAC) for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the sole arbitrator for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) days of the date of receipt of the list by the Parties, SIAC shall appoint, upon the request of either Party and from such list or otherwise, a sole arbitrator for the matter in dispute. (b) Where the Parties do not agree that the dispute concerns a technical matter, the Client and the Contractor shall each appoint one (1) arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the arbitrators named by the Parties do not succeed in appointing a third arbitrator within thirty (30) days after the latter of the two (2) arbitrators named by the

	Parties has been appointed, the third arbitrator shall, at the request of either Party, be appointed by SIAC. (c) If, in a dispute subject to paragraph (b) above, one Party fails to appoint its arbitrator within thirty (30) days after the other Party has appointed its arbitrator, the Party which has named an arbitrator may apply to the SIAC to appoint a sole arbitrator for the matter in dispute, and the arbitrator appointed pursuant to such application shall be the sole arbitrator for that dispute. **2. Rules of Procedure** - Except as otherwise stated herein, arbitration proceedings shall be conducted in accordance with the rules of procedure for arbitration of the United Nations Commission on International Trade Law (UNCITRAL) as in force on the date of this Contract. **3. Substitute Arbitrators** -If for any reason an arbitrator is unable to perform his/her function, a substitute shall be appointed in the same manner as the original arbitrator. **4. Nationality and Qualifications of Arbitrators -** The sole arbitrator or the third arbitrator appointed pursuant to paragraphs 1(a) through 1(c) above shall be an internationally recognized legal or technical expert with extensive experience in relation to the matter in dispute and shall not be a national of the Contractor's home country or of the home country of any of their members or Parties or of the Government's country. For the purposes of this Clause, "home country" means any of: (a) the country of incorporation of the Contractor or of any of their members or Parties; or (b) the country in which the Contractor's or any of their members' or Parties' principal place of business is located; or (c) the country of nationality of a majority of the Contractor's or of any members' or Parties' shareholders; or (d) the country of nationality of the Sub-Contractor concerned, where the dispute involves a subcontract.

	5. Miscellaneous - In any arbitration proceeding hereunder: (a) proceedings shall, unless otherwise agreed by the Parties, be held at Gurugram, India or such place as mutually agreed by both parties. The cost of Arbitration including the fees of the Arbitrator shall be borne equally by both the parties. (b) the English language shall be the official language for all purposes; and (c) the decision of the sole arbitrator or of a majority of the arbitrators (or of the third arbitrator if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement. **(B) In case of the Contractor or the Lead member of the Contractor (in the case of a Joint Venture or Consortium) being of Indian origin** If the efforts to resolve all or any of the disputes through amicable settlement fail, then such disputes or differences, whatsoever arising between the parties, arising out of the Contract or relating to effect of the Contract or the breach thereof shall be referred to Arbitration in accordance with the following provisions: (a) The Arbitration proceedings shall be assumed to have commenced from the day, a written and valid demand for arbitration is received by Managing Director of the Employer (MD/HRIDC). (b) The disputes so referred to arbitration shall be settled in accordance with the Indian Arbitration & Conciliation Act, 1996 and amended by the Arbitration and Conciliation (Amendment) Act, 2015 and any statutory modification or re-enactment thereof. Further, it is agreed between the parties as under: Number of Arbitrators - The Arbitral tribunal shall consist of: *3 (three) arbitrators* **1. Procedure for Appointment of Arbitrators** The arbitrators shall be appointed as per following procedure:

	a) Within 30 days from the day when a written and valid demand for Arbitration is received by MD/HRIDC, the Employer will forward a panel of not fewer than five (05) nominees to the Contractor. The Contractor will then give his consent for any one name out of the panel to be appointed as one of the arbitrators within 30 days of dispatch of the request by the Employer. b) The Employer will decide the second Arbitrator. MD/HRIDC shall appoint the two Arbitrators, including the name of one Arbitrator for whom consent was given by the Contractor, within 30 days from the receipt of the consent for one name of the Arbitrator from the Contractor. In case ~~the~~ Contractor fails to give his consent within 30 days of the request of the Employer, MD/HRIDC shall nominate both the Arbitrators from the panel. The third Arbitrator shall be chosen by the two Arbitrators so appointed by the parties out of the panel of Arbitrators provided to Contractor or from the larger panel of Arbitrators to be provided to them by the Employer at the request of two appointed Arbitrators (if so desired by them) and who shall act as presiding Arbitrator. In case of failure of the two appointed Arbitrators to reach upon consensus within a period of 30 days from their appointment, then, upon the request of either or both parties, the presiding Arbitrator shall be appointed by the MD/HRIDC within 14 days of receipt of request from either party or both parties. c) If one or more of the Arbitrators appointed as above refuses to act as Arbitrator, withdraws from his office as Arbitrator, or vacates his/their office/offices or is/are unable or unwilling to perform his functions as Arbitrator for any reason whatsoever or dies or in the opinion of the MD/HRIDC fails to act without undue delay, the MD/HRIDC shall appoint new Arbitrator/Arbitrators to act in his/their place except in case of new presiding Arbitrator who shall be chosen following the same procedure as mentioned in para (b) above. Such reconstituted Tribunal may, at its discretion, proceed with the reference from the stage at which it was left by the previous Arbitrator(s). d) The Employer at the time of offering the panel of Arbitrator(s) to be appointed as Arbitrator shall also supply the information with regard to the qualifications of the said Arbitrators nominated in the panel along with their professional experience, phone nos. and addresses to the Contractor. The

	minimum qualification and experience of the arbitrators which may be appointed by the Parties in accordance with the contract is set out below: (i) A working/retired officer (not below E-8 grade in a central public sector undertaking in India, with which the Employer has no direct business relationship), of engineering or accounts/finance discipline, having experience in management of construction contracts; or (ii) A retired officer (not below the SAG level in Indian Railways) of any Engineering Services of Indian Railways or Indian Railway Accounts Service, having experience in management of construction contracts; **2. Miscellaneous:** In any arbitration proceeding hereunder: (a) The language of arbitration shall be English. This arbitration shall be governed in accordance with the laws of India. (b) The venue of the arbitration shall be Gurugram, India. The cost of Arbitration including the fees of the Arbitrator shall be borne equally by both the parties. (c) The decision of the sole arbitrator or of a majority of the arbitrators (or of the third arbitrator if there is no such majority) shall be final and binding and shall be enforceable in High court at Chandigarh, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement. 21.6.2 In the event that the Contractor wishes to refer a dispute to arbitration in accordance with this Sub-Clause, it shall be required to serve a notice in this regard to the Managing Director, of the Employer for commencement of arbitration. 21.6.3 Pending the submission of and/or decision on a dispute and until the arbitral award is published, the Parties shall continue to perform their respective obligations under the contract without prejudice to a final adjustment in accordance with such award. 21.6.4 The arbitrators shall have full power to open up, review and revise any certificate, determination, instruction, opinion or valuation of the Engineer, and any decision of the DB, relevant to the dispute. Nothing shall disqualify representatives of the Parties and the Engineer from being called as a witness and giving evidence before the arbitrators on any matter whatsoever

	relevant to the dispute. However, Conciliator cannot be present as a witness by either party in the arbitral proceedings. 21.6.5 Neither Party shall be limited in the proceedings before the arbitrators to the evidence or arguments previously put before the DB to obtain its decision, or to the reasons for dissatisfaction given in its Notice of Dissatisfaction. 21.6.6 Neither party shall be limited in the proceedings before such arbitrators to the evidence or arguments put before the Engineer to obtain his decision. No decision given by the Engineer in accordance with the contract shall disqualify him from being called as a witness and giving evidence before the arbitrators on any matter, whatsoever, relevant to dispute referred to arbitration. 21.6.7 Arbitration may be commenced prior to or after completion of the Works. The obligations of the Parties, the Engineer and the DB shall not be altered by reason of any arbitration being conducted during the progress of the Works.

Appendix- General Conditions of Dispute Avoidance/Adjudication Agreement

Title	"General Conditions of Dispute Avoidance/Adjudication Agreement" is replaced with "General Conditions of DAAB Agreement".
1. Definitions	Sub-Clause 1.2: In both the first and third lines, "DAA Agreement" is replaced with "DAAB Agreement". Sub-Clause 1.3: -In the first line, "Dispute Avoidance/Adjudication Agreement" or "DAA Agreement" means" is replaced with: "DAAB Agreement" is as defined under the Contract and is". - In the first line of sub-paragraph (c), "DAA Agreement" is replaced with "DAAB Agreement". - In sub-paragraph (c)(ii), "chairman" is replaced with "chairperson". Sub-Clause 1.3 "DAAB Activities" is replaced with Sub-Clause 1.4 "DAAB Activities" and the subsequent Sub-Clauses under Clause 1 "Definitions" renumbered: Sub-Clause 1.7 to 12: Replace all instances of "DAA Agreement" with "DAAB Agreement". In Sub-Clause 1.8 a(i):" authorised representative of the contractor or of the Employer" is replaced with: "Contractor's Representative or authorised representative of the Employer".
3. Warranties	Sub-Clause 3.3 is deleted and replaced with the following: "When appointing the DAAB Member, each Party relies on the DAAB Member's representations, that he/she; a) has at least a bachelor's degree in relevant disciplines such as law, engineering, construction management or contract management; b) has at least ten years of experience in contract administration/management and dispute resolution, out of which at least five years of experience as an

arbitrator or adjudicator in construction-related disputes;

c) has received formal training as an adjudicator from an internationally recognized organization;

d) has experience and/or is knowledgeable in the type of work which the Contractor is to carry out under the Contract;

e) has experience in the interpretation of construction and/or engineering contract documents;

f) has familiarity with the forms of contract published by FIDIC since 1999, and an understanding of the dispute resolution procedures contained therein; and

g) is fluent in the language for communications stated in the Contract Data (or the language as agreed between the Parties and the DAAB)."

7. Confidentiality	In Sub-Clause 7.3: "or" is deleted after sub-paragraph (b), and the following added: "or (d) is being provided to the Bank."
9. Fees and Expenses	In Sub-Clause 9.1 (c): "business class or equivalent" is replaced with: "in less than first class". In Sub-Clause 9.4: "and air fares" and "other" are deleted from the first and second sentences respectively.
10. Resignation and Termination	In Sub-Clause 10.3: "the DAA Agreement" is replaced with: "a DAAB member's DAAB Agreement".

Annex- DAAB Procedural Rules

Rule 4.2 On the fourth line, "chairman" is replaced with "chairperson".

Rule 8.3 On the sixth line, "chairman" is replaced with "chairperson".

Form of Dispute Avoidance/Adjudication Agreement

All instances of "DAA Agreement" are replaced with: "DAAB Agreement".

In C (b): "chairman" is replaced with "chairperson".

Particular Conditions of Contract (PCC)

Part C – Prohibited Practices

1. The Bank requires that the Recipient (and all other beneficiaries of the Bank financing), as well as tenderers, suppliers, contractors, concessionaires and consultants under Bank-financed contracts for the Project, observe the highest standard of transparency and integrity during the procurement, execution and implementation of such contracts.

2. Definitions. In pursuance of this policy, the Bank defines the terms set forth below as Prohibited Practices:

   (a) "**coercive practice**" means impairing or harming, or threatening to impair or harm, directly or indirectly, any party or the property of a party to influence improperly the actions of a party;
   (b) "**collusive practice**" means an arrangement between two or more parties designed to achieve an improper purpose, including to influence improperly the actions of another party;
   (c) "**corrupt practice**" means the offering, giving, receiving or soliciting, directly or indirectly, of anything of value to influence improperly the actions of another party;
   (d) "**fraudulent practice**" means any act or omission, including a misrepresentation, that knowingly or recklessly misleads, or attempts to mislead, a party to obtain a financial or other benefit or to avoid an obligation.
   (e) "**misuse of resources**" means improper use of the Bank's resources, carried out either intentionally or through reckless disregard;
   (f) "**obstructive practice**" means any of the following practices: (i) deliberately destroying, falsifying, altering or concealing of evidence material to a Bank investigation; (ii) making false statements to investigators in order to materially impede a Bank investigation into allegations of a Prohibited Practice; (iii) failing to comply with requests to provide information, documents or records in connection with a Bank investigation; (iv) threatening, harassing or intimidating any party to prevent it from disclosing its knowledge of matters relevant to a Bank investigation or from pursuing the investigation; or (v) materially impeding the exercise of the Bank's contractual rights of audit or inspection or access to information; and
   (g) "**theft**" means the misappropriation of property belonging to another party.

3. Any occurrence, or suspected occurrence, of a Prohibited Practice in the procurement, award, or implementation of a Bank-financed contract is dealt with in accordance with the provisions of the Bank's Policy on Prohibited Practices. Suppliers, contractors, service providers and consultants selected pursuant to the provisions of Section II and concessionaires selected pursuant to paragraph 14.3 of the Bank's Procurement Instructions for Recipients, as well as the Recipient shall fully cooperate with the Bank (or a cofinancier undertaking an investigation

pursuant to paragraph 6.1 of the Bank's Procurement Instructions for Recipients) in any investigation into an alleged Prohibited Practice to be carried out pursuant to the Policy on Prohibited Practices, and permit the Bank or its representative (including such co-financier) to inspect such of their accounts and records as may be relevant for such investigation and to have such records and accounts audited by the auditors appointed by the Bank.

4. Provisions to this effect are included in the Legal Agreements and the procurement contracts with such entities.

5. If the Project is financed by a sovereign-backed loan, the Bank (or, where relevant, a co-financier having undertaken an investigation pursuant to paragraph 6.1 of the Bank's Procurement Instructions for Recipients):

   (a) may take any of the following additional actions in connection with a Prohibited Practice under the Project:

      (i) reject a proposal for award if it determines that the tenderer recommended for award, or any of its personnel, or its agents, or its sub-consultants, subcontractors, service providers, suppliers or their employees, has, directly or indirectly, engaged in a prohibited practice in competing for the contract in question; and

      (ii) cancel the undisbursed portion of the loan allocated to a contract (and require reimbursement of the disbursed portion of the loan allocated to the contract) if it determines at any time that representatives of the Recipient or of a recipient of any part of the proceeds of the loan engaged in a prohibited practice during the procurement, administration or implementation of the contract in question; and

   (b) requires that a clause be included in tender documents and in contracts financed by the Bank loan, requiring tenderers, suppliers and contractors, and their subcontractors, agents, personnel, consultants, service providers, or suppliers, to permit the Bank (and a co-financier undertaking an investigation pursuant to paragraph 6.1 of the Bank's Procurement Instructions for Recipients) to inspect all accounts, records, and other documents relating to the submission of tenders and contract performance, and to have them audited by auditors appointed by the Bank.

Section X - Contract Forms

Table of Forms

Notification of Intention to Award

[*This Notification of Intention to Award shall be sent to each Tenderer that submitted a Tender.*]

[*Send this Notification to the Tenderer's Authorized Representative named in the Tenderer Information Form*]

For the attention of Tenderer's Authorized Representative

Name: *[insert Authorized Representative's name]*

Address: *[insert Authorized Representative's Address]*

Telephone/Fax numbers: *[insert Authorized Representative's telephone/fax numbers]*

Email Address: *[insert Authorized Representative's email address]*

[IMPORTANT: insert below the date that this Notification is transmitted to Tenderers. The Notification must be sent to all Tenderers simultaneously. This means on the same date and as close to the same time as possible.]

