# Section VII-8:

## B. Tender Documents

| List of Documents | |
|---|---|
| 1 | Design Basis Report |
| 2. | List of Curve and Gradients |
| 3. | List of Control Points |
| 4 | List of Charted Utilities |
| 5 | Geotechnical Investigation Reports for Tunnel |
| 6 | Geotechnical Interpretive Report for Bridges |
| 7 | Approved Manufactures/Suppliers List |

# 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) |

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BHUBANESWAR-751010, ODISHA

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# 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 Prithalastation 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 constructedmovement 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:

[1] Finite Element Analysis code for Excavations and Slopes.

[2] RocData Manual

[3] IS: 456: 2000–Plain and Reinforced Concrete Code of Practice

[4] *RDSO Design and Construction Guidelines of Tunnels – G17*

[5] 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.

[6] IS:15026-2002: Tunneling methods in rock masses – Guidelines, Bureau on Indian Standards, New Delhi.

[7] Indian Railway Standard Code of Practice for Plain, Reinforced and Pre-Stressed Concrete Bridge [ IRS-CBC]

[8] IS 1893(Part-1): 2002 Criteria for earthquake resistant design of structures

[9] Seismic design and analysis of underground structures" by YMA Hashish, JJ Hook, Birger Schmidt and John I-Chiang Yao.

[10] 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

[11] .ITA guidelines for Tunnel ventilations and Fire Safety.

[12]. Other relevant IS Codes and IRS Code.

[13]. U.S. Army Corps of Engineers Manual EM1110-2-2901 _Engineering and Design Tunnel andShafts 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-FerozpurJhiraka 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 thearea.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.

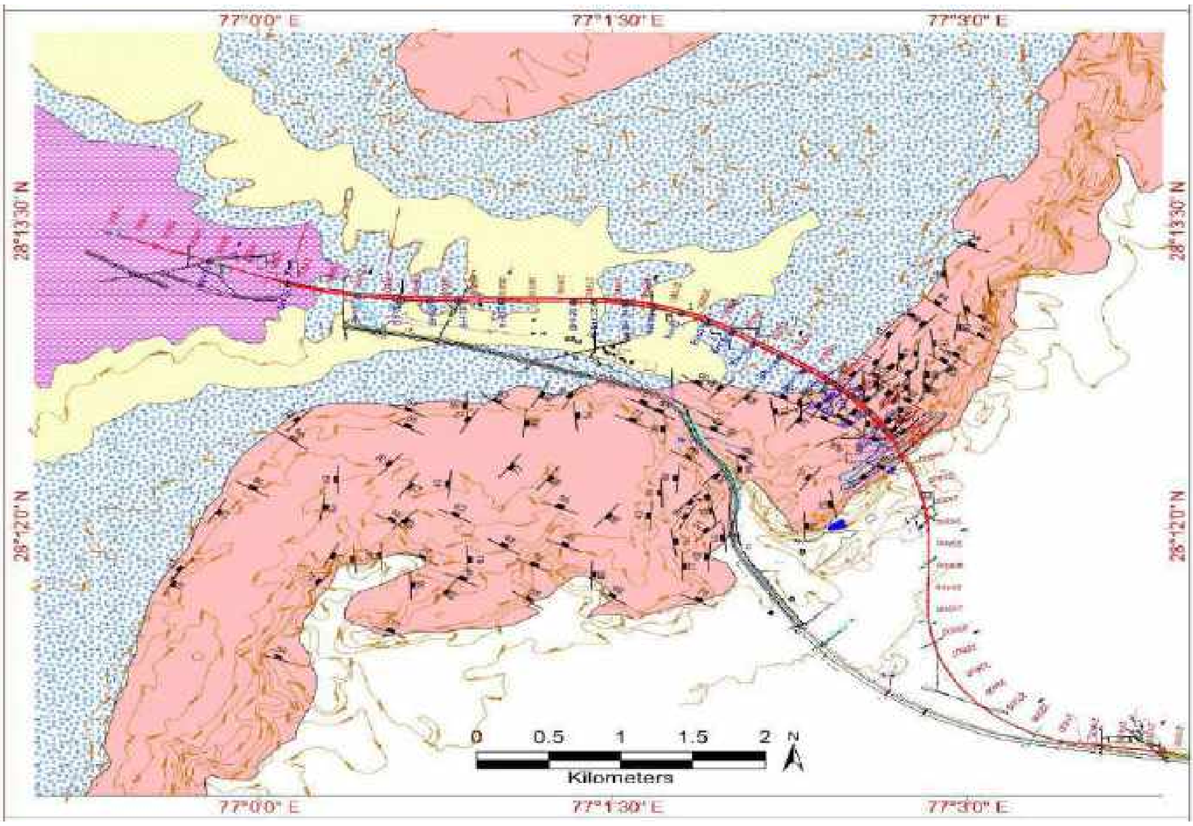


*Figure 1:* Google Map of proposed Tunnel

# 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 |
|---|---|---|---|

| 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 RocData 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 MassPortal (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 | c (peak) | MPa | 0.395 |
| | Φ (peak) | deg | 49.38 |
| | c (residual) | MPa | 0.354 |

| | | | |
|---|---|---|---|
| Parameters | 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 strength(fck) | MPa | IS 456:2000 | 25 |
| 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 |

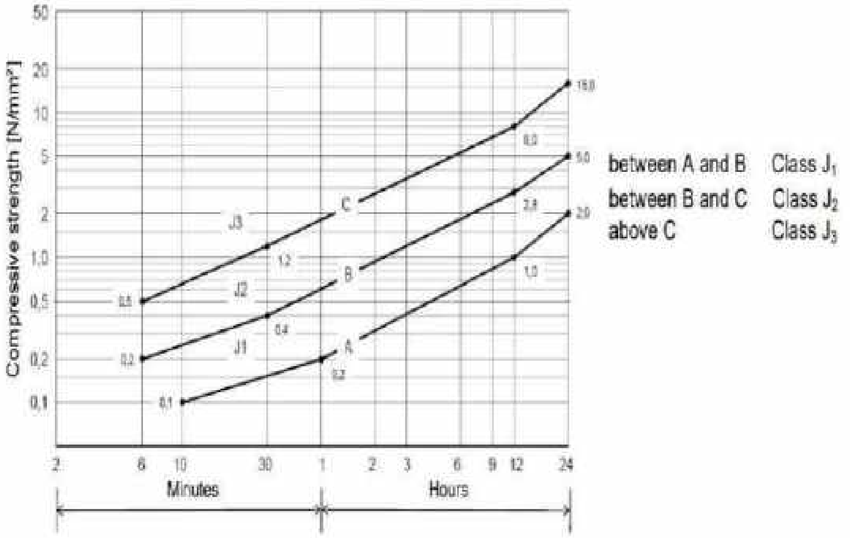


*Figure 2:*Early strength development of young shotcrete

### 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.

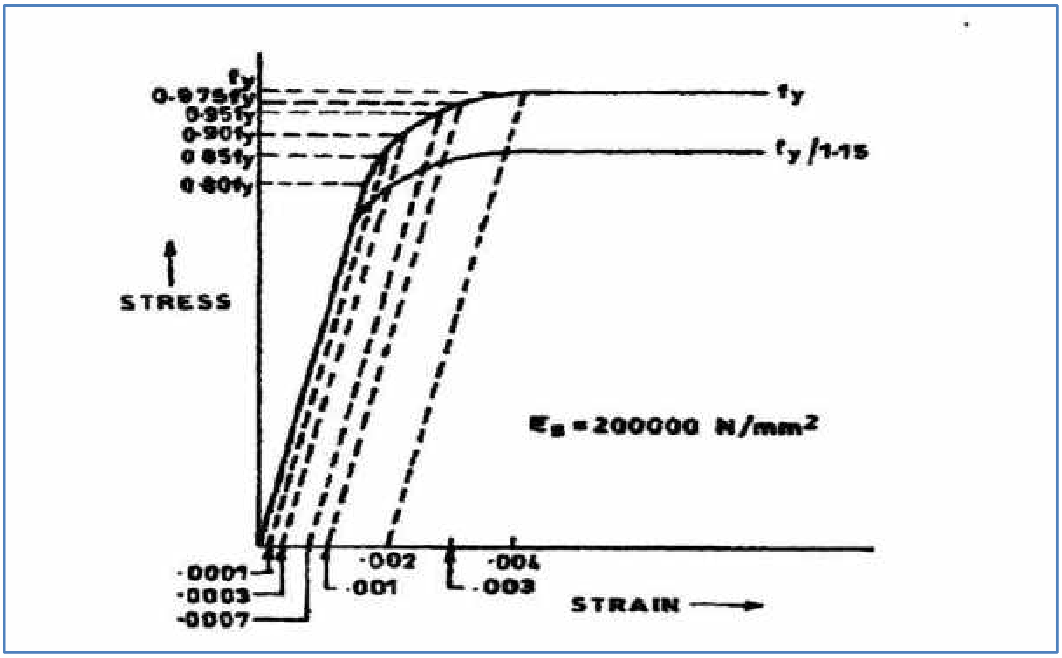


*Figure 3: Characteristic Curve of Fe500D*

### 7.2.10. *Self-Drilling Anchor*

For Portal P2 which falls in soil self-drillinganchor 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 sectionas 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 | $m^4$ | $7.18x10^{-6}$ | $2.12 \times 10^{-5}$ | $5.13 \times 10^{-5}$ |
| Modulus of Elasticity | MPa | 200000 | 200000 | 200000 |
| Yeild Strength of Steel Rib | MPa | 250 | 250 | 250 |

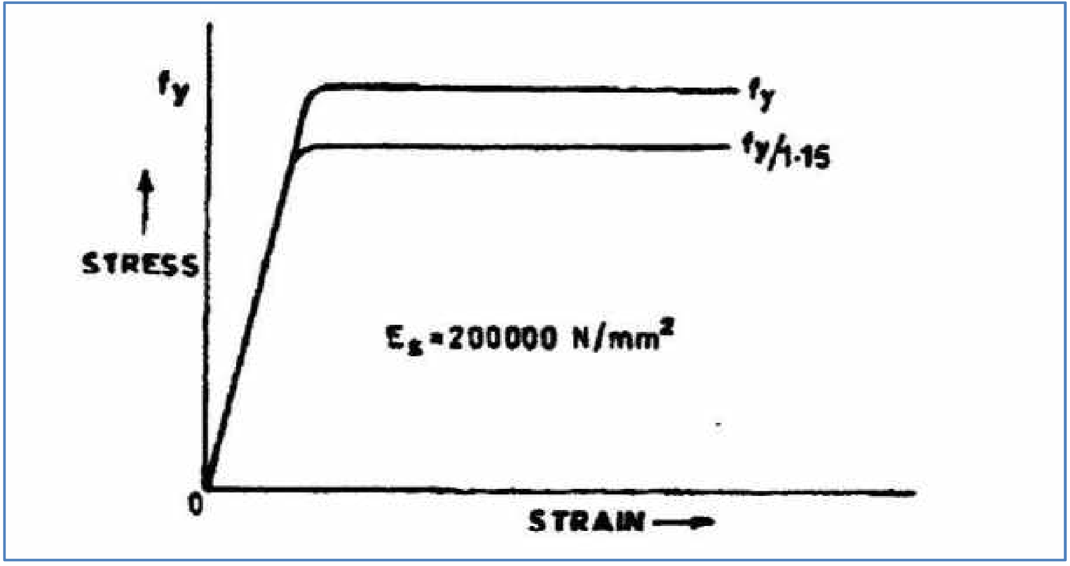


Figure 4:Characteristic Curve of Fe250

## 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), itshall be reanalyzed with suitable slope protection measures to achieve desired factor of safety.

### 7.2.1. 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.

### 7.2.2. Types of Failure

Various types of failure of portal cut slope have been given below, for which adequacy of support system shall be checked.

### 7.2.3. 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 ± $20^{o}$) 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.

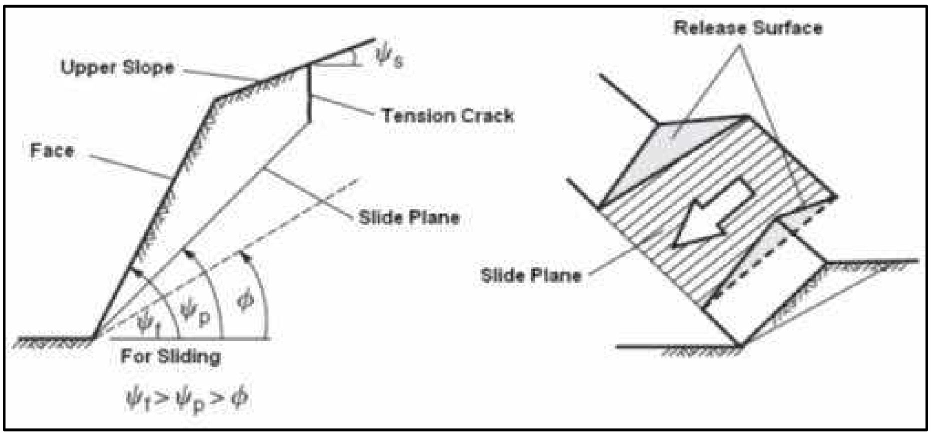


*Figure 5: Geometric Conditions for Planar Failure*

### *7.2.4. 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 ($\alpha_i$) and its plunge ($\psi_i$).
b) The plunge of the Ib 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:**$\psi_{fi}$ would only be the same as $\psi_f$, 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 $\alpha_i$ and $\alpha_{i'}$.

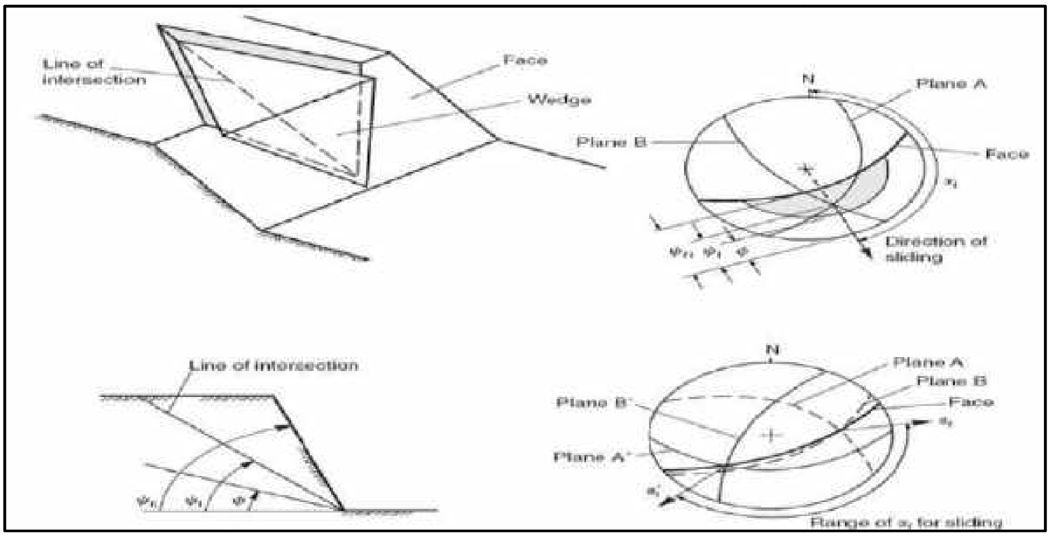


Figure 6: Geometric Conditions for Wedge Failure

### 7.2.5. 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.

### 7.2.6. 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.

### 7.2.7. Rock Fall Barrier

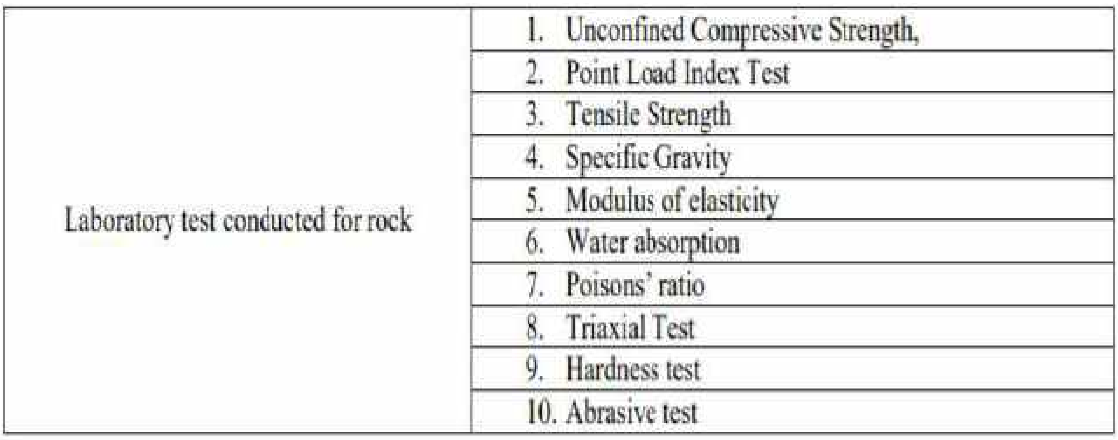
At portal-1 rock fall barrier at different locations shall be installed based on the size of the boulder and its kinetic energy to protect both portal and DFCC track.

## 8 Design Basis Report for Tunnel Underground Excavation

### 8.1. Geology of Tunnel

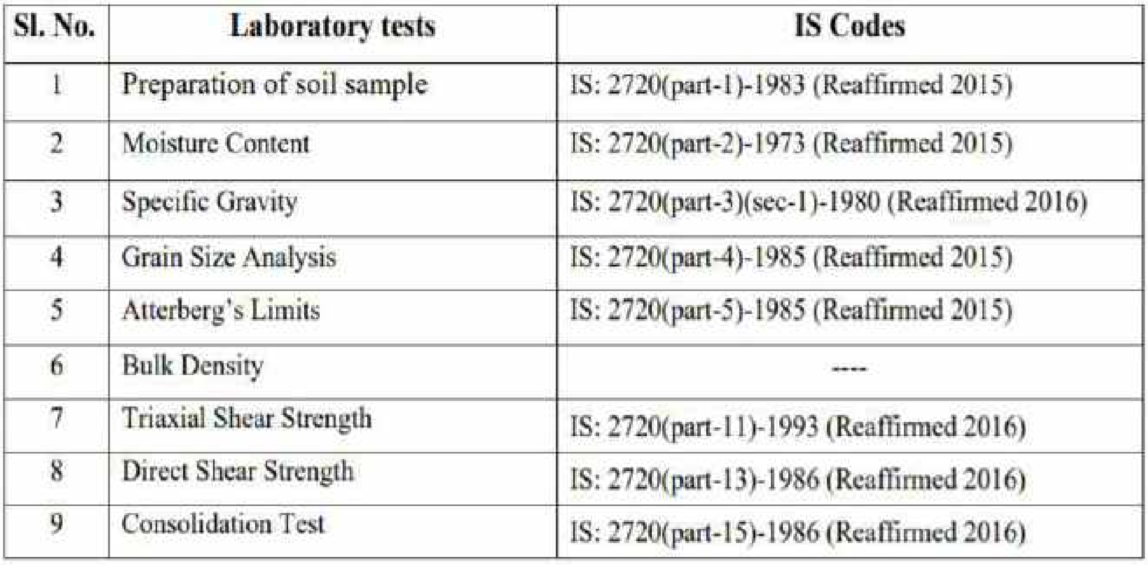
Proposed HORC tunnel for NATM is around3600 m long out of which 1120m is inside the rock while remaining 2480 m falls in soil as indicated in geological section. For 1120m long Tunnel sub surface exploration has been carried out with total 6 Nos of bore hole namely BH-13, BH-14, BH-15, BH-15A, BH-16& 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

$\sigma 1'$ = $\sigma_{3'} + \sigma_{ci} ((m_b \text{ x } \sigma_{3'} / \sigma_{ci}) + s)^a$

$m_b$ = $m_i$ exp ((GSI – 100)/(28-14D))

s = exp ((GSI-100)/ (9-3D))

a = ½ + 1/6 x (e-GSI/15 – e-20/3)

Em = Ei (0.02 + ((1-D/2)/ (1+e ((60+15D-GSI)/11))))

$\sigma_3$and $\sigma_1$' are the minor and major effective principal stresses at failure.

$\sigma_{ci}$ 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<br>(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*** | |
|---|---|---|
| $\Phi$ for cohesive soil (from Laboratory Test) | CL | 19° |
| $\Phi$ for non-cohesive soil (from corrected N Value) | ML | 32° |
| | ML-CL | |
| | SM | |
| Cohesion (C) (from Laboratory Test) | CL | 25 KPa |
| Cohesion (C) (from Laboratory Test) | ML | 3 KPa |
| | ML-CL | |
| | SM | |
| 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 ($\sigma_3$) | 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 ($\sigma_1$) | MPa | |
| | Out of Plane Horizontal Stress ($\sigma_z$) | 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 SteelFiber 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 forfibers.
- 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/m$^3$ of Shotcrete shall be derived.*

| Grade of mix | FRS | Reference Code | M35 |
|---|---|---|---|
| Modelled in Phase$^2$ 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 | $mm^2$ | 491 |
| 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 | $m^4$ | $1.16 \times 10^{-5}$ |
| Modulus of Elasticity | MPa | 200000 |
| Yield Strength of Steel | MPa | 500 |

Table 15: Lattice Girder Properties

## 8.7. NATM Tunneling – 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).

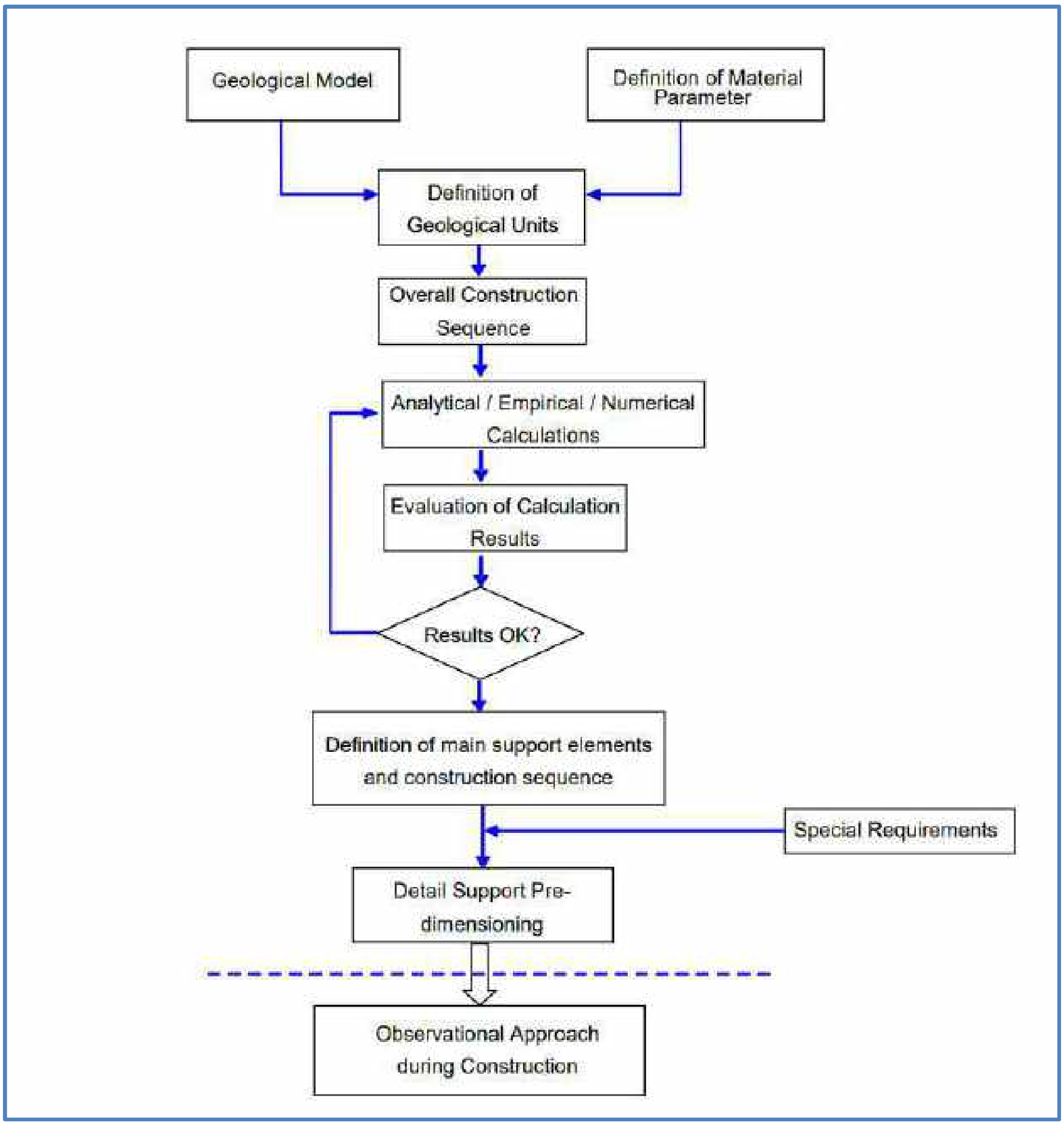
The primary support, which consists of shotcrete, generally reinforced by wire mesh, lattice girders (where required) and rock bolts, will provide the immediate support and stability of the excavation. The secondary liningwill provide the long-term support and durability of the tunnel.

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 RocData.

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 RocData 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 $\gamma_r$is partial safety factorand $\rho_r$density of rock , $\gamma_r = 1$ shall be adopted.

**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-Sinφ

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

$$S_b = 0.5m + 2.5m.\frac{RMR - 20}{65}$$ if 20<RMR<=85

$$S_b = 0.25m + \frac{(RMR - 10)^{1.5}}{140}.m$$ if 10 < RMR<= 20

$$S_b = 0.25m$$

RMR <=10

## 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**

$$F_{bd} = \frac{F_b}{\gamma_b}.\left(\frac{RMR}{85}\right)^{\frac{40}{RMR}}$$

## 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**

$$f_{cd} = \frac{f_{ck}}{\gamma_s}.\left[0.2 + 0.8.\left(\frac{RMR}{100}\right)^{\frac{3}{2}}\right]$$

**Where$f_{ck}$ is shotcrete cylinder strength and $\gamma_s$ 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 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.

### 9.7 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.

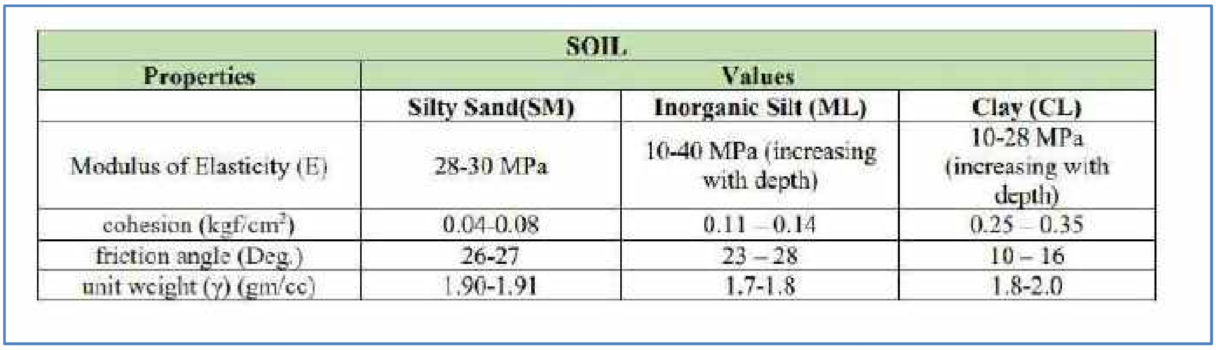
## *10.1 Sensitivity Analysis:*

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 ($\gamma$) (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 therock 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]**

- The dead load shall include self-weight of structural concrete. The self-weight of structural concrete is calculated internally by STAAD Pro software.
- 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 followed.

- 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)

$\nu$ 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 rail and 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 33.7 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 $\gamma_r$ is partial safety factor for lining design this will be equal to unity and $\rho_r$ density of rock.

**$P_v$** rock load intensity in kN/m$^2$

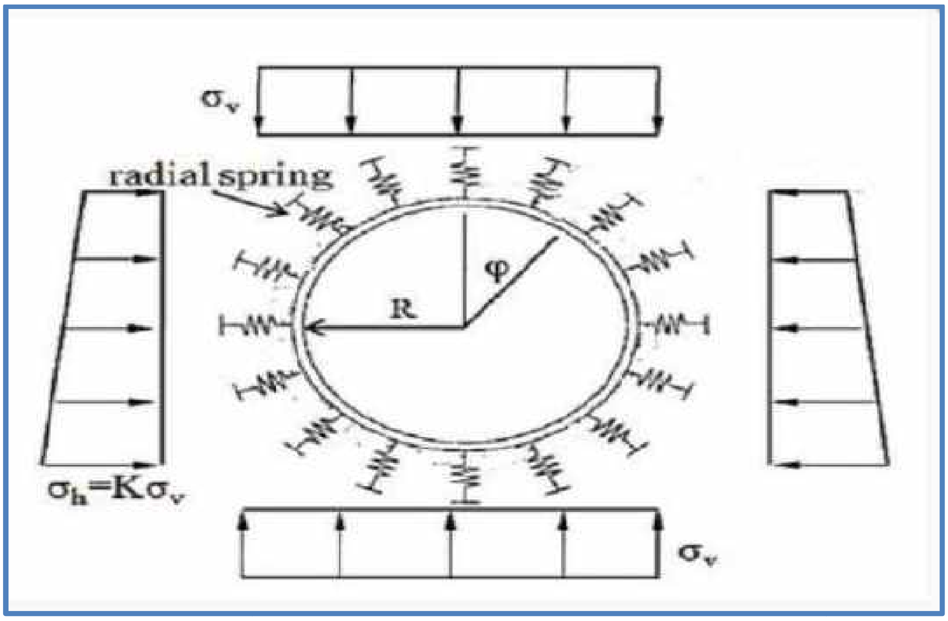
The effective lateral earth pressure is equal to the product of load due to weight of overburden and coefficient of lateral earth pressure $K_0$. The assumed Earth Pressure Coefficient $K_0 = 0.5$

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 $\sigma_v$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.

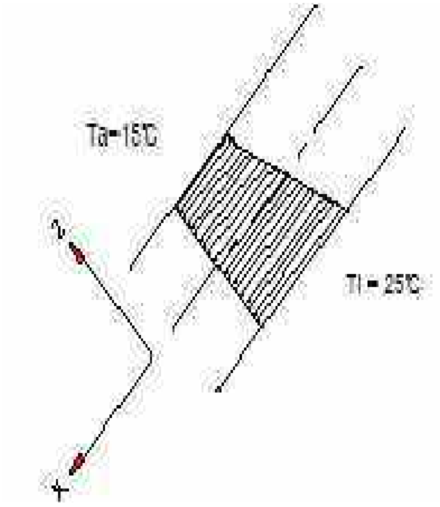
### 12.3.8 Water Pressure [G4]

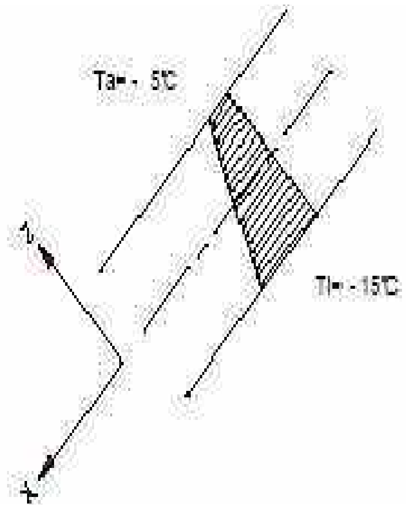
Water pressure on permanent lining shall be considered as per "design water table" along tunnel.

## 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. (Pl 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)
- $G_2$ Earthpressure
- $G_3$ 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.

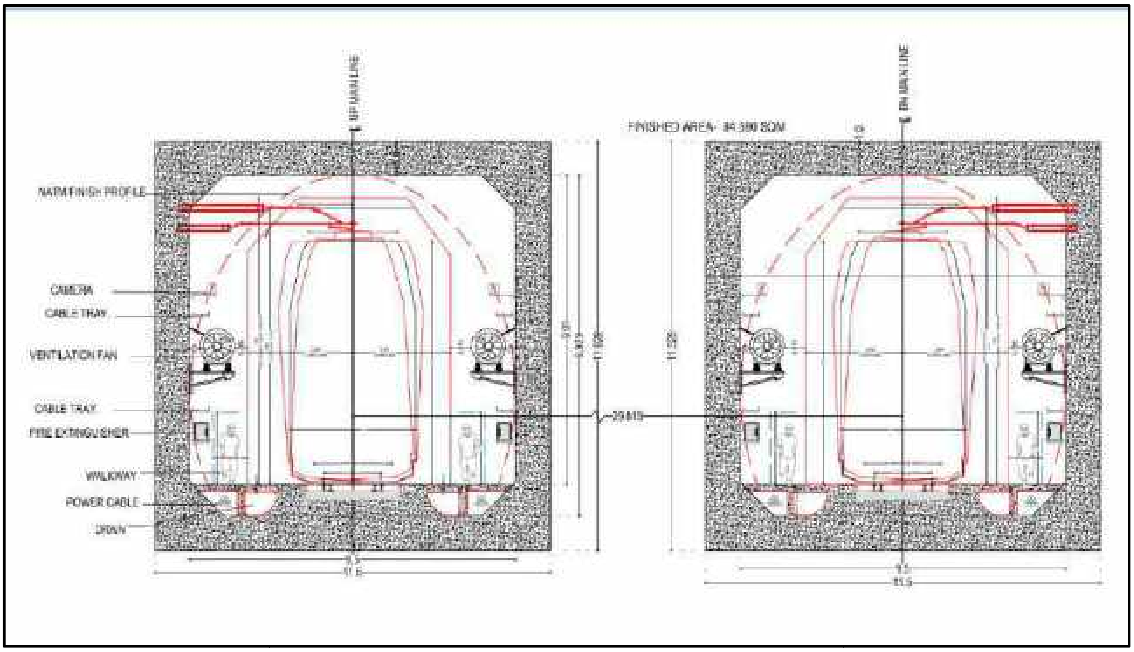


*Figure 7:*Twin Rectangular Shape Cut and Cover for Two Single track

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: ν = 0.2
- Unit weight: ϒ = 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+ѵ) **From EM 1110-2-2901**

where: E… Young's Modulus of soil/rock mass

ѵ …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 ($K_o \gamma H$)

### *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 V, the highest seismic zone in India. 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 0 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 = $0.5*A_h \times \gamma \times H_T$

## 13.7 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

To minimize ventilation requirement four rectangular permanent ventilation shafts at Chainage Km 26+080 and Chainage Km 27+680 has 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 of 3.5m x 3.6m. All the permanent ventilation shafts shall be lined with RCC and same shall be designed for all the loadings during construction and design life.

***Permanent ventilation shaft shall be designed for all load cases and combination as mentioned in Cut and Cover Design.***

## 16 Construction cum Utility Shaft

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. At the location of construction cum utility shaft cross passage shall be provided having the same cross-sectional area as the main tunnel. The size of construction shaft may be kept as per requirement of the contractor. Design and construction of construction cum utility shaft shall be carried out by the contractor accordingly .

## 17 Waterproofing System

Robust waterproofing of underground structures is one of the most cost-effective ways to enhance safety and function as well as to increase the useful design life of new and existing structures. Special maintenance due to deterioration of the structure can be eliminated or minimised and, more importantly, the structure is able to function for the duration of its design life. As water ingress through a sprayed concrete lining is possible through cracks and flaws; areas where the concrete may have a greater permeability than the surrounding, well installed concrete. cracks on the sprayed concrete lining are mainly located in the vicinity of lattice girders and construction joints, e.g. in the interface top heading-bench or bench-invert, in part due to the increased likelihood of shadowing or poorly compacted concrete in these zones. They are mostly caused by external loads, temperature changes, shrinkage, and placement of sprayed concrete. water tightness is directly related to the durability and serviceability of the sprayed concrete lining. Sprayed concrete can be produced to be watertight in small scale samples. However, building a large watertight sprayed concrete surface, as required for tunnel linings, can most practicably be done by means of additional measures. The waterproofing system should also protect the final permanent lining against aggressive environment. For serviceability of secondary lining for longer term sprayed water proofing membrane has been proposed. There are different types of spray applied waterproofing membranes. They may be produced by means of non-reactive systems (curing by hydration or air-drying), or reactive systems (curing by polymer reaction). They are all thin elements, typically with a total final thickness of 3- or 4-mm. Spray applied waterproofing membranes are produced and installed in situ against the primary tunnel lining and typically covered later on by a secondary tunnel lining or a non-structural protective layer (e.g. mortar or sprayed concrete) according to the design requirements. generally, the membrane can be applied in one stage directly onto the concrete lining or substrate. Some membranes require first the application of a primer layer onto the substrate before application of the membrane in one or two consecutive layers. when installed between the primary and secondary concrete linings, spray applied membranes may bond to both primary and secondary linings (double-bonding) or only to one lining (single-bonding), depending on the design requirements and the product chosen. In the case of a spray applied membrane with double bonding properties, the resulting sandwich-structure (concrete-membrane-concrete) may act as a quasi-monolithic structure, depending on the bonding characteristics and properties of the membrane. A typical sketch depicting application of sprayed water proofing membrane has been attached in Figure 8.

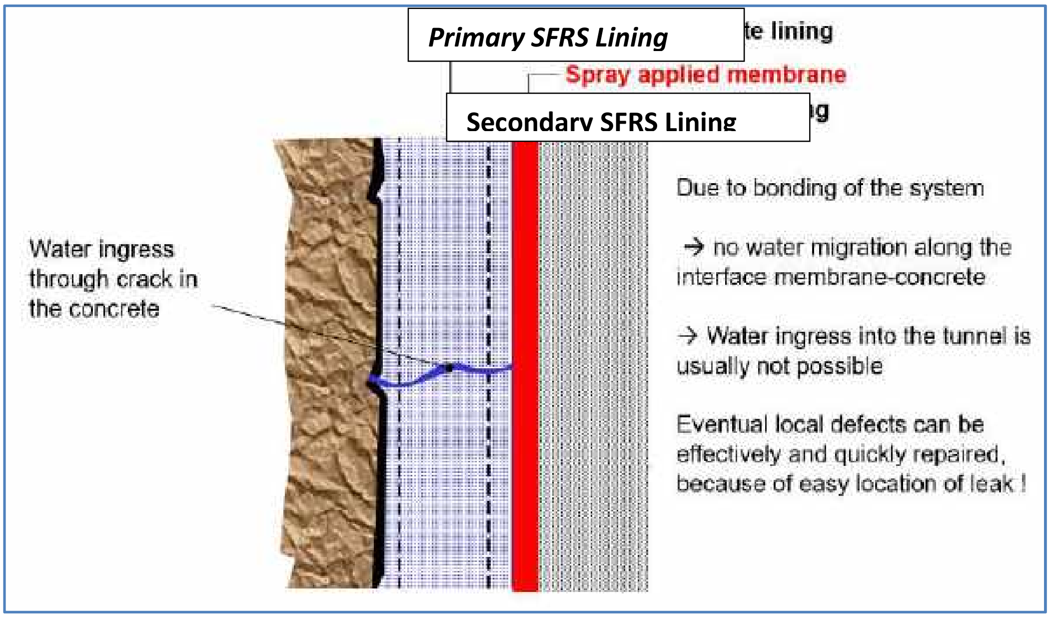


*Figure* 8:Water Proofing detail in Tunnel

Following are main features of sprayed water proofing membrane.

- Continuity without discrete joints; confinement measures (injection, tubes, weld links, compartmentalization with water stops etc.) are not required as the bond between the membrane and the substrate prevents waterpath developing between layers. •
- Spray applied membranes do not have any welded seams, and are simply connected by spraying a short overlap zone onto the previously applied membrane section •
- Easier and quicker location and repair of leaks. A seepage point through the membrane can be easily resolved locally precisely where the seepage occurs since this point corresponds to the seepage channel in the concrete behind the membrane •
- They can be combined with other waterproofing systems. Standard joint details between spray applied and sheet membranes are available, making the system totally flexible •
- They are compatible with all concrete placement techniques, allowing placement of a sprayed concrete inner lining, and reinforcement types (mesh, rebars and fibers) on either side of the membrane. The membrane

can be sprayed straight onto many types of penetrating items (e.g. anchored reinforcement) •

- There is no folding and stretching of the spray applied membrane during the casting or spraying of the secondary/ permanent lining as it is in intimate contact and fully bonded to the primary lining.

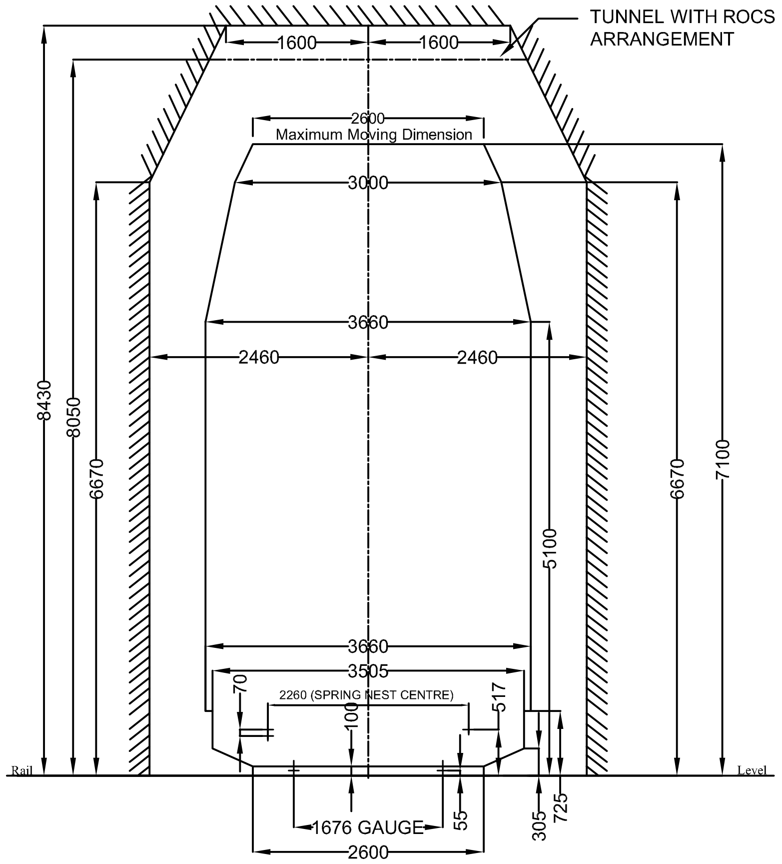
# Annexures

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.