DATE OF TRANSMISSION: This Notification is sent by: [*email/fax*] on [*date*] (local time)

Notification of Intention to Award

Employer: *[insert the name of the Employer]*
Project: *[insert name of project]*
Country: *[insert country where Tender is issued]*
Loan No.: *[insert reference number for loan]*
Tender No: *[insert Tender reference number from Procurement Plan]*
Contract Title: *[insert the name of the contract]*

This Notification of Intention to Award (Notification) notifies you of our decision to award the above contract. The transmission of this Notification begins the Standstill Period. During the Standstill Period you may:

a) request a debriefing in relation to the evaluation of your Tender, and/or

b) submit a Procurement-related Complaint in relation to the decision to award the contract.

1. The successful Tenderer

Name:	[*insert name of successful Tenderer*]
Address:	[*insert address of the successful Tenderer*]
Contract Price:	[*insert contract price of the successful Tender*]

2. List of all Tenderers *[INSTRUCTIONS: insert names of all Tenderers that submitted a Tender including the successful Tenderer, together with the corresponding Tender price*

as read out at tender opening and the evaluated Tender price (when rated criteria are not used).]

Name of Tenderer	Tender Price	Evaluated Tender Price (if applicable)
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]

Or

List of all Tenderers ***[INSTRUCTIONS: insert names of all Tenderers that submitted a Tender including the successful Tenderer, together with the corresponding Tender price as read out at tender opening and the evaluated Tender price, respective technical and financial scores, combined technical and financial score (when rated criteria are used).]***

Name of Tenderer	Tender Price	Evaluated Tender Price	Technical Score	Financial Score	Combined Score
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]			
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]			
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]			
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]			
[*insert name*]	[*insert Tender price*]	[*insert evaluated price*]			

3. Reason/s why your Tender was unsuccessful

[INSTRUCTIONS: State the reason/s why <u>this</u> Tenderer's Tender was unsuccessful. Do NOT include: (a) a point by point comparison with another Tenderer's Tender, or (b) information that is marked confidential by the Tenderer in its Tender.]

4. How to request a debriefing

DEADLINE: The deadline to request a debriefing expires at midnight on [*insert date*] (local time).

You may request a debriefing in relation to the results of the evaluation of your Tender. If you decide to request a debriefing your written request must be made within three (3) Business Days of receipt of this Notification of Intention to Award.

Provide the contract name, reference number, name of the Tenderer, contact details; and address the request for debriefing as follows:

Attention: [*insert full name of person, if applicable*]

Title/position: [*insert title/position*]

Agency: [*insert name of Employer*]

Email address: [*insert email address*]

Fax number: [*insert fax number*] ***delete if not used***

If your request for a debriefing is received within the 3 Business Days deadline, we will provide the debriefing within five (5) Business Days of receipt of your request. If we are unable to provide the debriefing within this period, the Standstill Period shall be extended by five (5) Business Days after the date that the debriefing is provided. If this happens, we will notify you and confirm the date that the extended Standstill Period will end.

The debriefing may be in writing, by phone, video conference call or in person. We shall promptly advise you in writing how the debriefing will take place and confirm the date and time.

If the deadline to request a debriefing has expired, you may still request a debriefing. In this case, we will provide the debriefing as soon as practicable, and normally no later than fifteen (15) Business Days from the date of publication of the Contract Award Notice.

5. How to make a complaint

Period: Procurement-related Complaint challenging the decision to award shall be submitted by midnight, [*insert date*] (local time).

Provide the contract name, reference number, name of the Tenderer, contact details; and address the Procurement-related Complaint as follows:

Attention: [*insert full name of person, if applicable*]

Title/position: [*insert title/position*]

Agency: [*insert name of Employer*]

Email address: [*insert email address*]

Fax number: [*insert fax number*] ***delete if not used***

At this point in the procurement process, you may submit a Procurement-related Complaint challenging the decision to award the contract. You do not need to have requested, or received, a debriefing before making this complaint. Your complaint must be submitted within the Standstill Period and received by us before the Standstill Period ends.

For more information see the Procurement Instructions for Recipients (Annex IV, Complaint Monitoring).

6. Standstill Period

DEADLINE: The Standstill Period is due to end at midnight on [*insert date*] (local time).

The Standstill Period lasts ten (10) Business Days after the date of transmission of this Notification of Intention to Award.

The Standstill Period may be extended as stated in Section 4 above.

If you have any questions regarding this Notification, please do not hesitate to contact us.

For and on behalf of the Employer:

Signature: _____

Name: _____

Title/Position: _____

Telephone: _____

Email: _____

Beneficial Ownership Disclosure Form

INSTRUCTIONS TO TENDERERS: DELETE THIS BOX ONCE YOU HAVE COMPLETED THE FORM

This Beneficial Ownership Disclosure Form ("Form") is to be completed by the successful Tenderer. In case of joint venture, the Tenderer must submit a separate Form for each member. The beneficial ownership information to be submitted in this Form shall be current as of the date of its submission.

For the purposes of this Form, a Beneficial Owner of a Tenderer is any natural person who ultimately owns or controls the Tenderer by meeting one or more of the following conditions:

- *directly or indirectly holding 25% or more of the shares*
- *directly or indirectly holding 25% or more of the voting rights*
- *directly or indirectly having the right to appoint a majority of the board of directors or equivalent governing body of the Tenderer*

Tender No.: [*insert number of Tender process*]

To: **Haryana Rail Infrastructure Development Corporation Limited**

In response to your request in the Letter of Acceptance *dated [insert date of letter of Acceptance]* to furnish additional information on beneficial ownership: *[select one option as applicable and delete the options that are not applicable]*

(i) we hereby provide the following beneficial ownership information.

Details of beneficial ownership

Identity of Beneficial Owner	Directly or indirectly holding 25% or more of the shares (Yes / No)	Directly or indirectly holding 25 % or more of the Voting Rights (Yes / No)	Directly or indirectly having the right to appoint a majority of the board of the directors or an equivalent governing body of the Tenderer (Yes / No)
[include full name (last, middle, first), nationality, country of residence]			

OR

(ii) *We declare that there is no Beneficial Owner meeting one or more of the following conditions:*

- directly or indirectly holding 25% or more of the shares
- directly or indirectly holding 25% or more of the voting rights
- directly or indirectly having the right to appoint a majority of the board of directors or equivalent governing body of the Tenderer

OR

(iii) We declare that we are unable to identify any Beneficial Owner meeting one or more of the following conditions. [If this option is selected, the Tenderer shall provide explanation on why it is unable to identify any Beneficial Owner]

- directly or indirectly holding 25% or more of the shares
- directly or indirectly holding 25% or more of the voting rights
- directly or indirectly having the right to appoint a majority of the board of directors or equivalent governing body of the Tenderer]"

Name of the Tenderer: *[*insert complete name of the Tenderer*] _____

Name of the person duly authorized to sign the Tender on behalf of the Tenderer: **[*insert complete name of person duly authorized to sign the Tender*] _____

Title of the person signing the Tender: [*insert complete title of the person signing the Tender*] _____

Signature of the person named above: [*insert signature of person whose name and capacity are shown above*] _____

Date signed [*insert date of signing*] **day of** [*insert month*], [*insert year*]_____

* In the case of the Tender submitted by a Joint Venture specify the name of the Joint Venture as Tenderer. In the event that the Tenderer is a joint venture, each reference to "Tenderer" in the Beneficial Ownership Disclosure Form (including this Introduction thereto) shall be read to refer to the joint venture member.

** Person signing the Tender shall have the power of attorney given by the Tenderer. The power of attorney shall be attached with the Tender Schedules.

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Letter of Acceptance

[letterhead paper of the Employer]

[date]

To: *[name and address of the Contractor]*

This is to notify you that your Tender dated *[date]* for execution of the **"C-4:** Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00 "

for the Accepted Contract Amount *[amount in numbers and words] [name of currency]*, as corrected and modified in accordance with the Instructions to Tenderers, is hereby accepted by our Agency.

You are requested to furnish (i) the Performance Security within 28 days in accordance with the Conditions of Contract, using, for that purpose, the Performance Security Form; and (ii) the additional information on beneficial ownership in accordance with TDS ITT 48.1, within eight (8) Business days using the Beneficial Ownership Disclosure Form, included in Section X, Contract Forms, of the Tender Document.

Authorized Signature: _____

Name and Title of Signatory: _____

Name of Agency: _____

Attachment: Contract Agreement

Contract Agreement

THIS AGREEMENT made the _____ day of _____, _____, between _____of _____ *[insert complete name of Employer and full business address]* (hereinafter "the Employer"), of the one part, and _____ of _____ *[insert complete name and nationality of Contractor as well as full business address]* (hereinafter "the Contractor"), of the other part:

WHEREAS the Employer invited tenders for the execution of the Works, described as "C-4: Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;

(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;

(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;

(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00**"**

The Employer and the Contractor agree as follows:

1. In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Contract documents referred to.

2. The following documents shall be deemed to form and be read and construed as part of this Agreement. This Agreement shall prevail over all other Contract documents.

    (a) the Letter of Acceptance;

    (b) the Letter of Tender;-Financial Part;

    (c) the Letter of Tender-Technical Part;

    (d) the Record of Meeting on Contract Negotiation (if any);

    (e) the addenda Nos _____ (if any);

    (f) the Particular Conditions of Contract;

    (g) the General Conditions of Contract;

(h) the Employer's Requirements;

(i) the Drawings*;*

(j) the Contractor's Technical Proposal;

(k) the Reference Information/Reports, and

(l) the completed Schedules and any other documents forming part of the contract, including, but not limited to:

i. the ESHS Management Strategies and Implementation Plans; and

ii. Code of Conduct (ESHS)**.**

3. In consideration of the payments to be made by the Employer to the Contractor as specified in this Agreement, the Contractor hereby covenants with the Employer to execute the Works and to remedy defects therein in conformity in all respects with the provisions of the Contract.

4. The Employer hereby covenants to pay the Contractor in consideration of the execution and completion of the Works and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract.

IN WITNESS whereof the parties hereto have caused this Agreement to be executed in accordance with the laws of _____ *[insert the name of the Contract governing law country]* on the day, month and year specified above.

For and on behalf of the Employer

Signed: *[insert signature]*
in the capacity of *[insert title or other appropriate designation]*
In the presence of *[insert identification of official witness]*

For and on behalf of the Contractor

Signed: *[insert signature of authorized representative(s) of the Contractor]*
in the capacity of *[insert title or other appropriate designation]*
in the presence of *[insert identification of official witness]*

Performance Security

Demand Guarantee

[Guarantor letterhead or SWIFT identifier code]

Beneficiary:

Haryana Orbital Rail Corporation Limited,
Plot No 143, 5th Floor, Railtel Tower,
Sector-44, Gurugram,
Haryana-122003

Date: _____ *[Insert date of issue]*

PERFORMANCE GUARANTEE No.: _____

Guarantor: *[Insert name and address of place of issue, unless indicated in the letterhead]*

We have been informed that _____ (hereinafter called "the Applicant") has entered into Contract No. _____ *dated* _____ with the Beneficiary, for the execution of "**C-4**: Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;
(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;
(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;
(v) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00."

Furthermore, we understand that, according to the conditions of the Contract, a performance guarantee is required.

At the request of the Applicant, we as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of _____ (),[1] such sum being payable in the types and proportions of currencies in which the Contract Price is payable, upon receipt by us of the Beneficiary's complying demand supported by the Beneficiary's statement, whether in the demand itself or in a separate signed document accompanying or identifying the demand, stating that the Applicant is in breach of its obligation(s) under the Contract, without the Beneficiary needing to prove or to show grounds for your demand or the sum specified therein.

This guarantee shall expire, no later than the …. Day of ……, 2…[2], and any demand for payment under it must be received by us at this office indicated above on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758, except that the supporting statement under Article 15(a) is hereby excluded.

_____

[signature(s)]

Note: All italicized text (including footnotes) is for use in preparing this form and shall be deleted from the final product.

[1] *The Guarantor shall insert an amount representing the percentage of the Accepted Contract Amount specified in the Letter of Acceptance, less provisional sums, if any, and denominated either in the currency(cies) of the Contract or a freely convertible currency acceptable to the Beneficiary.*

[2] *Insert the date twenty-eight days after the expected completion dateas described in GC Clause 11.9. The Employer should note that in the event of an extension of thisdate for completion of the Contract, the Employer would need to request an extension of this guarantee from the Guarantor. Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Employer might consider adding the following text to the form, at the end of the penultimate paragraph: "The Guarantor agrees to a one-time extension of this guarantee for a period not to exceed [six months][one year], in response to the Beneficiary's written request for such extension, such request to be presented to the Guarantor before the expiry of the guarantee."*

Advance Payment Security

Demand Guarantee

[Guarantor letterhead or SWIFT identifier code]

[Guarantor letterhead or SWIFT identifier code]

Beneficiary:

Haryana Orbital Rail Corporation Limited,
Plot No 143, 5th Floor, Railtel Tower,
Sector-44, Gurugram,
Haryana-122003

Date: _____ *[Insert date of issue]*

ADVANCE PAYMENT GUARANTEE No.: *[Insert guarantee reference number]*

Guarantor: [*Insert name and address of place of issue, unless indicated in the letterhead]*

We have been informed that _____ (hereinafter called "the Applicant") has entered into Contract No. _____ *dated* _____ with the Beneficiary, for the execution of "**C-4:** Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;
(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;
(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;
(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00".

Furthermore, we understand that, according to the conditions of the Contract, an advance payment in the sum _____ ( ) is to be made against an advance payment guarantee.

At the request of the Applicant, we as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of _____ ()[1] upon receipt by us of the Beneficiary's complying demand supported by the Beneficiary's statement, whether in the demand itself or in a separate signed document accompanying or identifying the demand, stating either that the Applicant:

(a) has used the advance payment for purposes other than the costs of mobilization in respect of the Works; or

(b) has failed to repay the advance payment in accordance with the Contract conditions, specifying the amount which the Applicant has failed to repay.

A demand under this guarantee may be presented as from the presentation to the Guarantor of a certificate from the Beneficiary's bank stating that the advance payment referred to above has been credited to the Applicant on its account number _____ at _____..

The maximum amount of this guarantee shall be progressively reduced by the amount of the advance payment repaid by the Applicant as specified in copies of interim statements or payment certificates which shall be presented to us. This guarantee shall expire, at the latest, upon our receipt of a copy of the interim payment certificate indicating that ninety (90) percent of the Accepted Contract Amount, less provisional sums, has been certified for payment, or on the ___ day of _____, 2___,[2] whichever is earlier. Consequently, any demand for payment under this guarantee must be received by us at this office on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758, except that the supporting statement under Article 15(a) is hereby excluded.

_____

[signature(s)]

[1] *The Guarantor shall insert an amount representing the amount of the advance payment and denominated either in the currency(ies) of the advance payment as specified in the Contract, or in a freely convertible currency acceptable to the Employer.*

[2] *Insert the expected expiration date of the Time for Completion. The Employer should note that in the event of an extension of the time for completion of the Contract, the Employer would need to request an extension of this guarantee from the Guarantor. Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Employer might consider adding the following text to the form, at the end of the penultimate paragraph: "The Guarantor agrees to a one-time extension of this guarantee for a period not to exceed [six months][one year], in response to the Beneficiary's written request for such extension, such request to be presented to the Guarantor before the expiry of the guarantee."*

Note: All italicized text (including footnotes) is for use in preparing this form and shall be deleted from the final product.

Retention Money Security

Demand Guarantee

_____ *[Guarantor letterhead or SWIFT identifier code]*

Beneficiary:

Haryana Orbital Rail Corporation Limited,
Plot No 143, 5th Floor, Railtel Tower,
Sector-44, Gurugram,
Haryana-122003

Date: _____ *[Insert date of issue]*

RETENTION MONEY GUARANTEE No.: *[Insert guarantee reference number]*

Guarantor: [*Insert name and address of place of issue, unless indicated in the letterhead]*

We have been informed that _____ *[insert name of Contractor, which in the case of a joint venture shall be the name of the joint venture]* (hereinafter called "the Applicant") has entered into Contract No. _____ *[insert reference number of the contract]*dated _____ with the Beneficiary, for the execution of "**C-4:** Composite Contract package in connection with New BG Railway Line of HORC project for:

(i) Design & Construction of Twin Tunnel using NATM and Cut & Cover method from km *24.850* to km 29.580;
(ii) Design & Installation of Ballastless Track (excluding supply of rails) from km *24.843* to km 29.680;
(iii) Detailed Design, Supply, Installation, Testing & Commissioning of General Electrical Services including Supply, Erection, Testing and Commissioning of 11kV HT/LT Power and Control Cable Network, GIS Substation (11/0.433) kVA, Tunnel lighting system etc. from km *24.843* to km 29.680;
(iv) Design & Construction of Embankment, Bridges and other miscellaneous works from km 12.00 to km 18.00."

Furthermore, we understand that, according to the conditions of the Contract, the Beneficiary retains moneys up to the limit set forth in the Contract ("the Retention Money"), and that when the Taking-Over Certificate has been issued under the Contract and the first half of the Retention Money has been certified for payment, payment of *[*insert the second half of the Retention Money

or if the amount guaranteed under the Performance Guarantee when the Taking-Over Certificate is issued is less than half of the Retention Money, the difference between half of the Retention Money and the amount guaranteed under the Performance Security is to be made against a Retention Money guarantee.

At the request of the Applicant, we, as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of _____ *[insert amount in figures]*()*[amount in words]*[1] upon receipt by us of the Beneficiary's complying demand supported by the Beneficiary's statement, whether in the demand itself or in a separate signed document accompanying or identifying the demand, stating that the Applicant is in breach of its obligation(s) under the Contract, without your needing to prove or show grounds for your demand or the sum specified therein.

A demand under this guarantee may be presented as from the presentation to the Guarantor of a certificate from the Beneficiary's bank stating that the second half of the Retention Money as referred to above has been credited to the Applicant on its account number _____ at _____ *[insert name and address of Applicant's bank].*

This guarantee shall expire no later than the …. Day of ……, 2…[2], and any demand for payment under it must be received by us at the office indicated above on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758, except that the supporting statement under Article 15(a) is hereby excluded.

_____

[signature(s)]

Note: All italicized text (including footnotes) is for use in preparing this form and shall be deleted from the final product.

[1] *The Guarantor shall insert an amount representing the amount of the second half of the Retention Money or if the amount guaranteed under the Performance Guarantee when the Taking-Over Certificate is issued is less than half of the Retention Money, the difference between half of the Retention Money and the amount guaranteed under the Performance Security and denominated either in the currency(ies) of the second half of the Retention Money as specified in the Contract, or in a freely convertible currency acceptable to the Beneficiary.*

[2] *Insert the same expiry date as set forth in the performance security, representing the date twenty-eight days after the completion date described in GCC Clause 11.9.The Employer should note that in the event of an extension of this date for completion of the Contract, the Employer would need to request an extension of this guarantee from the Guarantor. Such request must be in writing and must be made prior to the expiration date established in the guarantee. In preparing this guarantee, the Employer might consider adding the following text to the form, at the end of the penultimate paragraph: "The Guarantor agrees to a one-time extension of this guarantee for a period not to exceed [six months][one year], in response to the Beneficiary's written request for such extension, such request to be presented to the Guarantor before the expiry of the guarantee."*

Contractor's Warranty

This Agreement is made on the .....… day of … … … … … … between

(1) [ ] of [ ] [and [see Note 1]] ([jointly] "the Contractor").

(2) the Haryana Orbital Rail Corporation Limited [of/[whose registered office is at] [XXX] Limited, together with its successors and assigns, "the Employer") _____,

WHEREAS

(A) By a contract [_____] dated [_____] ("the Contract") made between

(1) the Haryana Orbital Rail Corporation Limited ("the Employer") and

(2) [("the Contractor") has agreed to design, execute, complete, test and commission (including Integrated Testing and Commissioning) and remedy any defects in the works ("the Works") upon the terms and conditions contained in the Contract.

(B) [See Note 3]
(C) At the request of the Employer and pursuant to the terms of the Contract the Contractor has agreed to enter into this Warranty.

NOW IT IS AGREED as follows:

1. The Contractor hereby warrants and undertakes that:

   (a) he will design, execute, complete, test and commission (including Integrated Testing and Commissioning) and remedy any defect in the Works in accordance with the terms of the Contract; and;
   (b) he owes a duty of care to the Employer in relation to the performance of its duties under the Contract; and
   (c) he will replace free of cost to the Employer any defect or failure of equipment /material/services provided in the Works for the duration of Defect Notification Period as per the Contract; and
   (d) he agrees that should any design modification be required to any equipment or component as a consequence of failure analysis, for the duration of Defect Notification Period as per the Contract, shall recommence from the date when the modified part is commissioned into service, and such modification shall be carried out free of cost to the Employer in all sub-systems and systems for all sections; and
   (e) he shall maintain the manufacture or spare of replacement parts for at least 10 years.

2. The liability of [the companies comprising [see Note 3]] the Contractor under this Warranty [shall be joint and several and [see Note 3]] shall not be released, diminished or in any way

affected by any independent inquiry or investigation into the Works or any matter related to the Contract whether carried out by or on behalf of the Employer or any liability or right of action which may arise out of such inquiry or investigation.

3. Insofar as the copyright or other intellectual property rights in any plans, calculations, drawings, documents, materials, plant, know-how and other information relating to the Works shall be vested in the Contractor, the Contractor grants to the Employer his successors and assigns a royalty free, non-exclusive and irrevocable licence (carrying the right to grant sub-licences) to use and reproduce any of the works designs or inventions incorporated and referred to in such documents or materials and any such know-how and information for all purposes relating to the Works or the Project including without limitation the design, manufacture, supply, installation, testing and commissioning (including Integrated Testing and Commissioning) reinstatement, extension and the remedy of any defect in the Works. To the extent that beneficial ownership of any such copyright or other intellectual property rights is vested in anyone other than the Contractor, the Contractor shall use best endeavours to procure that the beneficial owner thereof shall grant a like licence to the Employer. For the avoidance of doubt, any such licence granted shall not be determined if the Contractor shall for any reason cease to be employed in connection with the Works.
4. The provisions of this Warranty shall be without prejudice to and shall not be deemed or construed so as to limit or exclude any rights or remedies which the Employer may have against the Contractor, whether in tort or otherwise.
5. Nothing contained in this Warranty shall vary or affect the Contractor's rights and obligations under the Contract.
6. The address for service of all documents arising out of or in connection with this Warranty shall be:

   (a) upon the Employer, at [_____] India [Note 4];
   (b) upon the Contractor, at [_____] India [Note 4].

7. The Employer and the Contractor may change their respective nominated addresses for service of documents to another address in India but only by prior written notice to each other. All notices must be in writing.
8. This Warranty shall be governed by and construed according to the laws for the time being in force in India.
9.

   (1) Any dispute or difference of any kind whatsoever between the Employer and the Contractor arising under out of or in connection with this Warranty shall be referred to arbitration in accordance with the Conciliation and Arbitration rules set out in the General Conditions of Contract. “Dispute” as defined in the Contract shall be deemed to include any such dispute or difference between the Employer and Contractor.
   (2) In the event that the Employer is of the opinion that the issues in such a dispute or difference will or may touch upon or concern a dispute or difference arising under out of or in connection with the Contract (“the Contract Dispute”) then provided that an arbitrator has not already been appointed pursuant to Clause 9(1), the Employer may by notice in writing to the Contractor require and the Contractor shall be deemed to

have consented to the referral of such dispute or difference to the arbitrator to whom the Contract Dispute has been or will be referred.

(3) Save as expressly otherwise provided, the arbitrator shall have full power to open up, review and revise any decision, opinion, instruction, notice, order, direction, withholding of approval or consent, determination, certificate, statement of objections relating to the dispute.

(4) Subject to the foregoing provisions of this clause 9, the Employer and the Contractor agree to submit to the jurisdiction of the Courts of India at Gurugram, Haryana.

IN WITNESS where of this Warranty has been executed as a deed on the date written at the head hereof.

THE COMMON SEAL of)

[_____])

was affixed hereto)

in the presence of:)

Notes: (for preparation of but not for inclusion in the engrossment of this Warranty)

(1) If the Contractor comprises more than one company, each such company shall be a party and liability under this warranty will be joint and several, with consequential grammatical changes.
(2) If Note 1 applies, that fact and the joint venture or other relevant agreement must be recited.
(3) Delete if Note 1 does not apply.
(4) The address for service shall be in India.

FINANCIAL PART (PDF FILE)

To be signed and uploaded with BOQ (MS Excel File) as FINANCIAL PART of the Tender by the Tenderer.

Letter of Tender – Financial Part

INSTRUCTIONS TO TENDERERS: DELETE THIS BOX ONCE YOU HAVE COMPLETED THE DOCUMENT

The Tenderer must prepare this Letter of Tender on stationery with its letterhead clearly showing the Tenderer's complete name and business address.

Note: All italicized text is to help Tenderers in preparing this form.

Date of this Tender submission: [*insert date (as day, month and year) of Tender submission*]
Tender No.: [*insert tender reference number*]
Alternative No.: [*insert reference number if this is a Tender for an alternative*]

To: **[*insert complete name of Employer*]**

We, the undersigned, hereby submit the second part of our Tender, the Tender Price and Price Schedule. This accompanies the Letter of Tender – Technical Part.

In submitting our Tender, we declare that:

(a) **Tender Validity Period**: Our Tender shall be valid for the period specified in TDS 18.1 (as amended, if applicable) from the date fixed for the Tender submission deadline specified in TDS 22.1 (as amended, if applicable), and it shall remain binding upon us and may be accepted at any time before the expiration of that period;

(b) ***Tender Price:** The total price of our Tender including Provisional Sum is: [*insert the total price of the Tender in words and figures in INR*];

(c) **Commissions, Gratuities, Fees:** We have paid, or will pay the following commissions, gratuities, or fees with respect to the Tendering process or execution of the Contract: *[insert complete name of each Recipient, its full address, the reason for which each commission or gratuity was paid and the amount and currency of each such commission or gratuity]*

Name of Recipient	Address	Reason	Amount

(If none has been paid or is to be paid, indicate "none.")

Name of the Tenderer: **[*insert complete name of the Tenderer*]

Name of the person duly authorized to sign the Tender on behalf of the Tenderer: ***[*insert complete name of person duly authorized to sign the Tender*]

Title of the person signing the Tender: [*insert complete title of the person signing the Tender*]

Signature of the person named above: [*insert signature of person whose name and capacity are shown above*]

Date signed [*insert date of signing*] **day of** [*insert month*], [*insert year*]

* The total price of Tender including Provisional Sums quoted in this Letter of Tender-Financial Part shall be same as given in Worksheet BOQ3 (Price Schedule –Summary Sheet) of MS-Excel File which includes cost of Schedule 'A" plus Schedule 'B' plus Schedule 'C' plus Provisional Sum.

**In the case of the Tender submitted by Joint Venture/Consortium specify the name of the Joint Venture/Consortium as Tenderer

*** Person signing the Tender shall have the Power of Attorney given by the Tenderer. The power of attorney shall be attached with the Letter of Tender-Technical Part.

Appendix A to Financial Part: Schedule of Adjustment Data

1. Price adjustment

1.1 The amounts payable to the Contractor for Works shall be adjusted in accordance with the provisions of this Clause 1.0, Sub-Clause 13.7 of GCC and Sub-Clause 13.7, Specific Provision, Part B, Section IX-PCC.

1.2 The Contract Price shall be adjusted for increase or decrease in rates and prices of labour, materials, fuel and lubricants, equipment, Machinery, Plant and other Materials or inputs in accordance with the principles, procedures and formulae specified below:

a) Base month for the purpose of Price Adjustment shall be the month in which the Tender is opened for Civil & BLT Works and General Electrical Services Works. The 1st Quarter will start from Base month;

b) For Schedule-A, Price adjustment shall be applied on completion of the specified stage of the respective item of work.

c) Adjustment for each item of work/stage shall be made separately;

d) The following expressions and meanings are assigned to the value of the work done for Civil works:

EW = Value of work done for the completion of a stage under the Cost Centre 'CE' of Price Schedule 'A';

BR = Value of work done for the completion of a stage under the Cost Centre 'CB' of Price Schedule 'A';

TUNL = Value of work done for the completion of a stage under the Cost Centre 'CTU' of Price Schedule 'A';

BLT = Value of work done for the completion of a stage under the under the Cost Centre 'CBT' of Price Schedule 'A';

RW = Value of work done for the completion of a stage under the Cost Centre 'RW' of Price Schedule 'A';

SCHB = Value of work done under Price Schedule 'B';

MISC = Value of work done under Price Schedule 'C';

e) Price adjustment for change in costs of civil works shall be paid in accordance with the following formula:

i) VEW= 0.85 EW x [PLB x (LBi – LBo)/LBo + PF x (Fi –Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

ii) VBR = 0.85 BR x [PLB x (LBi – LBo)/LBo + PC x (Ci – Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

iii) VTUNL = 0.85 TUNL x [PLB x (LBi – LBo)/LBo + PC x (Ci –Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi– MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo + PXLP x(XLPi – XLPo)/XLPo];

iv) VBLT = 0.85 BLT x [PLB x (LBi – LBo)/LBo + PC x (Ci –Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi– MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

v) VRW = 0.85 RW x [PLB x (LBi – LBo)/LBo + PC x (Ci – Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

i) VSCHB = 0.85 RW x [PLB x (LBi – LBo)/LBo + PC x (Ci – Co)/Co + PS x (Si – So)/So + PF x (Fi – Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

ii) VMISC= 0.85 MISC x [PLB x (LBi – LBo)/LBo + PF x (Fi –Fo)/Fo + PMACH x (MACHi – MACHo)/MACHo + POTH x (OTHi - OTHo)/OTHo];

Where

VEW = Increase or decrease in the cost under the Cost Centre ‘CE’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VBR = Increase or decrease in the cost of Cost Centre ‘CB’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VTUNL = Increase or decrease in the cost under the Cost Centre ‘CTU’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VBLT = Increase or decrease in the cost under the Cost Centre ‘CBLT’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VRW = Increase or decrease in the cost under the Cost Centre ‘RW’ of Price Schedule ‘A’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VSCHB = Increase or decrease in the cost of work done under Price Schedule ‘B’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

VMISC = Increase or decrease in the cost of work done under Price Schedule ‘C’ during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (f);

PC, PF, PLB, PMACH, POTH, PS and PXLP are the percentages of cement, fuel and lubricants, labour, Plant Machinery and tools, other materials, steel/ steel components (including structural steel) and explosives, respectively for the relevant item as specified in sub-paragraph (f);

Co = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for sub-group Cement, Lime & Plaster for the Base Month;

Ci = The WPI for sub-group Cement, Lime & Plaster for the average price index of the 3 months of the quarter under consideration;

Fo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for group Fuel & Power for the Base Month;

Fi = The WPI for group Fuel & Power for the average price index of the 3 months of the quarter under consideration

LBo = The consumer price index for industrial workers – All India, published by Labour Bureau, Ministry of Labour, Government of India, (hereinafter called "CPI") for the Base Month;

LBi = The CPI for industrial workers – All India for the average price index of the 3 months of the quarter under consideration;

MACHo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for category- k "Manufacturing of Machinery for Mining, quarrying and construction' under (R) Manufacturing of Machinery and Equipment for the Base Month;

MACHi = The WPI for category- k "Manufacturing of Machinery for Mining, quarrying and construction' under (R) Manufacturing of Machinery and Equipment for the average price index of the 3 months of the quarter under consideration;

OTHo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for all commodities for the Base Month;

OTHi = The WPI for all commodities for the average price index of the 3 months of the quarter under consideration;

So = Average Rate of RINL for Rebar 8 mm (coil) as published for Ludhiana Branch on their website for the Base Month;

Si = Average rate of RINL for Rebar 8 mm (coil) as published for Ludhiana Branch on their website for the 3 months of the quarter under consideration;

If only one rate is published for the 3 months of the quarter under consideration, the published rate for that quarter shall be considered for the quarter under consideration.