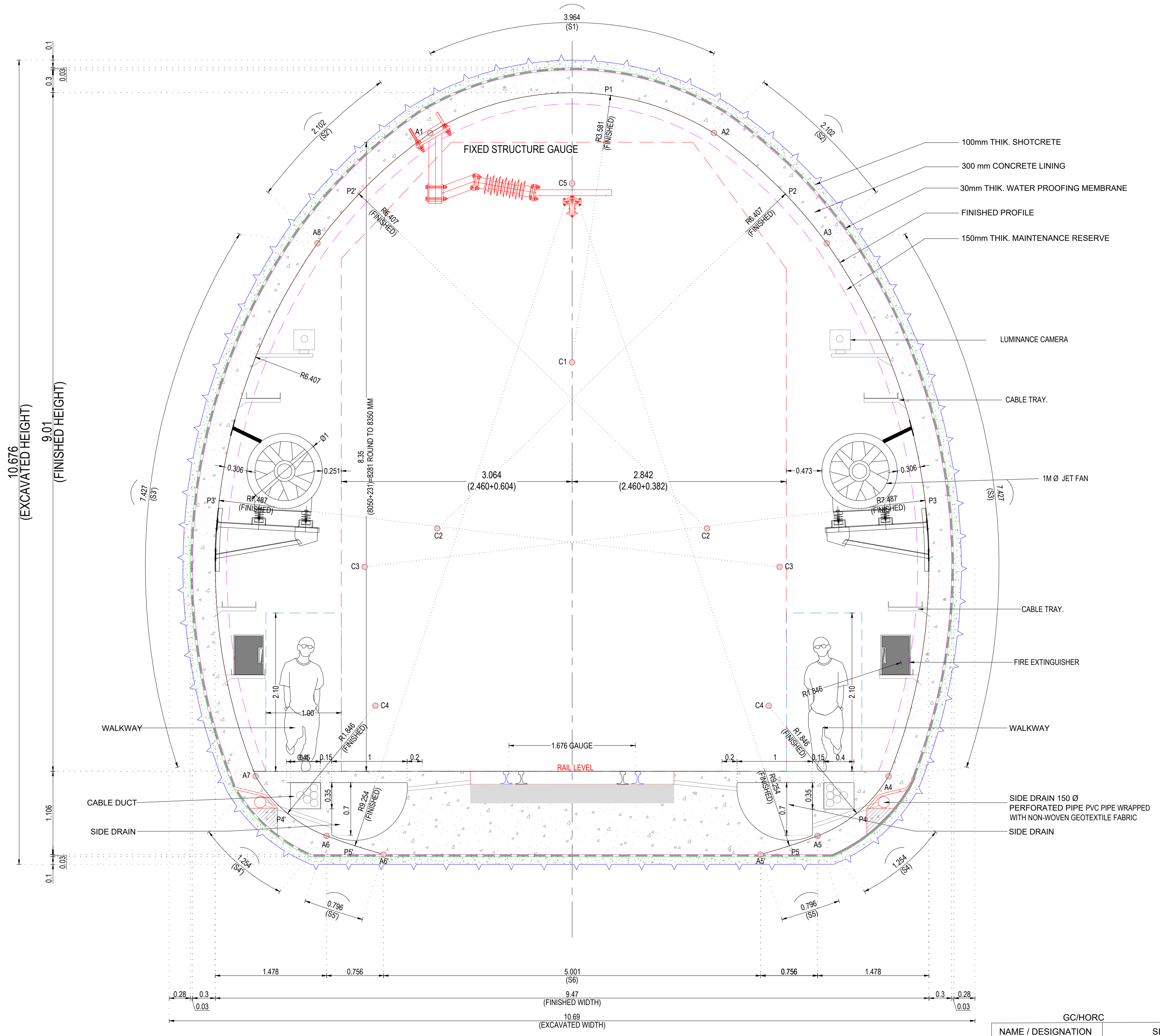
(iv) EXTRA VERTICAL CLEARANCE SHALL BE PROVIDED ON CURVES AS UNDER:

$$\text{EXTRA VERTICAL CLEARANCE (MM)} = \frac{\text{WIDTH OF MMD(MM) X SUPERELEVATION (MM)}}{\text{DYNAMIC GAUGE (MM)}}$$

(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.

# ANNEXURE-1



## 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.
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.

| 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<br>*PD* | ChahateyRam | SHIV OM DWIVEDI<br>*CPM/HRIDC* | |
| SUDHIR AGRAWAL<br>*DPD/CIVIL* | | RAJU SOLANKI<br>*DGM/CIVIL/S* | |
| AJAY VIJAYVARGIYA<br>*DPD/EST* | | *DGM/S&T* | |
| REETU PATIAL<br>*CDE /CIVIL* | | *DGM/Elect.* | |
| AMARNATH SINGH<br>*CRE/S&T* | | | |
| STIPHEN SAHOO<br>*SRE/Elect.* | | | |

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

*GC/HORC DRG. NO:-* GC-HRIDC-C4-DRW-TTL-CLT-01001_A0

*DRAWING NAME* SINGLE TRACK TUNNEL CROSS SECTION (ROCK)

*SCALE-* *AS SHOWN*

*SMC DRG. NO:-* SMC/HRIDC/TUN/CS-1(REV-5)

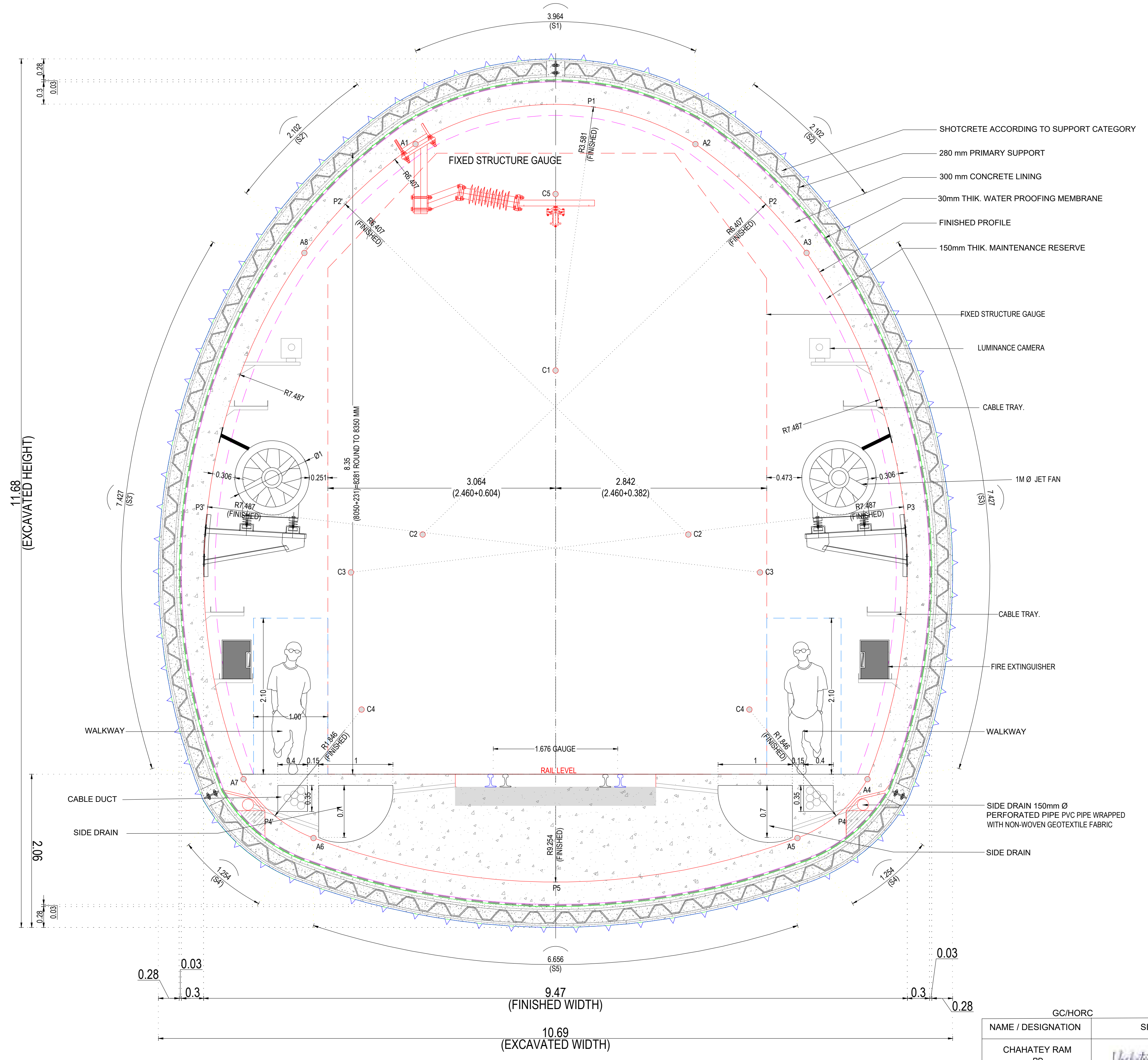
*CONSULTANT:*
S.M. CONSULTANTS
**An ISO 9001 Company**
Bhubaneswar / Balasore / Secunderabad / South Andaman / New Delhi
Web : www.smcindia.com , E-Mail : support@smcindia.com

*SIVENDRA KUMAR*
*TUNNEL DESIGNER*

*B.R.SHARMA*
*Sr.CONSULTANT / TUNNEL*

*A. A. SAMANT*
*PROJECT INCHARGE*

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION



## 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, BENCHING / MULTI DRIFT METHOD.
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.

| 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 |
| CHAHATEY RAM<br>*PD* | Chahatey Ram | SHIV OM DWIVEDI<br>*CPM/HRIDC* | |
| SUDHIR AGRAWAL<br>*DPD/CIVIL* | | RAJU SOLANKI<br>*DGM/CIVIL/S* | |
| AJAY VIJAYVARGIYA<br>*DPD/EST* | | *DGM/S&T* | |
| REETU PATIAL<br>*CDE /CIVIL* | | *DGM/Elect.* | |
| AMARNATH SINGH<br>*CRE/S&T* | | | |
| STIPHEN SAHOO<br>*SRE/Elect.* | | | |

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

*GC/HORC DRG. NO:-* GC-HRIDC-C4-DRW-TTL-CLT-01002_A0

*DRAWING NAME* SINGLE TRACK TUNNEL CROSS SECTION
(SOIL)

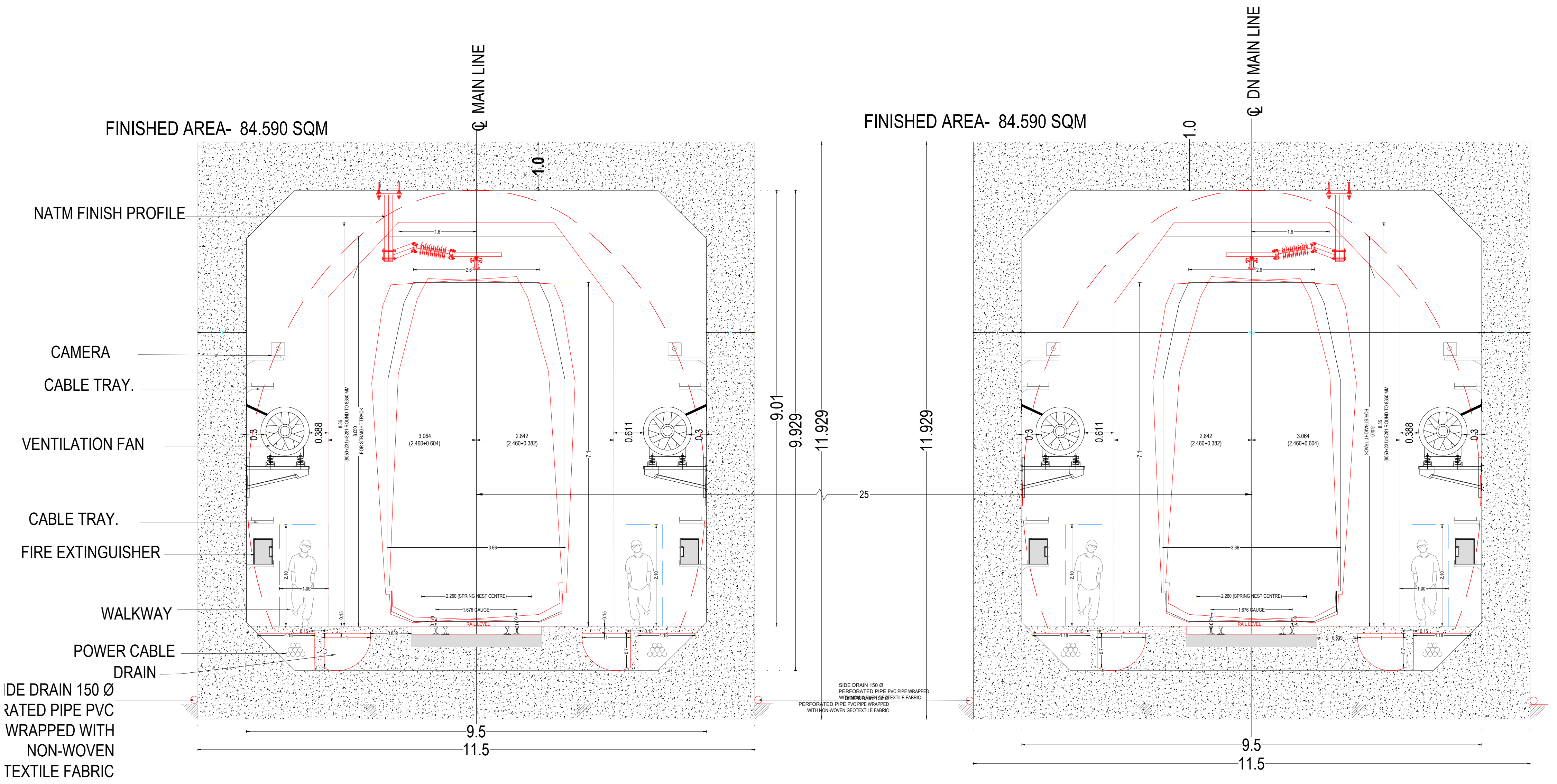
*SCALE-* *AS SHOWN*

*SMC DRG. NO:-* SMC/HRIDC/TUN/CS-2(REV-5)

*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*<br>*TUNNEL DESIGNER* | *B.R.SHARMA*<br>*Sr.CONSULTANT / TUNNEL* | *A. A. SAMANT*<br>*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.

| GC/HORC | | HRIDC | |
|---|---|---|---|
| NAME / DESIGNATION | SIGN | NAME / DESIGNATION | SIGN |
| CHAHATEY RAM<br>*PD* | Chahatey Ram | SHIV OM DWIVEDI<br>*CPM/HRIDC* | |
| SUDHIR AGRAWAL<br>*DPD/CIVIL* | | RAJU SOLANKI<br>*DGM/CIVIL/S* | |
| AJAY VIJAYVARGIYA<br>*DPD/EST* | | *DGM/S&T* | |
| REETU PATIAL<br>*CDE /CIVIL* | | *DGM/Elect.* | |
| AMARNATH SINGH<br>*CRE/S&T* | | | |
| STIPHEN SAHOO<br>*SRE/Elect.* | | | |

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

*GC/HORC DRG. NO:-* GC-HRIDC-C4-DRW-TTL-CLT-01008_A0

*DRAWING NAME* CUT & COVER SECTION OF TUNNEL

*SCALE-* *AS SHOWN*

*SMC DRG. NO:-* SMC/HRIDC/TUN/CS-3(REV-5)

*CONSULTANT:*

S.M.C.
S.M. CONSULTANTS
**An ISO 9001 Company**
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*A. A. SAMANT*
*PROJECT INCHARGE*

RELEASED FOR ☐ PRELIMINARY FOR APPROVAL ☑ TENDER ☐ CONSTRUCTION

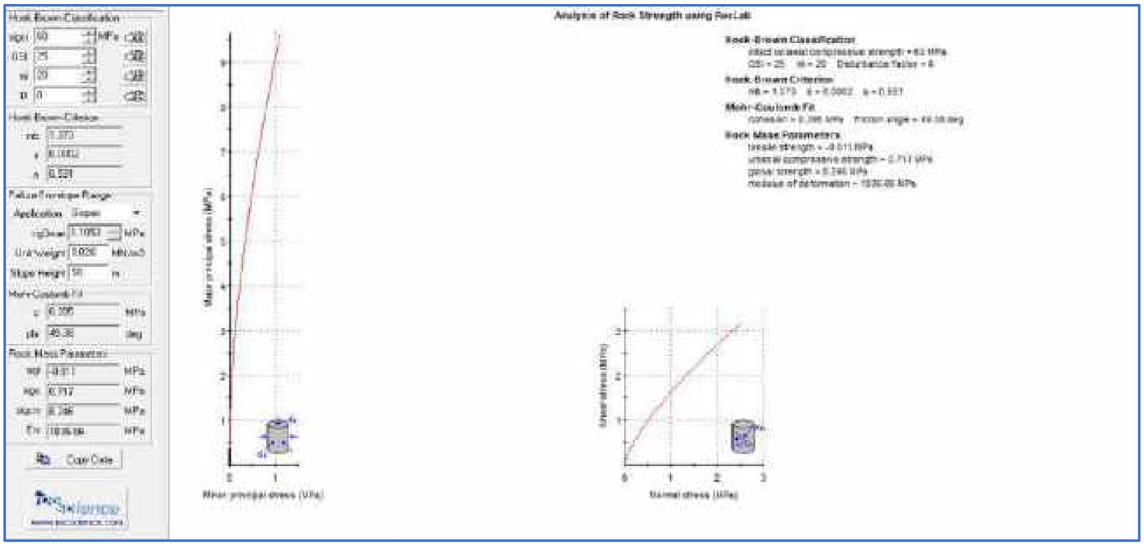


*Figure 1: Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.*

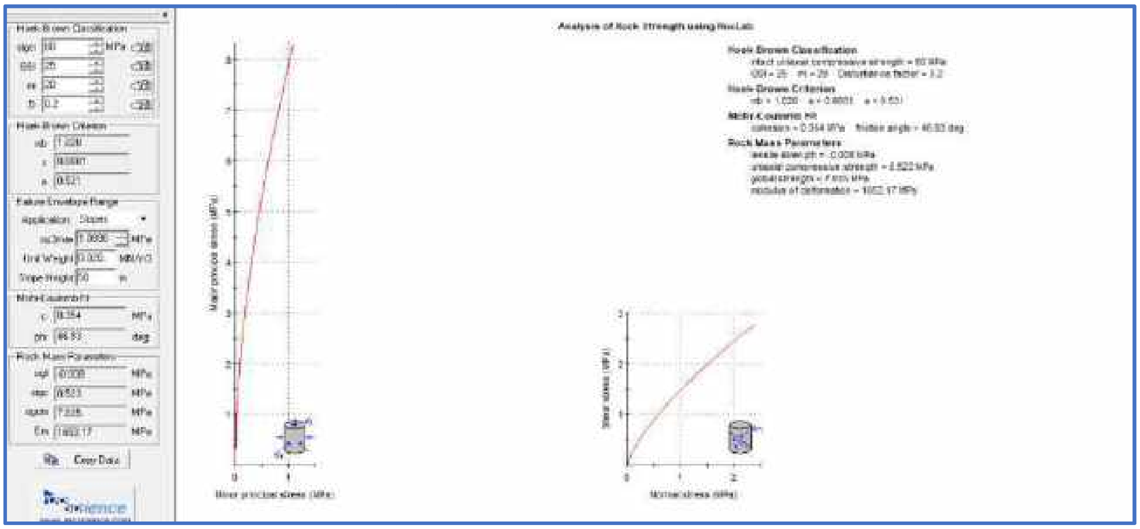


*Figure 2: Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.2.*

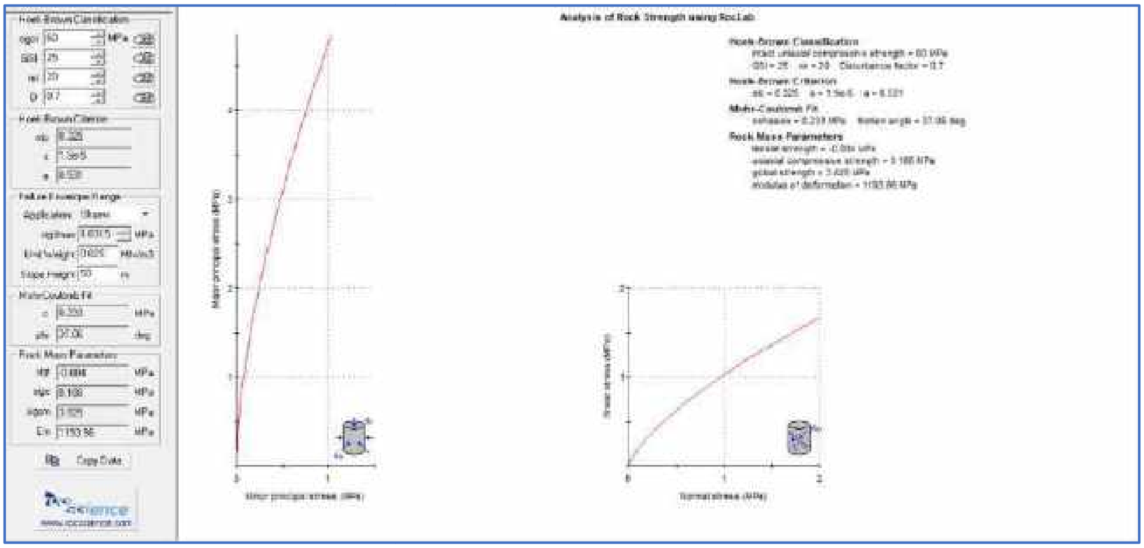


*Figure 3 :Above mentioned chart is Mohr Coulomb fit output from Roclab software for rock mass derived from intact rock property of laboratory with disturbance factor D=0.7*

**ANNEXURE-3**

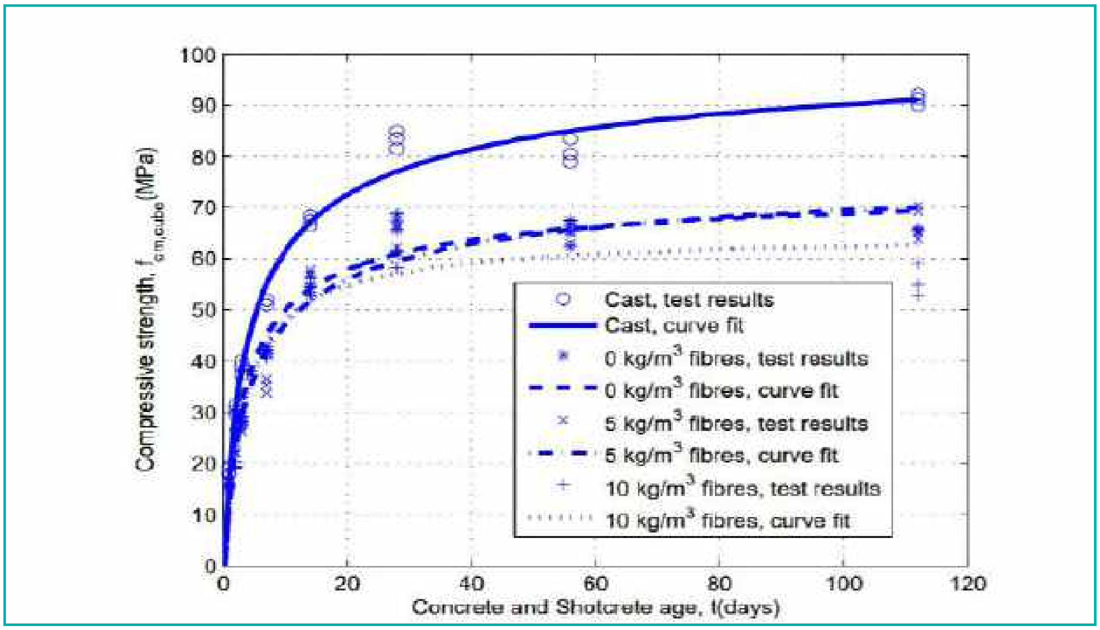


*Figure 1: Shotcrete Compressive Strength*

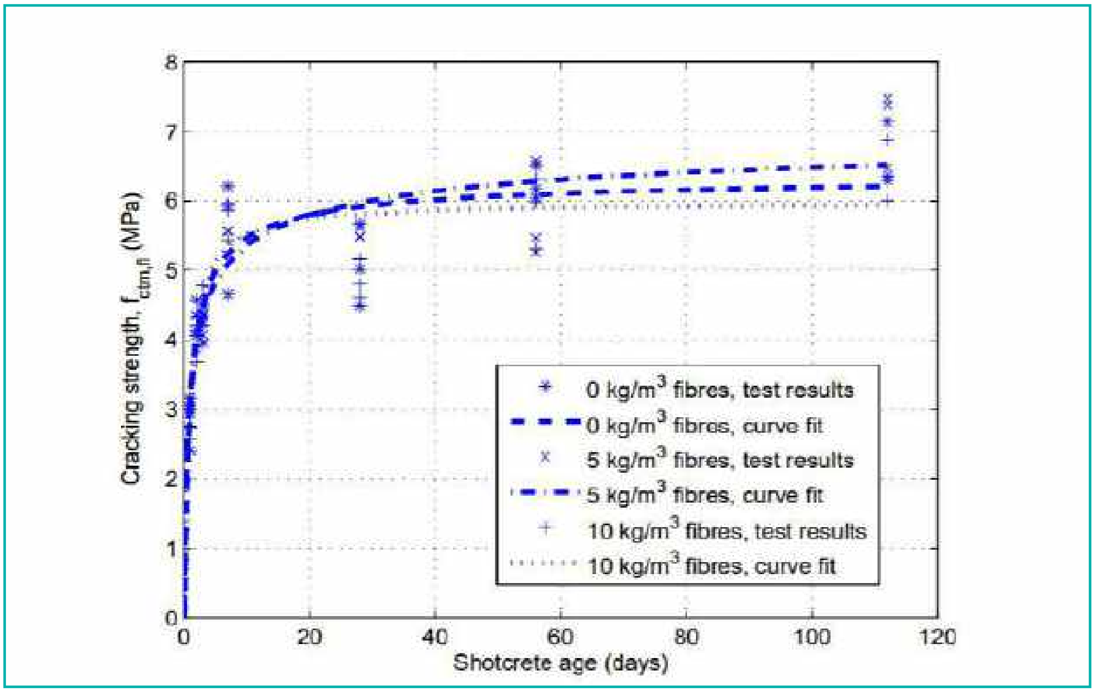


*Figure 2:Shotcrete Cracking Strength*

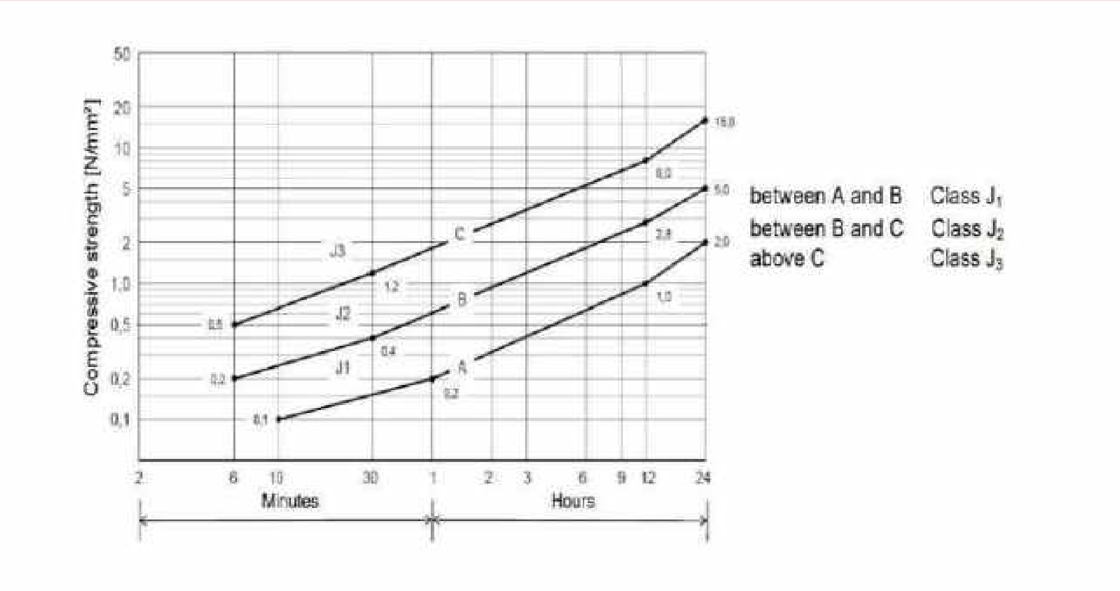


*Figure 3:* Early strength development of young shotcrete

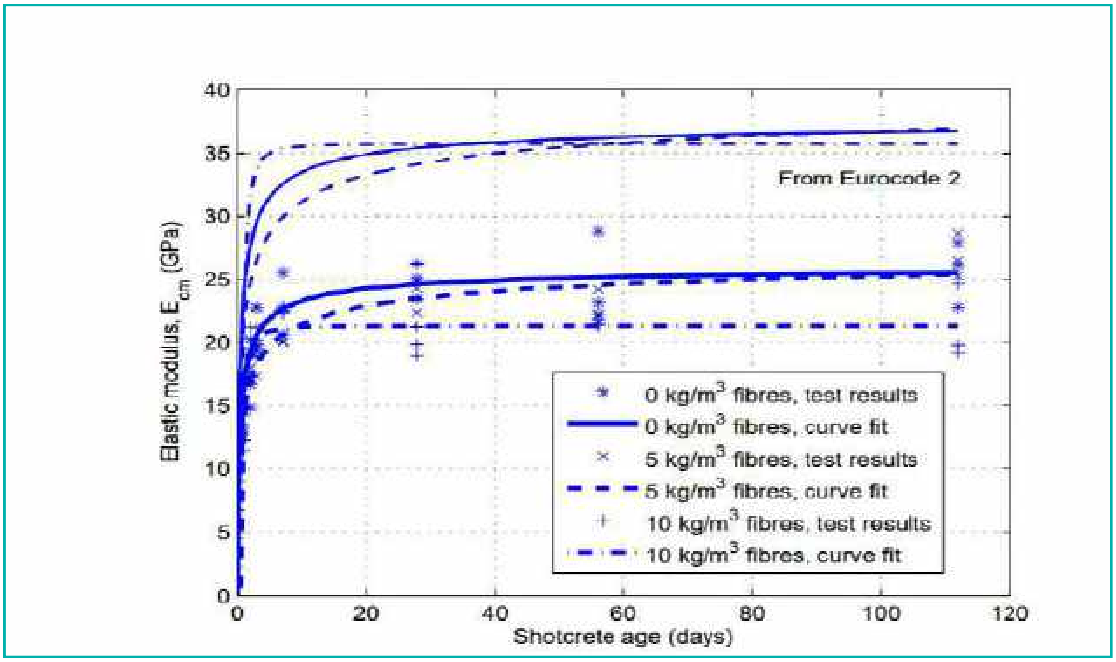
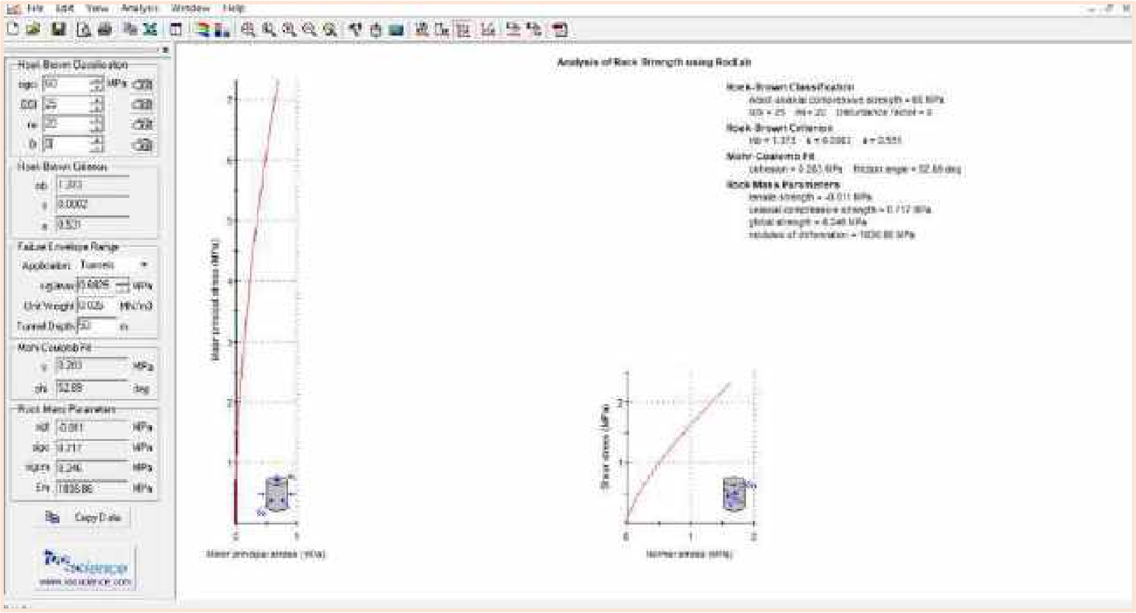


*Figure 4:Shotcrete Elastic Modulus*



Hoek Brown Classification
sigci 60 MPa
GSI 25
mi 20
D 0

Hoek Brown Criterion
mb 1.373
s 0.0002
a 0.531

Failure Envelope Range
Application: Tunnels
sig3max 0.6806 MPa
Unit Weight 0.026 MN/m3
Tunnel Depth 50 m

Mohr Coulomb Fit
c 0.263 MPa
phi 52.88 deg

Rock Mass Parameters
sigt -0.011 MPa
sigc 0.717 MPa
sigcm 8.246 MPa
Em 1836.86 MPa

Analysis of Rock Strength using RocLab

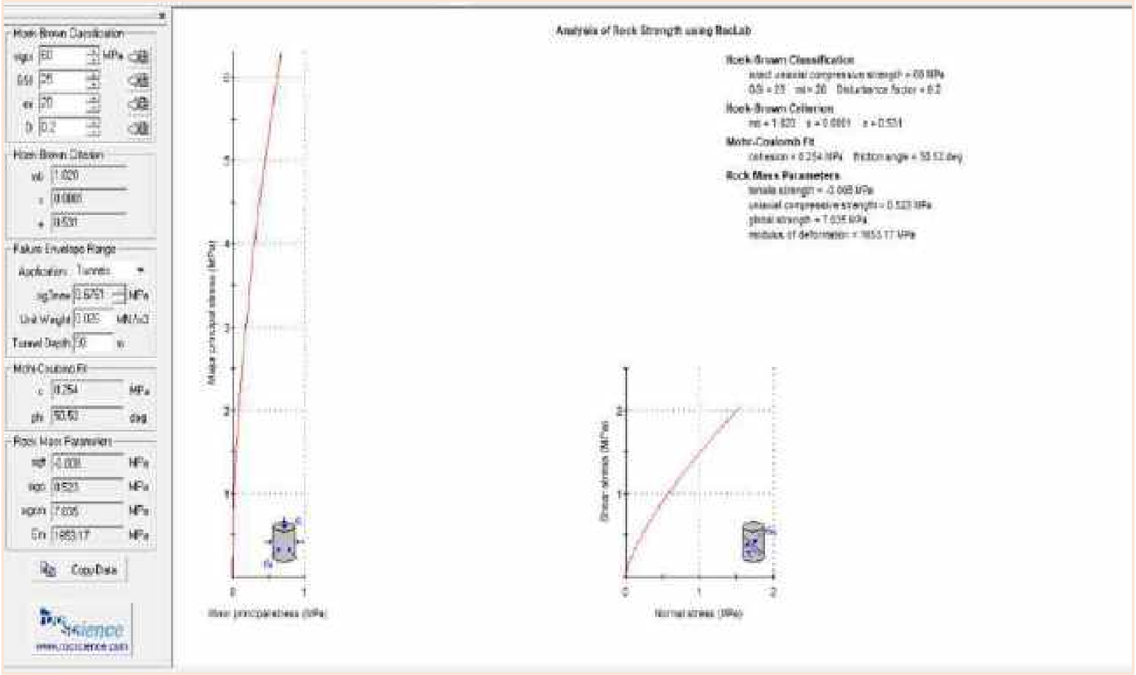
Hoek-Brown Classification
intact uniaxial compressive strength = 60 MPa
GSI = 25 mi = 20 Disturbance factor = 0

Hoek-Brown Criterion
mb = 1.373 s = 0.0002 a = 0.531

Mohr-Coulomb Fit
cohesion = 0.263 MPa friction angle = 52.88 deg

Rock Mass Parameters
tensile strength = -0.011 MPa
uniaxial compressive strength = 0.717 MPa
global strength = 8.246 MPa
modulus of deformation = 1836.86 MPa

*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.*



Hoek Brown Classification
sigci 60 MPa
GSI 25
mi 20
D 0.2

Hoek Brown Criterion
mb 1.020
s 0.0001
a 0.531

Failure Envelope Range
Application: Tunnels
sig3max 0.6751 MPa
Unit Weight 0.026 MN/m3
Tunnel Depth 50 m

Mohr Coulomb Fit
c 0.254 MPa
phi 50.53 deg

Rock Mass Parameters
sigt -0.008 MPa
sigc 0.523 MPa
sigcm 7.035 MPa
Em 1653.17 MPa

Analysis of Rock Strength using RocLab

Hoek-Brown Classification
intact uniaxial compressive strength = 60 MPa
GSI = 25 mi = 20 Disturbance factor = 0.2

Hoek-Brown Criterion
mb = 1.020 s = 0.0001 a = 0.531

Mohr-Coulomb Fit
cohesion = 0.254 MPa friction angle = 50.53 deg

Rock Mass Parameters
tensile strength = -0.008 MPa
uniaxial compressive strength = 0.523 MPa
global strength = 7.035 MPa
modulus of deformation = 1653.17 MPa

*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

**18.08.2022**

| 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 |  |

## Horizonatal 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 & Ca | Cd | CH. TTP-1 | CH. TTP-2 | TOTAL LENGTH |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 18 | RHS | 0.500 | 00° 30' 00.00" | 3500.000 | 0°51'14" | 20.000 | 70.900 | 51.900 | 45.000 | 45.000 | 11879.000 | 12021.000 | 142.000 | **Main Line UP line** |
| 2 | 19 | RHS | 0.831 | 00° 49' 52.44" | 2105.300 | 26°30'02" | 70.000 | 560.900 | 843.800 | 130.000 | 130.000 | 12070.000 | 13173.000 | 1103.000 |  |
| 3 | 11 | RHS | 0.583 | 00° 35' 00.00" | 3000.000 | 33°19'13" | S=0.139 M | 897.769 | 1744.646 | Ca=35 | cd=85 | 15574.000 | 17419.000 | 1845.000 |  |
| 4 | 12 | LHS | 2.481 | 02° 28' 52.36" | 705.300 | 65°50'48" | S=0.510 M | 1036.110 | 1838.786 | Ca=115 | cd=100 | 18108.453 | 20087.239 | 1978.786 |  |
| 5 | **15** | RHS | 0.884 | 00° 53' 01.81" | 1980.000 | 56°13'24" | S=0.412 M | 1102.582 | 2012.054 | Ca=110 | cd=65 | 23777.000 | 25930.000 | 2153.000 |  |
| 6 | **16** | RHS | 1.000 | 01° 00' 00.00" | 1750.000 | 32°0'30" | S=0.402 M | 501.942 | 977.639 | Ca=110 | cd=35 | 2634.000 | 27447.000 | 24813.000 |  |
| 7 | **17** | LHS | 0.500 | 00° 30' 00.00" | 3500.000 | 19°57'37" | S=0.096 M | 615.894 | 1219.304 | Ca=70 | cd=30 | 28474.000 | 29783.000 | 1309.000 |  |
| 1 | 7 | RHS | 1.167 | 01° 10' 00.00" | 1500.000 | 26°30'21" | 70.000 | 557.700 | 837.700 | 130.000 | 130.000 | 12073.179 | 13170.832 | 1097.653 | **Main Line DN line** |
| 2 | 11 | RHS | 0.250 | 00° 15' 00.00" | 7000.000 | 33°19'13" | S=0.139 M | 899.415 | 1747.844 | Ca=35 | cd=85 | 15574.000 | 17419.000 | 1845.000 |  |
| 3 | 12 | LHS | 2.481 | 02° 28' 52.36" | 705.300 | 65°50'48" | S=0.510 M | 1036.110 | 1838.786 | Ca=115 | cd=100 | 18108.453 | 20087.239 | 1978.786 |  |
| 5 | **15** | RHS | 0.884 | 00° 53' 01.81" | 1980.000 | 56°13'24" | S=0.425 M | 1102.582 | 1951.060 | Ca=110 | cd=65 | 23777.000 | 25930.000 | 2153.000 |  |
| 6 | **16** | RHS | 1.000 | 01° 00' 00.00" | 1750.000 | 32°0'30" | S=0.402 M | 501.942 | 994.396 | Ca=110 | cd=35 | 2634.000 | 27447.000 | 24813.000 |  |
| 7 | **17** | LHS | 0.500 | 00° 30' 00.00" | 3500.000 | 19°57'37" | S=0.097 M | 615.894 | 1393.489 | Ca=70 | cd=30 | 28474.000 | 29783.000 | 1309.000 |  |

# 3. LIST OF CONTROL POINTS

**Project Name:-Field verification for land boundary and supplying, fixing of boundary pillars along HORC alignment and it's connectivities to existing IR/DFC networks, picking up of finalized land boundary and centre line coordinates using DGPS (RTK Method) by establishing control points in connection with Haryana Orbital Rail Corridor (HORC) from Palwal to Sonipat**

| 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 |
| TCP-042 | 28°12'05.5195"N | 77°05'35.9737"E | 3121301.798 | 705462.378 | 194.676 |
| TCP-043 | 28°11'41.1865"N | 77°05'25.8750"E | 3120547.998 | 705199.897 | 196.170 |
| TCP-044 | 28°11'42.7878"N | 77°05'22.1513"E | 3120595.539 | 705097.490 | 194.453 |
| 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 |

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| 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 |
| TCP-070 | 28°13'19.9142"N | 76°59'51.8013"E | 3123433.416 | 696038.857 | 267.836 |
| TCP-071 | 28°13'30.9119"N | 76°59'07.9414"E | 3123752.284 | 694837.477 | 268.041 |
| TCP-072 | 28°13'34.8089"N | 76°59'10.8492"E | 3123873.541 | 694914.788 | 265.898 |
| TCP-073 | 28°13'52.9970"N | 76°58'45.2818"E | 3124421.995 | 694208.575 | 268.496 |
| 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 |
| TCP-079 | 28°14'57.9545"N | 76°57'26.5372"E | 3126386.614 | 692029.490 | 267.744 |
| TCP-080 | 28°15'01.0976"N | 76°57'26.4793"E | 3126483.340 | 692026.347 | 263.061 |
| TCP-081 | 28°15'15.1912"N | 76°56'53.7368"E | 3126902.765 | 691126.892 | 262.110 |
| TCP-082 | 28°15'18.2916"N | 76°56'54.8506"E | 3126998.690 | 691155.712 | 260.056 |
| TCP-083 | 28°15'32.5066"N | 76°56'21.7602"E | 3127421.762 | 690246.788 | 259.226 |
| TCP-084 | 28°15'34.3650"N | 76°56'24.1917"E | 3127480.027 | 690312.141 | 257.216 |
| TCP-085 | 28°15'52.5120"N | 76°55'53.0335"E | 3128025.036 | 689454.013 | 259.620 |
| TCP-086 | 28°15'55.2536"N | 76°55'55.6864"E | 3128110.581 | 689524.965 | 258.329 |
| TCP-087 | 28°16'11.0478"N | 76°55'26.5575"E | 3128584.097 | 688723.376 | 258.667 |
| TCP-088 | 28°16'13.5955"N | 76°55'27.8330"E | 3128663.075 | 688756.888 | 257.003 |
| TCP-089 | 28°16'33.0663"N | 76°54'57.7123"E | 3129249.383 | 687926.545 | 256.936 |
| TCP-090 | 28°16'35.3419"N | 76°54'59.4766"E | 3129320.192 | 687973.514 | 252.996 |
| 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 |
| TCP-094 | 28°17'29.7514"N | 76°54'21.8008"E | 3130978.772 | 686920.431 | 256.329 |
| TCP-095 | 28°17'57.4427"N | 76°54'00.7114"E | 3131822.106 | 686332.417 | 263.020 |
| TCP-096 | 28°17'59.4644"N | 76°54'04.6478"E | 3131886.023 | 686438.683 | 258.503 |
| 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 |

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# 4. LIST OF CHARTED UTILITIES

Nil

# 5. GEOTECHNICAL INVESTIGATION REPORTS FOR TUNNEL

## Contents

# 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 | Shireesty |
| GEOLOGIST | Dr Dipanjan Bhattacharjee<br>Assistant Professor<br>Department of Geology<br>Indira Gandhi National Tribal University<br>(A central university established by an act of Parliament)<br>Amarkantak, Madhya Pradesh-484887 |
| SENIOR CONSULTANT | Senior Consultant<br>Virendra Sinha<br>For S.M. Consultants |

| General Consultant | |
|---|---|
| PD/GC | |
| DPD/GC/CIVIL | |
| | |

| Client | | |
|---|---|---|
| CPM/HRIDCL | | |
| DGM/CIVIL/S/ HRIDCL | | |
| EXE/CIVIL/ HRIDCL | | |
| | | |

**Client:**

HRIDC

HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION
LIMITED.