If no rate is published by RINL for Rebar 8mm (coil) for the 3 months of the quarter under consideration, the value of Si and So will be taken as under:

"So": Wholesale Price Index for 'MS Bright Bars' individual commodity of group item (d) Mild Steel- Long products under (N) MANUFACTURE OF BASIC METALS, published by Office of Economic Adviser, Government of India, Ministry of Commerce & Industry Department of Industrial Policy & Promotion (DIIP) for the Base Month;

"Si": Average Wholesale Price Index for 'MS Bright Bars' individual commodity of group item (d) Mild Steel- Long products under (N) MANUFACTURE OF BASIC METAL, published by Office of Economic Adviser, Government of India, Ministry of Commerce & Industry Department of Industrial Policy & Promotion (DIIP) for the 3 months of the quarter under consideration;

XLPo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for explosives for the Base Month; and

XLPi = The WPI for explosives for the average price index of the 3 months of the quarter under consideration.

f) The following percentages shall govern the price adjustment of the Contract Price for costs of civil works:

Component	EW (Cost Centre CE of Price Schedule 'A')	BR & RW (Cost Centre CB and Cost Centre CRW of Price Schedule 'A')	TUNL (Cost Centre CTU of Price Schedule 'A')	BLT (Cost Centre CBT of Price Schedule 'A')	SCHB (Price Schedule 'B')	MISC (Price Schedule 'C')
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Cement (PC)	-	20%	20%	20%	20%	-
Fuel and lubricants (PF)	30%	20%	15%	20%	20%	30%
Labour (PLB)	20%	10%	10%	10%	10%	20%
Machinery and Plants (PMACH)	40%	15%	10%	15%	15%	40%

Component	EW (Cost Centre CE of Price Schedule 'A')	BR & RW (Cost Centre CB and Cost Centre CRW of Price Schedule 'A')	TUNL (Cost Centre CTU of Price Schedule 'A')	BLT (Cost Centre CBT of Price Schedule 'A')	SCHB (Price Schedule 'B')	MISC (Price Schedule 'C')
Other Materials (POTH)	10%	10%	10%	10%	10%	10%
Steel(PS)	-	25%	30%	25%	25%	-
Explosives (PXLP)	-	-	05%	-	-	-
Total	100%	100%	100%		100%	100%

g) The following expressions and meanings are assigned to the value of the work done for Various General Electrical Services works:

i) **ELEGWK** = Value of work done for the completion of a stage under Cost Center 'E1- General Electrical Services works of Price Schedule 'A';

ii) **INVELECTRICAL** = Value of work done for the completion of a stage under Cost Center 'E2'- Inventory/Spare Items' of Price Schedule 'A';

Note: - No price adjustment shall be paid against Sub-Cost Center- E3. (Maintenance and Manning of Electrical system).

h) Price adjustment for changes in cost for various General Electrical Services works shall be paid in accordance with the following formula:

i) **VELEGWK** = 0.85 ELEGWK x [PLB x (LBi – LBo)/LBo + POTH x (OTHi – OTHo)/OTHo]

ii) **VINVELECTRICAL** = 0.85 INVELECTRICAL x [POTH x (OTHi – OTHo)/OTHo];

Where: -

VELEGWK = Increase or decrease in the cost under cost center 'E1' of Price Schedule 'A' of General Electrical Services works with complete accessories during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (i);

VINVELECTRICAL = Increase or decrease in the cost under cost Centre 'E2' of Price Schedule 'A' of Inventory/Spare item during the period under consideration due to changes in the rates for relevant components as specified in sub-paragraph (i);

PLB and POTH and PELEX are the percentages of Labor and, All Other Commodities respectively for the relevant item as specified in sub-paragraph (i);

LBo = The consumer price index for industrial workers – All India, published by Labour Bureau, Ministry of Labour, Government of India, (hereinafter called "CPI") for the Base month;

LBi = The CPI for industrial workers – All India for the average price index of the 3 months of the quarter under consideration

OTHo = The wholesale price index as published by the Ministry of Commerce and Industry, Government of India (hereinafter called "WPI") for "All commodities" for the Base month;

OTHi = The WPI for all commodities for the average price index of the 3 months of the quarter under consideration;

i) The following percentages shall govern the price adjustment of the Contract Price for Various General Electrical Services works:

(i) For Electrical works, & Inventory /Spare Item:

Component	General Electrical Services Works except commissioning for the Division (E1 – E1.1, E1.2, & E1.3)	Inventory/Spare Item (E2)	Commissioning of Electrical system with complete accessories (E1.4)
Labour (PLB)	20%	-	100%
Electronics (PELEX)	-	-	-
PVC Insulated Cable (PIC)	-	-	-
Fibre Cable (POFC)	-	-	-

All other commodities (POTH)	80 %	100.00%	-
Total	100.00%	100.00%	100.00 %

Table A. Foreign Currency (FC)

Not applicable as Tenderer's are required to quote rates and prices only in INR.

Table B. Summary of Payment Currencies

For ……. [insert name of Works]

Name of Payment Currency	A Amount of Currency	B Rate of Exchange (local currency per unit of foreign)	C Local Currency Equivalent C = A x B	D Percentage of Net Tender Price (NTP) 100xC / NTP
For Schedule 'A'				
Local currency (INR)		**1.00**		
USD ($)				
EUR (€)				
JPY (¥)				
Schedule 'B'		**1.00**		
Schedule 'C'		**1.00**		
Net Tender Price				**100.00**
Provisional Sums Expressed in Local Currency (INR) in million	100,000,000.00	**1.00**	100,000,000.00	**Not Applicable**
TOTAL TENDER PRICE (including Provisional Sum)				

Note: *The Tenderer is required to propose and submit the schedules given in tables above as part of the Tender. The rates of exchange shall be the reference rate twenty-eight (28) days prior to the deadline for submission of Tenders published by the Reserve Bank of India (RBI) on its website https://www.rbi.org.in. In case the exchange rate of particular currency on given date is not available on RBI web site, it will be as per the web site https://www.fbil.org.in of Financial Benchmark India Private Limited (FBIL).*

Appendix B to Financial Part: Price Schedules

1 Preamble

1.1. The Price Schedules shall be read in conjunction with the Instructions to Tenderers, the General Conditions, the Particular Conditions and the Employer's Requirements *{General, Functional (Civil and BLT), Design (Civil and BLT), Construction (Civil and BLT), Outline Design Specifications (ODS)- Civil and BLT, Outline Construction Specifications (OCS)-Civil and BLT, General Electrical Services, Tender drawings and documents and Appendices}* and the Addenda (if any).

1.2. **Schedule 'A'** comprises scope of work to be executed under lump sum contract as detailed in Part 2- Employers' Requirements of Tender Document. *Cost of Schedule 'A' also includes cost of tree cutting for entire package C-4 as per Sub-Clause 10.14 of Appendix 10, Section VII-9: Appendices, Part 2 -Employer's Requirements of Tender Documents. The Tenderer has to quote a single lump sum amount against Schedule 'A'.* Payment to the Contractor will be made in accordance with payment stages/Milestones defined for each Cost Centre detailed in Clause 5.0 below unless otherwise specified in the Contract.

1.3. **Schedule 'B' -** Other civil works:

Schedule 'B' comprises of percentage rate for "Other civil works"**.** The work has to be carried out as per the description of items given in Schedule 'B' and directions of the Engineer. *Cost of design and drawings of all the temporary works, temporary road diversion is deemed to be included in the rates quoted for the relevant item of Schedule 'B' unless otherwise specified in the Contract.* The Tenderer has to quote the percentage Excess (+) or Less (-) over the total Estimated amount of Schedule 'B' *(which is shown as "Estimated Rate" against Schedule 'B' in BOQ2 of MS excel file on e- procurement portal)*. The payment against this Schedule 'B' will be made on the basis of quantities executed, measured and certified. Under this Schedule, the Contractor is required to carry out other civil works, which are not covered in Schedule 'A', as per site requirements and as per the direction of the Engineer.

1.4. **Schedule 'C'** comprises "Item rates for miscellaneous works". Under this Schedule, the Contractor has to undertake items or works not covered in Schedule 'A' or Schedule 'B'. Execution of items under this Schedule shall be carried out only after specific instructions of the Engineer. This Schedule consists of items for Civil works. The work has to be carried out as per Schedule of items given in this Schedule 'C'. This Schedule contains only Rate and Unit of items of the works. The basis of payment will be the actual quantities of work ordered and carried out, as measured by the Contractor and verified by the Engineer and valued at the rates and prices quoted in the Price Schedules. The Tenderer has to quote the percentage (%) Excess (+) or Less (-) over the *total Estimated Cost of Schedule 'C' (which is shown as "Estimated Rate" against Schedule 'C' in BOQ2 of MS excel file on e procurement portal)* Schedule 'C' for items to be executed against this head.

1.5. The Schedules may not generally give a full description of the works to be performed and the plant or equipment to be supplied under each item. Tenderers shall be deemed to have read the Employer's Requirements and the other sections of the Tender Documents and reviewed the Drawings to ascertain the full scope of the requirements included in each item prior to filling the rates and prices.

1.6. The price quoted in the Price Schedules for Schedule 'A'. Schedule 'B' and Schedule 'C' are for complete and finished items of the work in all respects. The Price quoted in the Price Schedules shall, except in so far as it is otherwise provided under the Contract, shall include all design, include all necessary survey work, plants , tools, machinery, Contractor's equipment, labour, compliance of labour laws, supervision, materials, transportation, handling, loading & unloading, storage, sampling, testing, fuel, oil, consumables, electric power, water, all leads & lifts, dewatering, all temporary works including temporary accesses, staging, form works and false works, stacking, provision and maintenance of all temporary works area, construction of temporary store and buildings, fencing, barricading, lighting, drainage arrangements, erection & maintenance of inspection facilities above and below ground such as brick, concrete and steel etc., reinstatement, remedy of any defects during the Defects Notification Period, safety measures for workmen and road users, preparation of design and drawings pertaining to permanent and temporary works, & *temporary diversion works, temporary road widening,* traffic diversion works, mobilisation and demobilisation, establishment and overhead charges, labour camps, insurance cost for labour and works, contractor's profit, all taxes including Goods and Service Tax (GST), insurance, royalties, duties, cess, octroi, other levies and other charges together with all general risks, liabilities and obligations set out or implied in the Contract.

The price and rates quoted by Tenderer shall be deemed to have included GST at the rate of 18% as notified by 47th GST Council on 29th June 2022 ***and Item 18.5 of Circular No. 177/09/2022-TRU dated 03rd August 2022 issued by Ministry of Finance, Government of India.***

1.7. The whole cost of complying with the provisions of the Contract shall be included in the items provided in the Price Schedules, and where no items are provided, the cost shall be deemed to be distributed among the rates and prices entered for the related items of the Work.

1.8. To the extent acceptable to the Employer for the purpose of making payments or partial payments, valuing variations or evaluating claims, or for such other purposes as the Engineer may reasonably require, the Contractor may provide the Engineer with a breakdown of any composite or lump sum items included in the Schedules.

1.9. The Provisional Sums included and so designated in the Price Schedules shall be expended in whole or in part at the direction and discretion of the Engineer. The Provisional Sum shall be used to cover the Employer's share of the DAAB members' fees and expenses, in accordance with Clause 21. No prior instruction of the Engineer shall be required with respect to the work of the DAAB in accordance with Sub-Clause 13.4 of Part B-Specific Provisions - Particular

Conditions of Contract. The Contractor shall submit the DAAB members' invoices and satisfactory evidence of having paid 100% of such invoices as part of the substantiation of those statements submitted under Sub-Clause 14.3. in accordance with Sub-Clauses 13.4 of the General Conditions.

1.10. The prices shall be quoted against Schedule 'A', Schedule 'B' and Schedule 'C' in the Price Schedule (Excel Workbook) uploaded on the e-Procurement portal.

1.11. The prices quoted shall be comprehensive and must include for complying in all respects with the Price Schedules, Instruction to Tenderers, the General Conditions, the Particular Conditions, Employer's Requirements, Specifications and Drawings and for all matters and things necessary for the proper construction, completion, and making good of any defect in part or of the whole of the Works.

1.12. No claims for additional payment shall be allowed for any error or misunderstanding by the Contractor of the work involved.

1.13. The rates quoted by the Tenderer are for design and construction of the Works as per approved Alignment Plan and Longitudinal Section and approved GADs of bridges as per the Scope of the Works.

2 Variations in Price Schedule 'A', Schedule 'B' and Schedule 'C'

2.1 Variations in Price Schedules shall be dealt in accordance with Sub Clause 13.3.1 of Part B-Specific Provisions, Section IX- Particular Conditions of Contract.

2.2 The through Chainages mentioned in the Scope of the Works/Tender Drawings can undergo some minor corrections, without any impact on the overall length/Scope of the Works.

3 Measurement and Payment

3.1 The measurement shall be made as per Price Schedules i.e. Schedule 'A'. Schedule 'B' and Schedule 'C' and other relevant provisions of the Contract such as Employer's Requirements and the Drawings.

3.2 If during execution of the Contract, it is decided by the Employer/Engineer that one or more items of Work/Milestone of a Cost Centre in a particular Price Schedule is not required to be executed, the proportionate amount against that particular Item of Work/Milestones shall not be paid. The Engineer's decision in this regard shall be final.

3.3 The Payment shall be made as per Clause 14 [Contract Price and Payment] of the General Conditions and Particular Conditions.

3.4 The Employer shall make interim payments to the Contractor in accordance with the provisions of Sub-Clause 14.6 [Issue of Interim Payment Certificates] of the General Conditions and Particular Conditions, as certified by the Engineer on the basis of the progress achieved for the items of works/stages/Milestones of the works.

3.5 The Contractor shall base its claim for interim payment in accordance with Sub-Clause 14.3 [Application for Interim Payment] of the General Conditions and Particular Conditions for each stage for various items of work on the basis of actual progress of work executed (i.e. Milestones achieved) till the end of the month for which the payment is claimed in relation to the Contractor's total executed quantity, supported with documents and updated programme in accordance with the Employer's Requirements.

3.6 The Employer may carry out necessary tests, either directly or through an independent agency, of the Works done by the Contractor for which payment has been accepted and certified by the Engineer. The payment shall depend upon the outcome of such tests.

3.7 Format for the Contractor's application for payment shall be agreed between the Engineer and the Contractor.

3.8 All necessary supplementary details to support progress claims, including all certified Request for Inspection in hard bound copy, shall be included with application for payment. Sketches, drawings, approvals, calculations, test reports etc. shall accompany an application for payment to be substantiated and certified by the Engineer and submitted to the Employer.

3.9 Even if no work is executed during the month, or the Contractor does not choose to issue an application for payment, a 'NIL' application shall be submitted.

3.10 For the purposes of payment, the Contractor shall submit to the Engineer a detailed Price Schedule indicating a further breakdown for each stage of payment contained in the Price Schedules within forty-two (42) days after the receipt of the Letter of Acceptance. Such cost breakdowns shall be subject to approval of the Engineer who shall review and evaluate with comments and/or issue approval within twenty-eight (28) days of receipt of same. The Contractor shall resubmit the cost breakdown structure corresponding to the Engineer's comments for review, if required.

3.11 The Engineer is not obliged to issue an Interim Payment Certificate until such breakdown structure of payment schedule has been submitted and accepted by the Engineer.

4 Methodology for Claiming Payment

4.1 The Contractor shall prepare his monthly application for payment in the agreed format in two hard copies and one soft copy. This shall be accompanied by supplementary details in accordance with Sub-Clause 14.3 [Application for Interim Payment Certificates] of the General Conditions. All hard copies shall bear the original signatures of the Contractor's Representative and be submitted to the Engineer.

4.2 If these are found in order, in accordance with Sub-Clause 14.6 [Issue of Interim Payment Certificates] of the General Conditions, then the Engineer shall forward two certified copies of the application along with certified supplementary details to the Employer, with his recommendation for payment; otherwise, all documents shall be returned to the Contractor for rectification and resubmission.

5 Schedules

5.1 Schedule "A'- Breakup of Lump Sum cost of Works under various Sub-Heads shall be as follows:

Sub-Head	Description	Percentage of the quoted lump sum cost of Schedule 'A'	No. of Cost Centres	Total Cost of each Sub-Head
1	**2**	**3**	**4**	**5**
C	Civil & BLT works	96%	6	C= 0.96xLS*
E	General Electrical Services works	4%	3	E=0.04xLS

*LS = Total lump sum *accepted* cost of Works for Schedule 'A'

5.2 Apportionment of Contract Price for payments under various Cost Centre for Sub-Head 'C'- Civil & BLT Works

Cost Centre	Description of Cost Centre	Percentage of Cost Centre 'C'	Total Cost of Cost Centre	Total Cost of Sub-Head 'C'
1	2	3	4	5
CG	General	2.00%	CG= 0.02x 'C'	96% of SCH 'A'
CE	Earthwork & blanketing	1.2%	CE=0.012x 'C'	
CB	Bridges	1.44%	CB=0.0144x 'C'	
CTU	Tunnel & Shafts	90.84%	CTU=0.9084x 'C'	
CBT	Ballastless Track	4.52%	CBT=0.0452x 'C'	
	Total	100%		

Note: Value of 'C' shall be as defined in Sub-Clause 5.1 above.

The percentage figures as filled in column (3) by the Employer for the apportionment of the Contract Price for completion of the Works corresponding to the various Sub-Heads and Cost Centres are fixed and payment will be released for different Cost centre as per above percentage break-up of Contract Price.

5.3 Stages of Payment i.e. Milestones of Cost Centre 'CG'- General

Cost Centre			'CG'- General	
Weightage of Cost Centre 'CG', (Y)-			2%	
Sub Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
CG1- General	CG.1	GT investigation	GT investigations and submission & approval of GIR.	20%
CG2- Design	CG.2.1		Submission and approval of preliminary and final design and Good for Construction (GFC) drawings of portals, tunnels, permanent ventilation shafts & construction cum utility shaft.	30%

Cost Centre			'CG'- General	
Weightage of Cost Centre 'CG', (Y)-			**2%**	
Sub Cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No.	**Description**		
1	2	3	4	5
	CG.2.2		Submission and approval of GAD, final design and Good for Construction (GFC) drawings of bridges and embankment	10%
	CG.2.3		Submission and approval of preliminary and final design and Good for Construction (GFC) drawings of Ballastless track	20%
CG.3- "As Built" Drawings & Documents	CG.3.1	As Built Drawings	Submission of "As Built" Drawings	10%
	CG.3.2	As Built Documents	Submission of "As Built" Documents	10%
			Total	**100%**

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CG.1 will be = 0.96x*LS*xXxY=0.96x *LS*x0.20 x 0.02.
2. Adjustment to Contract Price pursuant to GCC 13.7 shall **NOT** be applicable to the payments of Works executed under this Cost Centre.
3. Payment will be made on Completion of each Milestones as per weightage given in this Cost Centre

5.4 Stages of Payment i.e. Milestones of Cost Centre 'CE'- Earthwork and Blanketing

Cost Centre			**'CE'- Earthwork and Blanketing**	
Weightage of Cost Centre 'CE', (Y)-			**1.2%**	
Sub-Cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No.	**Description**		
1	2	3	4	5
CE.1- Earthwork	CE.1.1	Earthwork in formation from Ch 12000 to 12500 for double main line track.		
	CE1.1.1		Earthwork in embankment / cutting including compaction.	3.4%
	CE1.1.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE1.1.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.2	Earthwork in formation from Ch 12500 to 13000 for double main line track.		
	CE1.2.1		Earthwork in embankment / cutting including compaction.	3.4%
	CE1.2.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE1.2.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.3	Earthwork in formation from Ch 13000 to 13500 for double main line track.		
	CE1.3.1		Earthwork in embankment / cutting including compaction.	3.4%
	CE1.3.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE1.3.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.4	Earthwork in formation from Ch 13500 to 14000 for double main line track.		
	CE.1.4.1		Earthwork in embankment / cutting including compaction.	3.9%
	CE.1.4.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE.1.4.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.5	Earthwork in formation from Ch 14000 to 14500 for double main line track.		
	CE.1.5.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.5.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE.1.5.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.6	Earthwork in formation from Ch 14500 to 15000 for double main line track.		
	CE.1.6.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.6.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.2%
	CE.1.6.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.7	Earthwork in formation from Ch 15000 to 15500 for double main line track.		
	CE.1.7.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.7.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.3%
	CE.1.7.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.8	Earthwork in formation from Ch 15500 to 16000 for double main line track.		
	CE.1.8.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.8.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.3%
	CE.1.8.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.9	Earthwork in formation from Ch 16000 to 16500 for double main line track.		
	CE.1.9.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.9.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.3%
	CE.1.9.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.10	Earthwork in formation from Ch 16500 to 17000 for double main line track.		
	CE.1.10.1		Earthwork in embankment / cutting including compaction.	4.3%
	CE.1.10.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.3%
	CE.1.10.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.11	Earthwork in formation from Ch 17000 to 17500 for double main line track.		
	CE.1.11.1		Earthwork in embankment / cutting including compaction.	5.0%
	CE.1.11.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.4%
	CE.1.11.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of 12 months and after ensuring that vegetative cover is* properly rooted.	0.2%
	CE.1.12	Earthwork in formation from Ch 17500 to 18000 for double main line track.		
	CE.1.12.1		Earthwork in embankment / cutting including compaction.	5.0%
	CE.1.12.2		On cutting of *extra width & dressing of slopes* in profile, compaction, *providing vegetative cover including coir netting (where specified) and* drainage arrangement complete in all respects.	0.4%
	CE.1.12.3		On completion of maintenance *of slopes, drainage system & vegetative cover for a period of*	0.2%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			12 months and after ensuring that vegetative cover is properly rooted.	
	CE.1.13	Earthwork in formation from Ch. 29580 to 29680	On completion of earthwork in cutting including *providing vegetative cover including coir netting (where specified)* and drainage arrangement complete in all respect.	4.9%
CE.2- Blanketing	**CE.2.1**	Blanketing from Ch 12000 to 12500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.2	Blanketing from Ch 12500 to 13000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.3	Blanketing from Ch 13000 to 13500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.4	Blanketing from Ch 13500 to 14000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.5	Blanketing from Ch 14000 to 14500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.6	Blanketing from Ch 14500 to 15000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%

Cost Centre			'CE'- Earthwork and Blanketing	
Weightage of Cost Centre 'CE', (Y)-			1.2%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
	CE.2.7	Blanketing from Ch 15000 to 15500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.8	Blanketing from Ch 15500 to 16000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.9	Blanketing from Ch 16000 to 16500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.10	Blanketing from Ch 16500 to 17000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.11	Blanketing in formation from Ch 17000 to 17500 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
	CE.2.12	Blanketing from Ch 17500 to 18000 for double main line track.	Blanketing on subgrade/ prepared subgrade as per design profile including compaction complete in all respects.	3.3%
			Total	**100%**

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CE.1.1.1 will be = 0.96x*LS*xXxY=0.96x *LS*x0.034 x 0.012.

2. Adjustment to Contract Price pursuant to GCC 13.7 shall be applicable to the payments of Works executed under this Cost Centre / Price Schedule.
3. Payment will be made on Completion of each Milestones as per weightage given in this schedule.

5.5 Stages of Payment i.e. Milestones of Cost Centre 'CB'- for Bridges

Cost Centre			'CB'- Bridges	
Weightage of Cost Centre 'CB', (Y)-			1.44%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
CB.1- Minor Bridges	CB1.1	Construction of minor bridge No. 47, 48 & 49 between ch 12000 to 12500 for main line track.	On completion of *bridgeworks in all respects*	22.4%
	CB1.2	Construction of minor bridge No. 50 between ch 12500 to 13000 for main line track.	On completion of *bridgeworks in all respects*	5.6 %
	CB1.3	Construction of minor bridge No. 51 between ch 13000 to 13500 for main line track.	On completion of *bridgeworks in all respects*	6.3 %
	CB1.4	Construction of minor bridge No. 52 between ch 13500 to 14000 for main line track.	On completion of *bridgeworks in all respects*	4.4 %
	CB1.5	Construction of minor bridge No. Nil between ch 14000 to14500 for main line track.	-	0%
	CB1.6	Construction of minor bridge No. 54 & 55 between ch 14500 to 15000 for main line track.	On completion of *bridgeworks in all respects*	21.7%
	CB1.7	Construction of minor bridge No. 56 between ch 15000 to15500 for main line track.	On completion of *bridgeworks in all respects*	5.8%
	CB1.8	Construction of minor bridge No. 57 between ch 15500 to16000 for main line track.	On completion of *bridgeworks in all respects*	14.8%
	CB1.9	Construction of minor bridge No. Nil between ch 16000 to16500 for main line track.	-	0%
	CB1.10	Construction of minor bridge No. Nil between ch	-	0%

Cost Centre			'CB'- Bridges	
Weightage of Cost Centre 'CB', (Y)-			1.44%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
		16500 to17000 for main line track.		
	CB1.11	Construction of minor bridge No. Nil between ch 17000 to17500 for main line track.	-	0%
	CB1.12	Construction of minor bridge No. Nil between ch 17500 to18000 for main line track.	-	0%
CB.2- Major Bridges	CB.2.1	Foundation	On completion of the foundation work including pile caps/ well caps and foundations for wing and return walls and testing.	4.0%
	CB.2.2	Substructure	On Completion of Abutment/Piers including Abutment/Pier Cap without bearings.	
	CB.2.2.1		Pier/Abutment	3%
	CB.2.2.2		Pier/Abutment cap	0.5%
	CB.2.2.3		Completion of the wing walls, return walls in all respects	2.5%
	CB.2.3	Superstructure	On completion of superstructure *including launching in position*.	5.0%
	CB.2.4		On completion of balance works as per drawing like- protection works including Toe wall, Pitching, inspection platform at each pier & abutment *including* access ladder, inspection steps, Bridge plaque, Bridge board, painting of HFL, *Height gauge & drainage arrangements in*	4%

Cost Centre			'CB'- Bridges	
Weightage of Cost Centre 'CB', (Y)-			1.44%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
			RUBs and testing on completion, if any, complete in all respect and fit for use.	
			Total	**100%**

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CB1.1 will be = 0.96x*LS*xXxY=0.96x *LS*x0.224 x 0.0144.

2. Adjustment to Contract Price pursuant to GCC 13.7 shall be applicable to the payments of Works executed under this Cost Centre / Price Schedule.

3. Payment will be made on Completion of each Milestones as per weightage given in this schedule.

4. CB2-Major Bridges:
   (ii) For the purpose of stage payment/Milestones, cost of a bridge shall be taken in proportion to its linear length measured along the alignment to the total linear length of all major bridges.
   (iii) Payment of each stage/Milestones for a bridge will be made on completion of the relevant stage as per the weightage given in this schedule in proportion to the cost of the bridge.

5. Stages CB.2.1 to CB.2.2 will further be subdivided into the number of piers + 2 abutments, as applicable as per approved drawing by the Engineer, and Milestones for completed work for each pier and abutment shall be made as per the requirement of the stages stated above.