**Consultant:**

S. M. C.

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
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# Contents

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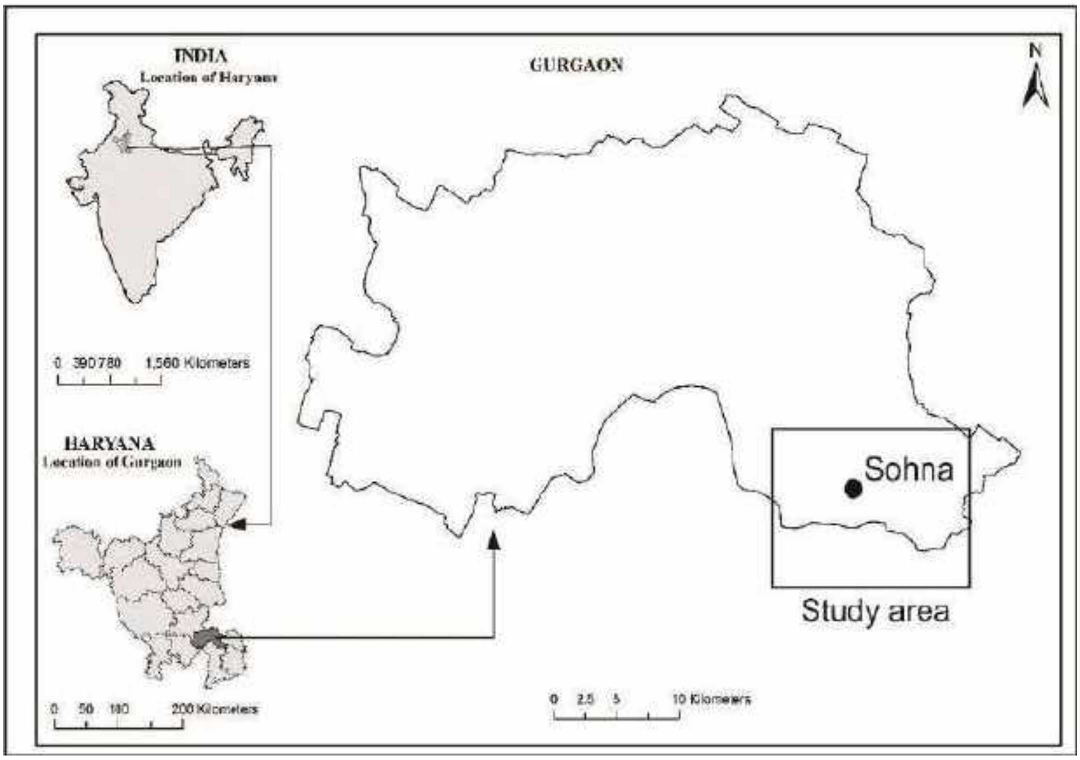
# 1 CHAPTER: INTRODUCTION

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

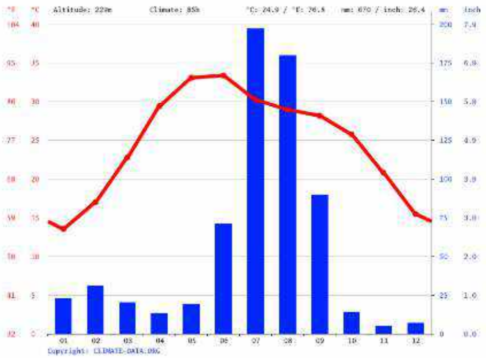
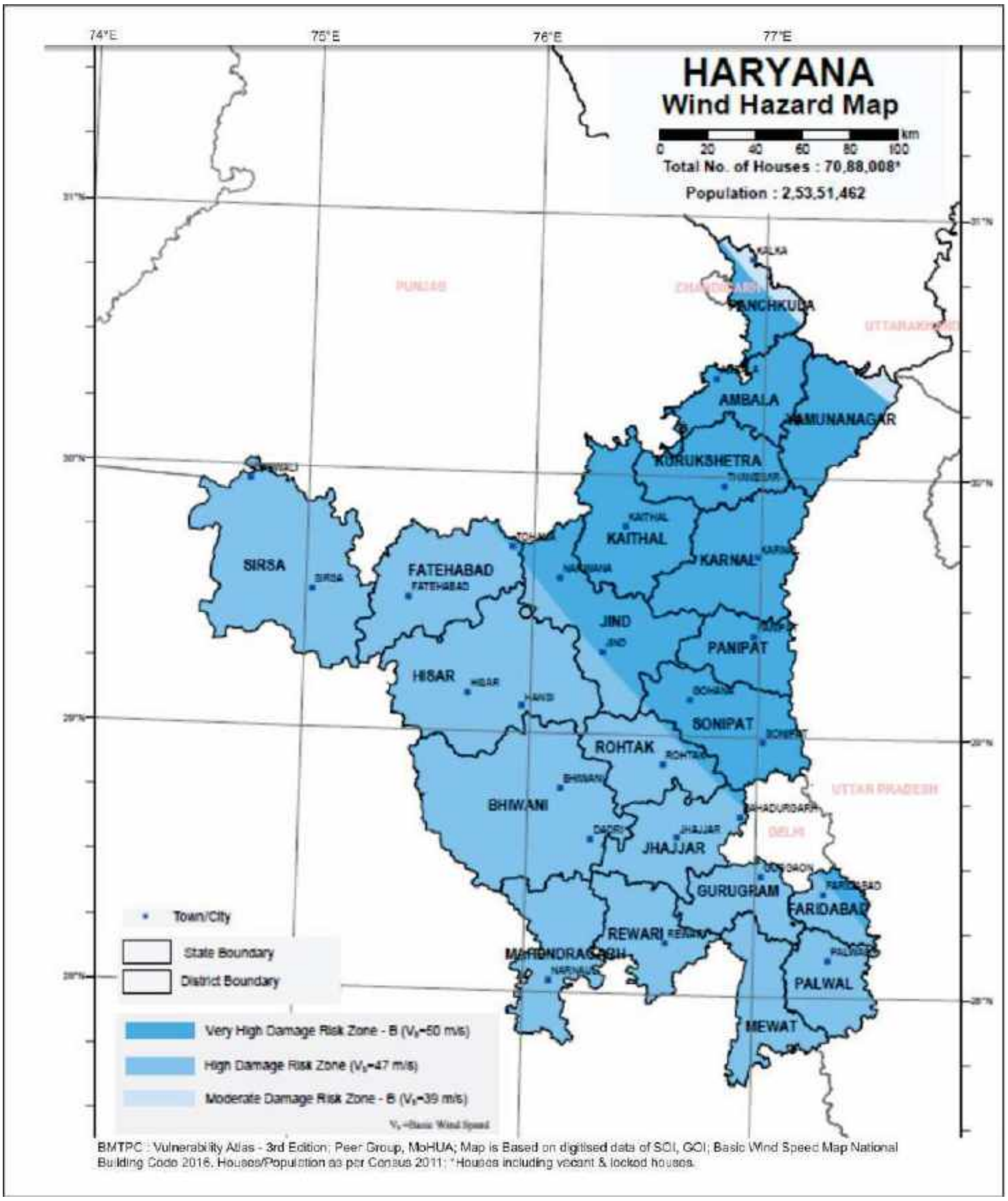


**Figure 2: Graph showing month wise rainy days for Gurgaon district. (Climate-data.org)**

restricted to this monsoon, though winter months also get some scanty rains Average annual rainfallis about 600 mm.

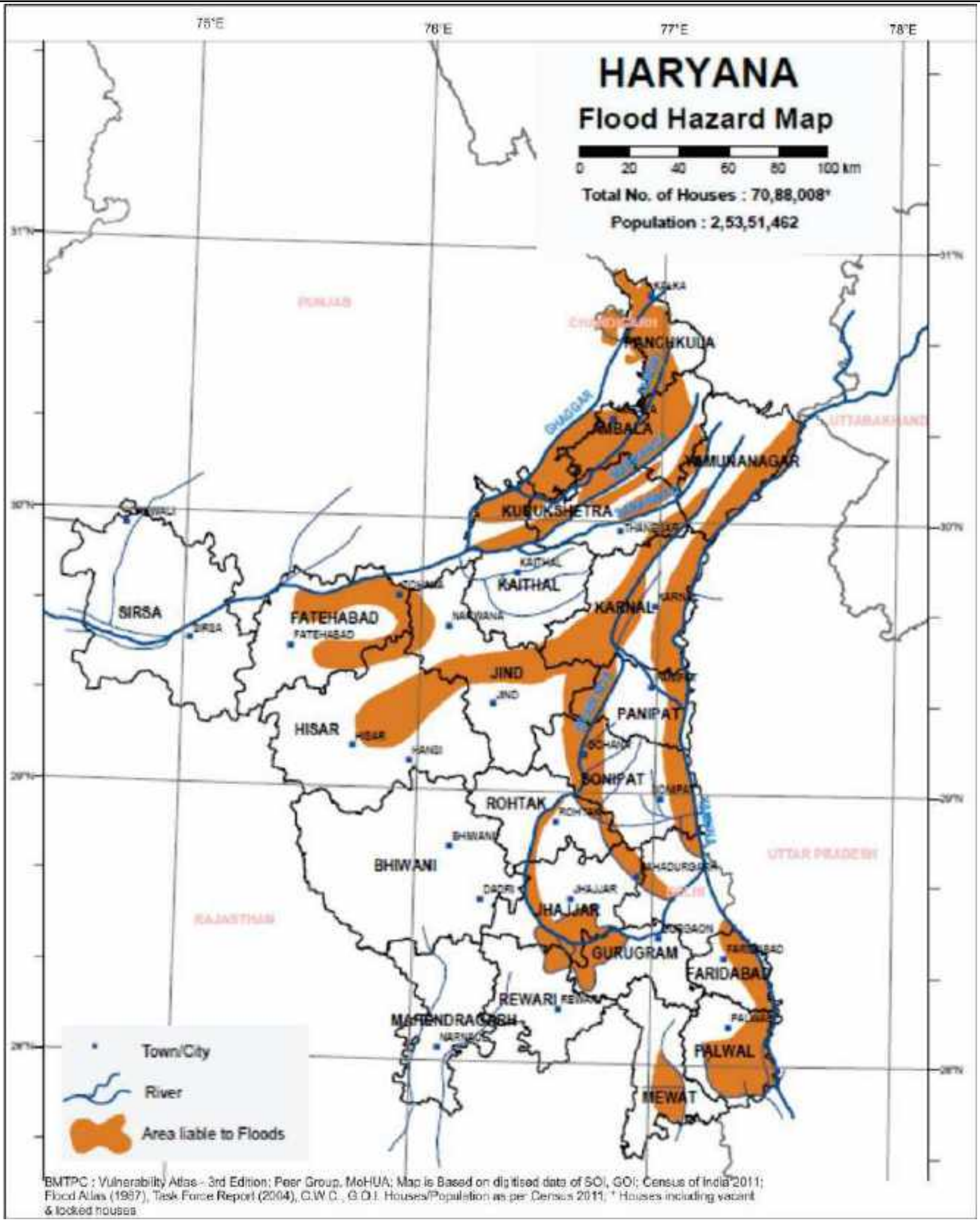
Climatic condition of the area is much varied characterized by hot and moist sub-humid climate. It has mainly 4 seasons. The summer season is from March to Mid-June, the period from Mid-June to September is the Rainy season, October and November constitute the post monsoon season and winter is from December 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:



BMTPC : Vulnerability Atlas - 3rd Edition; Peer Group, MoHUA; Map is Based on digitised data of SOI, GOI; Basic Wind Speed Map National Building Code 2016. Houses/Population as per Census 2011; *Houses including vacant & locked houses.

**Figure 3: Wind Hazard map of Haryana (adopted from BMTPC)**



BMTPC : Vulnerability Atlas - 3rd Edition; Peer Group, MoHUA; Map is Based on digitised data of SOI, GOI; Census of India 2011; Flood Atlas (1987), Task Force Report (2004), C.W.C., G.O.I. Houses/Population as per Census 2011; * Houses including vacant & locked houses

**Figure 4: Flood zonation map of Haryana (adopted from BMTPC)**

## 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.

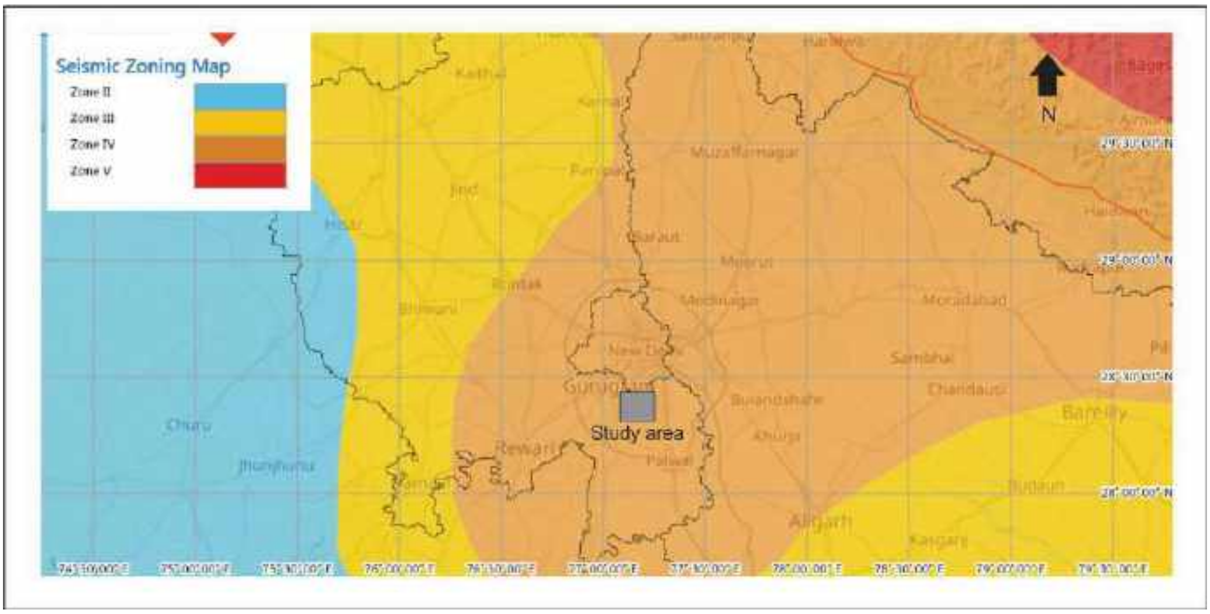


**Figure 5: Seismic map of state Haryana (adopted from National Centre for seismology)**

# 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.

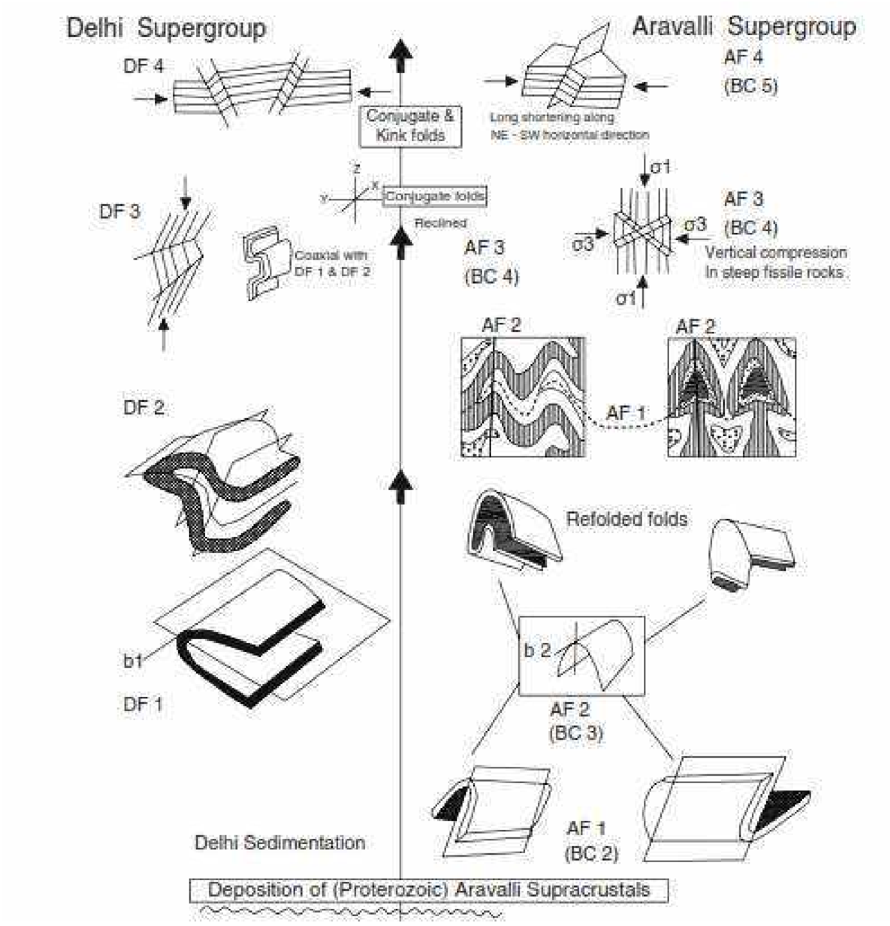
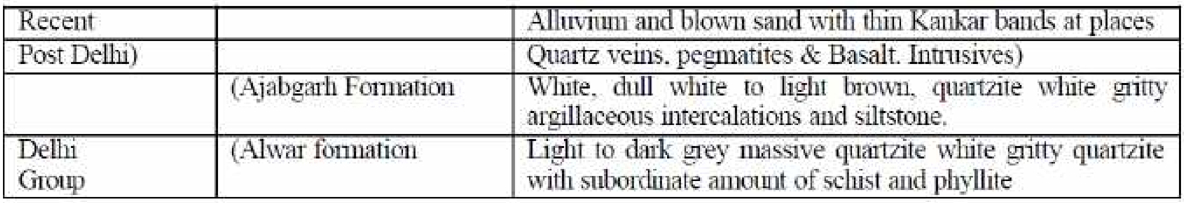


**Figure 6: Regional structure of Delhi fold belt (Naha and Mohanty 1988).**



| | | |
|---|---|---|
| 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.

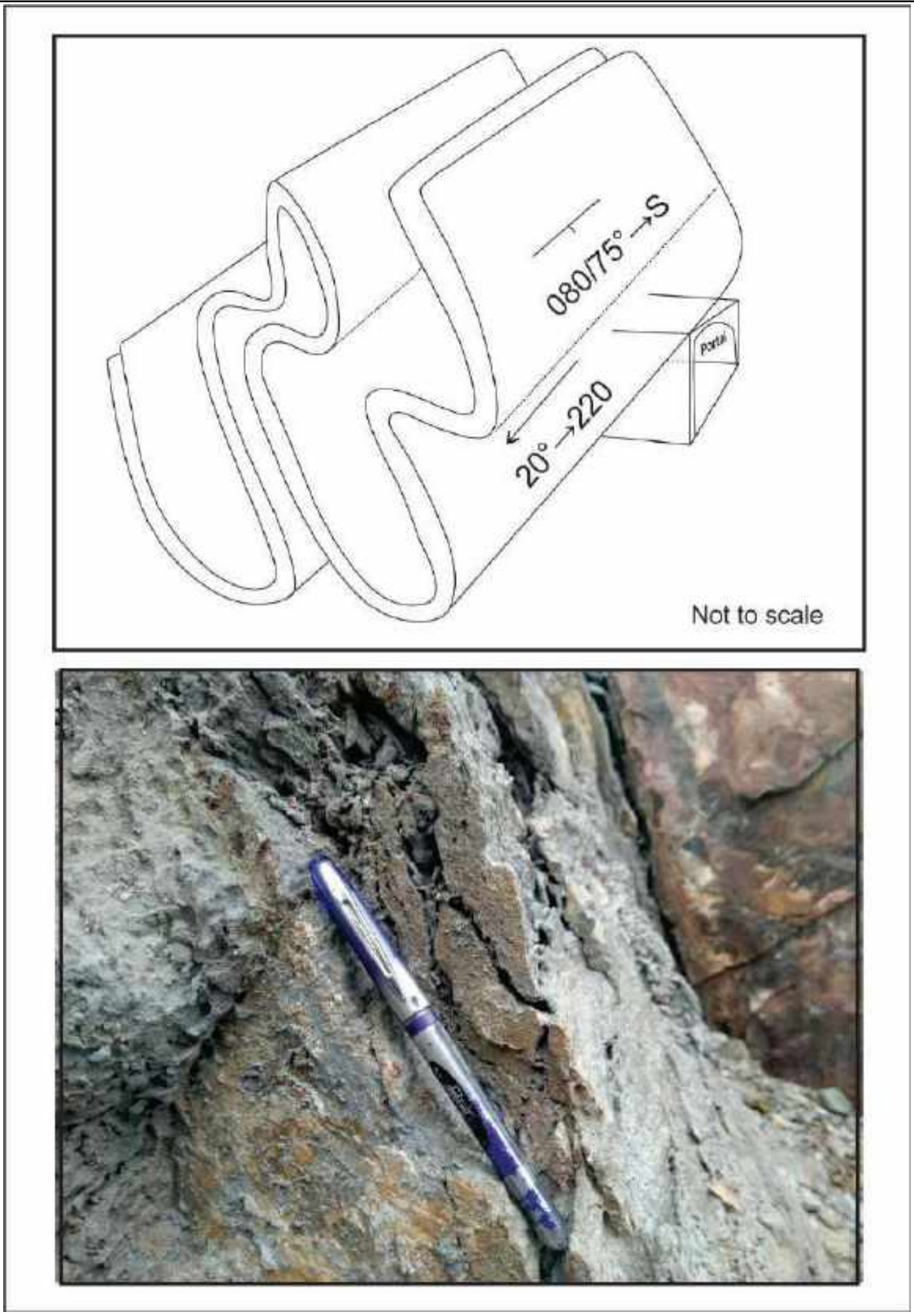


Figure 7: Superposed fold observed at 28 12’ 33.57’’, 77 02’57.08’’

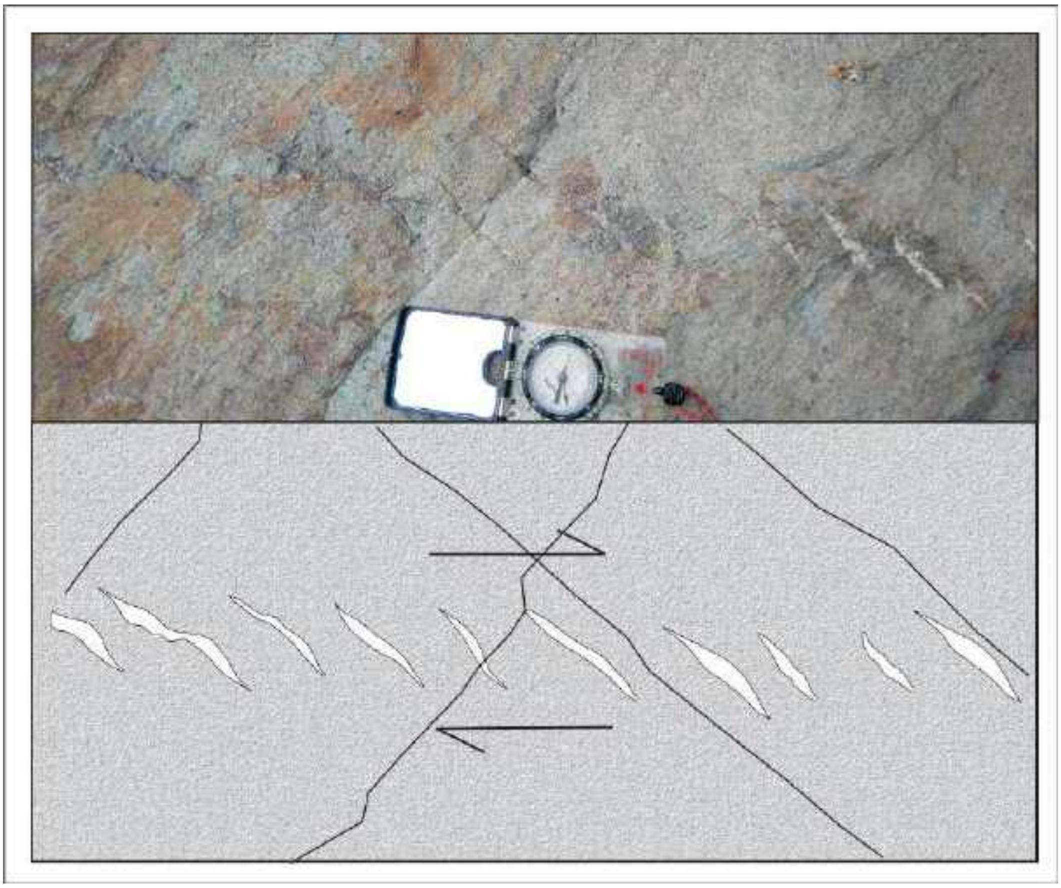


**Figure 8 : Gash veins showing a dextral slip.**

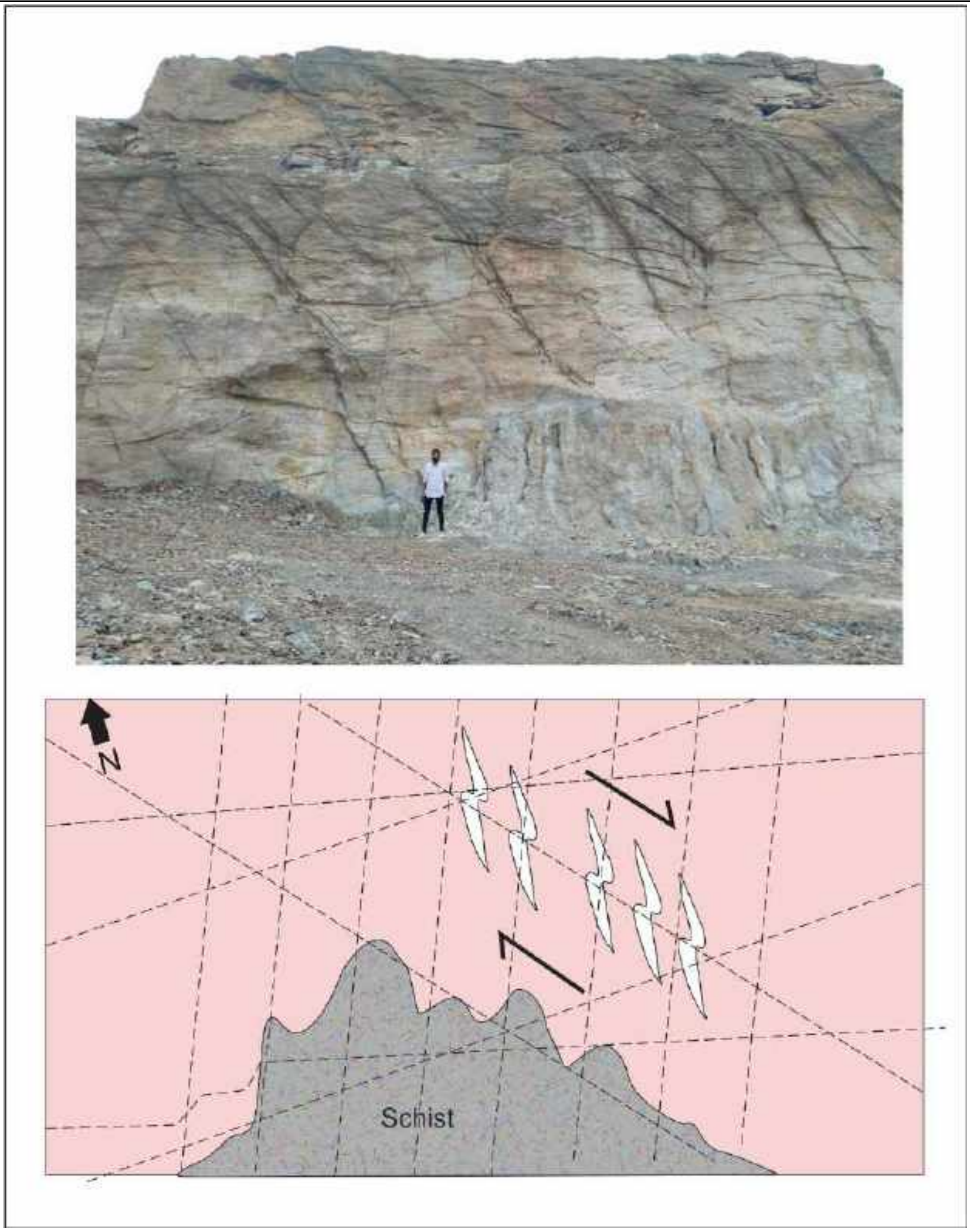


**Figure 9: Shear zone observed at location 28 12’ 20.93’’, 77 02’ 40.**

Figure 10: Multiple joint sets were observed throughout the area.

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 |

| 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 |

| 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 |

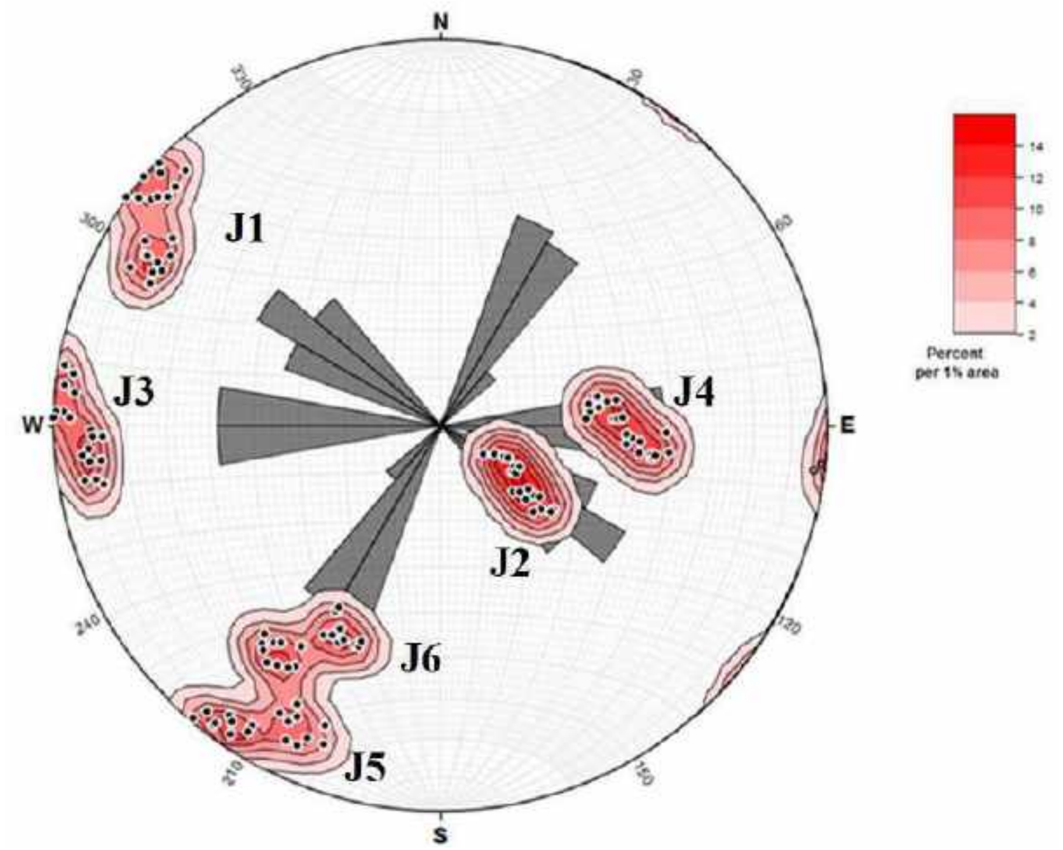


**Figure 11: Rose and contour diagram of the orientation of the joint set.**

### 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;

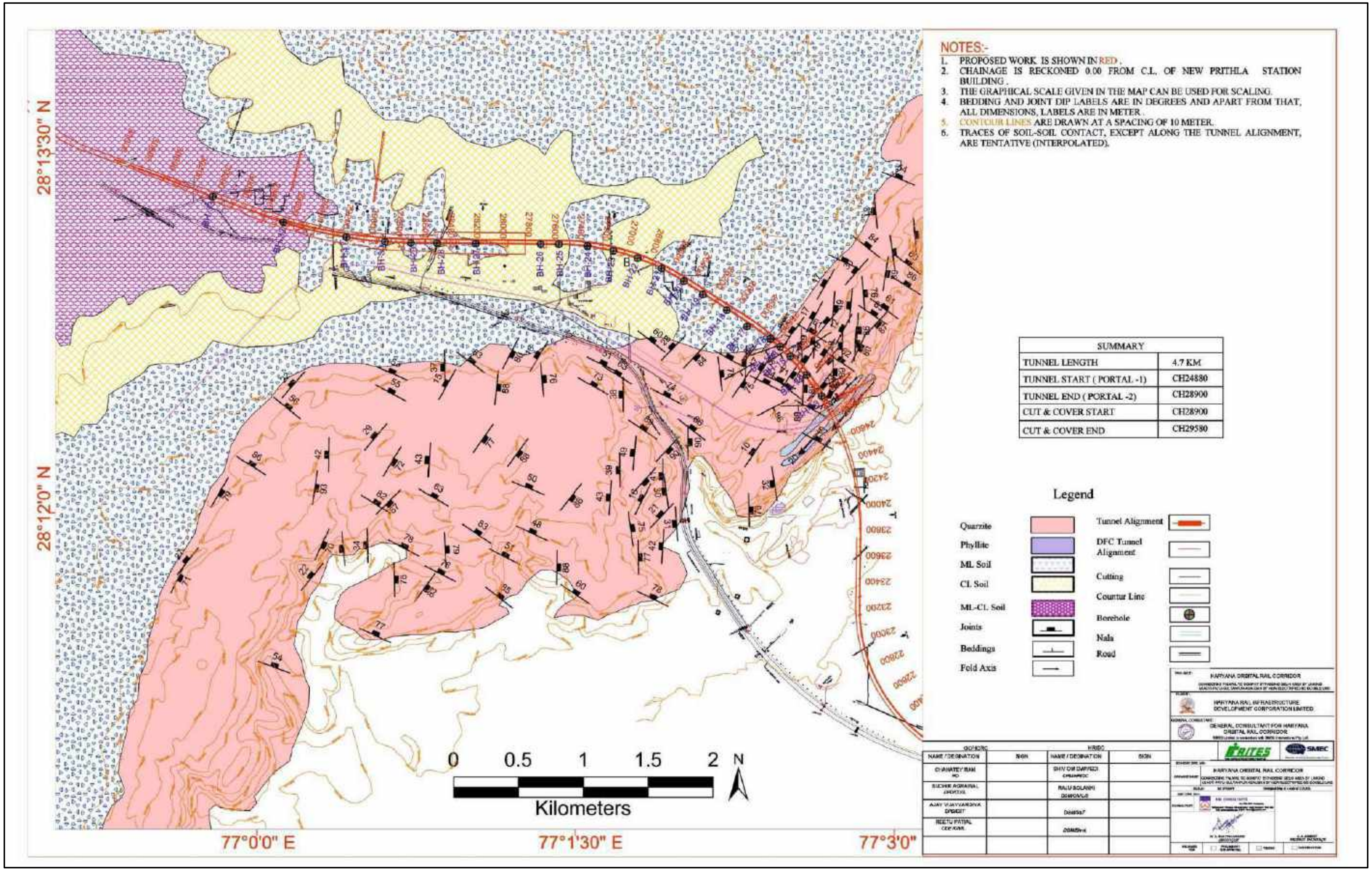
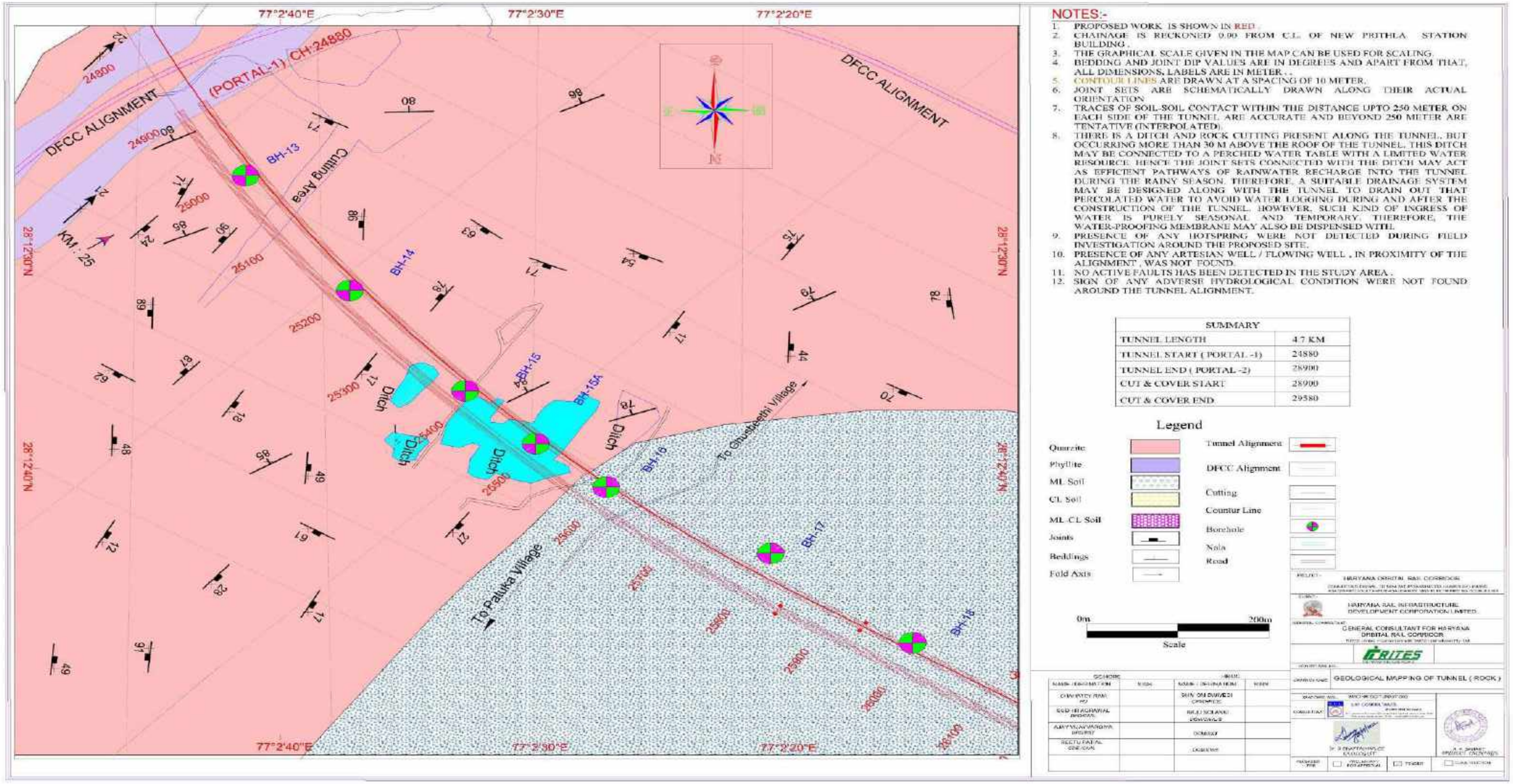


Figure 12: Geological map of the area at 1:25000 scale.