6. For PSC slabs payment against sub cost centre 2.3 shall be released as per following schedule-

(i) On casting of PSC slabs: 50%

(ii) On prestressing: 20%

(iii) On completion in all respect: 30%

7. *The cost of Milestones included cost of all temporary work and temporary diversion of road wherever required for all bridges included in Schedule 'A', Section VII-2, Employer's Requirements.*

5.6 Stages of Payment i.e. Milestones of Cost Centre 'CTU'- Tunnel & Shafts

Cost Centre			'CTU'- Tunnel	
Weightage of Cost Centre 'CTU', (Y)-			90.84	
Sub-cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
CTU.1– Permanent ventilation Shafts and Construction cum utility shaft	CTU1.1	Completion of excavation for construction of permanent ventilation shafts and Construction cum utility shaft		
	CTU1.1.1		Construction of Permanent Ventilation Shaft No. 1 at Chainage 26080	0.8%
	CTU1.1.2		Construction of Permanent Ventilation Shaft No. 2 at Chainage 26080	0.8%
	CTU1.1.3		Construction of Permanent Ventilation Shaft No. 3 at Chainage 27680	0.8%
	CTU1.1.4		Construction of Permanent Ventilation Shaft No. 4 at Chainage 27680	0.8%
	CTU1.1.5		Construction of Construction cum Utility Shaft at Chainage 26950	0.8%
CTU.2- NATM Drive	CTU2.1	On completion of first round of the Excavation by NATM from		
	CTU2.1.1		Face F1	0.5%
	CTU2.1.2		Face F2	0.5%
	CTU2.1.3		Face F3	0.5%
	CTU2.1.4		Face F4	0.5%
	CTU2.1.5		Face F5	0.5%
	CTU2.1.6		Face F6	0.5%

Cost Centre			**'CTU'- Tunnel**	
Weightage of Cost Centre 'CTU', (Y)-			**90.84**	
Sub-cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No.	**Description**		
1	2	3	4	5
	CTU2.1.7		Face F7	0.5%
	CTU2.1.8		Face F8	0.5%
	CTU2.1.9		Face F9	0.5%
	CTU2.1.10		Face F10	0.5%
	CTU2.1.11		Face F11	0.5%
	CTU2.1.12		Face F12	0.5%
	CTU2.1.13		Face F13	0.5%
	CTU2.1.14		Face F14	0.5%
CTU.3	CTU.3.1	NATM Main Drive of both tunnels from chainage *24850 (Up line) & 24853 (Dn line) t*o 26067.5m	On Completion of NATM Main Drive (On account payment will be made on proportionate basis based on actual work progress in m divided by Total length of NATM drive)	11%
	CTU.3.2	NATM Main Drive of both tunnels from chainage 26092.5m to 27667.5m and from chainage 27692.5m to 28480m	On Completion of NATM Main Drive (On account payment will be made on proportionate basis based on actual work progress in m including Benching divided by Total length of NATM drive)	37.4%
CTU.4-Secondary Lining	CTU4.1	Secondary lining in both tunnels in NATM portion	On completion of Secondary Lining (on account payment will be made on proportionate basis based on actual progress of work in meter divided by total length of NATM tunnel)	14%
CTU.5-Cut & Cover Tunnel	CTU 5.1	Excavation of Cut & Cover Tunnel	Excavation for Cut & Cover tunnel (On account payment will be made on proportionate basis based on actual progress of work in sqm on Plan divided by Total area in sqm on Plan)	4.6%

Cost Centre			'CTU'- Tunnel	
Weightage of Cost Centre 'CTU', (Y)-			90.84	
Sub-cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
	CTU 5.2	Cut & Cover Tunnel Structures	Completion of Cut & Cover Tunnel Structures including waterproofing, backfill & drainage arrangement (on account payment will be made on proportionate basis based on actual work progress in sqm on Plan divided by Total area in sqm on Plan)	10%
CTU5-Cross Passage	CTU5.1	Cross Passage	Construction of Cross Passages	3.0%
CTU6-Miscellaneous works	CTU6.1	Miscellaneous	Construction of Portal P2, Footpath, Drainage, Restoration of the Areas etc. complete in all respect.	9.0%
			Total	**100%**

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CTU1.1.1will be = 0.96x*LS*xXxY=0.96x *LS*x0.008 x 0.9084.
2. Adjustment to Contract Price pursuant to GCC 13.7 shall be applicable to the payments of Works executed under this Cost Centre / Price Schedule.
3. *Inc case of any addition / reduction in the length of tunnel due to change in the location of Portal P-1, payment/deduction shall be made @ INR 9.60 lacs per metre addition/reduction in the length of tunnel.*

5.7 Stages of Payment i.e. Milestones of Cost Centre 'CBT'- Ballastless Track

Cost Centre			'CBT'- Ballastless Track	
Weightage of Cost Centre 'CBT', (Y)-			4.52%	
Sub-Cost Centre	Item of Work		Milestone	Weightage (X)
	No.	Description		
1	2	3	4	5
CBT.1	CBT1.1	Supply of Fastening system	On supply of Track fitting/fastening system complete	15%
	CBT1.2	Construction of ballastless track	Construction of ballastless track (On account payment will be made on proportionate basis based on actual work progress in meter divided by total length of ballastless track)	65%
	CBT1.3	Misc. works	On completion of all balance works as per drawings like welding into LWR, destressing, drainage, supply of spare fittings/ fastenings for BLT etc. complete.	10%
	CBT1.3	Maintenance	Maintenance of ballastless track for one year after start of traffic (to be paid monthly on pro rata basis based on satisfactory performance certificate by the Engineer.)	10%
			Total	100%

Note:

1. The value of each Milestone will be 96% of total lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example*, the value of Milestone* CBT1.1 will be = 0.96x*LS*xXxY=0.96x *LS*x0.15 x 0.0452.
2. Adjustment to Contract Price pursuant to GCC 13.7 shall be applicable to the payments of Works executed under this Cost Centre / Price Schedule.

6 Apportionment of the Contract Price for Schedule 'A' under various Cost Centre for Sub-Head 'E'-General Electrical Services works

Cost Centre	Description of Cost Centre	Percentage of Cost Centre	Total Cost of Cost Centre	Total Cost of Sub-Head "E"
1	**2**	**3**	**4**	
E1	General Electrical Services works	94.36%	E1=0.9436 x 'E'	4% of Schedule 'A"
E2	*Contract* Spare*s, Tools & Tackles and Measuring Instruments*	4.83%	E2=0.0483 x 'E'	
E3	Maintenance and Manning of electrical system for one year	0.81%	E3=0.0081x 'E'	
	Total	**100%**		

6.1 Stages of Payment i.e. Milestones of cost center E1. – General Electrical Services works

Cost center			E1. – General Electrical Services works	
Weightage of Cost Centre 'E1', (Y)			94.36 %	
Sub Cost Centre	Item of Work		Milestone	Weightage (X)
	No	Description		
1	2	3	4	5
E1.1	E1.1.1	Drawing and Design	Preparation and Submission of Drawing and Design for General Electrical Services works, Plan, Specifications, Load calculations, Reports and Drawing of civil structure/building for sub-stations etc. required for commissioning of Electrical System.	5.00%
E1.2	E1.2.1	Supply of Electrical Equipment and associated materials	Supply of equipment and associated material for the Electrical system and material for construction of civil structure/building for sub- stations. i. Major Electrical item like – 11 kVA GIC Panel, Transformers, DG sets, All types of cables, Cable Tray, LT Panels, all types of LED fittings and its associated items.	60.00%
E1.3	E1.3.1	Installation & Erection of Electrical Equipment	Delivery to Site from , Installation and Site Testing of all equipments for Electrical system (includes pre-installation tests and post installation tests). i. Construction of building for sub-stations. ii. Installation of all Electrical equipment iii. Installation of all required sensors and Earthing system.	20.00%
E1.4	E.1.4.1	Testing and Commissioning	System Acceptance Tests (SAT) and Integrated Commissioning and Charging of Total Electrical system	15.00%
			Total	**100%**

Note:

1 The value of each Milestone will be 4% of total Lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example, *the value of Milestone* E1.1.1 will be = *0.04xLSxXxY* = 0.04 x*LSx* 0.05x 0.9436.

2 Adjustment to Contract Price Shall Not be applicable E1.1 to the payments of Works executed under Cost Centre 'E1'.

3 Payment will be made on completion of each Milestones as per weightage given in this Cost Centre.

4 Payment against the Sub Cost Centre E1.2 shall be made for quantities as per the approved Design, on receipt of Material at contractor's depot, production of inspection certificates & other documents and against BG of equivalent amount.

5 Payment against each Sub Cost Centre shall be made only on completion of work under Sub Cost Centre.

6.2 Stages of Payment i.e. Milestones of cost center E2 – *Contract Spares, Tools & Tackles and Measuring Instruments*

Cost center			**E2 – Contract Spares, *Tools & Tackles and Measuring Instruments***	
Weightage of Cost Centre 'E2', (Y)			**4.83%**	
Sub Cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No	**Description**		
1	**2**	**3**	**4**	**5**
E2.1	E2.1.1	*Contract Spares, Tools & Tackles and Measuring Instruments etc..*	Supply of *Contract Spares, Tools & Tackles and Measuring Instruments etc.*	100%
			Total	**100%**

Note:

1. The value of each Milestone will be 4% of total Lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example, *the value of Milestone* E2.1.1 will be = *0.04xLSxXxY* = 0.04 x 1x 0.0483.
2. Adjustment to Contract Price shall be applicable to the payments of Works executed under Cost Centre 'E2'.
3. Payment will be made on completion of each Milestones as per weightage given in this Cost Centre.

6.3 Stages of Payment i.e., Milestones of Cost Centre E3 – Maintenance and Manning of Electrical system *for one year*

Cost center			**E3 – Maintenance and Manning of Electrical system *for one year***	
Weightage of Cost Centre 'E3', (Y)			**0.81%**	
Sub Cost Centre	**Item of Work**		**Milestone**	**Weightage (X)**
	No	**Description**		
1	**2**	**3**	**4**	**5**
E3.1	E3.1.1	Maintenance and Manning of *Electrical system* for one year	Maintenance and Manning of Electrical system *for one year*	100.00%

Note:

1. The value of each Milestone will be 4% of total Lump sum *accepted* cost of Works *for* Schedule 'A' *(LS)* multiplied by X * Y. For example, *the value of Milestone* E3.1 will be = *0.04xLSxXxY* = 0.04 x *LS x* 1x 0.0081.

2. Adjustment to Contract Price shall be applicable to the payments of Works executed under Cost Centre 'E3'.

3.Payment will be made on completion of each Milestones as per weightage given in this Cost Centre.

7 Schedule 'B': Other civil works

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
Schedule B1:- NWR-USSOR 2019 BASED ITEMS							
1	011010	Earthwork in cutting (classified) in formation, trolley refuges, side drains, level crossing approaches, platforms, catch water drains, diversion of nallah & finishing to required dimension and slopes to obtain a neat appearance to standard profile inclusive of all labour, machine & materials and removing & leading all cut spoils either to make spoil dumps beyond 10m from cutting edge or for filling in embankment with leads within 2 km on either side of cutting edge, lifts, ascent, descent, loading, unloading, all taxes / royalty, clearance of site and all incidental charges, bailing & pumping out water, if required, etc. complete as per directions of the Engineer in-Charge. The work is to be executed as per latest / updated edition of "Guidelines for Earthwork in Railway Projects" issued by RDSO, Lucknow. Cut trees shall be property of Railways and to be deposited in the railway godown unless specified otherwise in the Special Conditions of Contract. {Note - (i) All usable earth arising from cut spoils shall be led into bank formation and Unusable spoils shall be dumped / stacked (ii) All hard rock /and boulders not fit for					

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		filling will be stacked by the contractor and will be property of the HRIDC.}					
1a	011012	Soft rock not requiring blasting in all conditions	2000	Cum	347.68	389.85	**779,700.00**
1b	011013	In hard rock requiring blasting with explosives and blasting/drilling equipment Including all incidental work in all conditions. Rate includes cost of all explosive material.	45000	Cum	545.17	611.28	**27,507,600.00**
1c	011014	In rock and very hard rock with hammer / chisel / pavement breaker etc. where blasting is not permitted due to special circumstances and if specifically ordered in writing including drilling and all incidental work in all conditions	5000	Cum	1,225.22	1,373.80	**6,869,000.00**
2	022010	Earthwork in excavation by mechanical means (Hydraulic Excavator)/Manual Means for foundations and floors of the bridges, retaining walls etc. including setting out, dressing of sides, ramming of bottom, getting out the excavated material, back filling in layers with approved material and consolidation of the layers by ramming and watering etc. including all lift, disposal of surplus soil upto a lead of 300m, all types of shoring and strutting with all labour and material complete as per drawing and technical specification as directed by Engineer. **Note**: This item will be used for excavation work in					