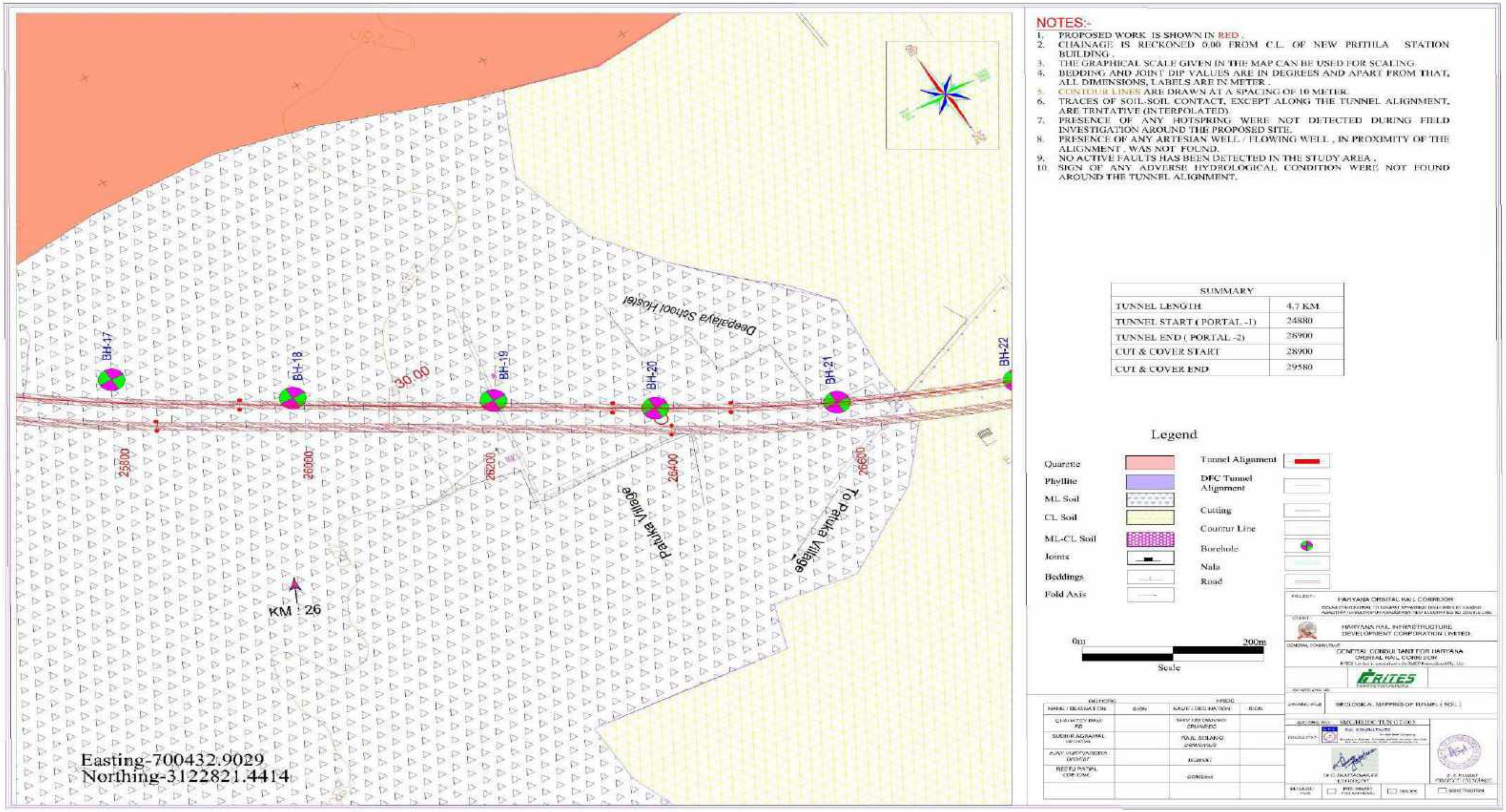


NOTES:-

1. PROPOSED WORK IS SHOWN IN RED.
2. CHAINAGE IS RECKONED 0.00 FROM C.L. OF NEW PRITHLA STATION BUILDING.
3. THE GRAPHICAL SCALE GIVEN IN THE MAP CAN BE USED FOR SCALING.
4. BEDDING AND JOINT DIP VALUES ARE IN DEGREES AND APART FROM THAT, ALL DIMENSIONS, LABELS ARE IN METER . .
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. JOINT SETS ARE SCHEMATICALLY DRAWN ALONG THEIR ACTUAL ORIENTATION
7. TRACES OF SOIL-SOIL CONTACT WITHIN THE DISTANCE UPTO 250 METER ON EACH SIDE OF THE TUNNEL ARE ACCURATE AND BEYOND 250 METER ARE TENTATIVE (INTERPOLATED).
8. THERE IS A DITCH AND ROCK CUTTING PRESENT ALONG THE TUNNEL, BUT OCCURRING MORE THAN 30 M ABOVE THE ROOF OF THE TUNNEL. THIS DITCH MAY BE CONNECTED TO A PERCHED WATER TABLE WITH A LIMITED WATER RESOURCE. HENCE THE JOINT SETS CONNECTED WITH THE DITCH MAY ACT AS EFFICIENT PATHWAYS OF RAINWATER RECHARGE INTO THE TUNNEL DURING THE RAINY SEASON. THEREFORE, A SUITABLE DRAINAGE SYSTEM MAY 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.
9. PRESENCE OF ANY HOTSPRING WERE NOT DETECTED DURING FIELD INVESTIGATION AROUND THE PROPOSED SITE.
10. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL , IN PROXIMITY OF THE ALIGNMENT , WAS NOT FOUND.
11. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA .
12. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

| SUMMARY | |
|---|---|
| TUNNEL LENGTH | 4.7 KM |
| TUNNEL START ( PORTAL -1) | 24880 |
| TUNNEL END ( PORTAL -2) | 28900 |
| CUT & COVER START | 28900 |
| CUT & COVER END | 29580 |

**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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5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. TRACES OF SOIL-SOIL CONTACT, EXCEPT ALONG THE TUNNEL ALIGNMENT, ARE TRNTATIVE (INTERPOLATED)
7. PRESENCE OF ANY HOTSPRING WERE NOT DETECTED DURING FIELD INVESTIGATION AROUND THE PROPOSED SITE.
8. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL , IN PROXIMITY OF THE ALIGNMENT , WAS NOT FOUND.
9. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA .
10. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

| SUMMARY | |
|---|---|
| TUNNEL LENGTH | 4.7 KM |
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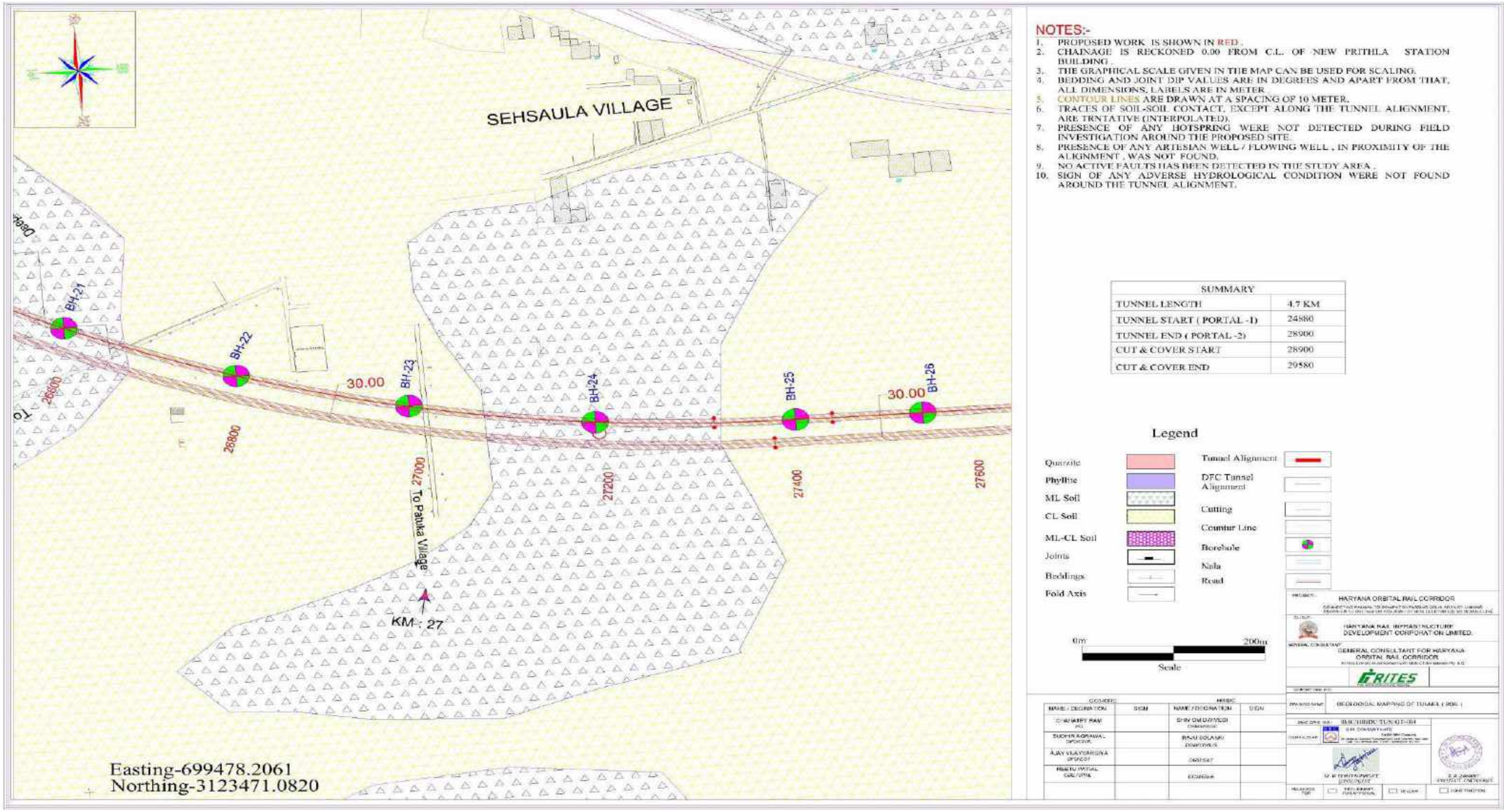
| TUNNEL END ( PORTAL -2) | 28900 |
| CUT & COVER START | 28900 |
| CUT & COVER END | 29580 |

**Figure 14: Detailed structural map of the major soil area at 1:2000 scale.**



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4. BEDDING AND JOINT DIP VALUES ARE IN DEGREES AND APART FROM THAT, ALL DIMENSIONS, LABELS ARE IN METER .
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. TRACES OF SOIL-SOIL CONTACT, EXCEPT ALONG THE TUNNEL ALIGNMENT, ARE TRNTATIVE (INTERPOLATED).
7. PRESENCE OF ANY HOTSPRING WERE NOT DETECTED DURING FIELD INVESTIGATION AROUND THE PROPOSED SITE.
8. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL , IN PROXIMITY OF THE ALIGNMENT , WAS NOT FOUND.
9. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA .
10. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

| SUMMARY | |
|---|---|
| TUNNEL LENGTH | 4.7 KM |
| TUNNEL START ( PORTAL -1) | 24880 |
| TUNNEL END ( PORTAL -2) | 28900 |
| CUT & COVER START | 28900 |
| CUT & COVER END | 29580 |

**Figure 15: Detailed structural map of the major soil area at 1:2000 scale.**

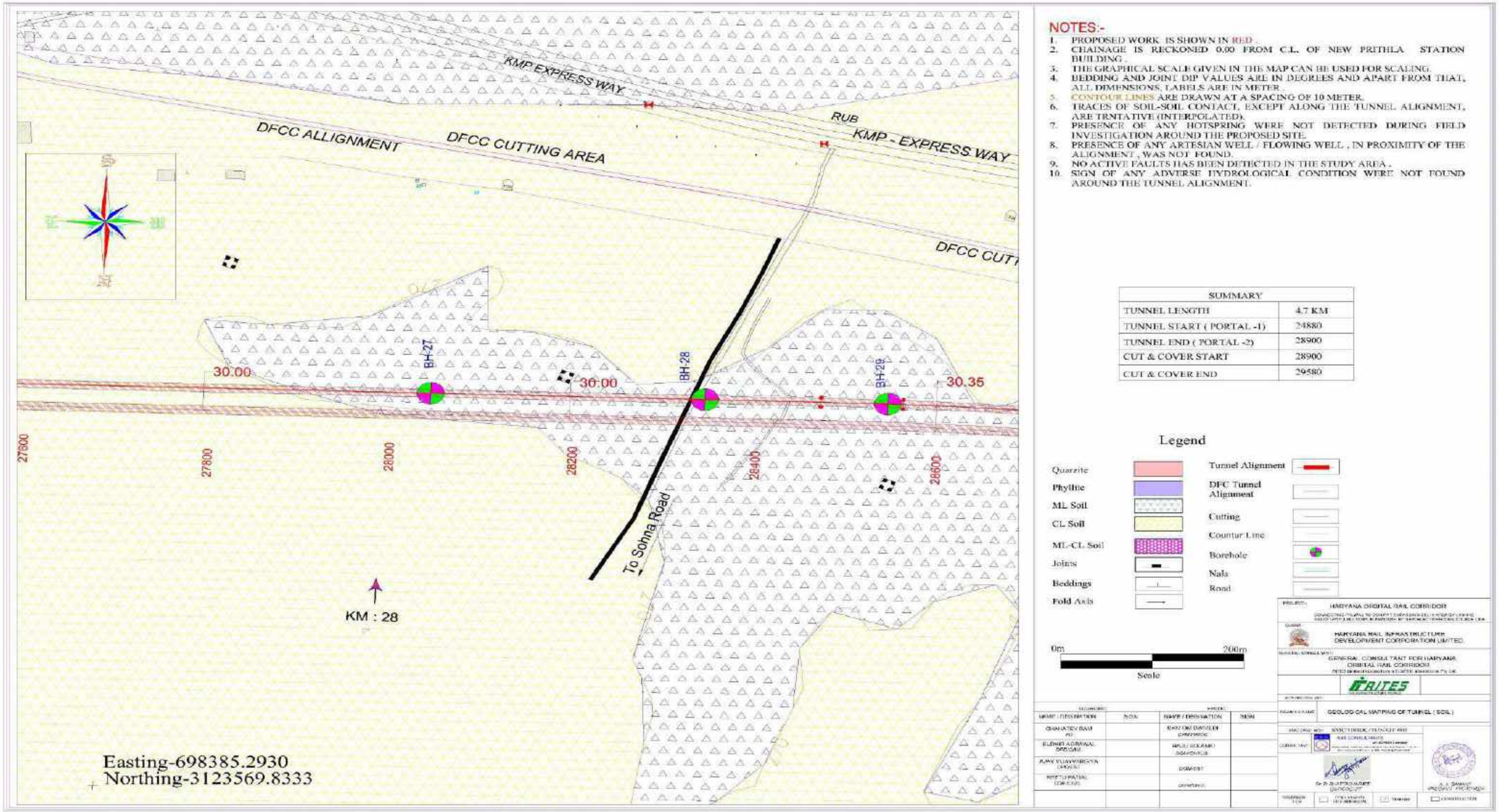


Figure 16: Detailed structural map of the major soil area at 1:2000 scale.

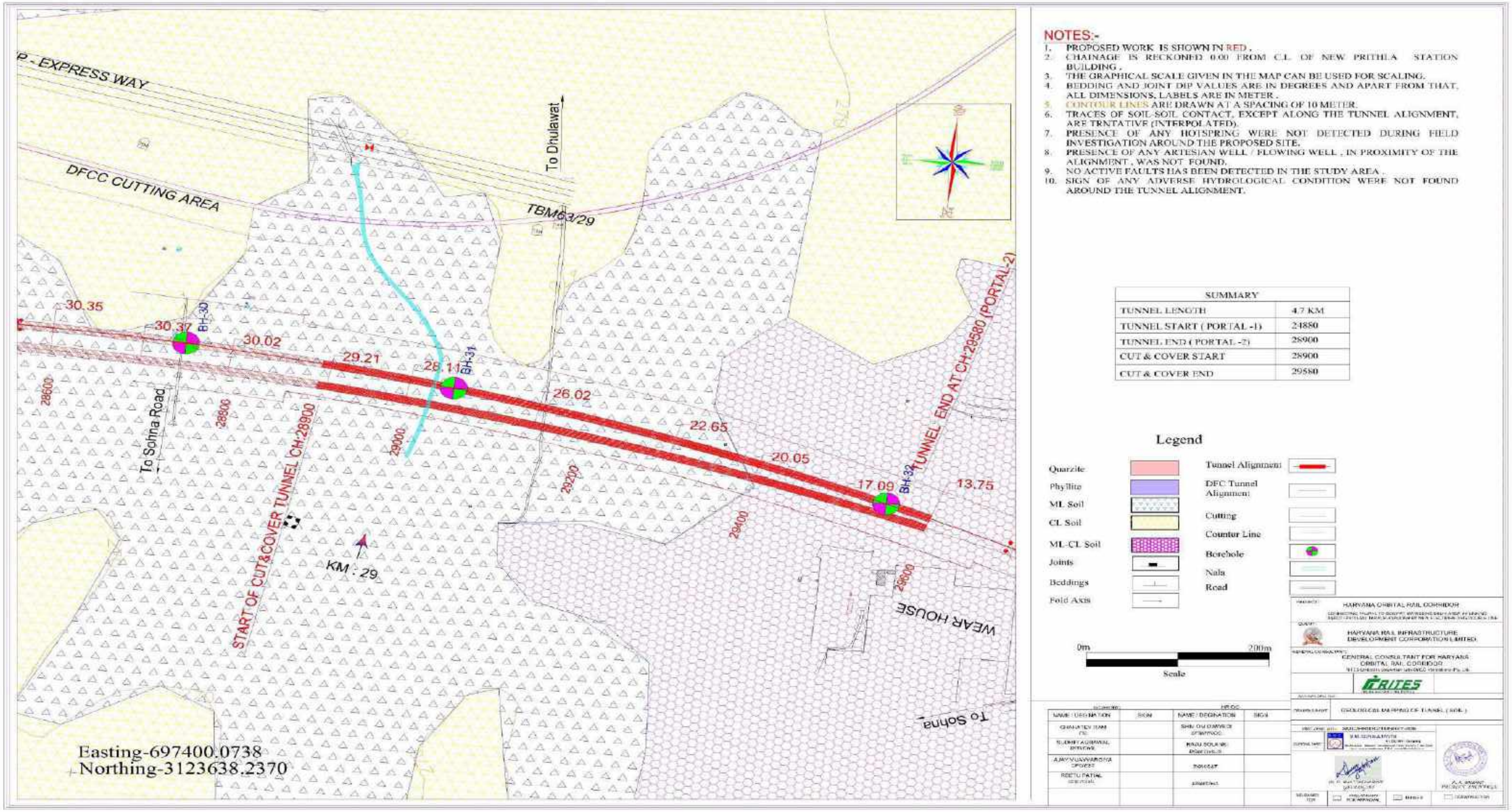
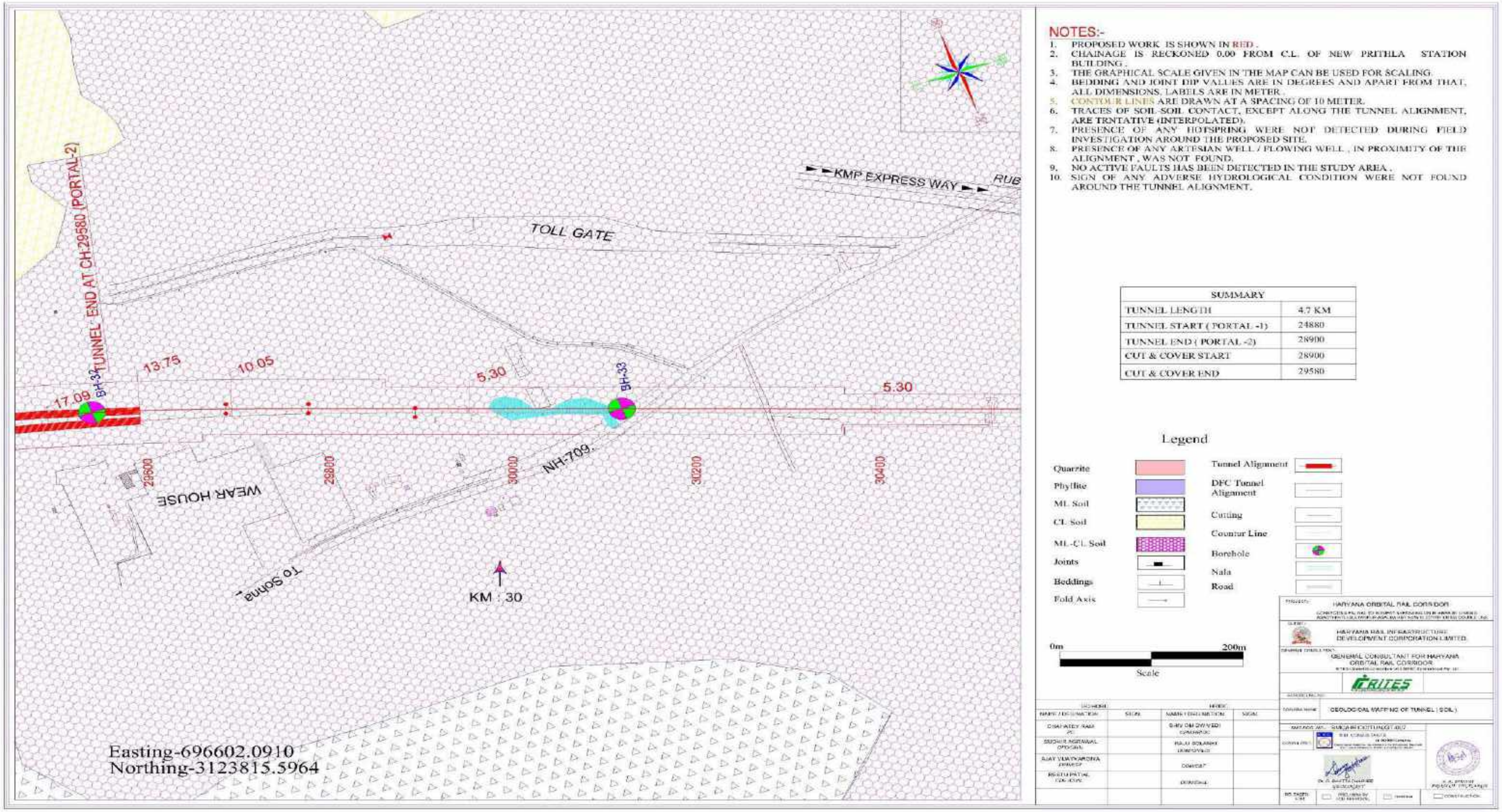


**Figure 17: Detailed structural map of the major soil area at 1:2000 scale.**



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8. PRESENCE OF ANY ARTESIAN WELL / FLOWING WELL, IN PROXIMITY OF THE ALIGNMENT, WAS NOT FOUND.
9. NO ACTIVE FAULTS HAS BEEN DETECTED IN THE STUDY AREA.
10. SIGN OF ANY ADVERSE HYDROLOGICAL CONDITION WERE NOT FOUND AROUND THE TUNNEL ALIGNMENT.

| SUMMARY | |
|---|---|
| TUNNEL LENGTH | 4.7 KM |
| TUNNEL START ( PORTAL -1) | 24880 |
| TUNNEL END ( PORTAL -2) | 28900 |
| CUT & COVER START | 28900 |
| CUT & COVER END | 29580 |

Figure 18: Detailed structural map of the major soil area at 1:2000 scale.

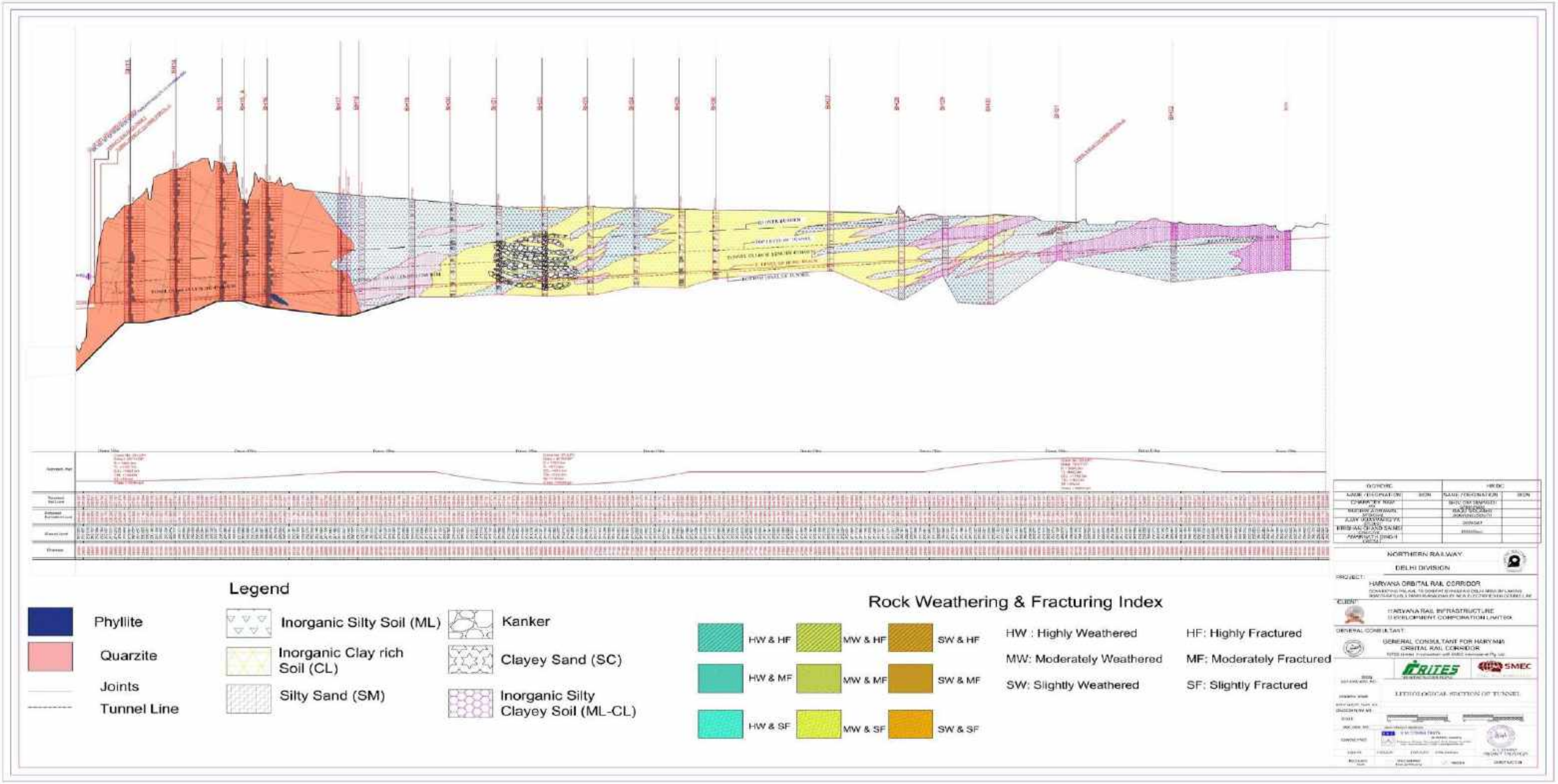


Figure 19: L-Section along the hilly terrain (1:25000 H and 1:2500 V). Joint sets are schematically drawn along their actual orientation.

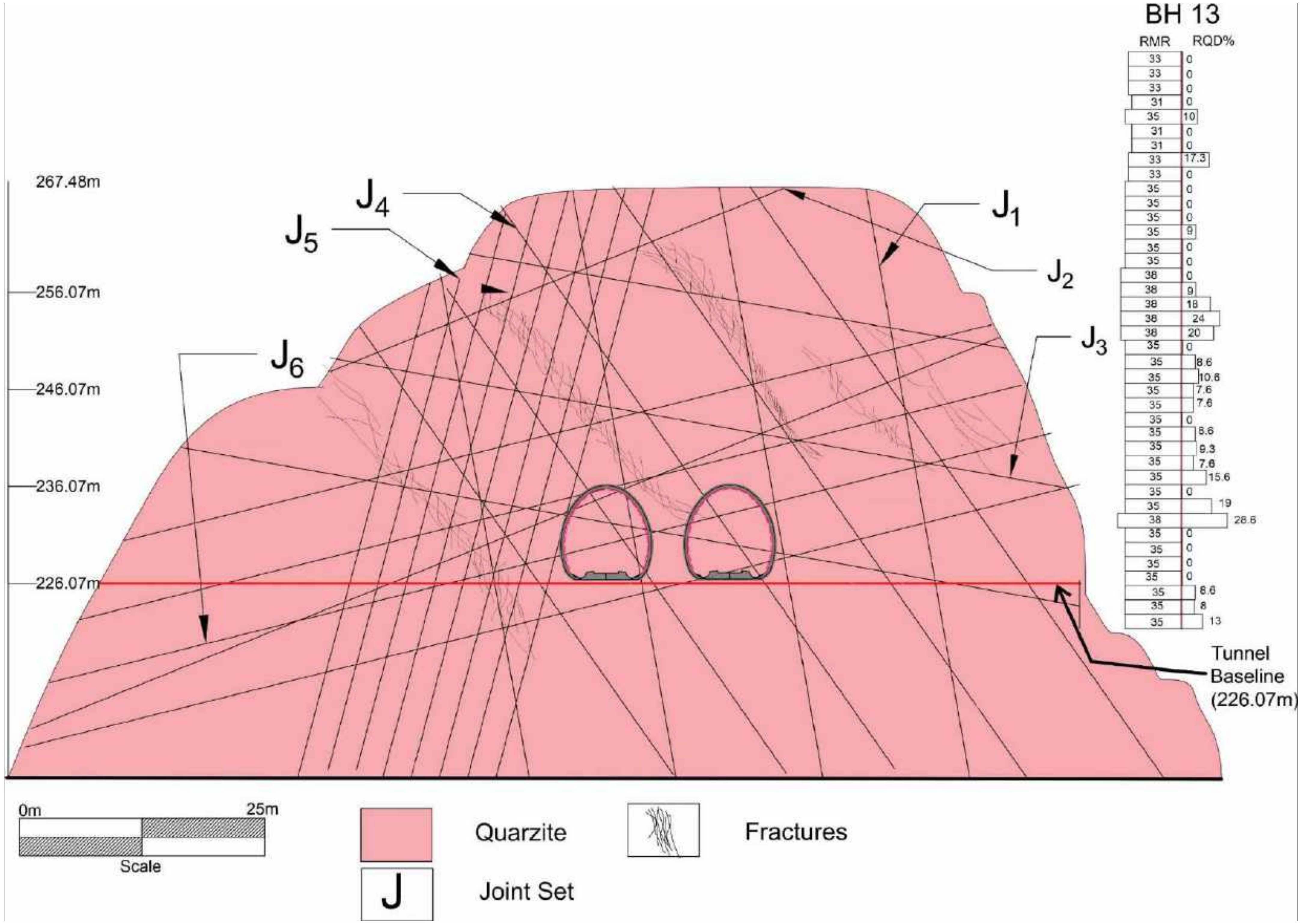


**Figure 20: Detailed cross section of the portal face on the mountain front. Joint sets are schematically drawn along their actual orientation. Average spacing between the joints are as follows J1: 300 cm, J2:252.78cm, J3:160cm, J4:80cm,J5:32cm,J6:100cm.**

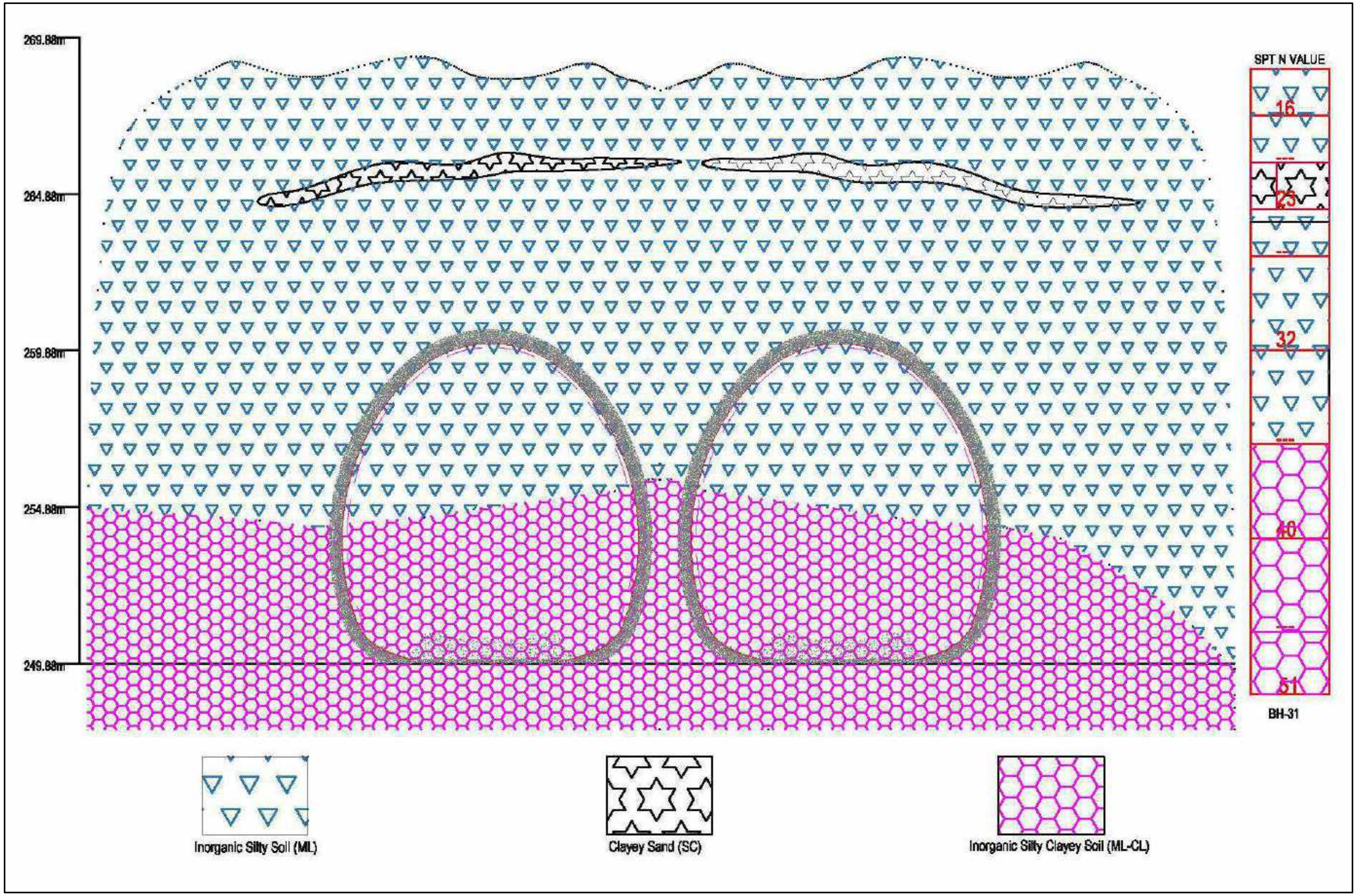


**Figure 21: Detailed lithological cross section at the end of NATM Structure in soil (CH 28900).**

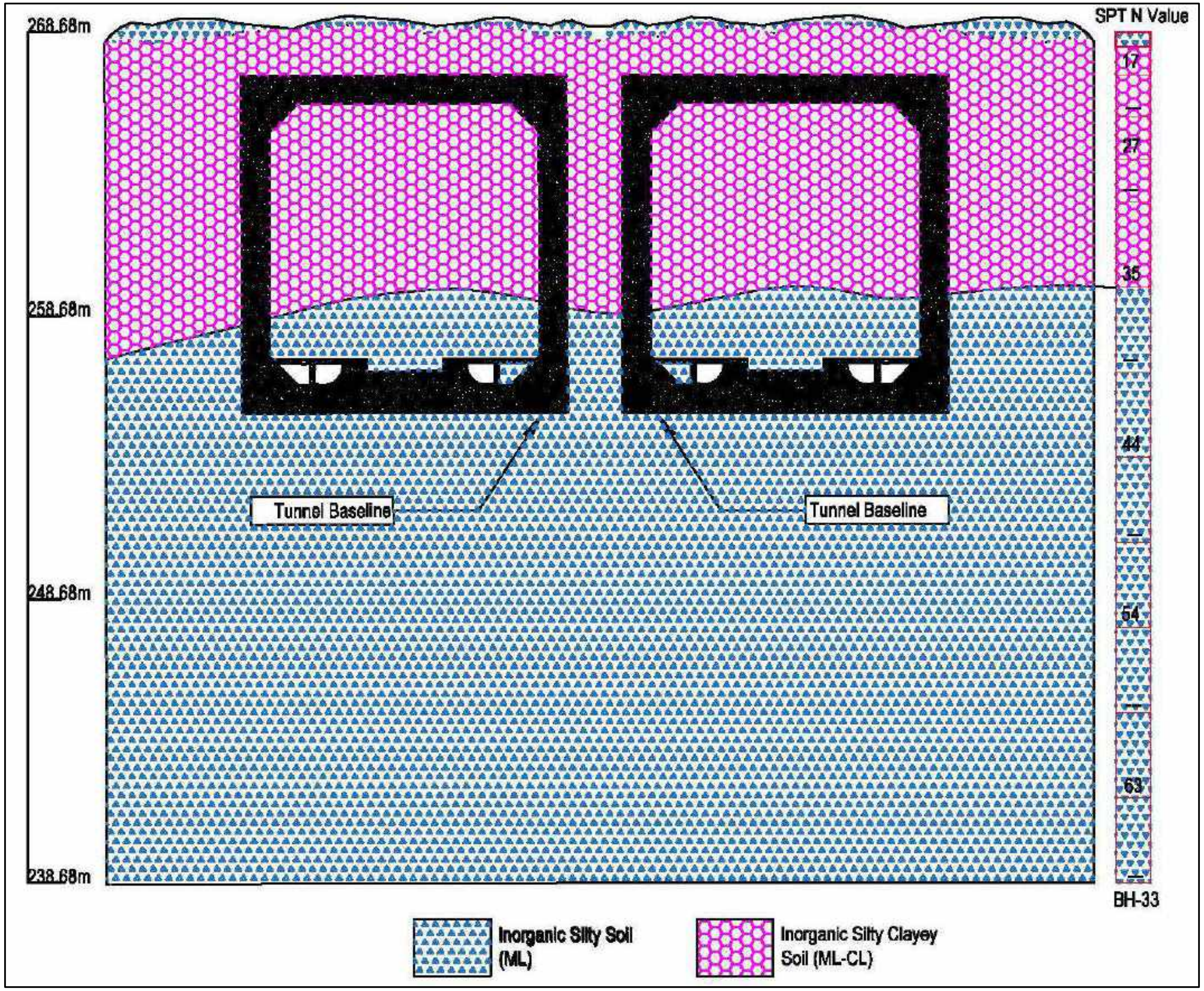


**Figure 22: Cut and Cover structure at the end of tunnel – Portal II (CH29600).**

# 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.

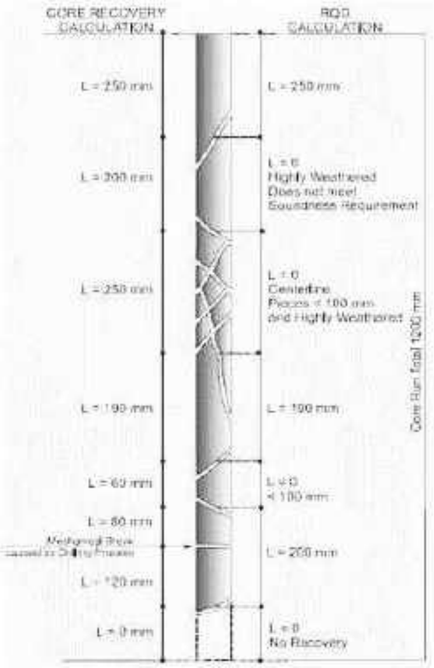
**Table 5 Parker test results**

| **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 | | |
| | | $p_w$ / 1 | 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; 1 = 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.

**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<br>RMR: 81-100 | Full face:<br>3 m advance | Generally, no support required except for occasional spot bolting | | |
| 2. Good rock<br>RMR: 61-80 | Full face:<br>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<br>RMR: 41-60 | Top heading and bench: 1.5-3 m advance in top heading;<br>Commence support after each blast;<br>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 |

| **Rock mass class** | **Excavation** | **Support** | | |
|---|---|---|---|---|
| | | Rock bolts (20 mm diam., fully bonded) | Shotcrete | Steel sets |
| 4. Poor rock<br>RMR: 21-40 | Top heading and bench: 1.0-1.5 m advance in top heading;<br>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<br>RMR < 21 | Multiple drifts:<br>0.5-1.5 m advance in top heading;<br>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)**

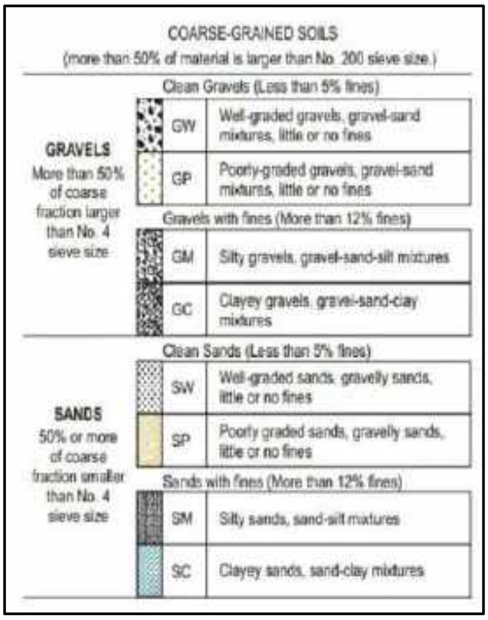
| BH NO. | AVERAGE RMR VALUE | MAXIMUM RMR VALUE | MINIMUM RMR VALUE |
|---|---|---|---|
| BH-13 | 34.95 | 40 | 31 |
| BH-14 | 34.18 | 38 | 31 |
| BG-15 | 33.23404 | 40 | 24 |
| BH-15A | 29.47059 | 43 | 27 |
| BH-16 | 37.61905 | 48 | 30 |
| BH-17 | 41.2 | 47 | 32 |

**Based on the average RMR value of the rock mass it falls into “Poor” category**

## 5.3 The Unified Soil Classification System (USCS) :

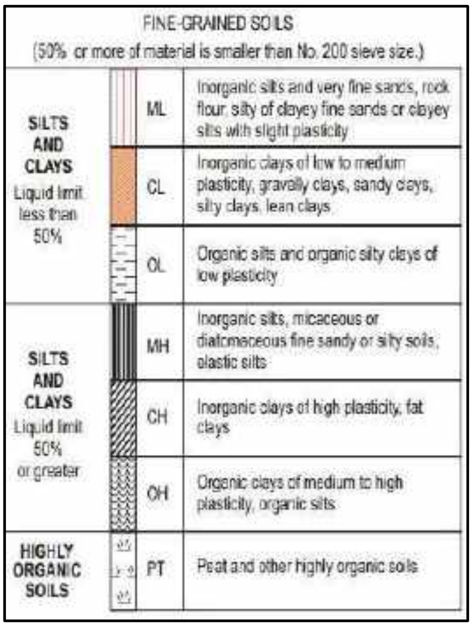
Though RMR classification provide great insight to classify the different types hard rocks of with reference to the tunnel designing, but it loses its reliability in classification soil or highly weathered rock. The main problem with using RMR for weak rock mass classification is that ratings are not 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.



| COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.) | | | |
|---|---|---|---|
| GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size | Clean Gravels (Less than 5% fines) | GW | Well-graded gravels, gravel-sand mixtures, little or no fines |
| | | GP | Poorly-graded gravels, gravel-sand mixtures, little or no fines |
| | Gravels with fines (More than 12% fines) | GM | Silty gravels, gravel-sand-silt mixtures |
| | | GC | Clayey gravels, gravel-sand-clay mixtures |
| SANDS 50% or more of coarse fraction smaller than No. 4 sieve size | Clean Sands (Less than 5% fines) | SW | Well-graded sands, gravelly sands, little or no fines |
| | | SP | Poorly graded sands, gravelly sands, litte or no fines |
| | Sands with fines (More than 12% fines) | SM | Silty sands, sand-silt mixtures |
| | | SC | Clayey sands, sand-clay mixtures |

**Figure 23: USCS Classification of coarse-grained soil.**



| FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.) | | |
|---|---|---|
| SILTS AND CLAYS Liquid limit less than 50% | ML | Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity |
| | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays |
| | OL | Organic silts and organic silty clays of low plasticity |
| SILTS AND CLAYS Liquid limit 50% or greater | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts |
| | CH | Inorganic clays of high plasticity, fat clays |
| | OH | Organic clays of medium to high plasticity, organic silts |
| HIGHLY ORGANIC SOILS | PT | Peat and other highly organic soils |

**Figure 24: USCS Classification of fine-grained soil**

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.

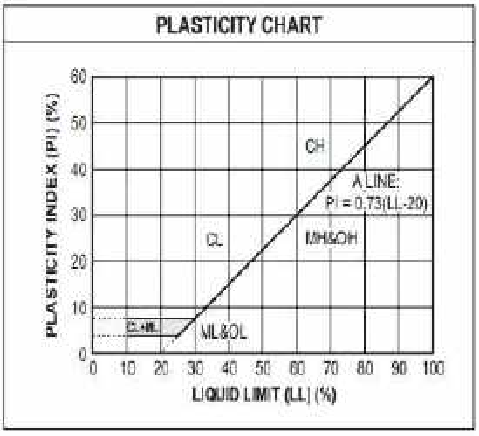


**Figure 25 Relation between Liquid Limit and Plasticity Index of soil for USCS**

## 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

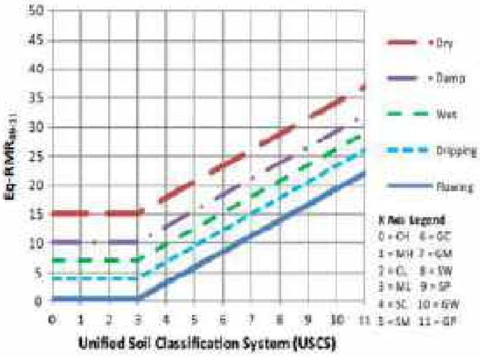


**Figure 26 Graph showing correlation between USCS classification and RMR Classification. (Warren,2016)**

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

$$"RMR = a . LnQ + b"$$

The value of *'a'* and *'b'* are different for different equation purposed by different author and they vary over a range of value.

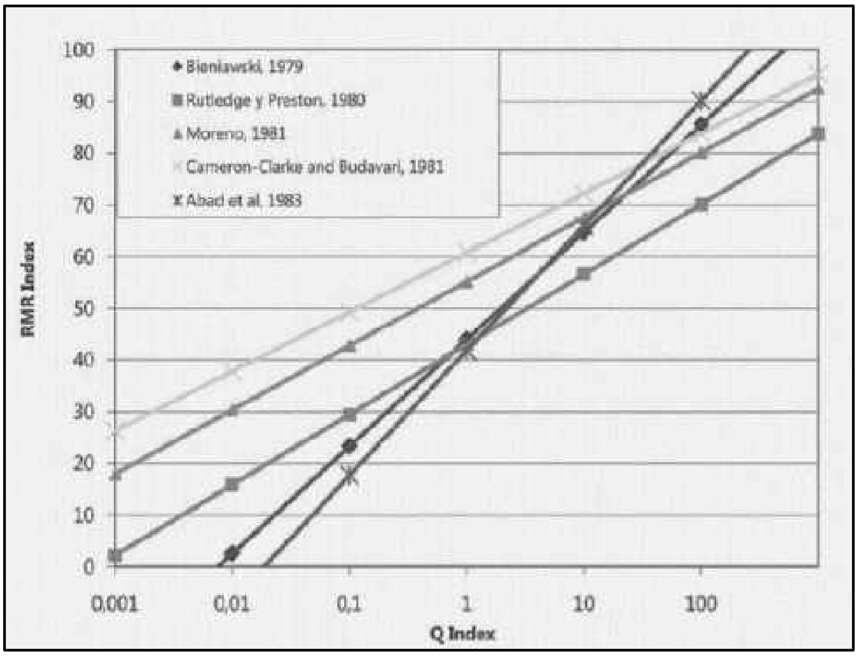


**Figure 27: Graph showing correlation between different empirical equation for conversion between Q Index and RMR Index (adopted from Castro-fresno)**

$"RMR = 9\,LnQ + 44"$ Bieniawski;1984

"$\boldsymbol{RMR = 5.9\,LnQ + 43}$" Rutledge and Preston;1978

"$\boldsymbol{RMR = 5.4\,LnQ + 55.2}$" Moreno Tallon; 1980

"$\boldsymbol{RMR = 10.5\,LnQ + 41}$" Cameron-Clarke and Budavari;1981

"$\boldsymbol{RMR = 5\,LnQ + 60.8}$" 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<br>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)<br>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.<br>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<br>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 | | $\sigma_c/\sigma_1$ | $\sigma_c/\sigma_2$ | 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.<br>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<br>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 $5 \leq \sigma 1/\sigma 3 \leq 10$, reduce σc to 0.75 σc. When $\sigma 1/\sigma 3 > 10$, reduce σc to 0.5 $\sigma_c$, where $\sigma_c$ = unconfined compression strength, σ1 and σ3 are the major and minor principal stresses, and σ1σ2= maximum tangential stress (estimated from elastic theory)<br>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) | | | | |

| 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:

$\sigma_t$ = 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.

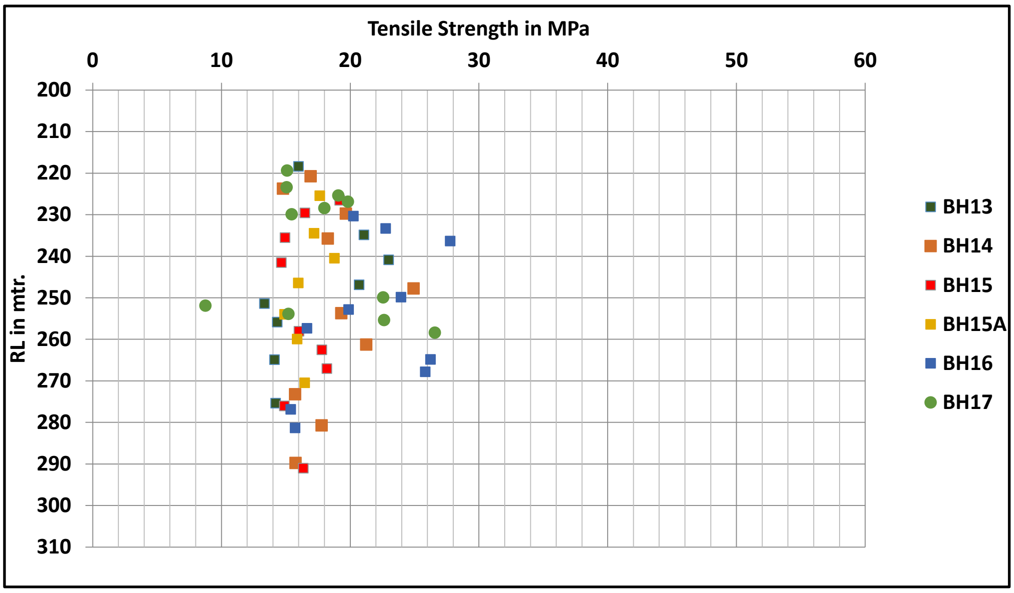


Figure 28: Tensile Strength of rock mass from entire borehole length vs RL. (Refer to Annexure B in Geotechnical Report for detail).

**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.

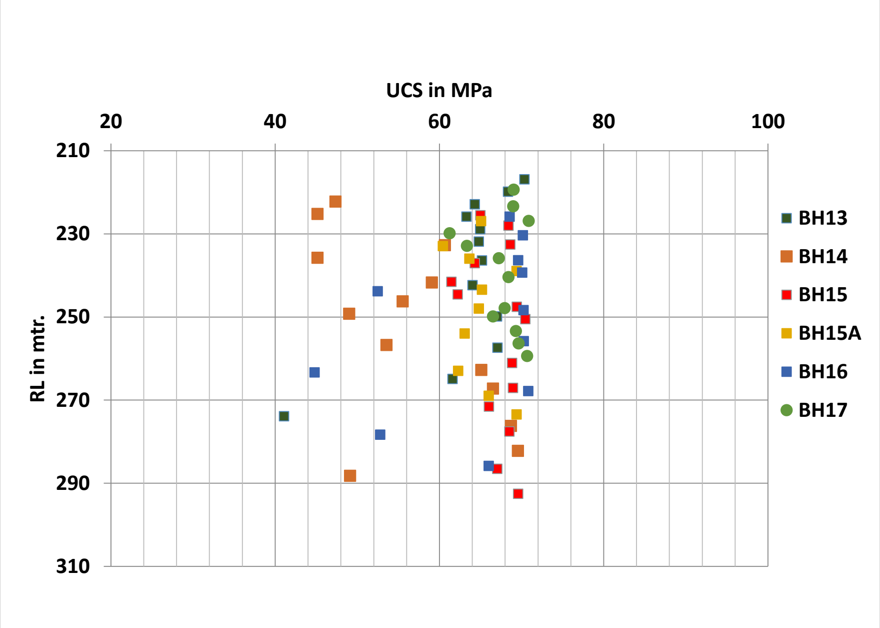


**Figure 29: Unconfined Compressive Strength (UCS) of rock mass from entire borehole length vs RL (Refer to Annexure C in Geotechnical Report for detail).**

**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: $I_I(50)$ = 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.

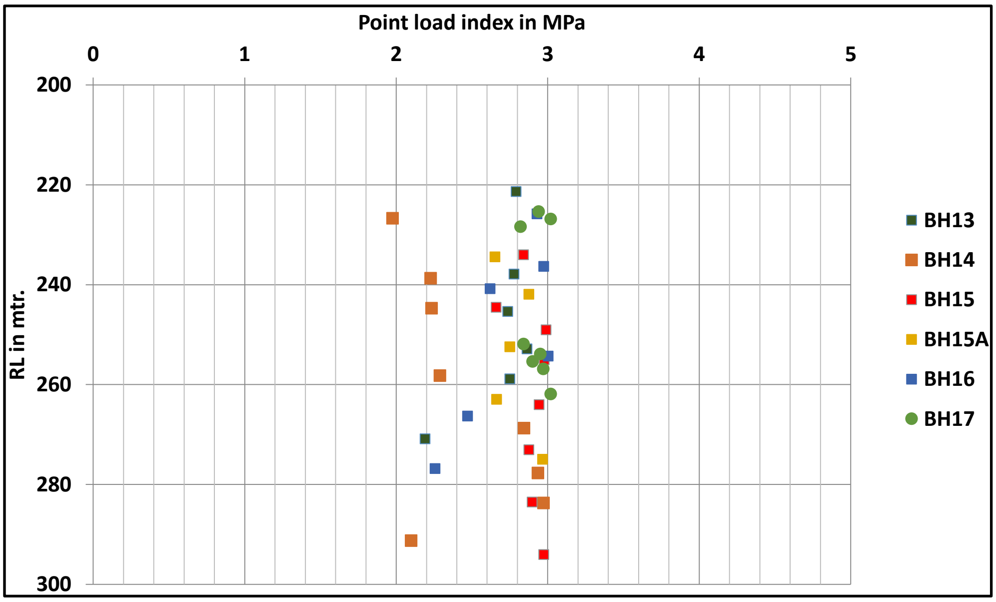


**Figure 30: Point Load Index (PLI) of rock mass from entire borehole length vs RL. (Refer to Annexure E in Geotechnical Report for detail).**

**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 $\sigma$ 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

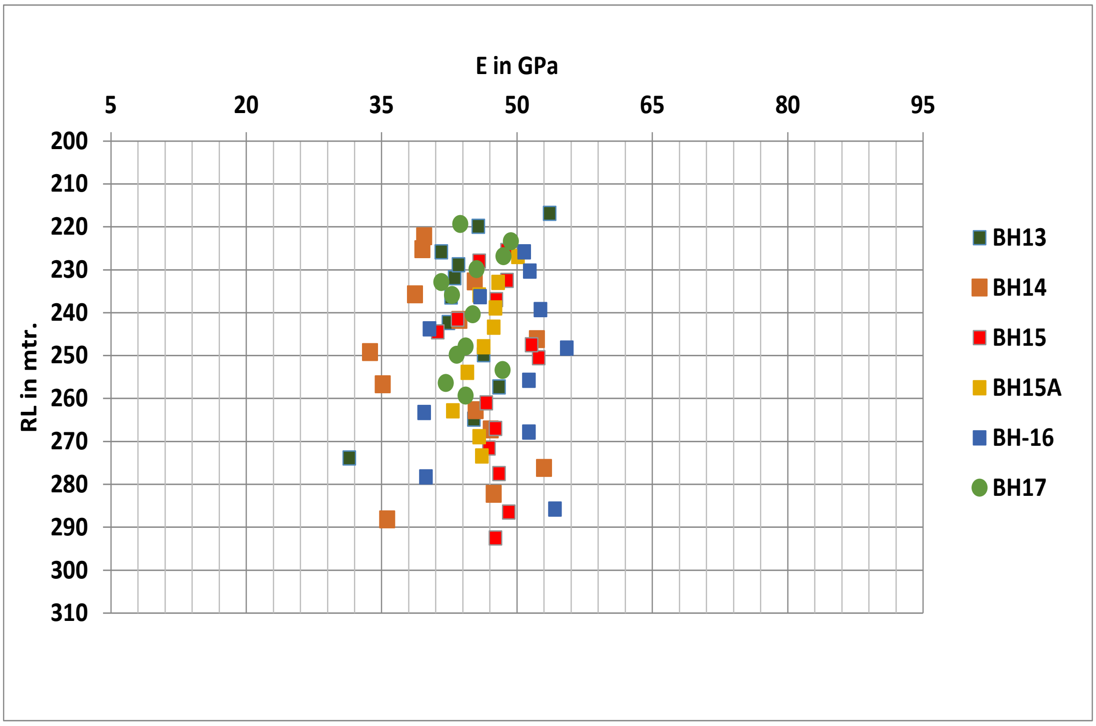


**Figure 31: Modulus of Elasticity (E) of rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).**

**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 (ν) –**

Poisson's ratio shall be calculated as the ratio of the total diametric strain $\varepsilon d$ to the total axial strain $\varepsilon a$ 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

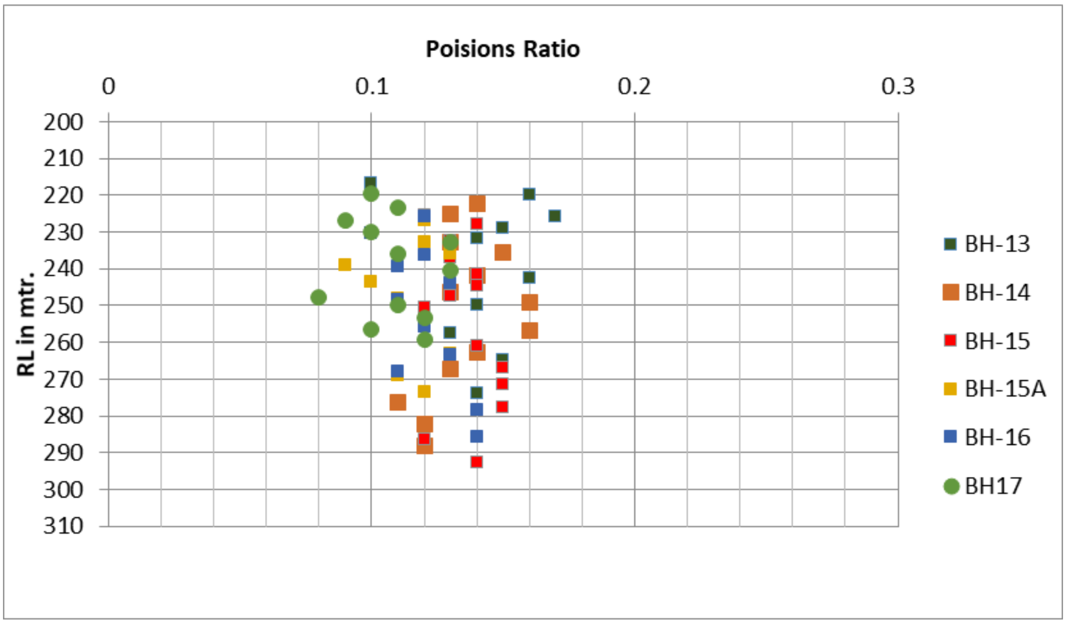


**Figure 32: Poisson's Ratio distribution for the entire rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).**

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 $\emptyset$ 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.

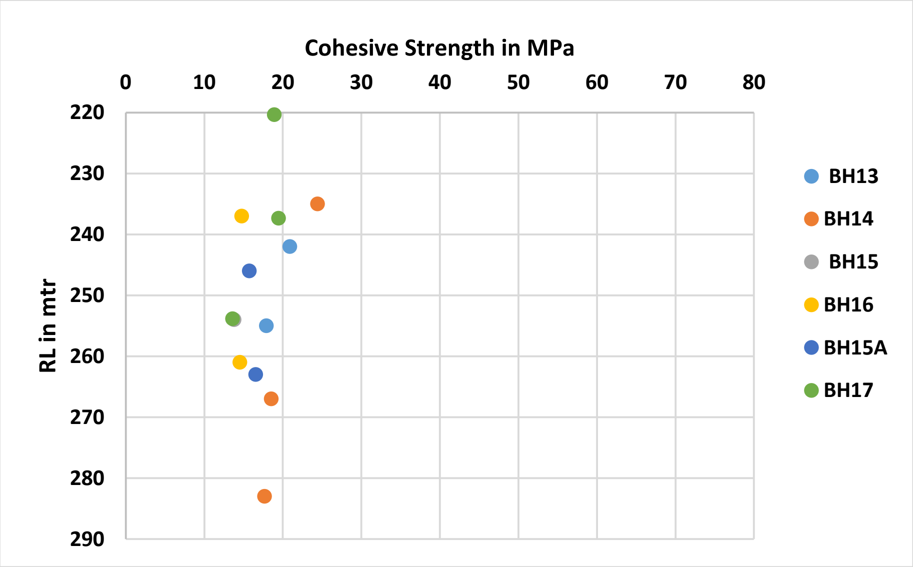


**Figure 33: Cohesive strength of rock mass from entire borehole length vs RL (Refer to Annexure F in Geotechnical Report for detail).**

**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 |

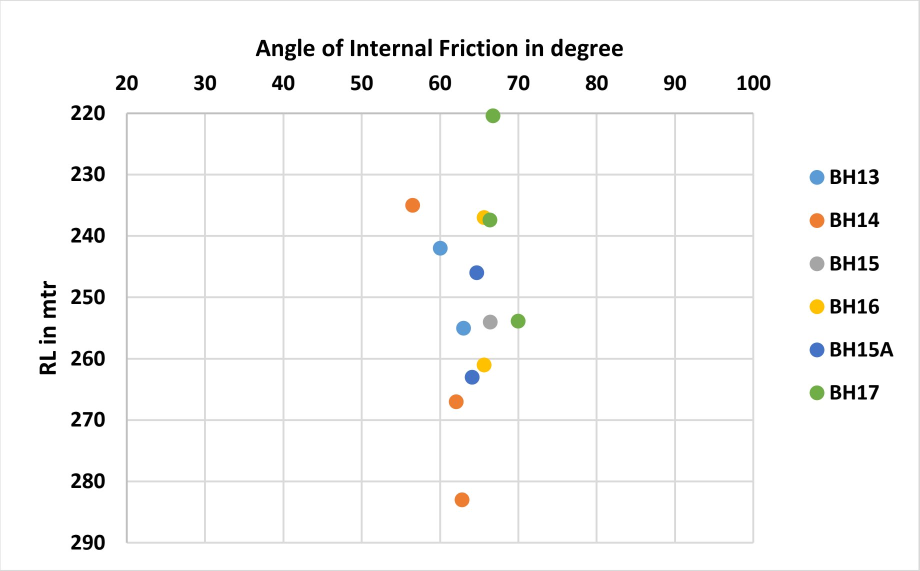


**Figure 34: Angle of internal friction of rock mass from entire borehole length vs RL (Refer to Annexure G in Geotechnical Report for detail).**

**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.

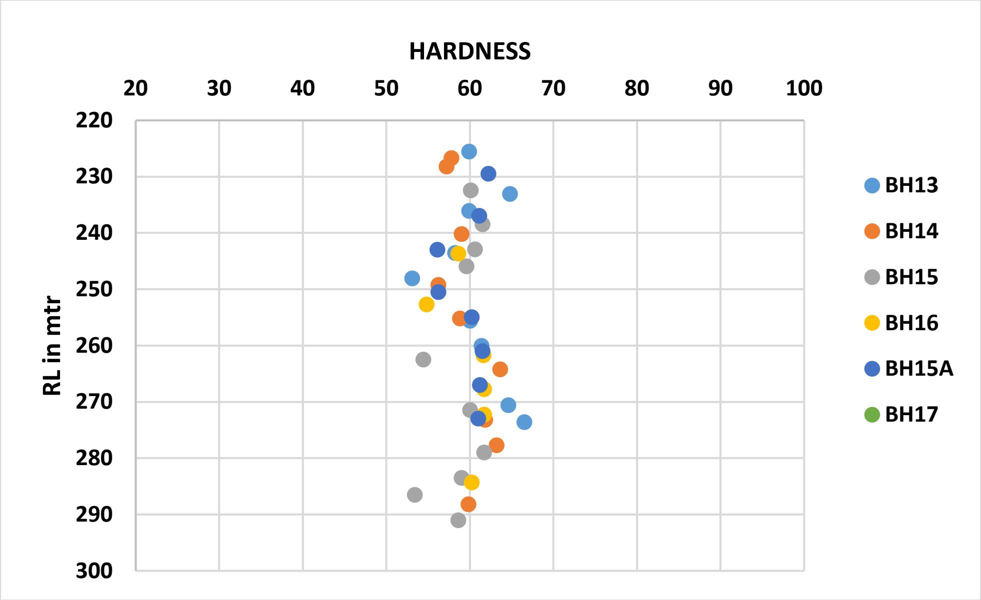


**Figure 35: Hardness of rock mass from entire borehole length vs RL. (Refer to Annexure H in Geotechnical Report for detail).**

**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

$$\text{CAI or CAIs}=\frac{1}{10\in}\sum_{1}^{10} di$$

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

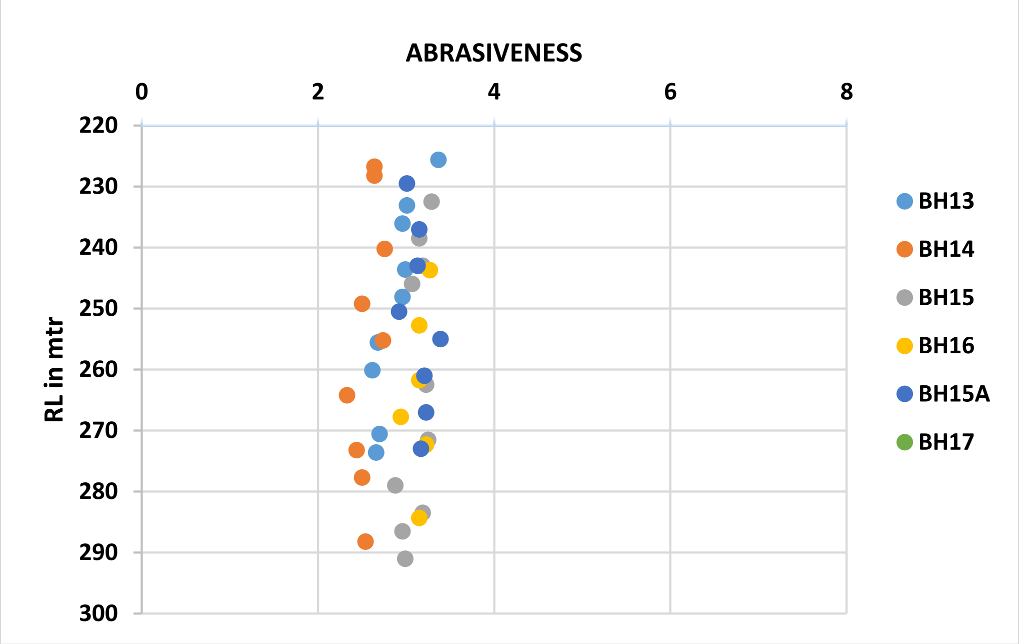


**Figure 36: Abrasiveness of rock mass from entire borehole length vs RL. (Refer to Annexure I in Geotechnical Report for detail).**

**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 |

| 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.