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		connection with other miscellaneous works also like side drains, foundation for OHE masts and other miscellaneous structures in connection with Gauge Conversion, Doubling, New lines.					
2a	022011	All kinds of soils	6000	Cum	195.57	219.29	**1,315,740.00**
3	022040	Providing and laying in position machine batched, machine mixed and machine vibrated Design Mix Cement Concrete of specified grade **(M-20** Cast in-Situ) using 20mm graded crushed stone aggregate and coarse sand of approved quality in RCC raft foundation & Pile cap including finishing, using Admixtures in approved proportions (as per IS:9103), to modify workability & other properties without impairing strength and durability complete as per specifications and direction of the Engineer in charge. Payment for cement, reinforcement and shuttering shall be paid extra. **Note**-Cement concrete in drainage and other miscellaneous works shall be paid under this item.	1,737	Cum	2,840.33	3,184.77	**5,531,945.49**
4	022070	Providing and fixing Weep Holes in Abutments, RCC Box, Wing walls and Return walls etc., of new bridges with 110mm dia UPVC pipe (IS :13592) Type A ISI marked with all contractor's men,	1,500	Rmt	242.28	282.93	**424,395.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		material, transportation, all taxes as per specifications and as directed by Engineer-in-Charge.					
5	023010	Earth work in OPEN excavation in foundation of bridges, for placing of well curbs of all shapes and designs in all kinds of soil including taking out the excavated soil, levelling, ramming of bottom of excavation and trimming of sides, returning the soil in layers, consolidation, disposal of surplus soil within a lead of 300m, including all lift, dewatering, shoring and strutting complete as per technical specification and as directed by Engineer in charge. (compaction of surplus soil when led to the bank will be paid as per relevant item separately)	300	Cum	293.36	328.94	**98,682.00**
6	023030	Supplying, Fabrication, assembly, erection & placing in position the cutting edge of well curb with structural steel including MS sheet/Plates of specified thickness for pier/abutment complete as per approved plans and as per direction of Engineering In charge including all operations like cutting, bending, straightening, drilling holes, bolting, riveting, welding, threading, jointing of steel sections including outer and inner places liners and skin plates, stiffeners, hooks, bottle nuts, bond rods etc. as per design including all ascent, descents, leads, lifts, handing, re-handling, all other obstructions	9	MT	96,774.58	108,510.24	**976,592.16**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		whatsoever, diverting channels, pumping / bailing out of water wherever required including cost of steel such as flats, sheets, angles, steel bars etc. with all labour and material as a complete job					
7	023040	Dry/Wet Sinking of Circular Wells (Other than pneumatic method) in all types of strata except hard rock requiring ballasting, including bailing and pumping out water, removal of excavated soil with all labour and material required for sinking as per drawing and direction of the Engineer in charge, disposal of surplus soil in the adjoining bank/embankment (compaction to be paid separately under the relevant item).					
7a	023041	From initial level of cutting edge & upto 3m depth	777	Cum	183.34	205.57	**159,769.00**
7b	023042	Above 3m to 10m depth	1,813	Cum	294.64	330.37	**599,092.96**
7c	023043	Above 10m to 15m depth	1,295	Cum	410.28	460.03	**595,876.86**
7d	023044	Above 15m to 20m depth	1,295	Cum	563.53	631.87	**818,461.21**
7e	023045	Above 20m to 25m depth	1,295	Cum	809.02	907.13	**1,175,005.49**
7f	023045	Above 25m to 30m depth	648	Cum	1,249.18	1,400.67	**907,213.96**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
8	023090	Providing and laying in position machine batched, machine mixed and machine vibrated Design Mix Cement Concrete of specified grade (Cast in-Situ) using 20mm graded crushed stone aggregate and coarse sand of approved quality in the following elements of well including finishing, using Admixtures in approved proportions (as per IS:9103), to modify workability & other properties without impairing strength and durability complete as per drawings and technical specifications as directed by Engineer. Payment for cement, reinforcement and shuttering shall be made extra.					
8a	023091	In well Curb	249	Cum	3,124.37	3,503.26	**871,260.76**
8b	023092	In Steining of wells	3,338	Cum	3,124.37	3,503.26	**11,694,932.86**
8c	023093	In Bottom plug for wells including arrangements for placing concrete under water with tremie or bottom opening skips.	432	Cum	3,124.37	3,503.26	**1,512,707.67**
8d	023095	In Intermediate/Top plug with internal shuttering	259	Cum	2,982.35	3,344.01	**866,432.99**
8e	023096	In Well cap and corbel, if provided	412	Cum	2,982.35	3,344.01	**1,378,735.32**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
9	023100	Supplying and filling ordinary sand in between bottom plug and top plug in wells including all lead lift handling, re-handling, as a complete job. Sand should be simultaneously filled with water for three days to achieve full compaction so that further chances of shrinkage due to voids are eliminated					
9a	023102	Using sand from other than River bed (This item is to be operated if suitable sand is not available in River Bed for filling	3,173	Cum	2,031.30	2,277.63	**7,227,831.04**
10	025020	Providing and applying two coats of coal tar or bitumen confirming to IS:3117– latest version on the top and sides of RCC box/slabs @ 1.70 kg/sqm after cleaning the surface with all labour and materials complete job as directed by the Engineer	3,150	Sqm	155.67	174.55	**549,832.50**
11	025030	centering and shuttering including strutting, propping etc. and removal of form for :					
11a	025031	All types of bridge sub-structures, e.g. pier, abutment, wing wall, retaining wall, RCC box type foundations, Abutment cap, Pier Cap, Inspection Platform & Pedestal over Pier cap, Fender wall, Diaphragm wall etc. upto 5m above ground level	16,500	Sqm	671.94	753.42	**12,431,430.00**
11b	025032	All types of bridge super-structures, e.g. slabs, I-girders, T-girders, Box girders etc. upto 5m above ground level	3,200	Sqm	874.49	980.54	**3,137,728.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
11c	025033	Extra for additional height over item no. 025031 & 025032 wherever required with adequate bracing, propping etc. over initial height of 5 metres for every additional height of 1 metre or part thereof	2,600	Sqm	110.17	123.53	**321,178.00**
12	025060	Supply and using Cement at Worksite					
12a	025062	Ordinary Portland Cement 53 grade	335	MT	7,398.80	8,623.08	**2,888,731.80**
12b	025063	Pozzolana Portland Cement	2060	MT	6,905.10	8,047.69	**16,578,241.40**
13	025070	Steel reinforcement for R.C.C. work including straightening, cutting, bending, placing in position and binding all complete					
13a	025072	Thermo-Mechanically Treated bars of grade Fe-500D or more.	1,576,620	Kg	78.01	87.70	**138,269,574.00**
14	031020	Providing and laying in position machine batched, machine mixed and machine vibrated Design Mix Cement Concrete of specified grade using 20mm graded crushed stone aggregate and coarse sand of approved quality for the Precast Prestressed (Post tensioned) concrete girder/Box (spans upto 30.5m) in contactor's casting yard, including finishing, using Admixtures in approved proportions (as per IS:9103), to modify workability & other properties without impairing strength and durability, complete as per drawings, specifications and direction of the	290	Cum	2,840.33	3,184.77	**923,583.30**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		Engineer. Payment for Shuttering, Cement, reinforcement, HTS cables, anchorage cones, stressing of cables and grouting of the ducts will be done extra. Launching of girder/slab in position is not included in this item.					
14a	031021	Deduct from 0310220 for casting of Slab in place of Girder/Box	290	Cum	42.48	47.63	**-13,812.70**
15	031040	Providing, fabricating & fixing in position to exact design profiles, prestressing H.T.S. cables of all classification made from Low Relaxation strands conforming to IS:14268– latest version in Prestressed (Post tensioned) Concrete girders/slabs etc. including supplying, cutting, making into cables with necessary spacers, colour coding, protecting with water soluble oil at all time, anchoring of cables, supplying and placing spiral corrugated type galvanized metal steel ducts sheathing made up of Cold Rolled Cold Annealed (CRCA) mild steel conforming to IS:513 of required diameter/ thickness, vent pipe, placing, bending, routing, fixing, stressing & grouting of cable ducts with cement grout, Anchorage sets in required number with provision for future prestressing if any including all lead and lift with contractor's own materials, labour, equipments etc. complete as per drawings & specifications. Rate also includes	13	MT	179,099.63	232,655.79	**3,024,525.27**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		covering anchorage pads with epoxy mortar of approved quality to avoid corrosion. Cement for grouting to be paid separately. Payment shall be made in terms of weight of HTS cables as per drawing.					
16	031140	Providing and fixing in position GI Drainage Spouts of required length with Grating in RCC slab and filling bitumen along kerb as shown in drawing with contractor's pipes, bitumen, tools, equipment, lead, lifts etc. complete as per specifications and as directed by Engineer in-charge					
16a	031142	100mm dia. Drainage Spouts	120	Metre	1,202.50	1,348.32	**161,798.40**
17	041330	Launching & fixing in specified Bridge location all types of Steel Plate girders / PSC girders / Slabs including loading/unloading and transport to the site of launching with a lead of five kilometres & lifting to any height as per site requirement, provision of approaches for leading, cleaning of bed block and minor repairs to bed block with epoxy if required, as directed by Engineer in charge with all labour, tools and plant, equipment etc., complete					
17a	041331	PSC girders / slabs	910	MT	6,346.14	7,115.72	**6,475,305.20**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
18	041390	Supplying fabricating and erecting welded and/or bolted and/or riveted steel work in built up sections, trusses and framed work, staging, racks etc.for Steel Structures other than bridge girders, using RSJ, tees, angles and channels/flats, plates, gussets, round or square bars, cleats, bolts etc., with contractors own steel including cutting, bending, straightening, drilling, riveting, hoisting, fixing, erecting, welding, bolting etc., with Providing stiffeners wherever required as per approved drawing including applying a priming coat of a approved steel primer with all contractor's materials, labour, tools & plants, lead & lift including crossing of tracks if required etc., complete as per specification and as directed by Engineer-in-charge.	70	MT	86,019.71	122,227.99	**8,555,959.30**
19	051170	Providing and laying of filter media consisting of granular materials of GW, GP, SW groups as per IS:1498 (latest) in required profile behind boulder filling of abutments, wing walls / return walls etc. above bed level with all labour and material complete job as per drawing and technical specification of RDSO Guidelines.	8,500	Cum	2,658.72	2,587.70	**21,995,450.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
20	052230	Providing cast in situ bridge number plaques as per Railway drawing in cement concrete 1:2:4 mix using 20mm hard stone aggregate embedded in 30mm notch in Bridge parapet coping duly engraving the letter and figures and an arrow indicating the direction of flow and finishing the top exposed surface with cement mortar 1:3, painting letters and figures with two coats of black enamel paint on two coats of white background with all labour, tools, cement, paint etc. with all leads and lifts.	5	Each	801.69	898.91	**4,494.55**
21	052240	Providing cast in-situ plaques for bridge foundations details of size 45cmx45cmx5cm in cement concrete 1:2:4 mix using 20mm hard stone aggregate embedded in 30mm deep notch over abutment & piers, engraving the letters & figures with CM 1:3 and finished smooth including painting letters and figures with 2 coats of black enamel and plaque with white enamel with all labour, tools, cement, paint, curing etc. as a complete job.	10	Each	1,049.88	1,177.20	**11,772.00**
Schedule B2:- DSR-2021 BASED ITEMS							
22	10.16	Steel work in built up tubular (round, square or rectangular hollow tubes etc.) trusses etc., including cutting, hoisting, fixing in position and applying a priming coat of approved steel primer, including					

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		welding and bolted with special shaped washers etc. complete.					
22a	10.16.2	Hot finished seamless type tubes	2,000	Kg	168.95	183.55	**367,100.00**
23	10.28	Providing and fixing stainless steel (Grade 304) railing made of Hollow tubes, channels, plates etc., including welding, grinding, buffing, polishing and making curvature (wherever required) and fitting the same with necessary stainless steel nuts and bolts complete, i/c fixing the railing with necessary accessories & stainless steel dash fasteners , stainless steel bolts etc., of required size, on the top of the floor or the side of waist slab with suitable arrangement as per approval of Engineer-in-charge, (for payment purpose only weight of stainless steel members shall be considered excluding fixing accessories such as nuts, bolts, fasteners etc.).	800	Kg	612.25	665.14	**532,112.00**
24	16.30.2	Providing and applying tack coat using hot straight run bitumen of grade VG - 10, including heating the bitumen, spraying the bitumen with mechanically operated spray unit fitted on bitumen boiler, cleaning and preparing the existing road surface as per specifications On bituminous surface @ 0.50 Kg / sqm	4,252	Sqm	36.60	39.76	**169,059.52**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
25	16.33.2	2.5 cm premix carpet surfacing with 2.25 cum and 1.12 cum of stone chippings of 13.2 mm and 11.2 mm size respectively per 100 sqm and 52 kg and 56 kg of hot bitumen per cum of stone chippings of 13.2 mm and 11.2 mm size respectively, including a tack coat with hot straight run bitumen, including consolidation with road roller of 6 to 9 tonne capacity etc. complete (tack coat to be paid for separately). With paving Asphalt grade VG - 30 with no solvent	4,125	Sqm	254.80	276.81	**1,141,841.25**
26	16.40	Providing and laying seal coat of premixed fine aggregate (passing 2.36 mm and retained on 180 micron sieve) with bitumen using 128 kg of bitumen of grade VG - 10 bitumen per cum of fine aggregate and 0.60 cum of fine aggregate per 100 sqm of road surface, including rolling and finishing with road roller all complete	4,125	Sqm	79.85	86.75	**357,843.75**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
27	16.55.1	Providing and laying bituminous macadam using crushed stone aggregates of specified grading premixed with bituminous binder, transported to site by tippers, laid over a previously prepared surface with paver finisher equiped with electronic sensor to the required grade, level and alignment and rolling with smooth wheeled, vibratory and tandem rollers as per specifications to achieve the desired compaction and density, complete as per specifications and directions of Engineer-in-Charge.50 to 100 mm average compacted thickness with bitumen of grade VG-30 @ 3.50% (percentage by weight of total mix) prepared in Batch Type Hot Mix Plant of 100-120 TPH capacity.	1,200	Cum	7,756.40	8,426.50	**10,111,800.00**
28	16.69	Providing and laying at or near ground level factory made kerb stone of M-25 grade cement concrete in position to the required line, level and curvature, jointed with cement mortar 1:3 (1 cement: 3 coarse sand), including making joints with or without grooves (thickness of joints except at sharp curve shall not to more than 5mm), including making drainage opening wherever required complete etc. as per direction of Engineer-in-charge (length of finished kerb edging shall be measured for payment). (Precast C.C. kerb stone shall be approved by Engineer-in-charge).	20	Cum	8,613.55	9,357.71	**187,154.20**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
29	16.75	Providing and laying C.C. pavement of mix M-25 with ready mixed concrete from batching plant. The ready mixed concrete shall be laid and finished with screed board vibrator , vacuum dewatering process and finally finished by floating, brooming with wire brush etc. complete as per specifications and directions of Engineer-in-charge. (Note:- Cement content considered in this item is @ 330 kg/cum. Excess/less cement used as per design mix is payable/ recoverable separately).	220	Cum	8,277.55	8,992.68	**1,978,389.60**
30	16.78.2	Construction of granular sub-base by providing close graded Material conforming to specifications, mixing in a mechanical mix plant at OMC, carriage of mixed material by tippers to work site, for all leads & lifts, spreading in uniform layers of specified thickness with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per specifications and directions of Engineer-in-Charge. With material conforming to Grade-II (size range 53 mm to 0.075 mm) CBR Value-25	600	Cum	2,775.65	3,015.45	**1,809,270.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
31	16.79	Providing, laying, spreading and compacting graded stone aggregate (size range 53 mm to 0.075 mm) to wet mix macadam (WMM) specification including premixing the material with water at OMC in for all leads & lifts, laying in uniform layers with mechanical paver finisher in sub- base / base course on well prepared surface and compacting with vibratory roller of 8 to 10 tonne capacity to achieve the desired density, complete as per specifications and directions of Engineer-in-Charge	550	Cum	2,803.65	3,045.87	**1,675,228.50**
32	16.91	Providing and laying factory made chamfered edge Cement Concrete paver blocks in footpath, parks, lawns, drive ways or light traffic parking etc, of required strength, thickness & size/ shape, made by table vibratory method using PU mould, laid in required colour & pattern over 50mm thick compacted bed of sand, compacting and proper embedding/laying of inter locking paver blocks into the sand bedding layer through vibratory compaction by using plate vibrator, filling the joints with sand and cutting of paver blocks as per required size and pattern, finishing and sweeping extra sand. complete all as per direction of Engineer-in-Charge.					
32a	16.91.1	60 mm thick C.C. paver block of M-30 grade with approved color design and pattern.	450	SQM	932.35	1,012.90	**455,805.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
33		Items included in Delhi Schedule of Rate-(Horticulture & Landscaping) 2020		LS			**1,060,000.00**
Schedule B3:- NS BASED ITEMS							
34	NS-1	Earthwork in filling with contractor's own earth of approved quality from borrow areas including all lead all lead, lift, ascent, descent, royalty, taxes, cess, compensation, crossing of nallahs /stream and other obstructions including mechanical compaction in layers with watering to 95% of MDD (as per IS 2720 part 8), handling, re-handling, dressing to the final profile with all labour, material, tools, plant, machinery and equipment, taxes, cess etc. as a complete job in accordance with the specification and drawings.	2,000	Cum	271.46	287.75	**575,500.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
35	NS-2	Supplying and laying in position **M-35 RCC** as per approved design mix with admixtures and manufactured in fully automatic batching plant and transported to site of work in transit mixer for all lifts & leads, having continuous agitated mixer, pumping concrete from transit mixer to site of laying, compacting, finishing & curing, with all labour, material, tools, plants, machinery and equipment, taxes, cess etc., as a complete job ,but excluding supplying & fixing form work (centring & shuttering),in accordance with the specification and drawings.Note – (i) Cost of cement is included in the above item.(ii) Cost of Reinforcement steel is not included in the above item and will be paid separately under item no.8(I) (USSOR item No. 025072)(iii) Cost of supplying & fixing form work (centring & shuttering) is not included in the above item (except pile cap & open foundation) and will be paid separately under relevant item no. 6(i),(ii),(iii) (USSOR item No. 025030)					
35a	NS-2A	In Pile caps, open foundation & RCC Box/Sub way, well steining, well cap	4,935	Cum	7,776.37	8,242.95	**40,678,958.25**
35b	NS-2B	In Piers, abutments, box	960	Cum	8,098.18	8,584.07	**8,240,707.20**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
35c	NS-2C	Abutment cap & Pier Cap, pedestals, approach slab, Deck slab	460	Cum	8,421.36	8,926.64	**4,106,254.40**
35d	NS-2D	Retaining walls, wing walls, return walls, drop walls, curtain walls, toe walls etc. of all heights	700	Cum	7,888.74	8,362.06	**5,853,442.00**
36	NS-3	Providing Boulder Backing behind wing wall, return wall, retaining wall with hand packed boulders & cobbles not less than 15cm in any direction & not less than 15kg (except smaller boulders required for filling voids) including all lead, lift, labour & other incidental charges as complete work in all respect. Cost of boulder/cobbles is included in this item.	1,900	Cum	1,475.82	1,564.37	**2,972,303.00**
37	NS-4	Providing and fixing of 75mm dia PVC pipe for weep holes in abutments, Wing Wall, Return Wall, Face wall, retaining wall etc. at suitable intervals as directed by the Engineer-in-charge.	1,000	Rmt	231.00	244.86	**244,860.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
38	NS-5	Casting, supplying and installation of Pre-cast cement concrete blocks of size 25X25 X20cm. or of required size as directed by the Engineer for protective works at bridges & banks like pitching, toe wall, flooring, drains etc. using M20 design concrete mix with 20mm aggregate size including Contractor's shuttering, leading to bridge site from casting depot, including dressing and levelling of surface, providing gravel backing, laying & jointing blocks with cement mortar 1:3 with Contractor's labour and as directed by Engineer-in-charge (All labour and materials including cement by Contractor). Note: i) Payment for gravel backing will be paid under item no. NS-6 of this Bill. ii) 60% Payment shall be made after casting of pre-cast concrete blocks and bringing at work site. The balance 40% will be made on completion of laying and finishing. iii) Measurement is based on quantity calculation of blocks used only (no of blocks x volume of one block).	1,400	Cum	7,731.14	8,195.01	**11,473,014.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
39	NS-6	Supplying and laying of 150mm thick well graded stones aggregate/gravel as base layer over the slopes of embankment with manual dressing with water compaction including the cost of supply of all material, labour, lead, lift, tools, plants, crossing of tracks etc. complete as per approved drawings and technical specifications.	1,080	Cum	2,139.90	2,268.29	**2,449,753.20**
40	NS- 7	Supply & installation of precoated galvanized iron profile sheets (size, shape and pitch of corrugation as approved by Engineer-in-charge) 0.50mm +/- 5% total coated thickness (TCT) thick Zinc coating 120gsm as per IS:277 in 240mpa steel grade, 5-7microns epoxy primer on both side of the sheet and polyester top coat 15-18 microns. Sheet should have protective guard film of 25 microns minimum to avoid scratches while transportation and should be supplied in single length upto 12 metre or as desired by Engineer-in-charge. The sheet shall be fixed using self drilling / self tapping screws of size (5.5 x 55mm) with EPDM seal or with polymer coated J or L hooks, bolts and nuts 8mm diameter with bitumen and G.I. limpet washers or with G.I. limpet washers filled with white lead complete upto any pitch in horizontal/vertical or curved surfaces excluding the cost of purlins, rafters and trusses and including cutting to size and shape wherever required.	100	Sqm	756.52	801.91	**80,191.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
41	NS-8	Ø25 SN Bolts (Cement grouted): Supply, drilling, installation and grouting of SN type rockbolts of the specified length, Yield strength ≥500 MPa (slopes, tunnel support & face bolts) as per approved drawings and Specifications or as directed by Engineer, with contractors men, material, consumables, plants, equipments, machineries, including all lead & lifts loading , unloading etc required for the complete job.	4,500	Rmt	430.25	456.07	**2,052,315.00**
42	NS-9	Wire Mesh: Supply, cutting, placing and fixing into position with appropriate anchors of 150x150x6 mm or 100x100x4 mm welded wire fabric of Fy=480 MPa as reinforcement in primary lining & inner lining with contractors men, material, cost of pins, hooks, consumables , tools & plants, equipments, machineries, including all lead & lifts, loading , unloading, handling complete job .	11	MT	77408	82,052.48	**902,577.28**
43	NS-10	M30 Shotcrete : Shotcreting with wiremesh/fibers as per design Primary lining :Shotcrete for primary (outer) lining of Tunnel or Niches, grade M30, including face sealing shotcrete, temporary invert, filling of cavities, widening of top heading footing in tunnel and slope stabilization and in open excavation etc. Note: The Dry shotcrete shall also be payable under this item.	250	Cum	10269	10,885.14	**2,721,285.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
44	NS-11	Supply of structural steel for steel ribs of various sections confirming IS 2062 of Grade-A from approved manufacturers at various sites including all transportation and freight charges and all taxes, duties etc. with contractors men, material, tools & plants, equipments, machineries, testing, all lead & lifts, loading , unloading , etc complete	4	MT	77968.38	82,646.48	**330,585.92**
45	NS-12	Steel Ribs: Fabrication and erection in position permanent tunnel steel ribs including of variable geometry and or member size as per design/assembly, using structural steel Grade A, Yield stress ≥250MPa with all accessories such as bolt/nuts, washers, plates, tie rods etc., including cutting, drilling, cold bending, welding, threading, leveling, aligning and fixing in position of all rods, gusset/ wall plates, pre-stressing by blocking against rock-surface etc. as per approved drawings and Specifications or as directed by Engineer with contractor's men, material, consumables, tools and plants, equipments, machineries, including all lead and lift, loading, unloading. Rate to cover supports & scaffoldings required during the course of erection etc. complete.Note: Payment for supply of structural steel shall be paid as per approved drawing	1	MT	9944	10,540.64	**10,540.64**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		(excluding all wastages) separately as per item NS-11.					
46	NS-13	Lattice Girders: Fabrication and erection of lattice girders using high strength reinforcing steel Fe-500D with all accessories such as bolt/nuts, washers, plates, tie rods etc, including all lead, lift, wastage, storing, drilling holes, fixing in phases etc. and installation of accessories for joining the Lattice girder segments and fixing into place as per approved drawings and Specifications or as directed by Engineer. The rate shall include costs of all materials except as noted below, labour, equipment, welding, etc for the complete job including additional cost for enlargement of top heading footing. (Payment for supply of reinforcement steel (excluding all wastages) will be made separately as per item NS-11)	3	MT	9944	10,540.64	**31,621.92**
47	NS-14	Providing, fabricating & laying of colour coated galvalume (Proflex system roofing)material for self supported roofing system, material shall be of following specification, BMT 0.90mm to 1.00mm,APT 0.95mm tolerance +/- 0.02mm thick ,Width 605 mm or as decided by railway (Tolerance +/- 2mm),including supplying, loading ,transporting, uploading & stacking at site ,fabricating and laying with all contractors tools, plants, machineries	100	Sqm	2370.98	2,513.24	**251,324.00**