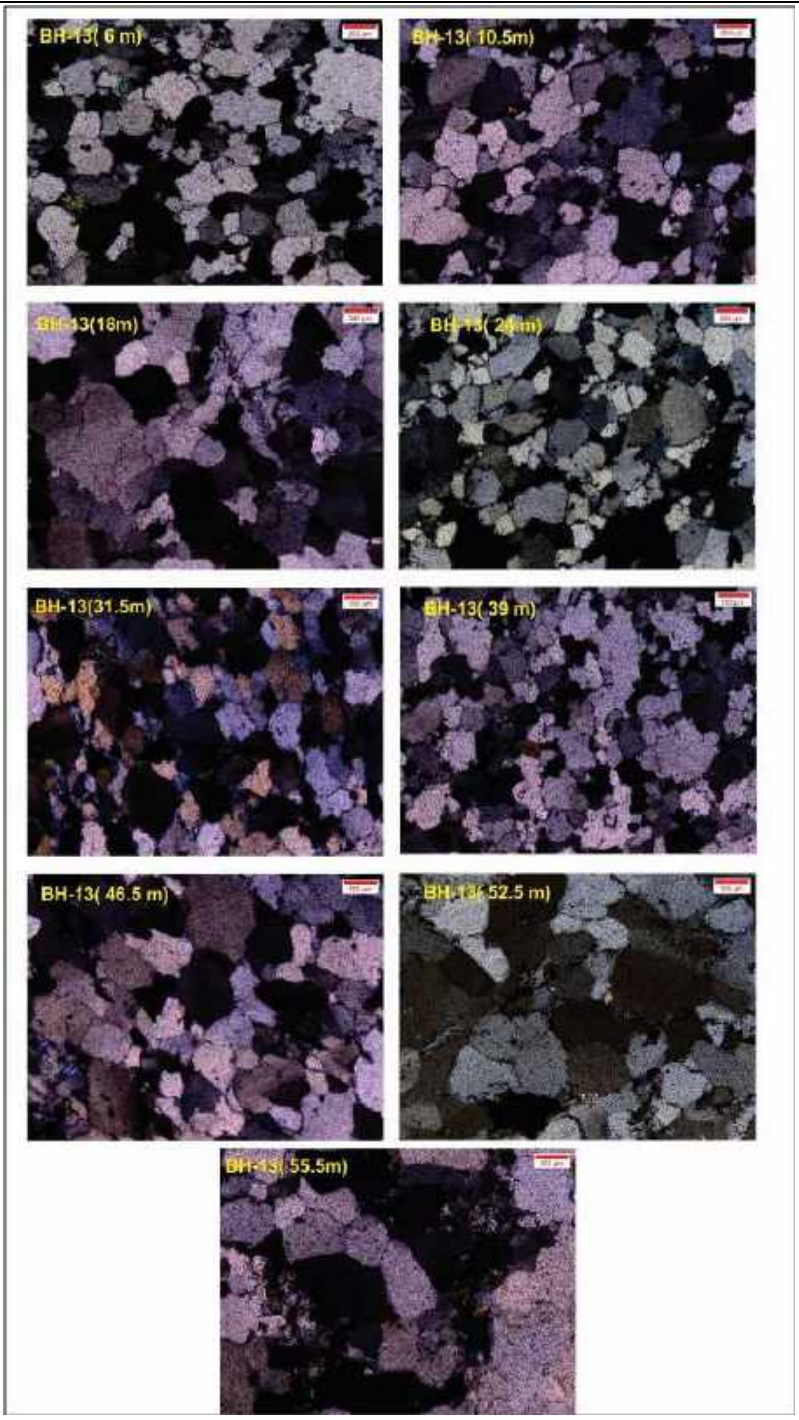


**Figure 37: Borehole 13 sample under optical microscope (Cross polarized 5X)**

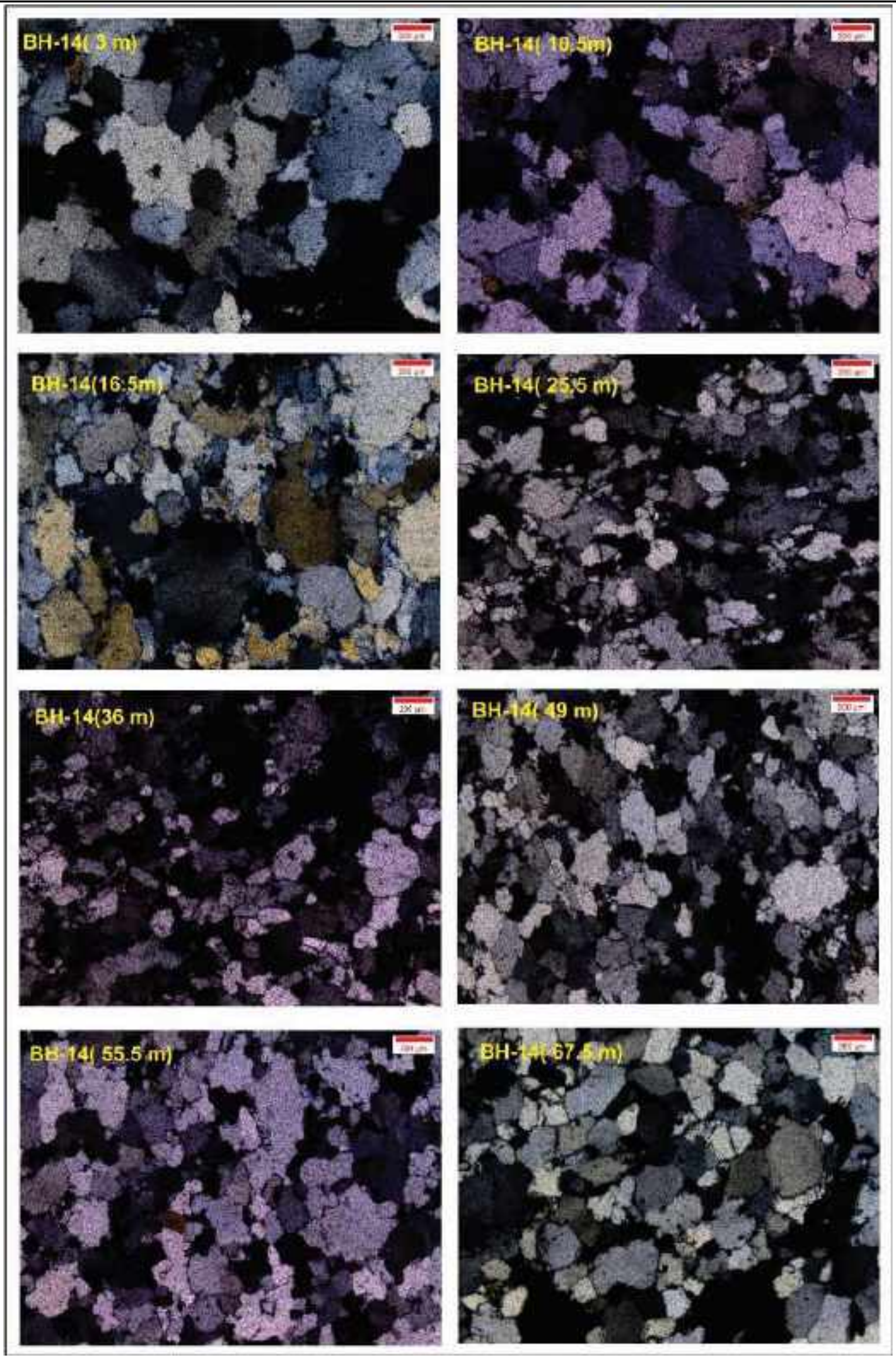


**Figure 38: Borehole 14 samples under optical microscope (Cross polarized 5X)**

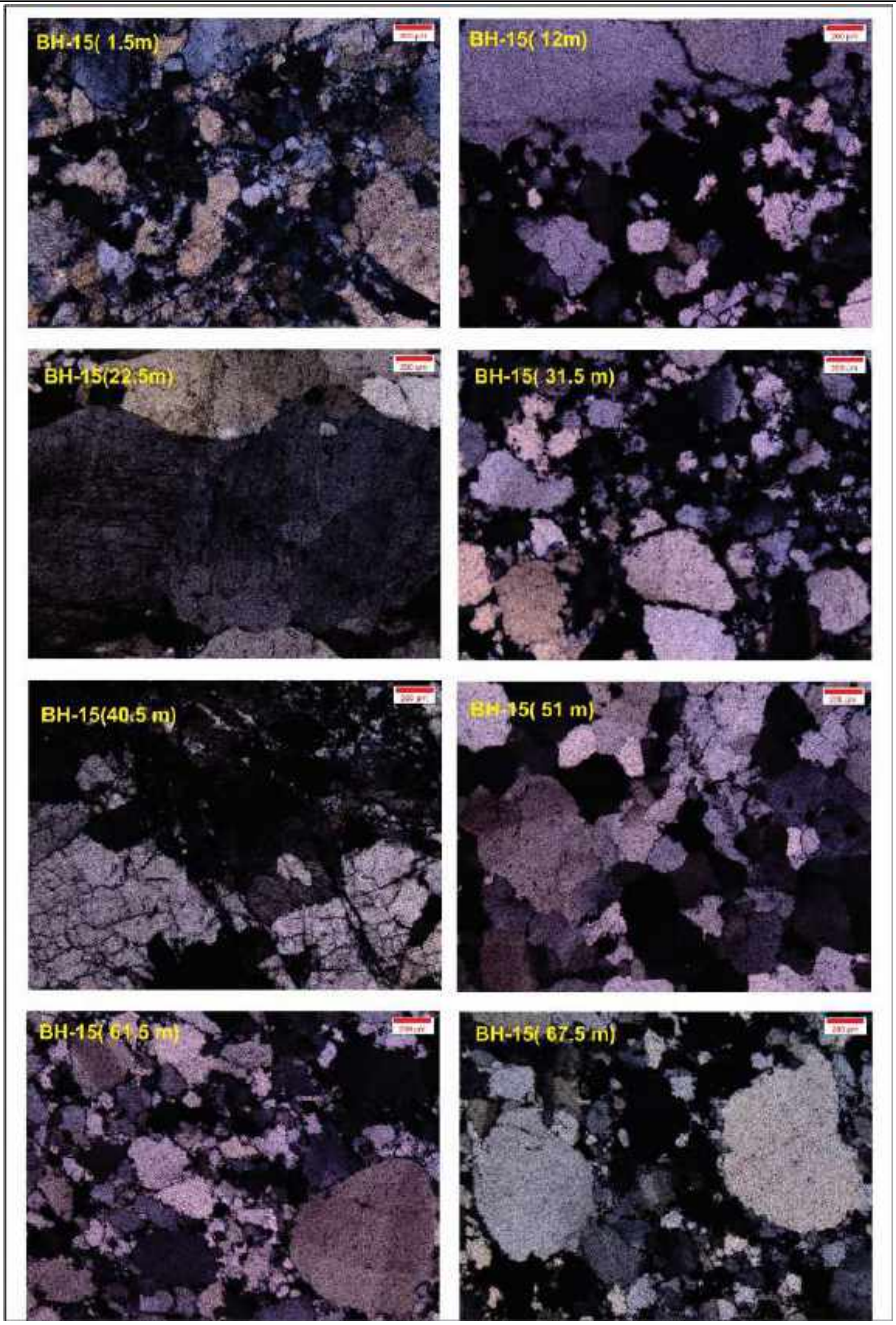


**Figure 39: Borehole 15 Samples under optical microscope (cross polarized 5X).**

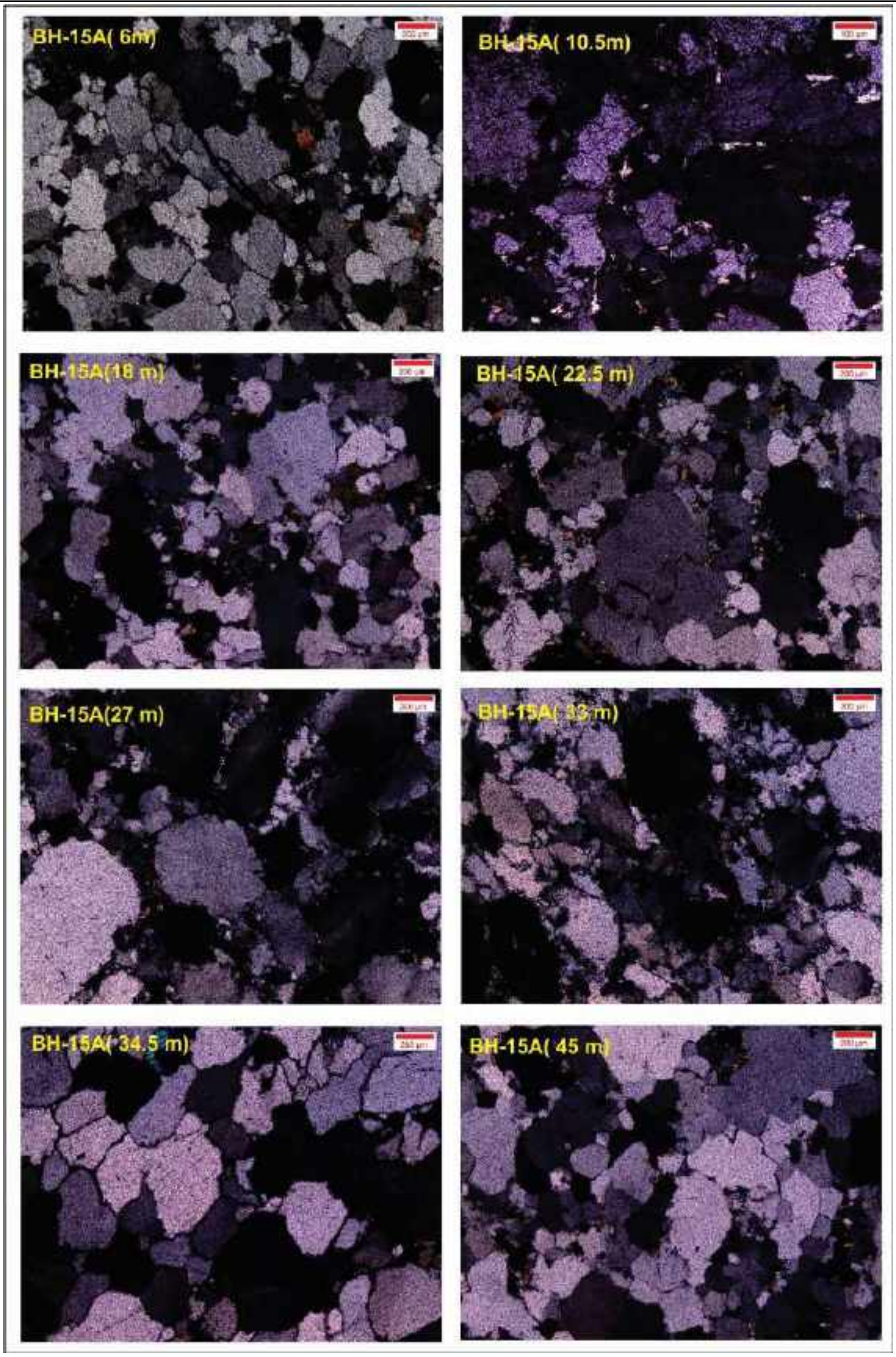


**Figure 40: Borehole 15(A) Samples under optical microscope (cross polarized 5X).**

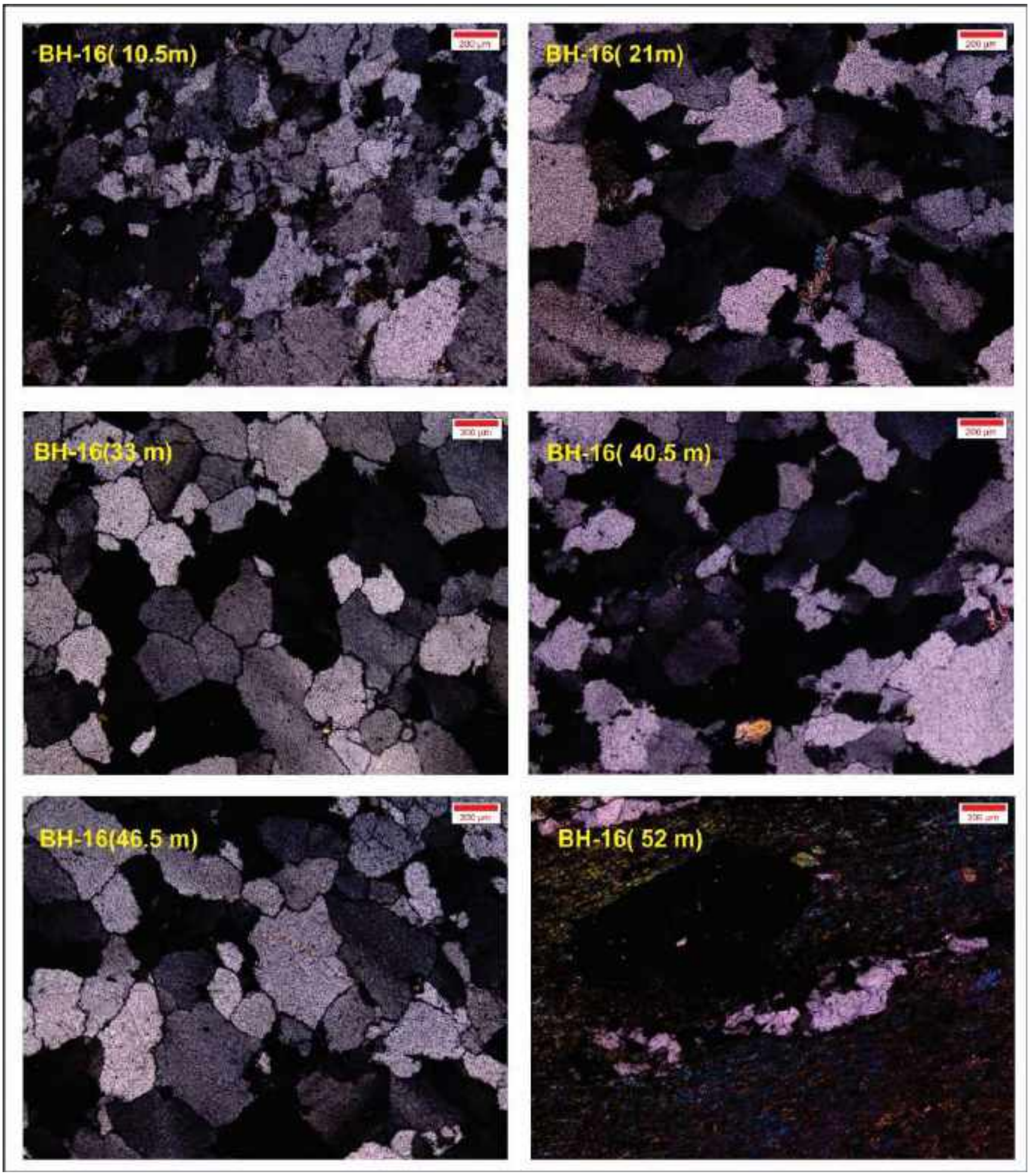


**Figure 41: Borehole 16 sample under optical microscope (cross polarized 5X).**

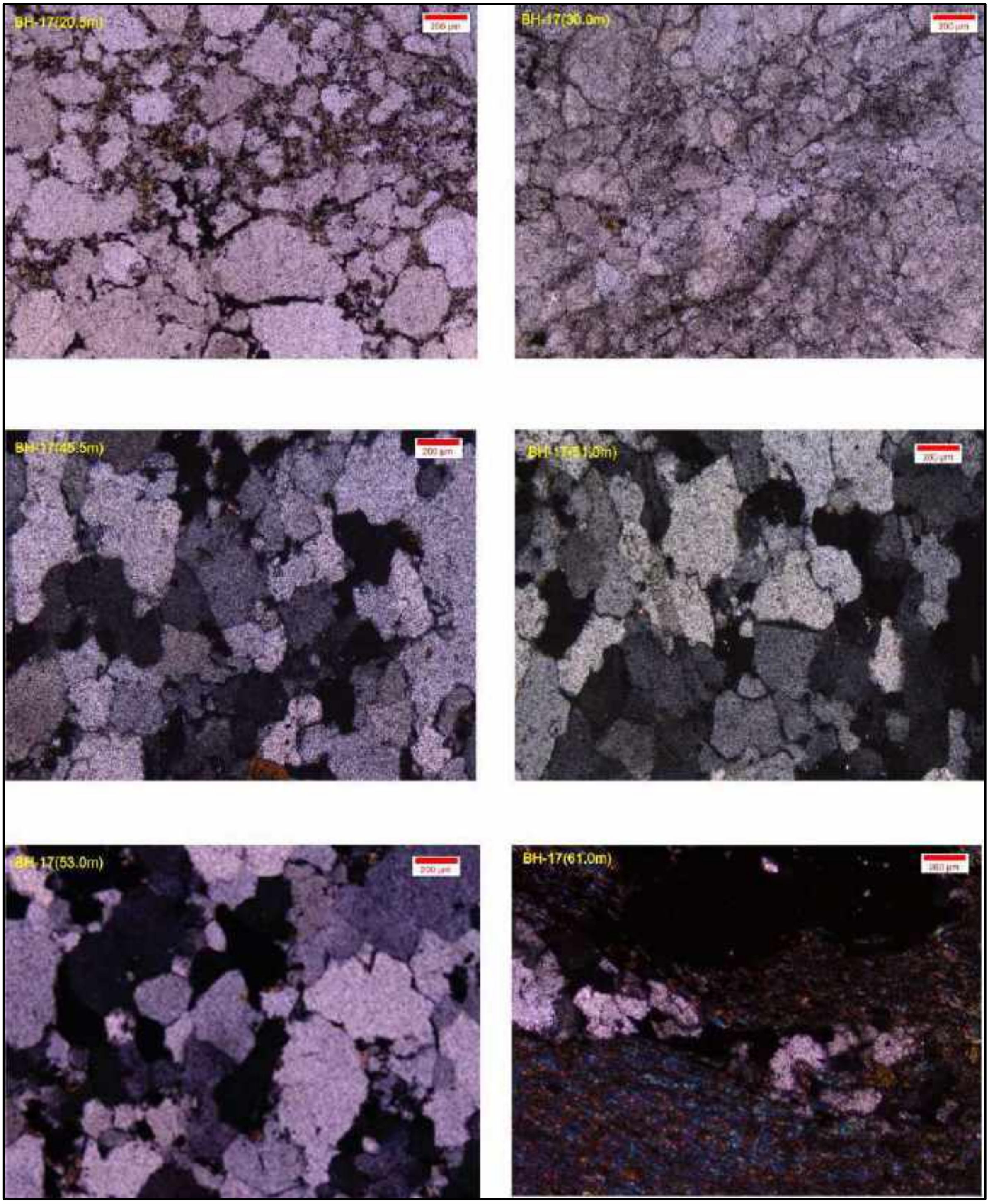


**Figure 42: Borehole 17 sample under optical microscope**

## 6.1.11 Grain size analysis

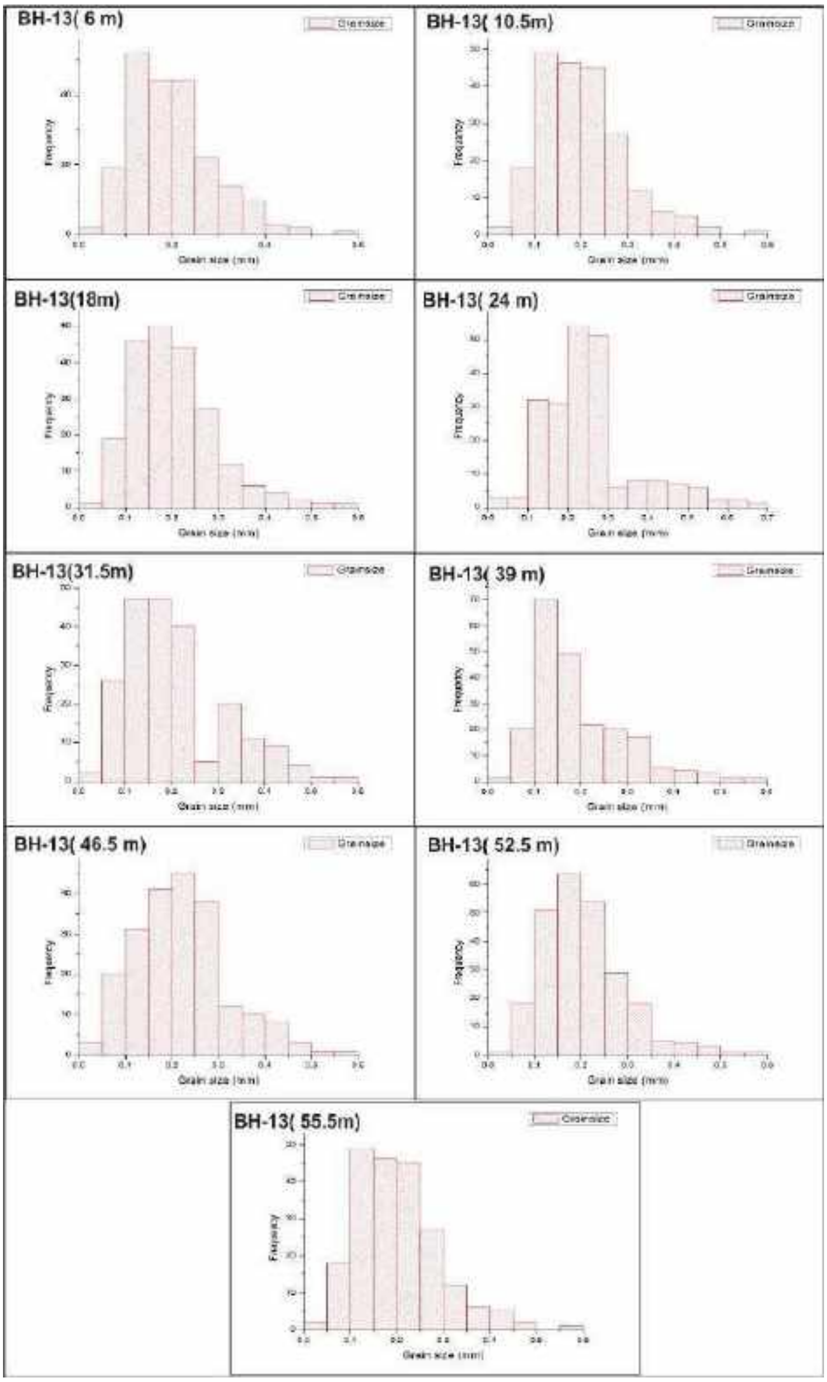


Figure 43: Borehole 13 Grain size analysis histogram.

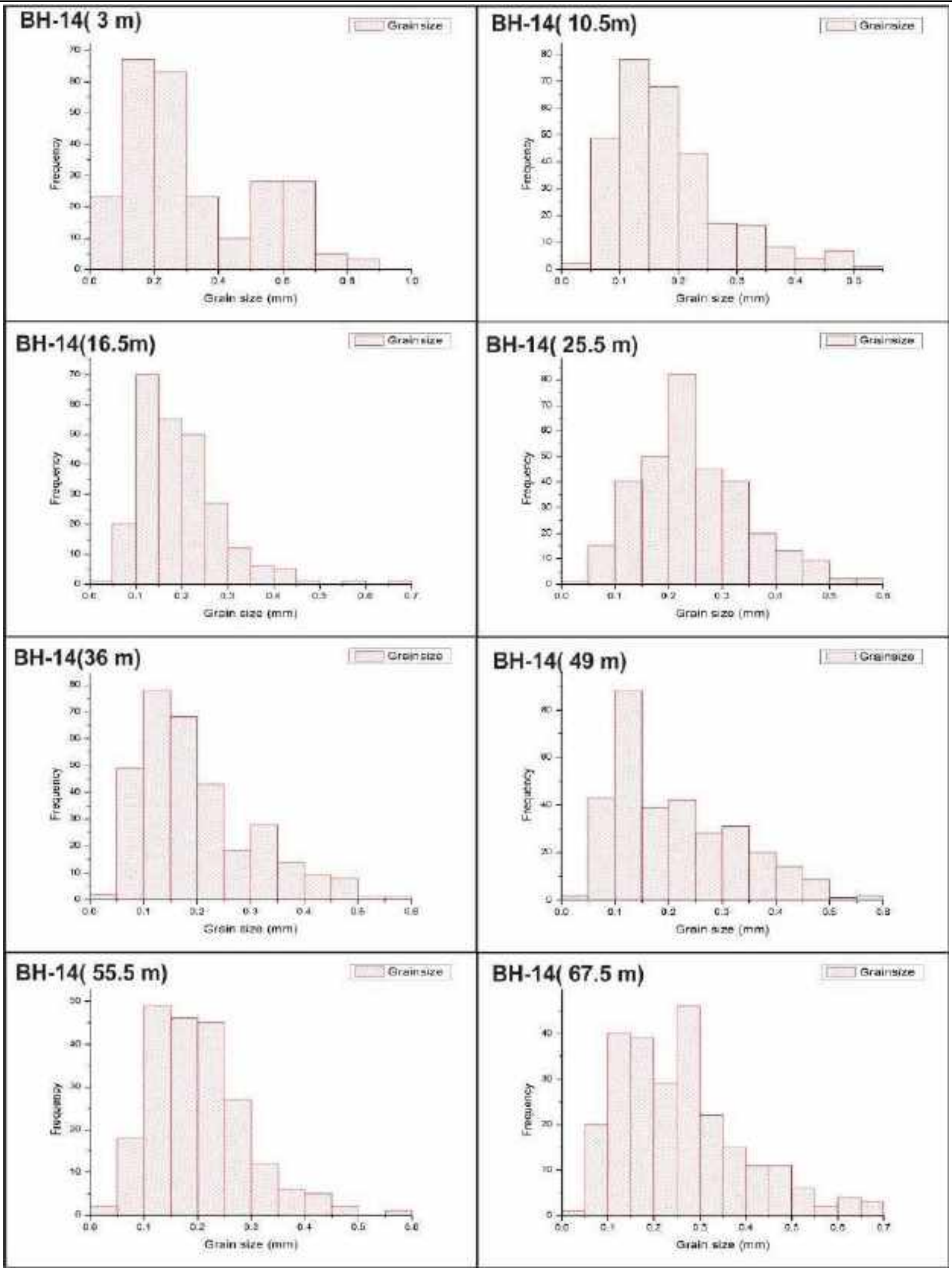


**Figure 44: Borehole 14 Grain size analysis histogram**

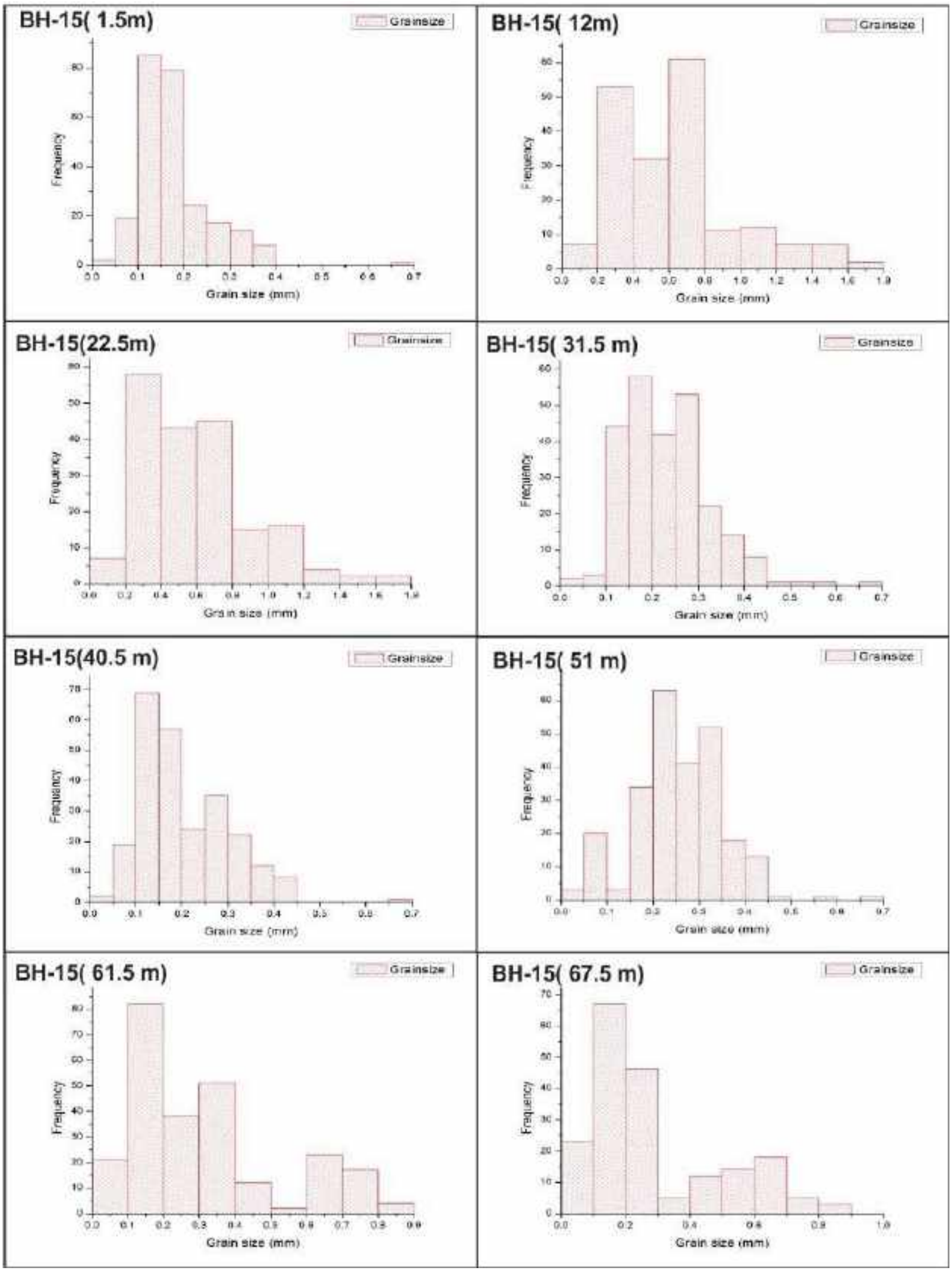


**Figure 45: Borehole 15 Grain size analysis histogram**

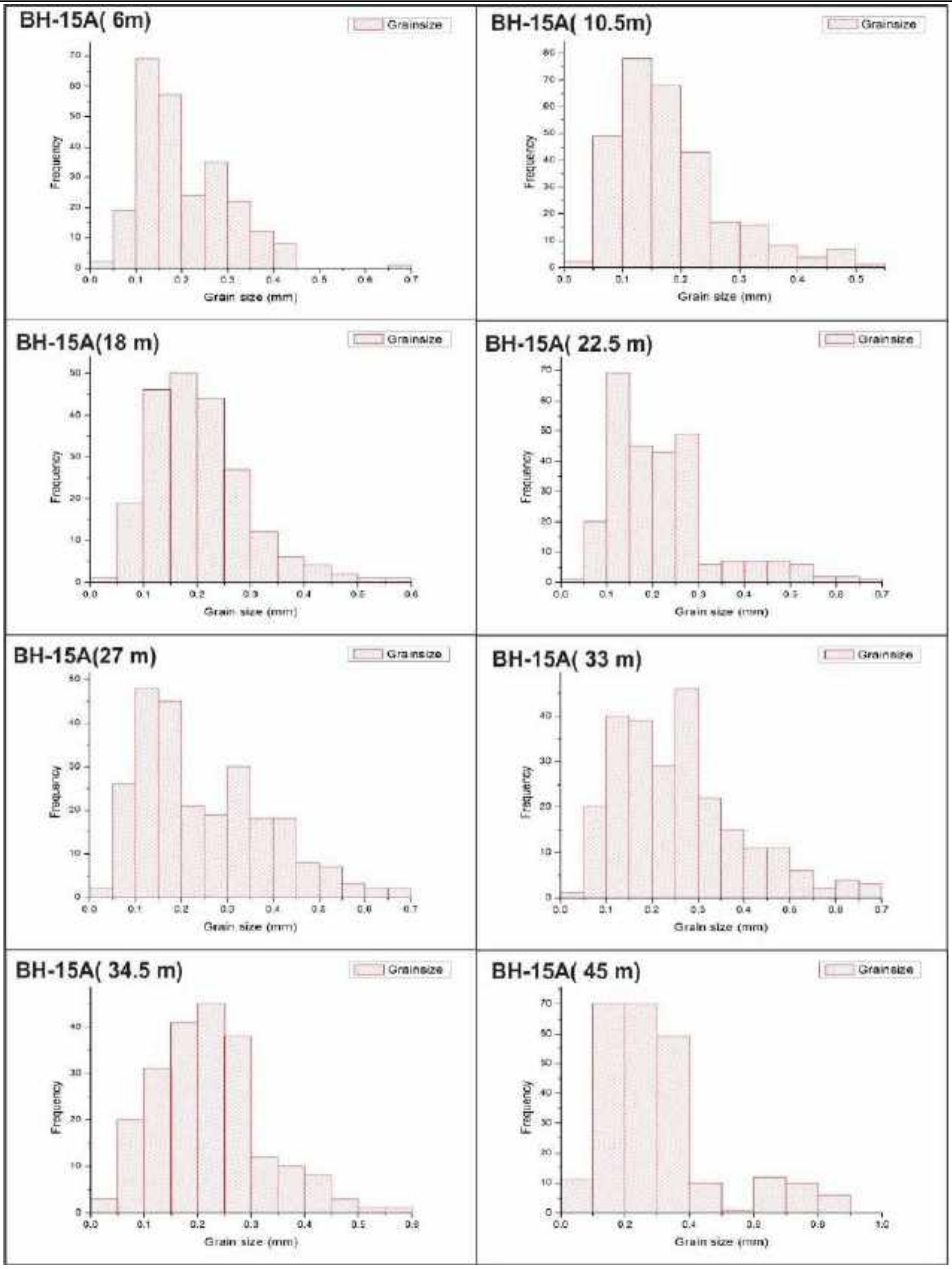


Figure 46: Borehole 15(A) Grain size analysis histogram.

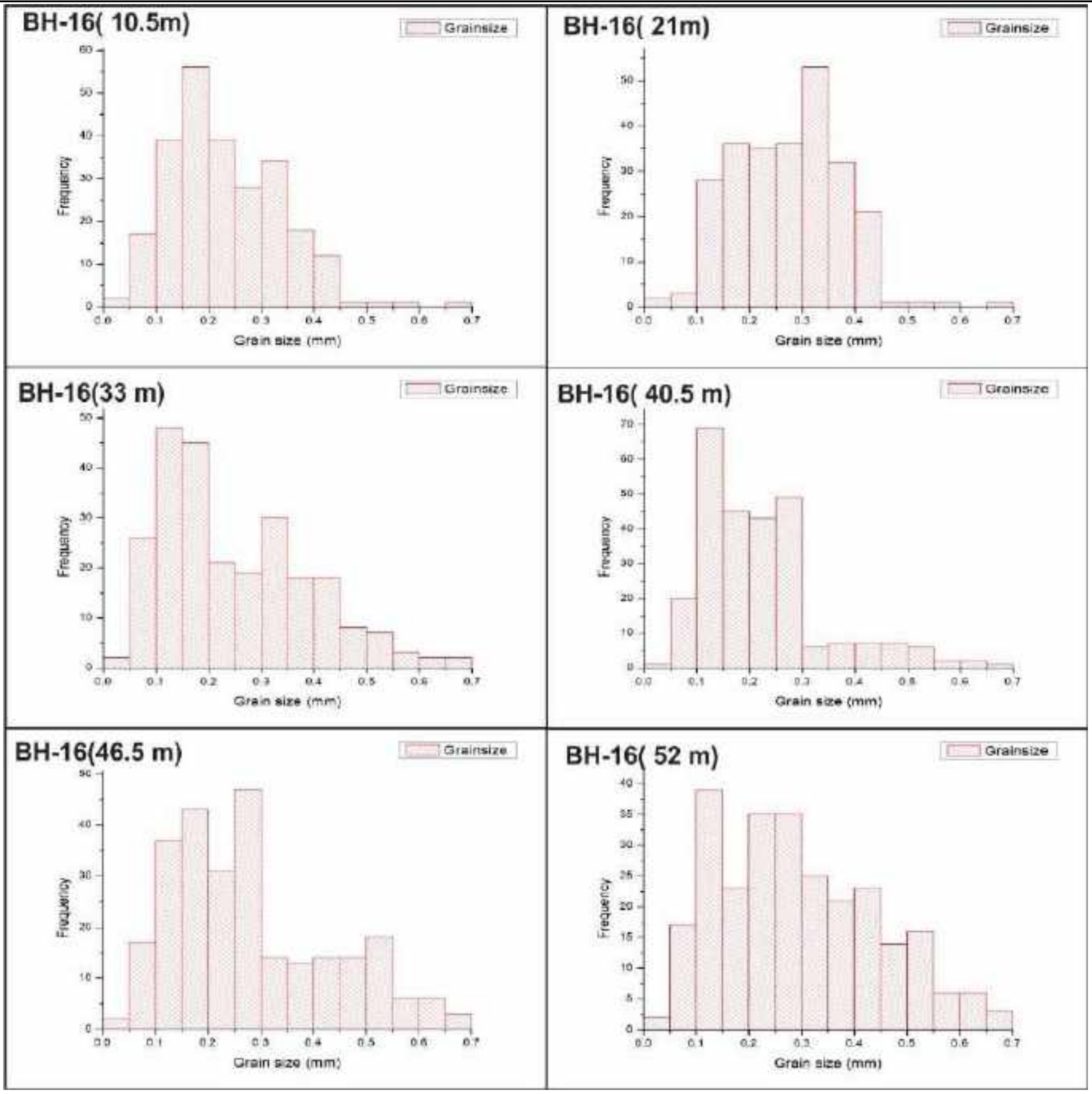


**Figure 47: Borehole 16 Grain size analysis histogram.**

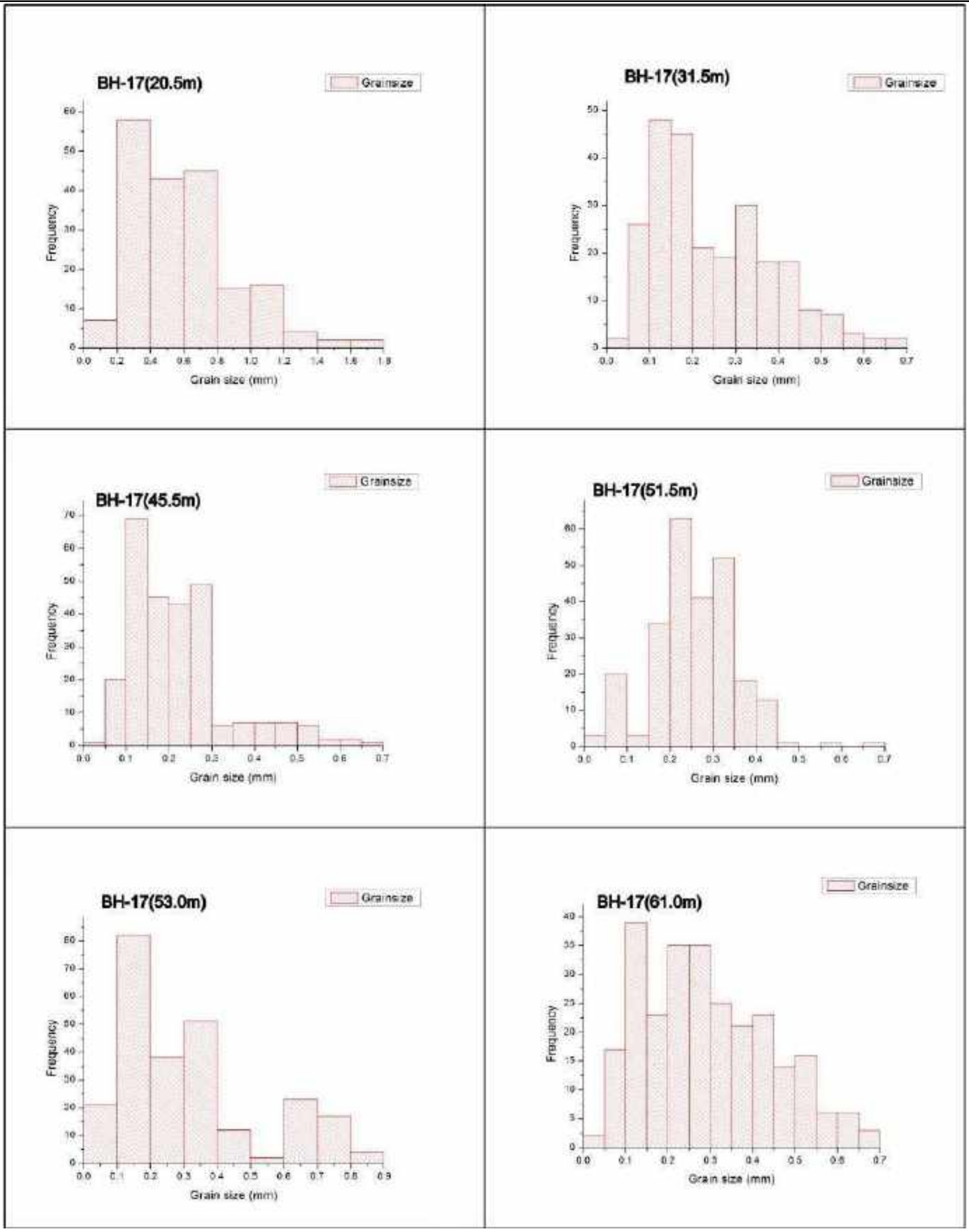


Figure 48: Borehole 17 Grain size analysis histogram.

**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

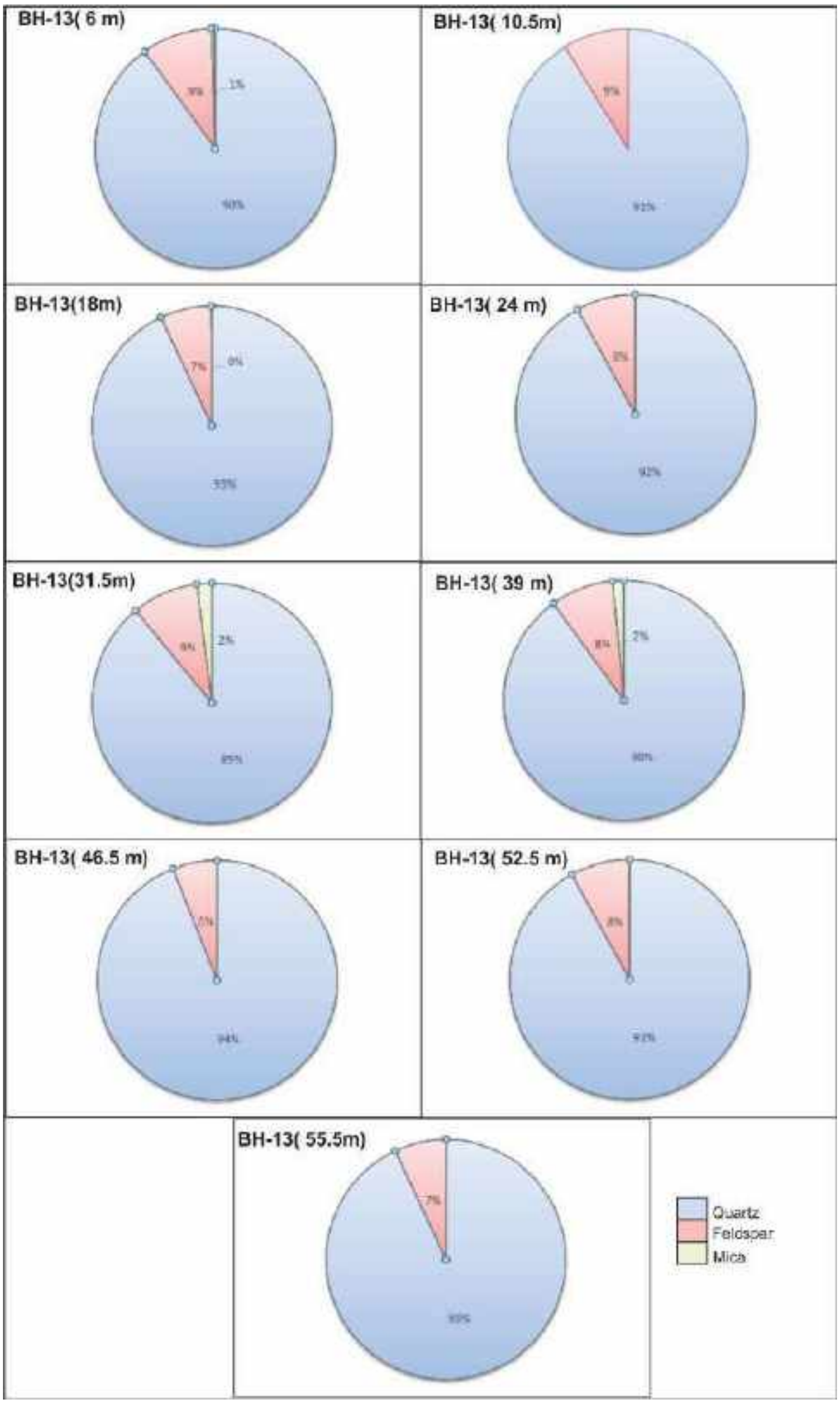


**Figure 49: Borehole 13 Mineral percentage**

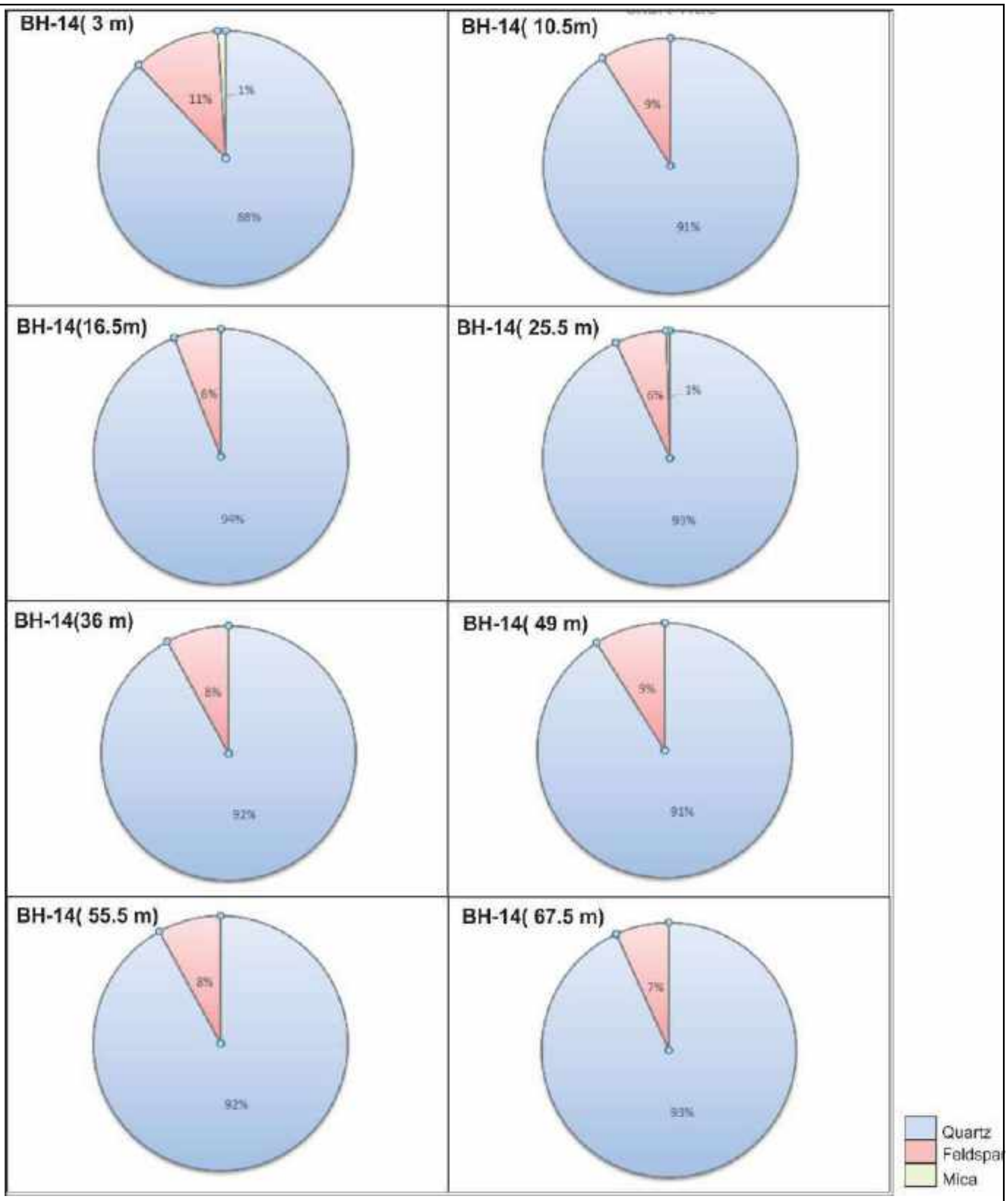


**Figure 50: Borehole 14 Mineral percentage.**

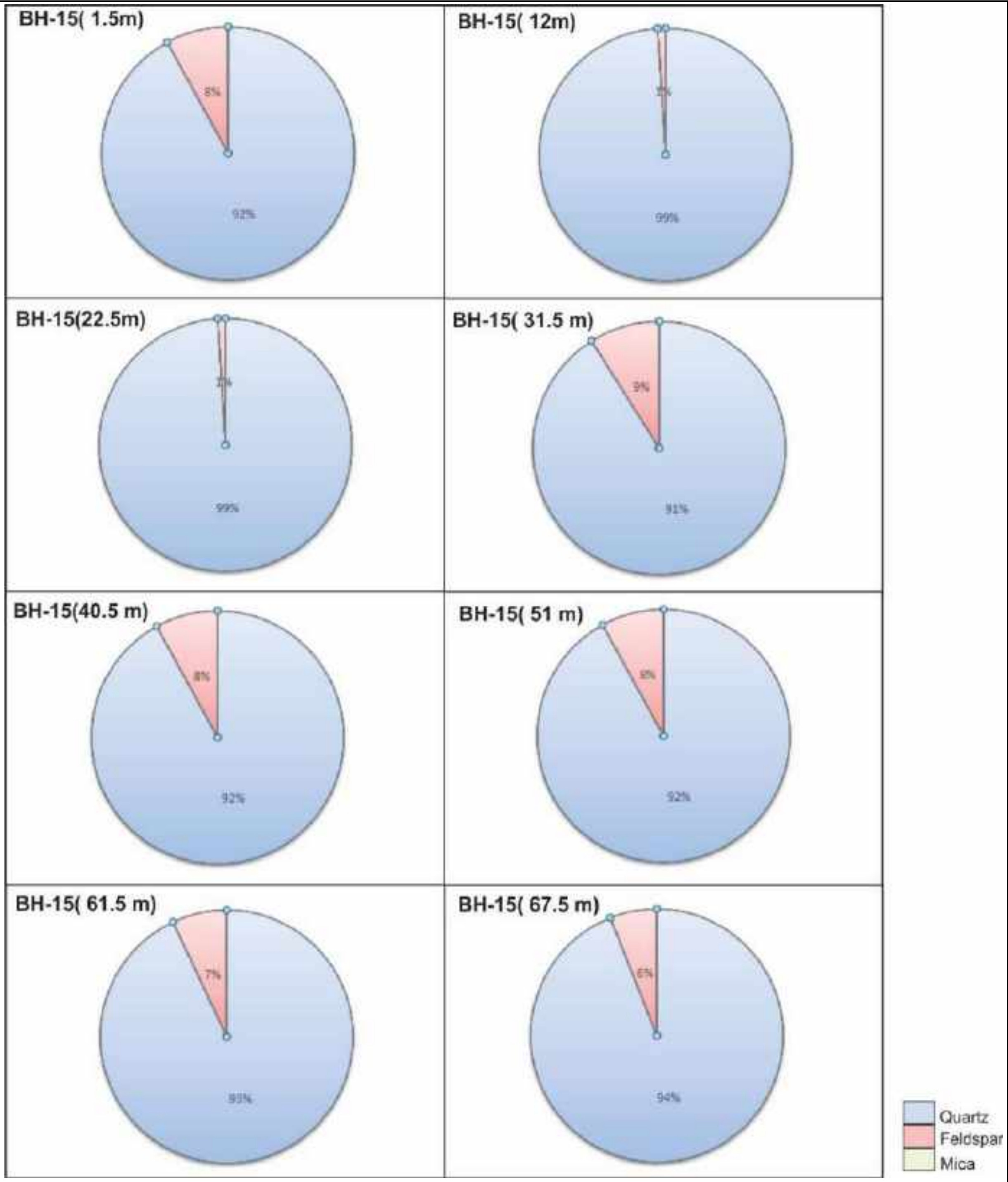


**Figure 51: Borehole 15 Mineral percentage.**

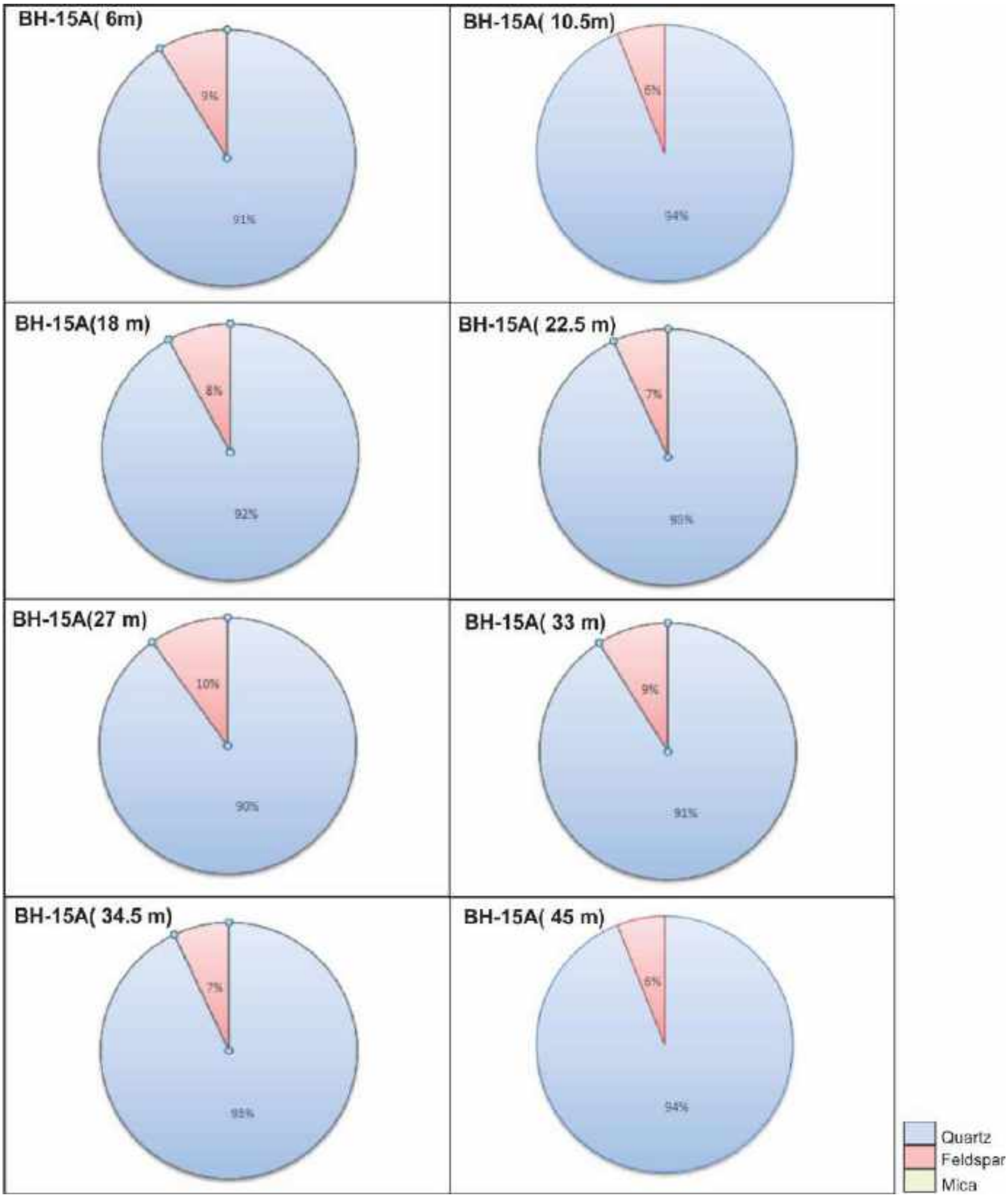


**Figure 52: Borehole 15(A) Mineral percentage.**

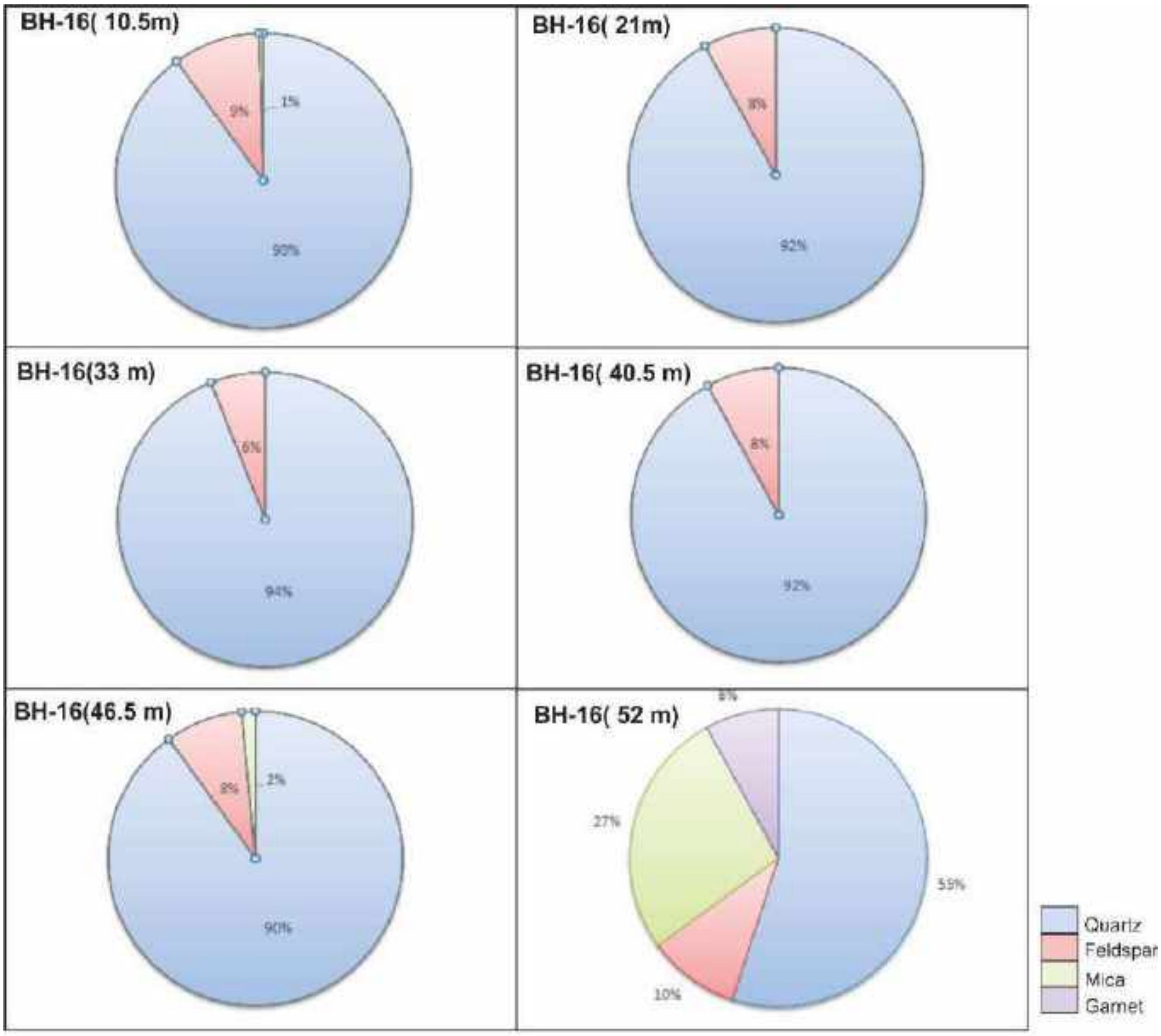


**Figure 53: Borehole 16 Mineral percentage.**

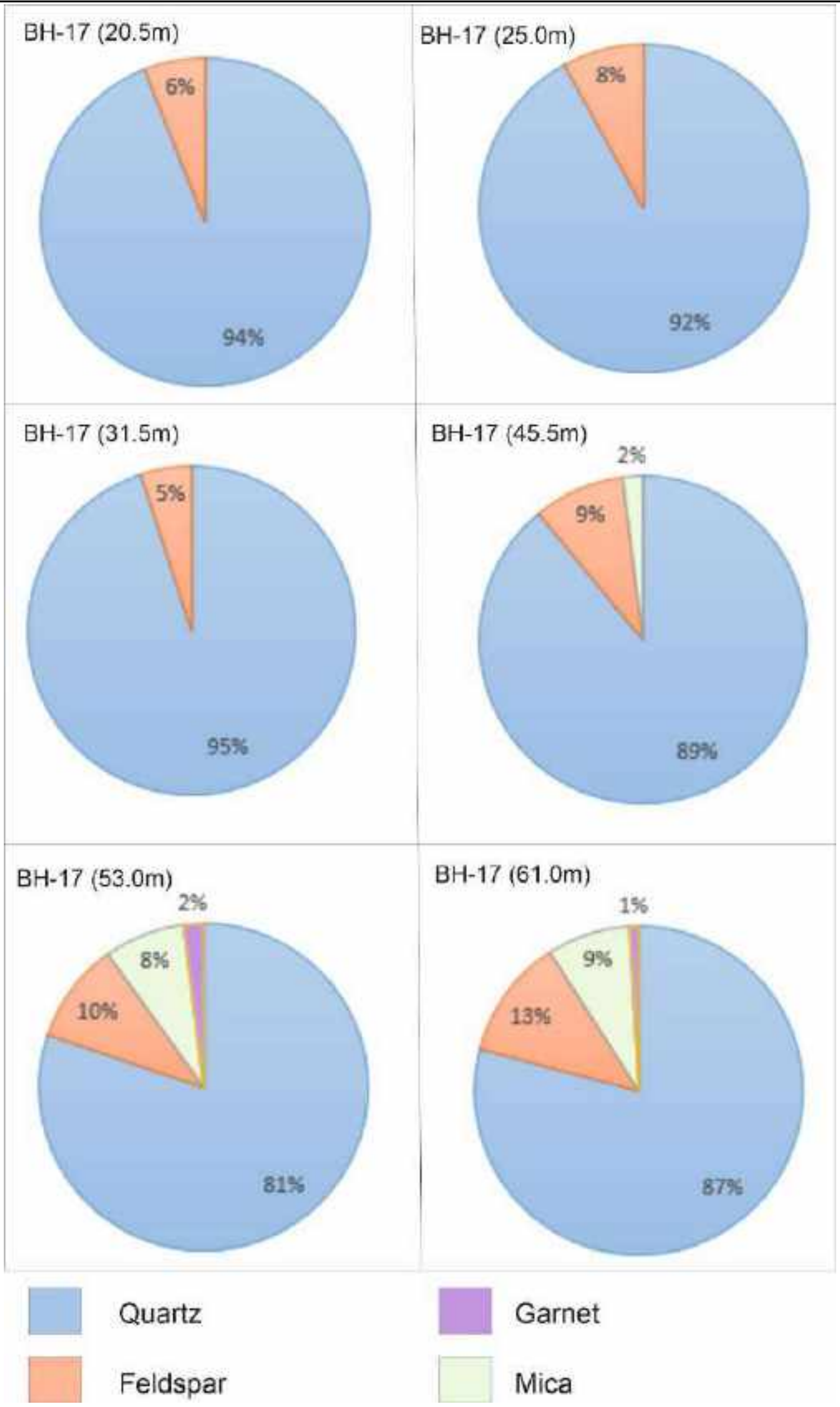


**Figure 54: Borehole 17 Mineral percentage.**

## 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.

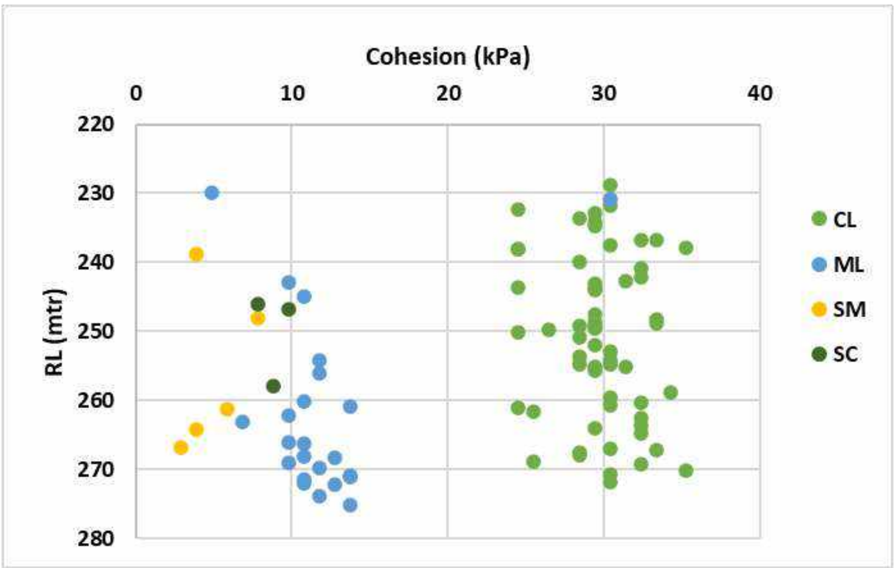


**Figure 55: Variation in cohesion value of soil with RL.**

**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.

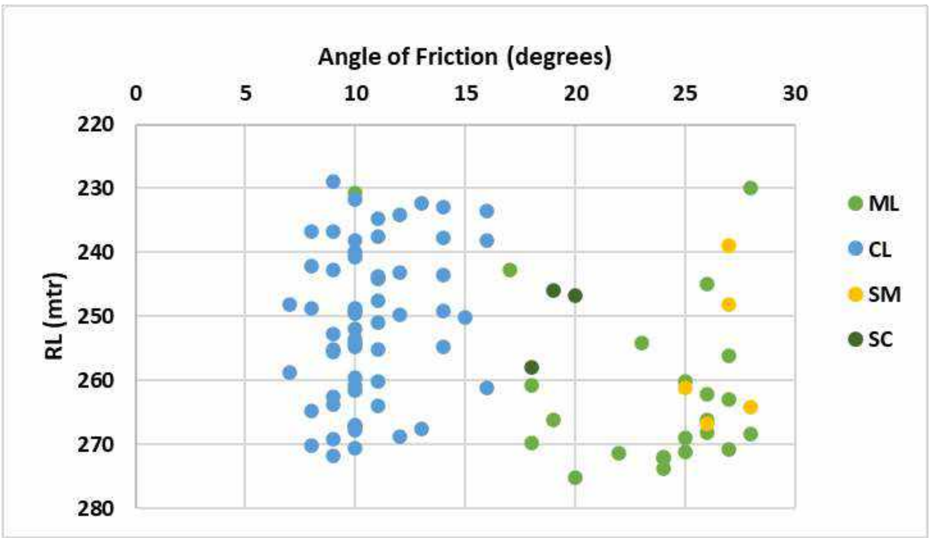


**Figure 56: Variation in phi value of soil with RL**

**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.

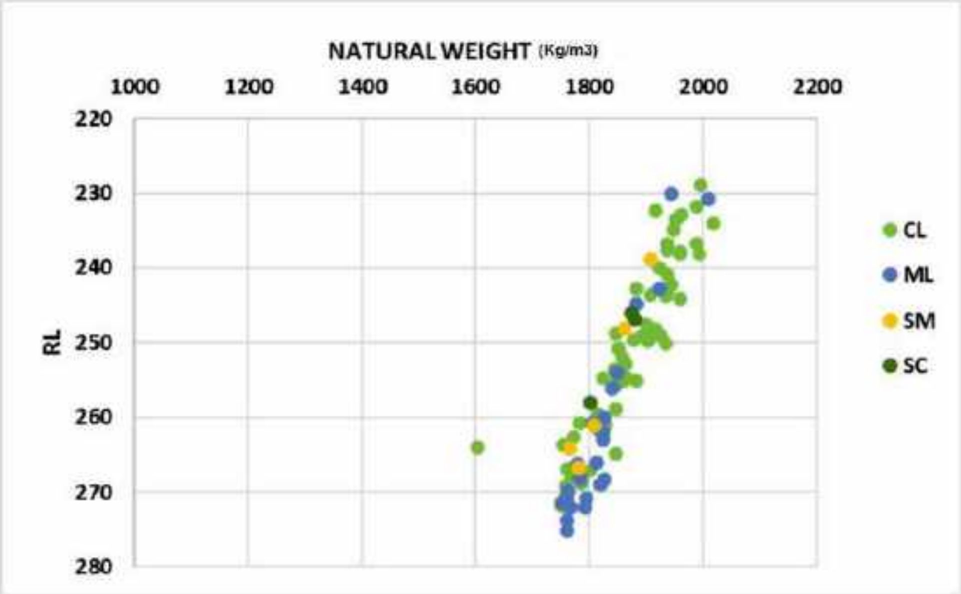


**Figure 57: Variation in density value of soil with RL**

**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.

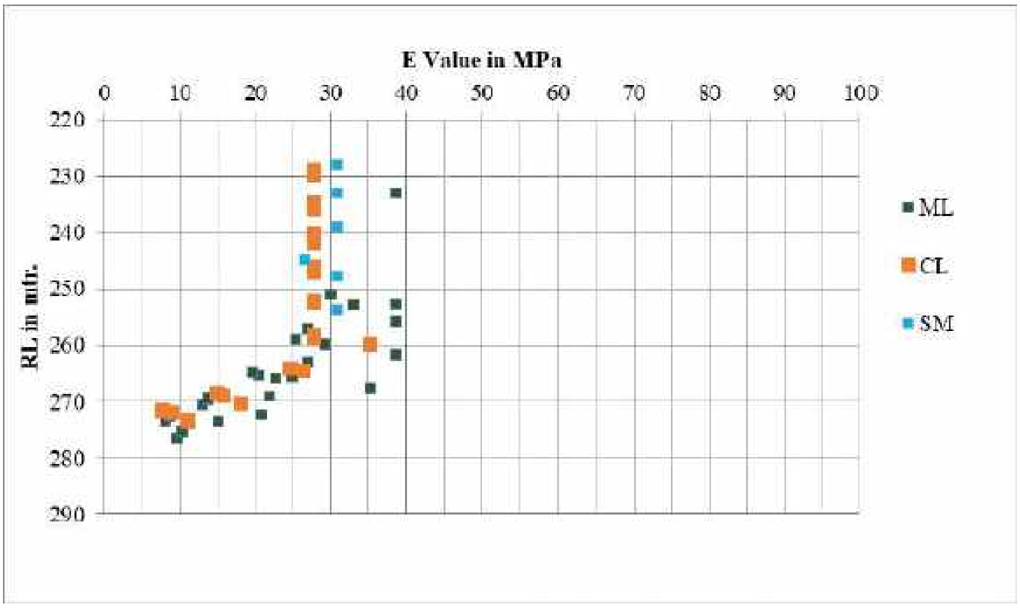


**Figure 58: graph for Modulus of elasticity for soil vs RL.**

**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: 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** | **07-09-2021** | | |
| | | | | | **NAME OF GEOLOGIST** | **Gaurav Chunekar** | | |

**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 | |
| 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) | | Lithological Description | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
| | Top | Bottom | | | | | Rating | Class | Depth of sample (m) | Type of Sample Collected | |
| 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 | Slightly Weathered, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite | 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 | | 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 |

**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 Weatherd, 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 Weatherd, 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 |

**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**<br>**S.M Consultants** | | | **WATER TABLE RECORD DATE** | **29-08-2021** | | |
| | | | | | **NAME OF GEOLOGIST** | **Gaurav Chunekar** | | |

| 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 | |
| 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) | | Lithology | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top | Bottom | | | | | Rating | Class | Depth of sample (m) | Sample Collected | |
| 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) | | Lithology | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top | Bottom | | | | | Rating | Class | Depth of sample (m) | Sample Collected | |
| 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) | | Lithology | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top | Bottom | | | | | Rating | Class | Depth of sample (m) | Sample Collected | |
| 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) | | Lithology | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top | Bottom | | | | | Rating | Class | Depth of sample (m) | Sample Collected | |
| 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 |

**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) | | Lithology | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top | Bottom | | | | | Rating | Class | Depth of sample (m) | Type of sample Collected | |
| 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 |

| **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) | 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 |

**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) | | Lithology | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
| | Top | Bottom | | | | | Rating | Class | Depth of sample (m) | Type of sample Collected | |
| 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: 90°** | | | **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) | | | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top | Bottom | Lithology | | | | Rating | Class | Depth of sample (m) | Type of Sample Collected | |
| 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) | | | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Top | Bottom | Lithology | | | | 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) | | Lithology | Structural conditions | % of Core-Recovery | % RQD | RMR | | Samples | | Q VALUE |
| | Top | Bottom | | | | | Rating | Class | Depth of sample (m) | Type of Sample Collected | |
| 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 |

**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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|---|---|---|---|---|---|---|---|---|
| **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 |

**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 | BH-15 | 0.00 | 1.50 | |
| 85 | | 1.50 | 3.00 | 69.58 |
| 86 | | 3.00 | 4.50 | |
| 87 | | 4.50 | 6.00 | |
| 88 | | 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 |

| 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<br>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 | |

| 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/$m^3$) | | (%) |
| 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/m$^3$)** | | **(%)** |
| **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** | | | |
| | | | | | | |

| 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 |

| **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** | **BH-16** | **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** | | **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** | | | |

| 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 | | | |
| 51.50 | BH17/1221/R/62 | | | |
| | BH17/1221/R/63 | 25.13 | 2.54 | 0.81 |
| | 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 | 25.73 | 2.62 | 0.2 |
| | BH17/1221/R/72 | | | |
| | BH17/1221/R/73 | | | |
| 54.50 | BH17/1221/R/74 | | | |
| | BH17/1221/R/75 | | | |
| | 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 |
| 61.00 | BH17/1221/R/83 | | | |
| | BH17/1221/R/84 | | | |
| | BH17/1221/R/85 | 25.31 | 2.57 | 0.45 |
| | BH17/1221/R/86 | | | |
| 62.00 | BH17/1221/R/87 | | | |
| | BH17/1221/R/88 | 25.68 | 2.61 | 0.42 |
| | 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

# 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 | |

| 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** | **BH-15** | **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** | | **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** | | |

| **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** | | |

| **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<br>49.8 | 0.11<br>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** | | |

| **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** | |

# 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.**

| *Consultant:* | **Geotechnical Investigation Report** | | *Client:* |
|---|---|---|---|
| **S.M. CONSULTANTS**<br>**BHUBANESWAR** | **Job No.:** | 830 | **Haryana Rail Infrastructure Development Corporation Ltd** |
| | **REPORT. No.:** | SMC/2050 | |

# 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 |

**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%) | | | | | | | | | | | | | | | | | | |

**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) | | | | | | | | | | | | | | | | | | | |

**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%) | | | | | | | | | | | | | | | | | | |

**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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ine 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%) | | | | | | | | | | | | | | | | | | |

**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 % | | | | | | | | | | |
| 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.**

# 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 |

## 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 |

## 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 |

# 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 |

**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 |

**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 |

# 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 |

**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 |

**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%) | | | | | | | | | | | | | | | | | | |

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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ine 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**<br>**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) | | | | | | | | | | | | | | | | | | |

**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 |

**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 |

# 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**

| | | | | Grain size analysis | | | | Hydrometer Analysis | | Atterberg's Limit | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sl. No. | Sample Collected at | Type of soil collected | S.P.T N Value | 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 % | 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 |
| 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 |

# 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 |

# 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 |

# 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 |

**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 |

**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 |

**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 |

# 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 |

# 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 |

# 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 |

# 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**

| | | | | Grain size analysis | | | | Hydrometer Analysis | | Atterberg's Limit | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sl. No. | Sample Collected at | Type of soil collected | S.P.T N Value | 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 % | 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 |
| 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 |

# 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**

| | | | | Grain size analysis | | | | Hydrometer Analysis | | Atterberg's Limit | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sl. No. | Sample Collected at | Type of soil collected | S.P.T N Value | 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 % | 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 |
| 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 |

**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 |

# 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 |

**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 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 | 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**<br>**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 |

**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 |

# 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$^2$ | 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 % | | | | | | | | | | |
| 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 |

**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)<br>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**<br>**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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 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 | 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 |

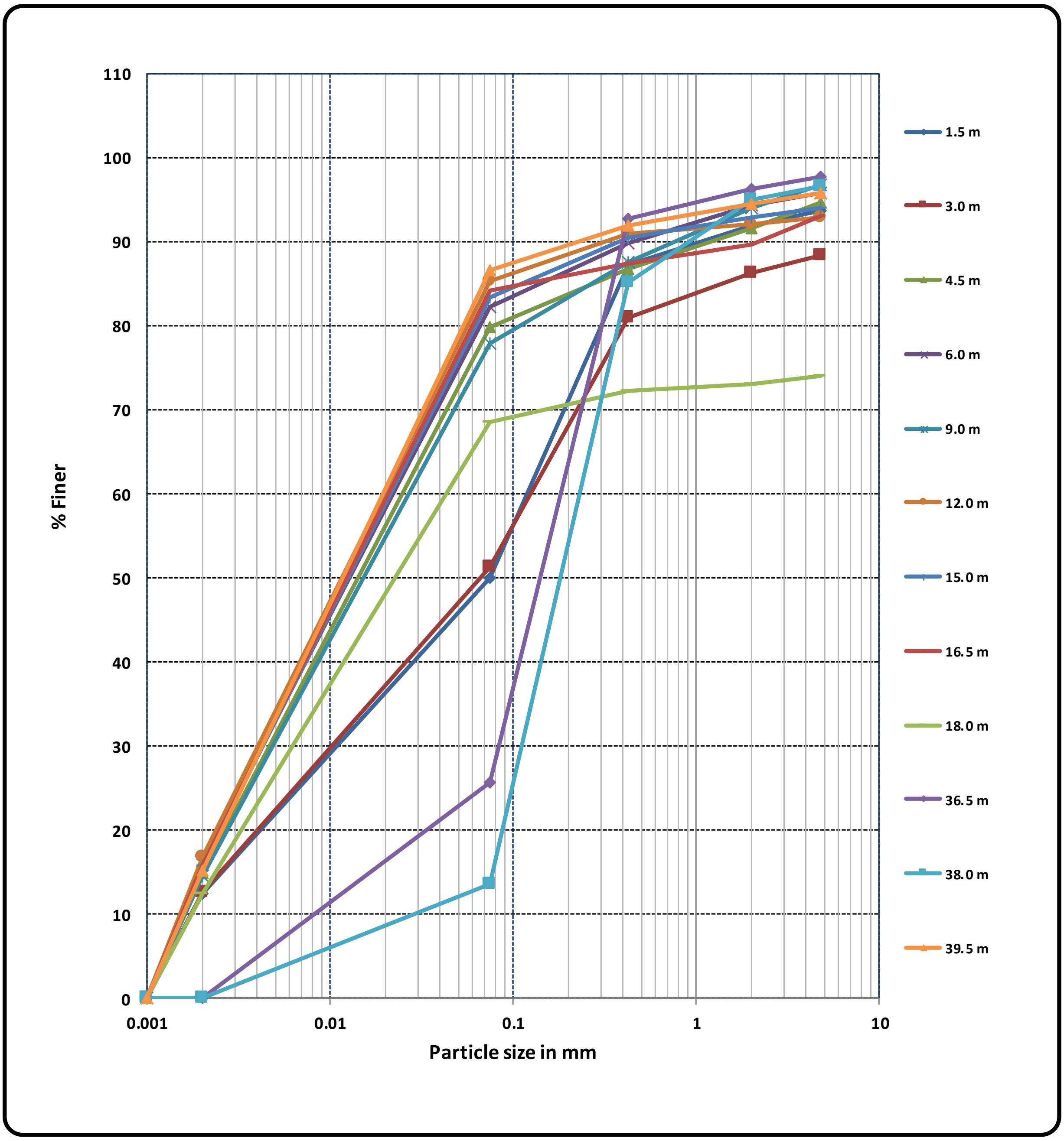
**Contd… BH-33, (CH-30125)**

**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**

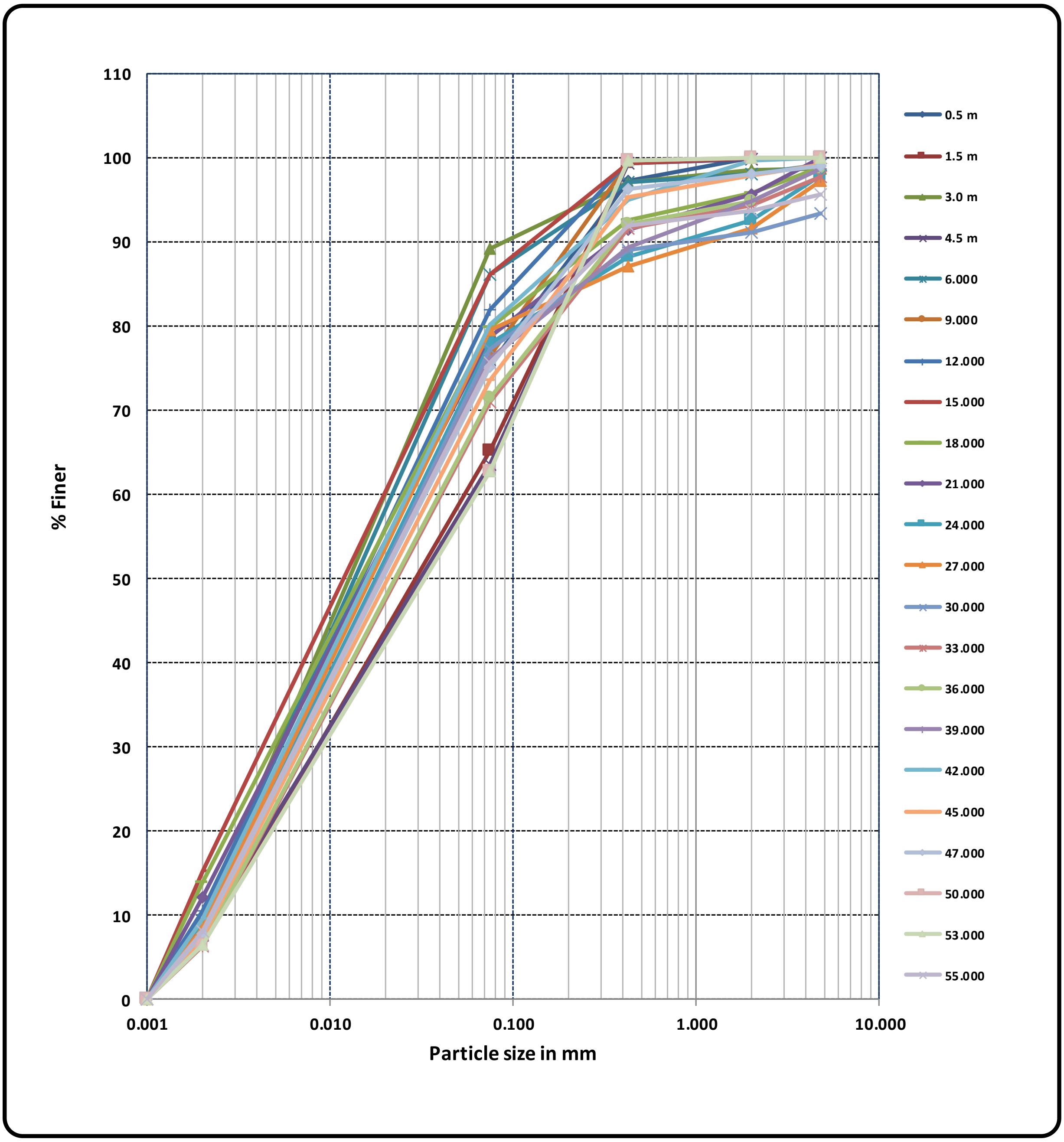
| Sl. No. | Sample Collected at | Type of soil collected | S.P.T N Value | Grain size analysis | | | | | | Atterberg's Limit | | | Field Moisture Content in % | Bulk density in gm/cc. | Dry density in gm/cc | Cohesion ( C ) Kgf/cm$^2$ | Angle of shearing resistance ( ϕ ) in degree | Triaxial test (UU) 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) | (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 | 1.56 | 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

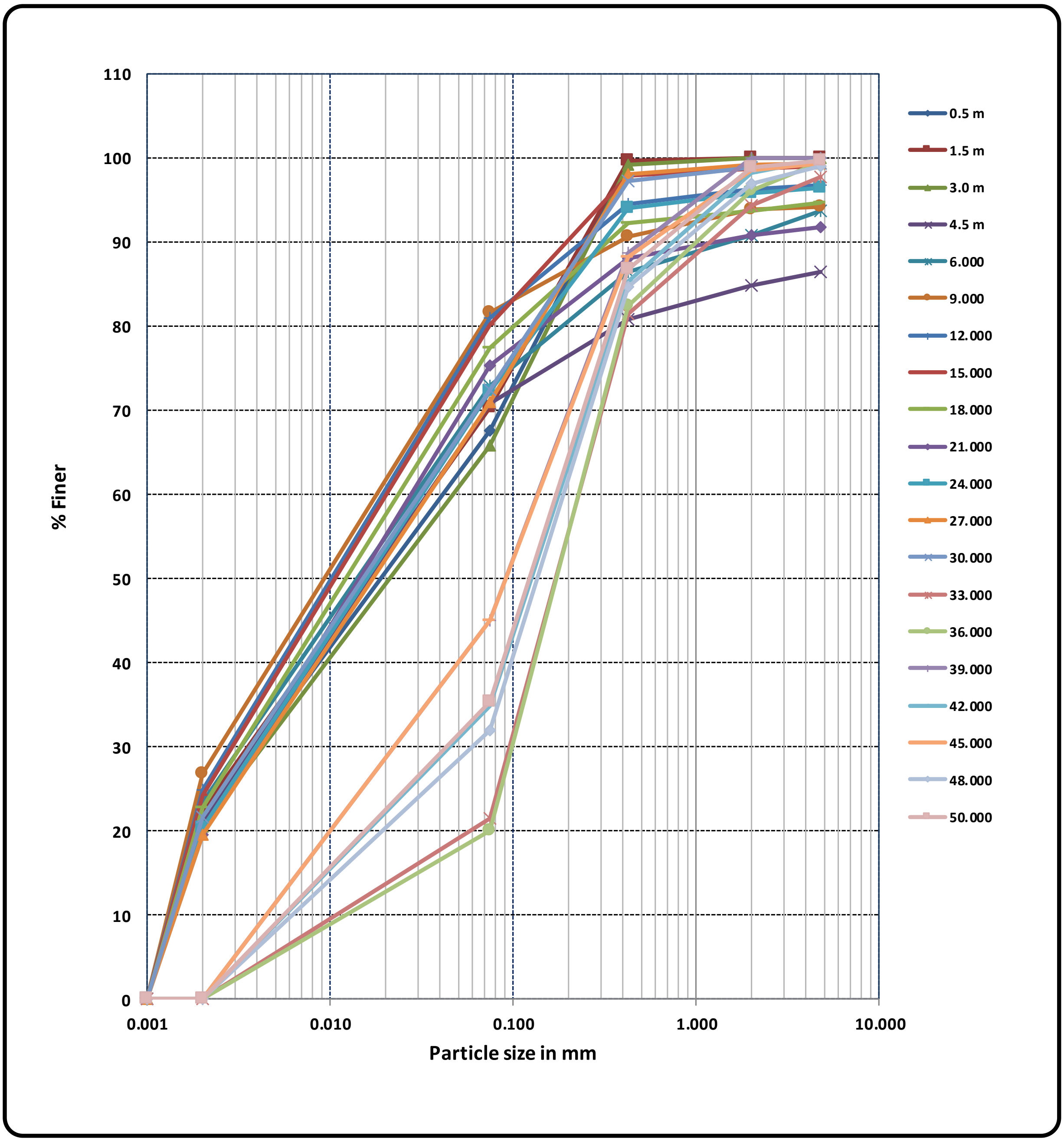
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-17



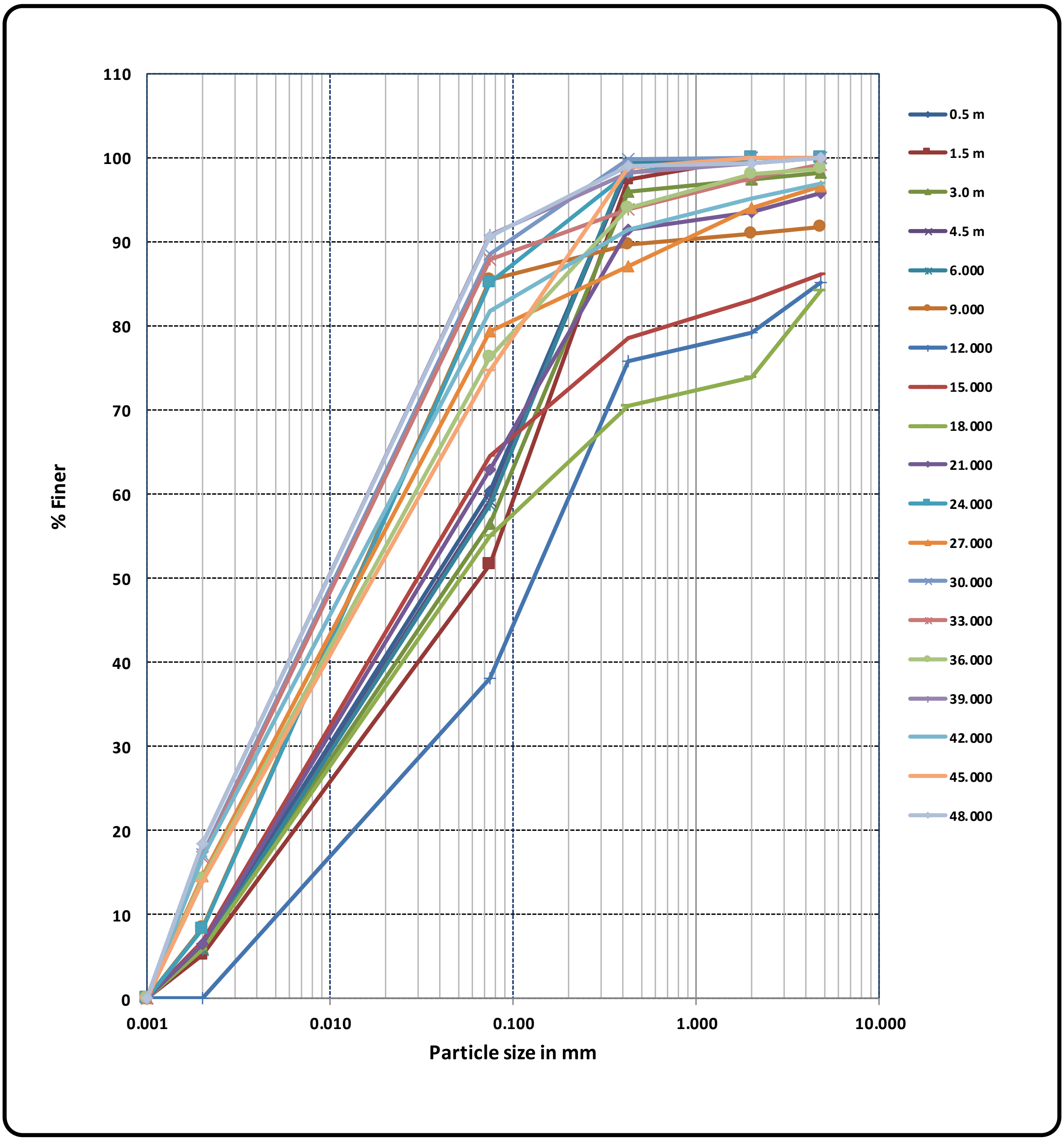
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-18



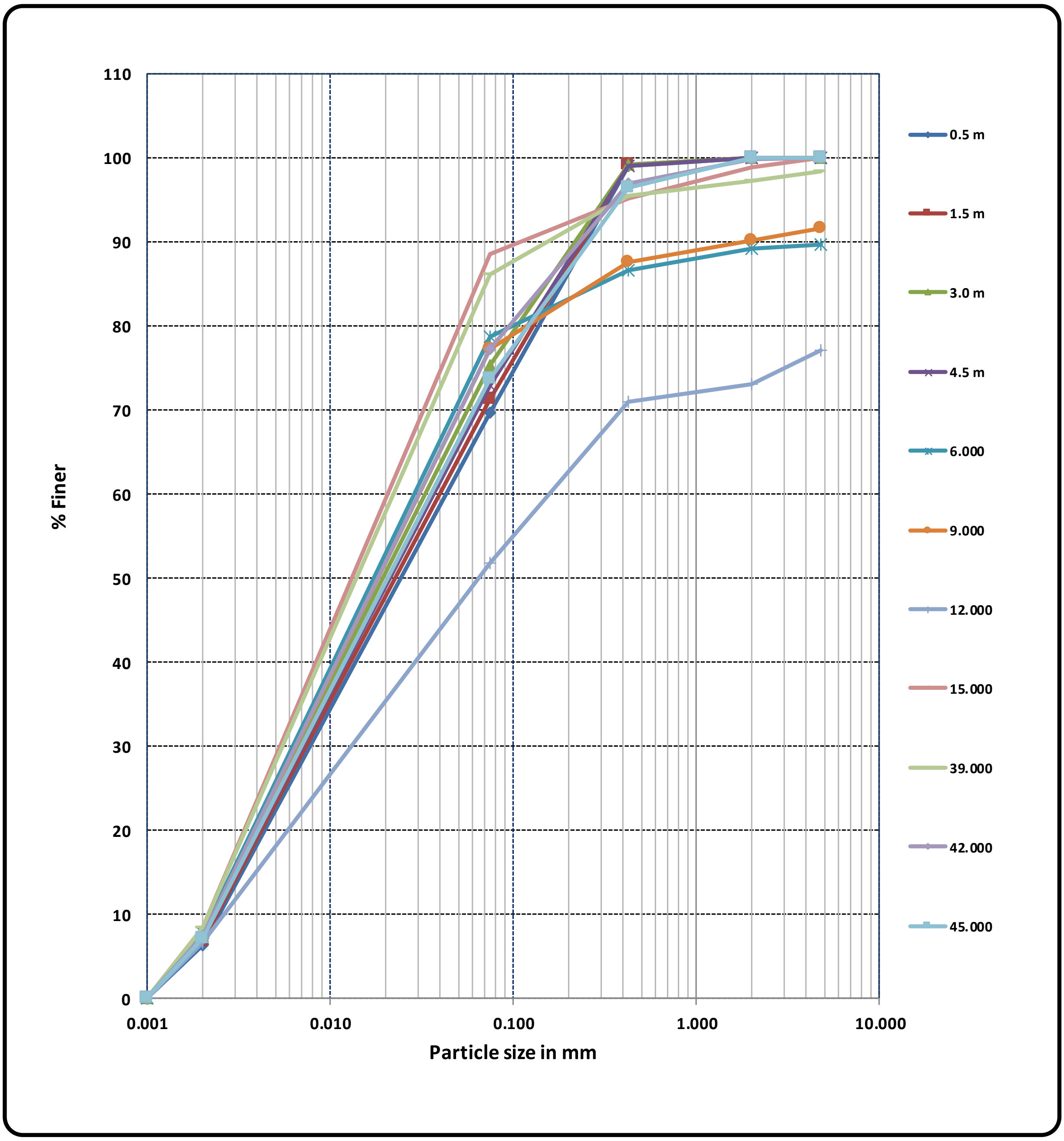
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-19