Schedule 'B' Other Civil Works							
S. No	**Item No.**	**Description of Item**	**Quantity**	**Unit**	**NWR USSOR/DSR Rate in INR**	**Estimated Rate including GST @ 18 % in INR**	**Estimated Amount in INR**
		materials and fixtures labours including all lead and lift and laps/wastage if any etc. complete. The colour of sheet will be decided by Engineer. The rate is also inclusive of designing of roofing system, proof checking and providing execution drawing. Fabrication and installation of self supported roofing.					
						Total Amount of Schedule 'B'	**389,447,602.42**

8 Schedule 'C': Item rate for miscellaneous woks

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
DSR-21 Items						
1	DSR-21 19.35	Providing and laying Non Pressure NP-3 class (Medium duty) R.C.C. pipes including collars/spigot jointed with stiff mixture of cement mortar in the proportion of 1:2 (1 cement : 2 fine sand) including testing of joints etc. complete.				
I	19.35.1	450mm dia. RCC pipes	Metre	2385.5	8.64%	**2,591.61**
II	19.35.2	600 mm dia RCC pipes.	Metre	3051.55	8.64%	**3,315.20**
2	DSR-21 19.6	Providing and laying non-pressure NP2 class (light duty) R.C.C. pipes with collars jointed with stiff mixture of cement mortar in the proportion of 1:2 (1 cement : 2 fine sand) including testing of joints etc. complete :				
I	19.6.1	100 mm dia. R.C.C. pipe	Metre	447.25	8.64%	**485.89**
II	19.6.2	150 mm dia. R.C.C. pipe	Metre	493.1	8.64%	**535.70**

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
III	19.6.3	250 mm dia. R.C.C. pipe	Metre	811	8.64%	**881.07**
3	DSR-2021 16.90	Providing and laying tactile tile (for vision impaired persons as per standards) of size 300x300x9.8mm having with water absorption less than 0.5% and conforming to IS:15622 of approved make in all colours and shades in for outdoor floors such as footpath, court yard, multi modals location etc., laid on 20mm thick base of cement mortar 1:4 (1 cement : 4 coarse sand) in all shapes & patterns including grouting the joints with white cement mixed with matching pigments etc. complete as per direction of Engineer-in-Charge.	Sqm	1719	8.64%	**1,867.52**
4	DSR-21 11.26	Kota stone slab flooring over 20 mm (average) thick base laid over and jointed with grey cement slurry mixed with pigment to match the shade of the slab, including rubbing and polishing complete with base of cement mortar 1: 4 (1 cement : 4 coarse sand) Cost of cement is included in this item.				
I	11.26.1	25 mm thick	Sqm	1706.6	8.64%	**1,854.05**

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
USSOR-2019(NWR) Items						
5	USSOR-2019(NWR) 031110	Load testing of one or more spans of bridge as selected by the Engineer as per approved load test procedure following relevant IS/IRC/Railway codes with contractor's labour, deflection measuring instruments, loading materials, recoding and analyzing the load testing results including all lead & lift, etc. complete as required. The rates are all inclusive and will be paid after load test is finished and girder is cleared of the kentledges/loading material etc. The load shall be 1.25 times the stipulated design load.				
I	031111	For Span design load upto 100 MT	Each	85662.09	12.13%	**96,052.90**
II	031112	Extra for every increase 1 MT or part thereof in the span design load capacity upto 800 MT	MT	845.81	12.13%	**948.41**

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
6	021010	Exploratory drilling of boreholes down to required depth, drilling of 150mm dia. boreholes in all type of soils except hard rock & large boulders (boulder core more than 30cm) including refilling, reinstating surface and disposing off surplus material including use of mechanical rigs with power operated winches as well as percussion/chiselling tool for advancing through occasional seams of hard strata to be employed, where necessary in Dry area.				
I	021011	0m to 10m	Metre	1,213.51	12.13%	**1,360.71**
II	021012	10m to 20m	Metre	1,296.46	12.13%	**1,453.73**
III	021013	20m to 30m	Metre	1,431.59	12.13%	**1,605.24**
IV	021014	30m to 40m	Metre	1,554.68	12.13%	**1,743.26**
7	*021050*	*Drilling of NX size borehole (75mm dia.) in all types of hard rock and collection of rock core samples from boreholes and preserving in boxes*				
I	*021051*	*0m to 10m*	*Metre*	*3,189.64*	*12.13%*	***3,576.54***
II	*021052*	*10m to 20m*	*Metre*	*3,418.43*	*12.13%*	***3,833.09***
III	*021053*	*20m to 30m*	*Metre*	*3,775.66*	*12.13%*	***4,233.65***

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
8	*021060*	*Conducting in-situ full size Plate Load Test (PLT) at selected location as per IS:1888 including making loading arrangements & casting of RCC/cast in-situ concrete footing as per codal provisions including excavation and refilling of trial pit*				
I	*021062*	*Plate size 45cm x 45cm*	*Each*	*27,754.18*	*12.13%*	***31,120.76***
II	*021063*	*Plate size 60cm x 60cm*	*Each*	*31,000.02*	*12.13%*	***34,760.32***
9	*021080*	*Conducting SCPT for soil as per IS:4968*	*Each*	*47,313.49*	*12.13%*	***53,052.62***
10	*021090*	*Conducting DCPT for soil as per IS:4968*	*Each*	*37,394.02*	*12.13%*	***41,929.91***
11	*021110*	*Taking out 100mm dia. & 450mm long undisturbed samples of soil from bore holes, including provision of air tight containers for packing and, labelling incl. transporting the samples to laboratory. Piston sampler shall be used for extracting undisturbed samples where necessary. Samples shall be collected as per IS:2720.*	*Each*	*152.52*	*12.13%*	***171.02***
12	*021120*	*Taking out 100mm dia. & 450mm long disturbed samples of soil from bore holes, including provision of air tight containers for packing, labelling and transporting the samples to laboratory. Samples shall be collected as per IS:2720.*	*Each*	*164.57*	*12.13%*	***184.53***

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
13	*021130*	*Conducting standard penetration test as per IS:2131 at approximate1.5m intervals in bore holes, as directed by the Engineer in charge*	*Each*	*852.27*	*12.13%*	***955.65***
14	*021150*	*Conducting laboratory Tests on collected soil samples as per relevant IS code*				
I	*021151*	*Moisture Content/Dry Density*	*Each*	*287.66*	*12.13%*	***322.55***
II	*021152*	*Atterberg Limits*	*Each*	*586.02*	*12.13%*	***657.10***
III	*021153*	*Specific Gravity*	*Each*	*631.51*	*12.13%*	***708.11***
IV	*021154*	*Grain size analysis including Hydrometer analysis*	*Each*	*731.85*	*12.13%*	***820.62***
V	*021155*	*Direct Shear Test*	*Each*	*2,140.70*	*12.13%*	***2,400.37***
VI	*021156*	*Natural Density*	*Each*	*709.11*	*12.13%*	***795.13***
VII	*021157*	*Consolidation Test*	*Each*	*6,886.37*	*12.13%*	***7,721.69***
VIII	*021158*	*Unconfined Compression Test*	*Each*	*2,006.91*	*12.13%*	***2,250.35***
IX	*021159*	*Tri-axial Test*	*Each*	*2,408.29*	*12.13%*	***2,700.42***
NS Items						
15	*NS-1*	*Boring 1200 mm diameter piles using Hydraulic Rig in all kinds of strata including boulder studded soil, underground structure like channel, sewer manholes, old foundation or any other obstruction, irrespective of sub-soil water level in all conditions whether dry or under water, shoe and temporary casing pipe, if*	*Rmt*	*10,232.00*	*6.00%*	*10,845.92*

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
		required, with contractor plant, machinery & equipment for pile boring, use of bentonite slurry including all operations, cleaning of bore holes, supplying and laying in-situ with tremie pipe M-35 RCC in piles as per approved design mix with admixtures and manufactured in fully automatic batching plant and transported to site of work in transit mixer for all lifts & leads, having continuous agitated mixer, pumping concrete from transit mixer to site of laying including supplying & fixing form work (centering & shuttering), compacting, finishing, curing, chipping off pile top to remove laitance concrete above cut off level, removal and disposal of surplus excavated earth/debris/muck outside ROW including all lead, lift, ascends, descends, loading, unloading handling, re-handling, crossing of stream, nallahs, railway track, level crossing etc. with all labour, material, tools, plants, machinery and equipment, taxes, cess etc. as a complete job in accordance with the Specification and the Drawings. *Note –* *i. Cost of cement is included in the above item.*				

Schedule 'C' Item rate for miscellaneous woks						
S. No	**Item Reference DSR-21/USSOR-2019 (NWR)/NS**	**Description of Item**	**Unit**	**Basic Rate in INR**	**Add % Above for Estimate**	**Estimated Rate in INR**
		ii. Cost of Reinforcement steel is not included in the above item and will be paid separately under relevant item of Schedule-B. *iii. Cost of temporary casing pipe is included in the above item. However, cost of permanent casing pipe is not included in this item and shall be paid separately under item, if required and approved by the Engineer.*				

Total Estimated cost of Schedule 'C'- INR 2.00 Crore (INR 20 million).