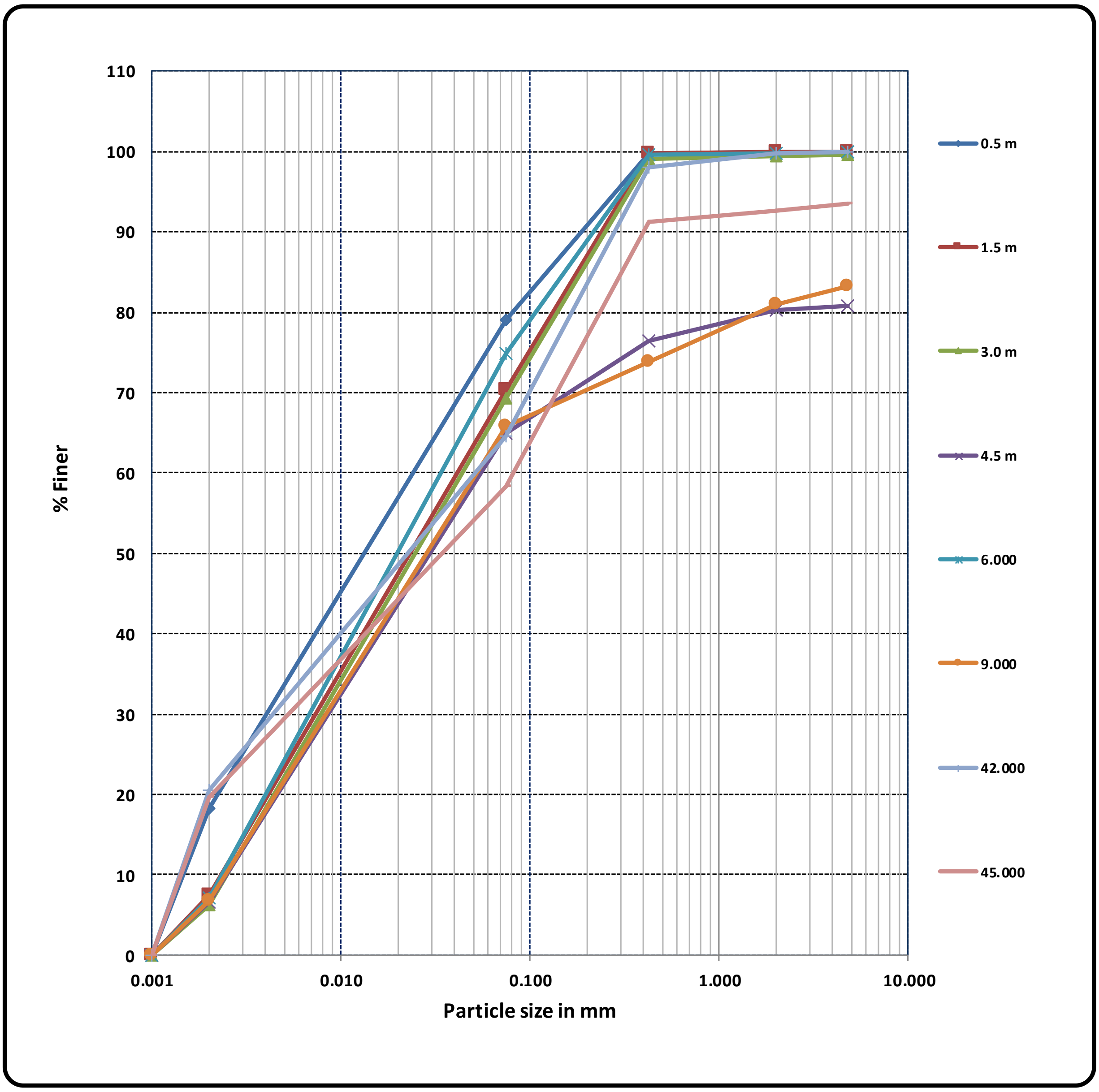
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-20



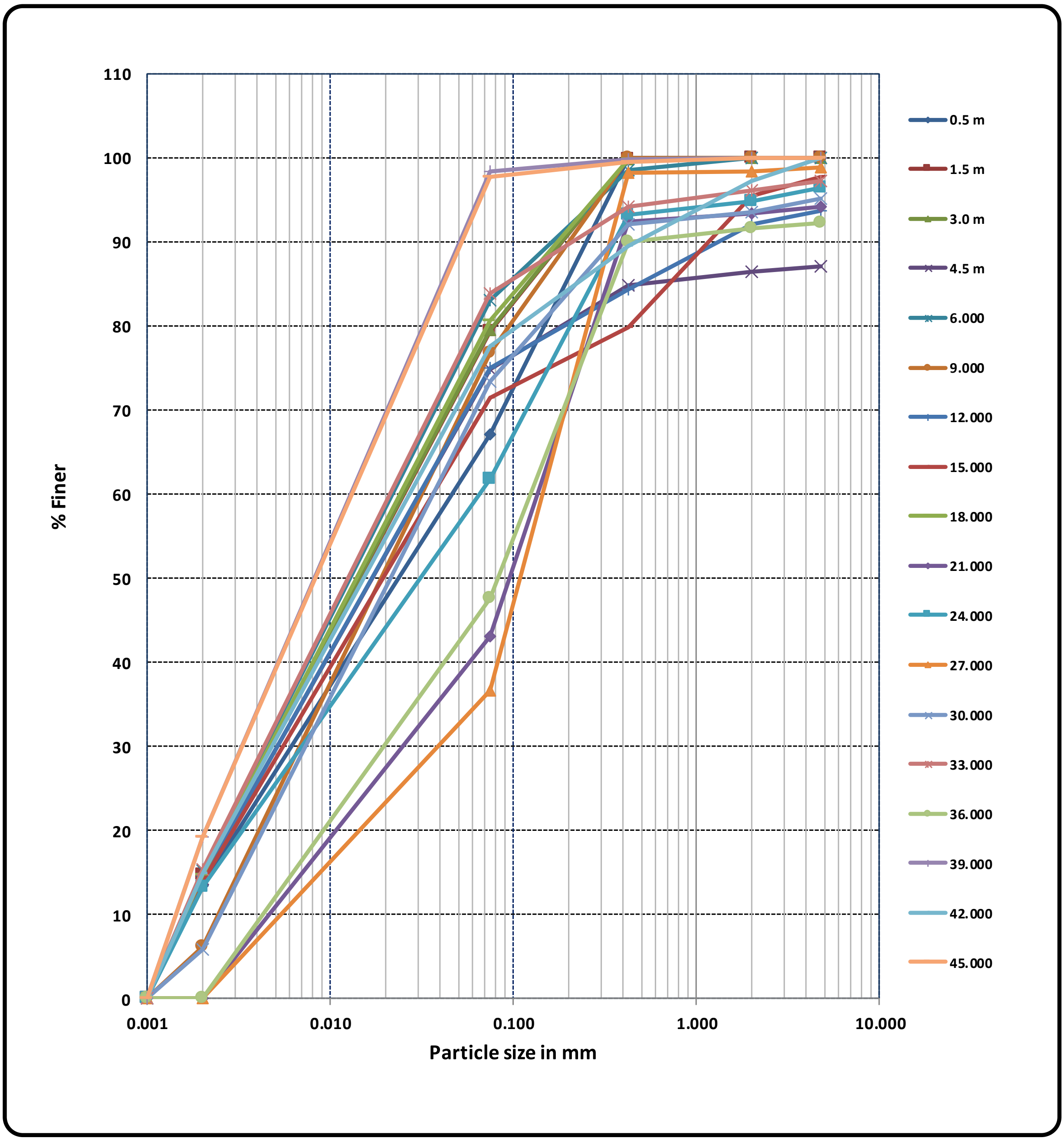
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-21



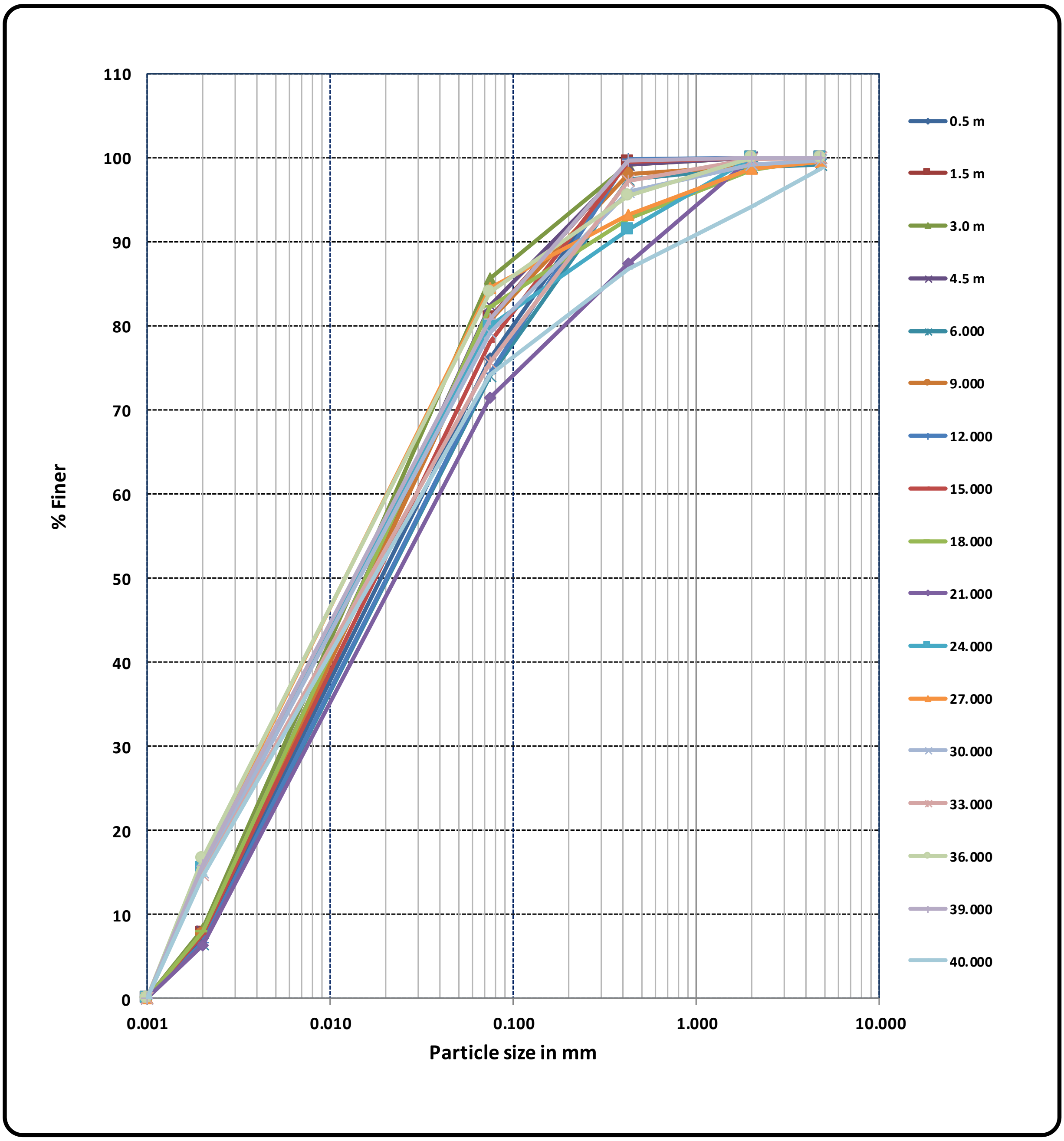
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-22



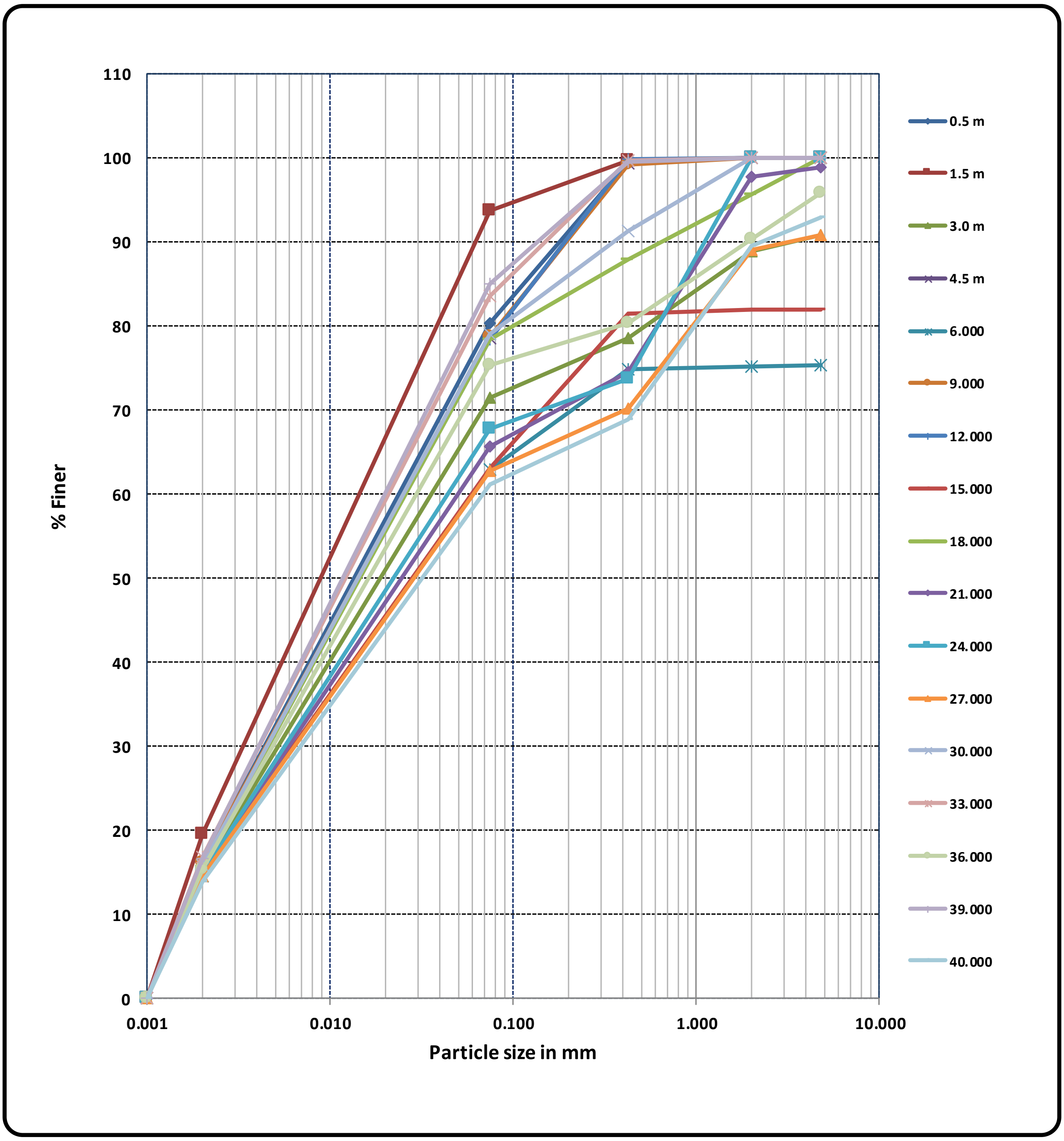
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-23



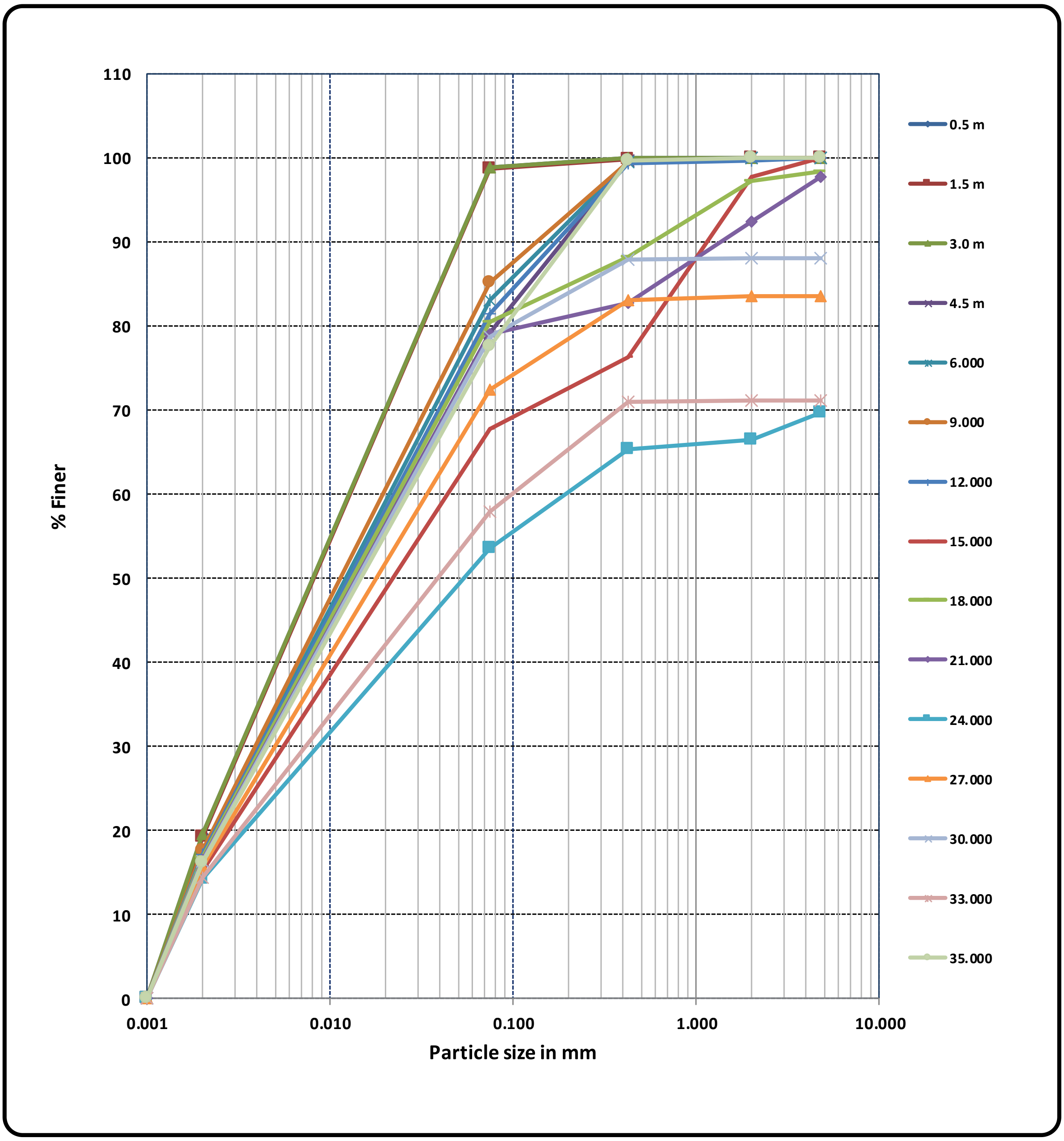
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-24



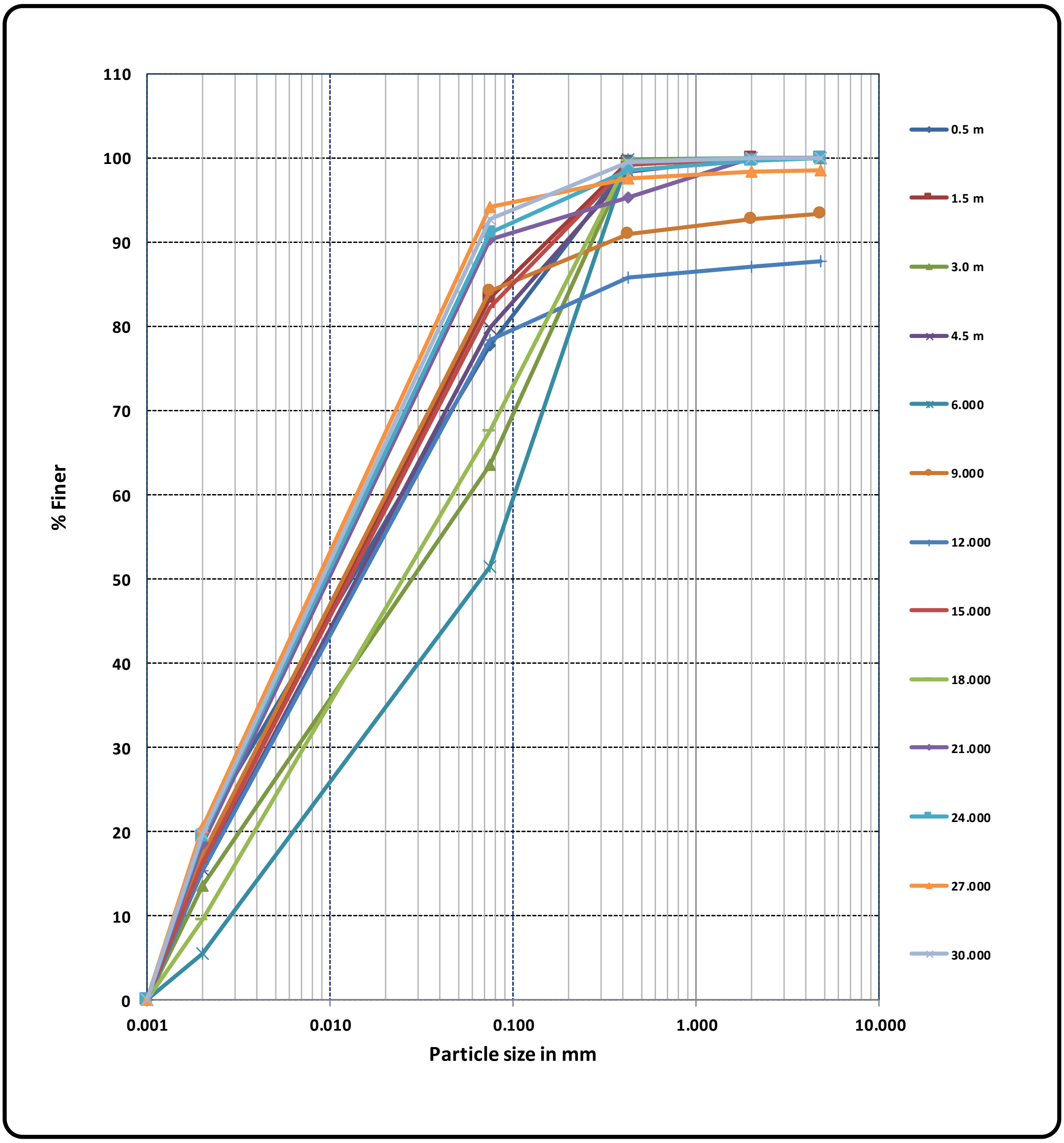
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-25



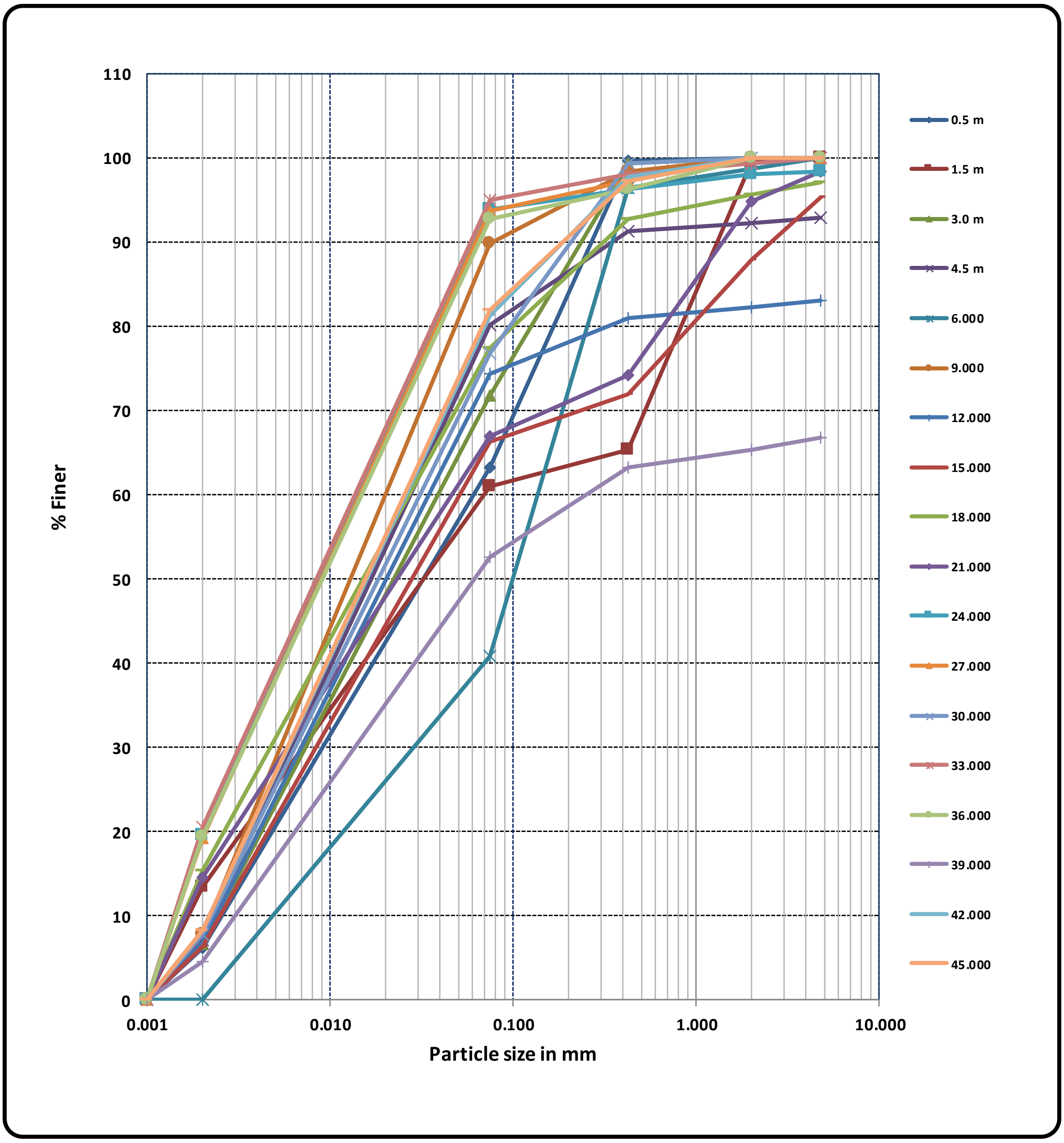
GRAIN SIZE DISTRIBUTION CURVE OF BH NO-26



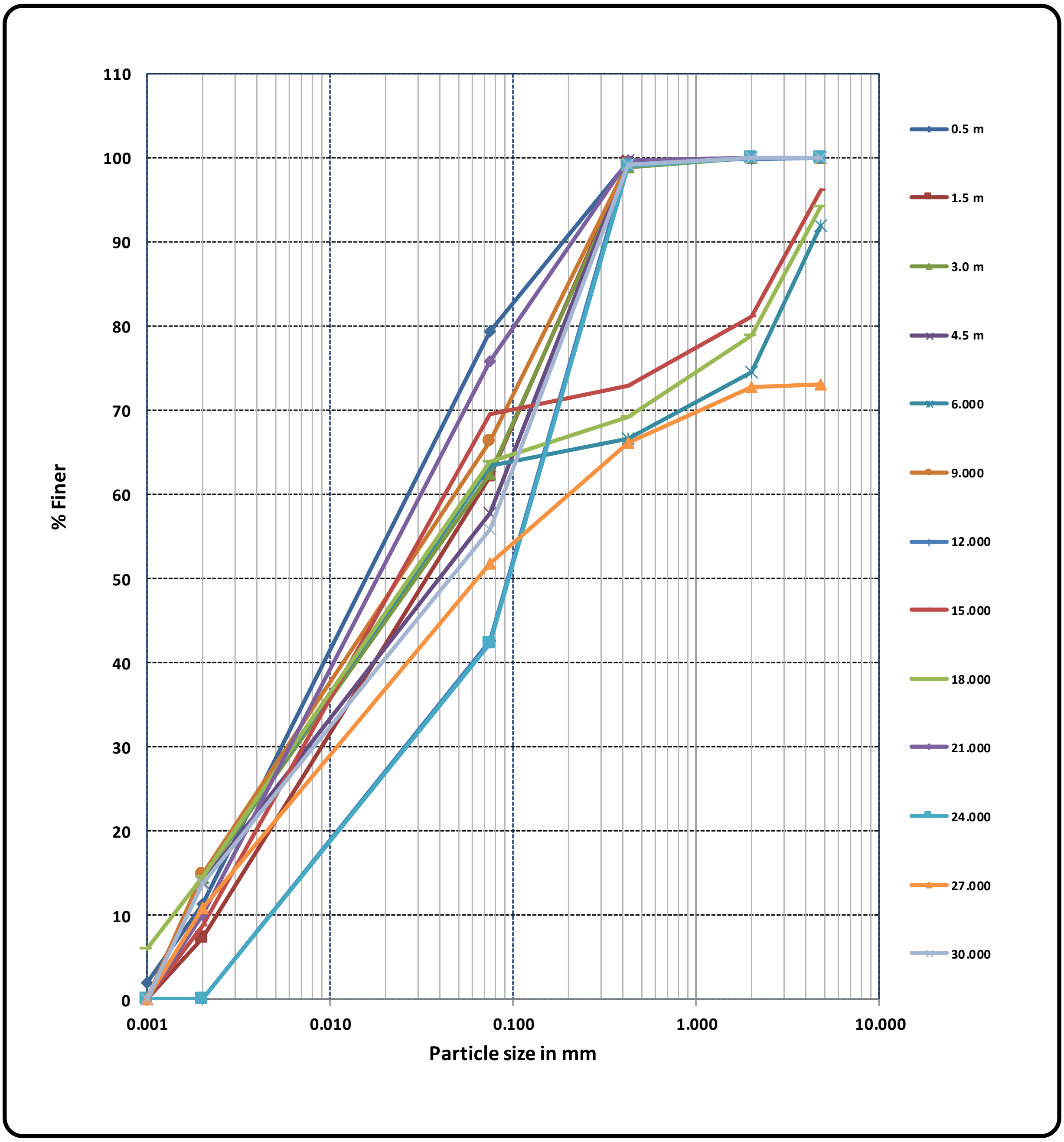
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-27



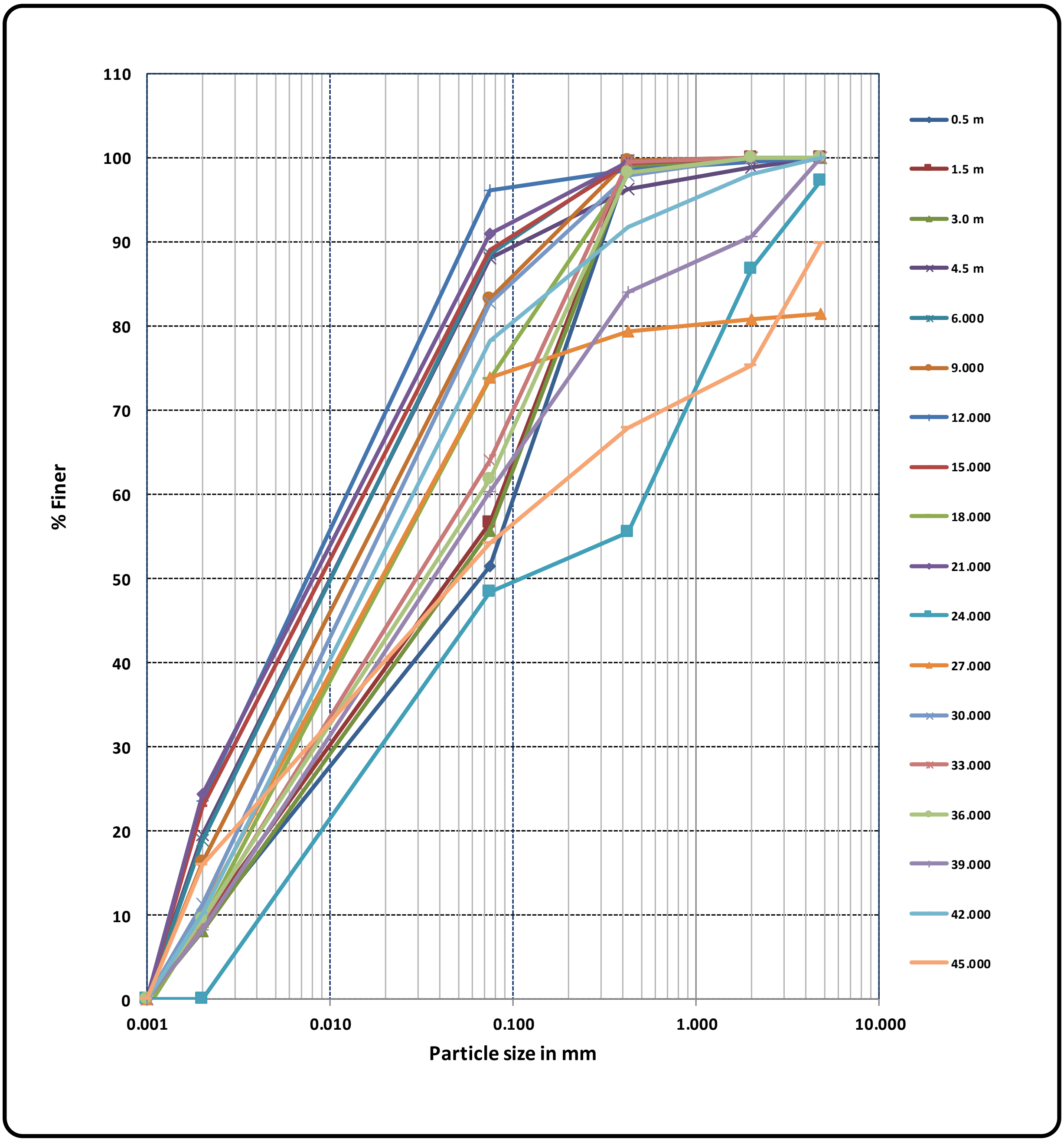
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-28



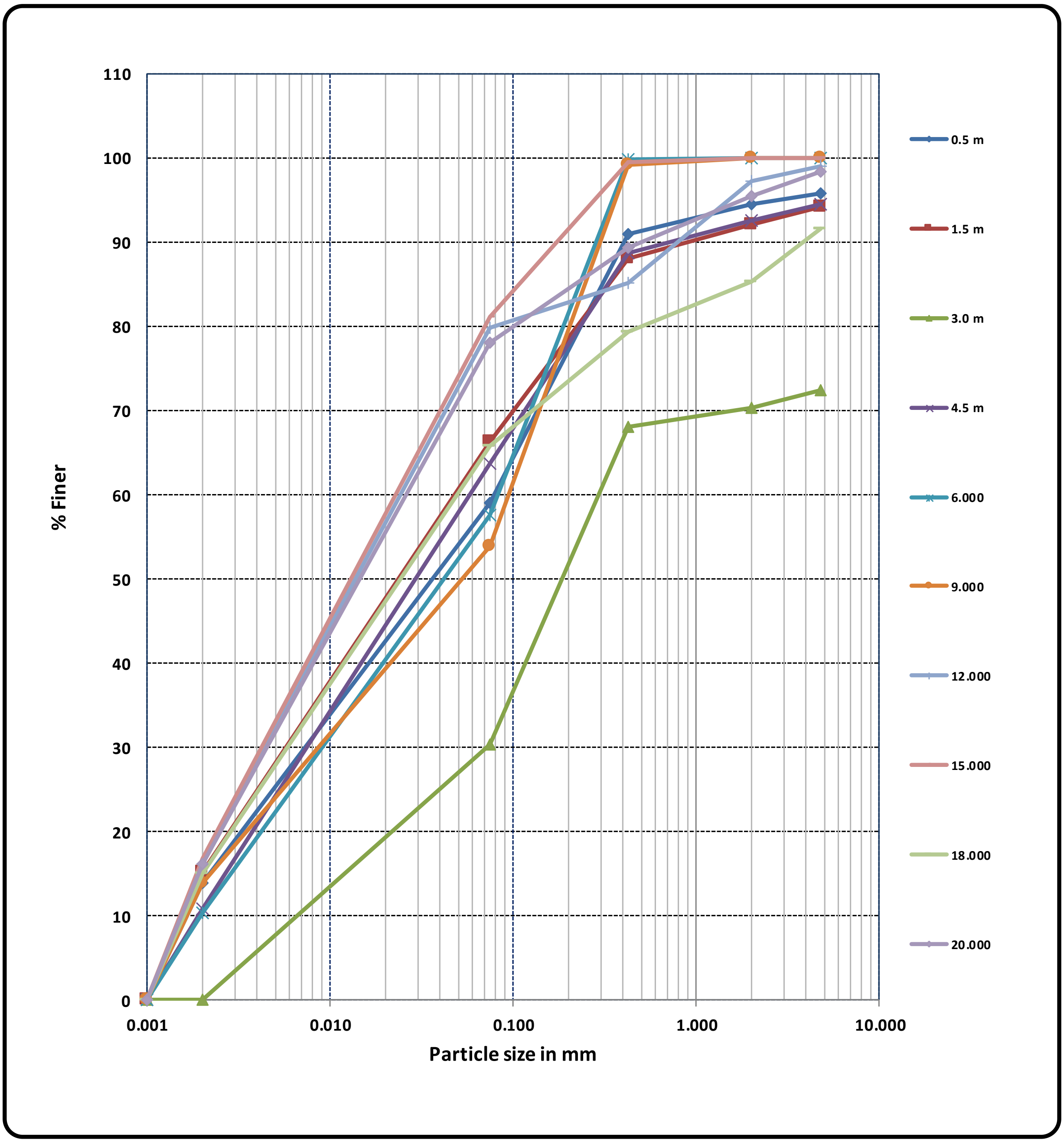
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-29



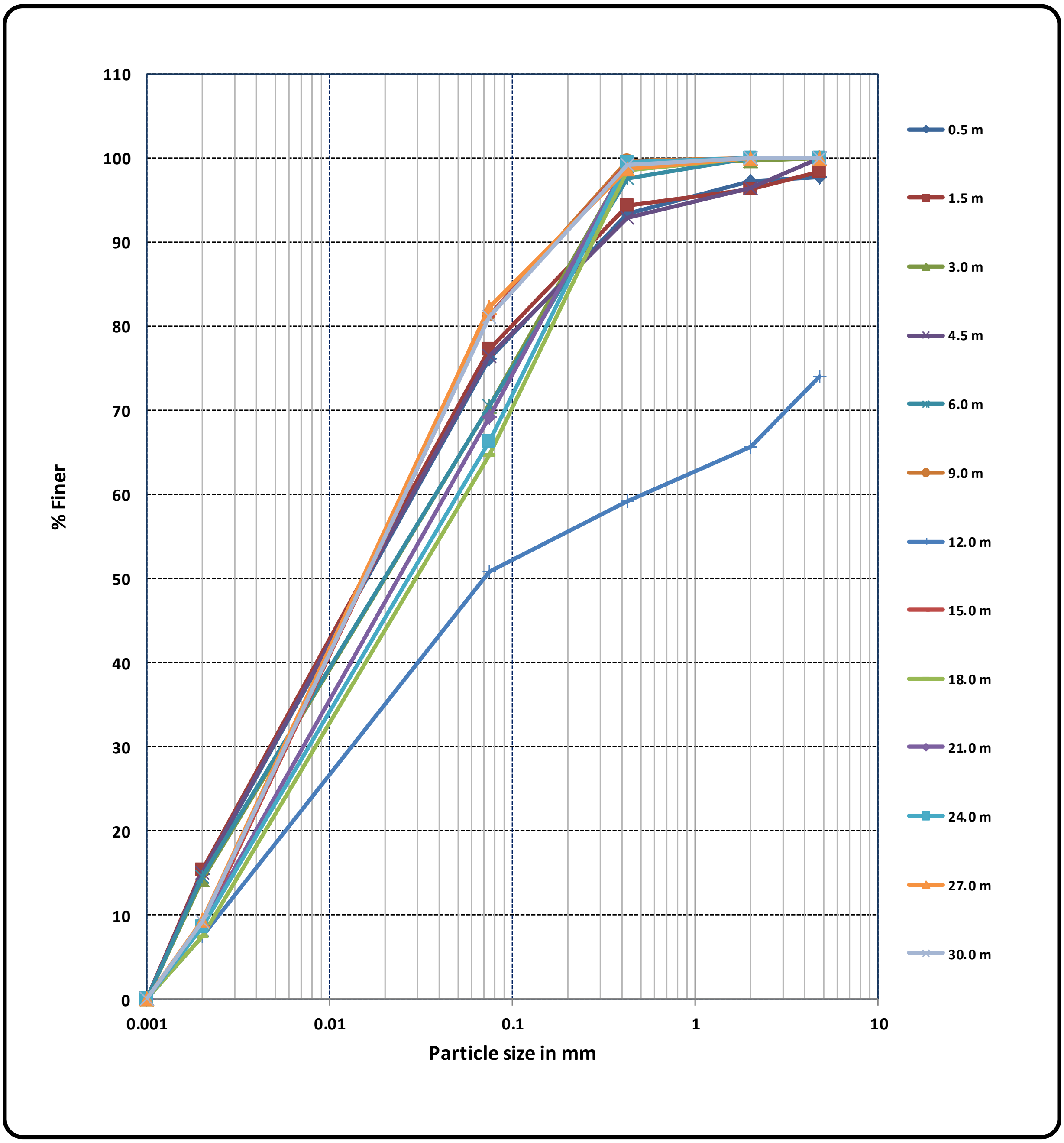
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-30



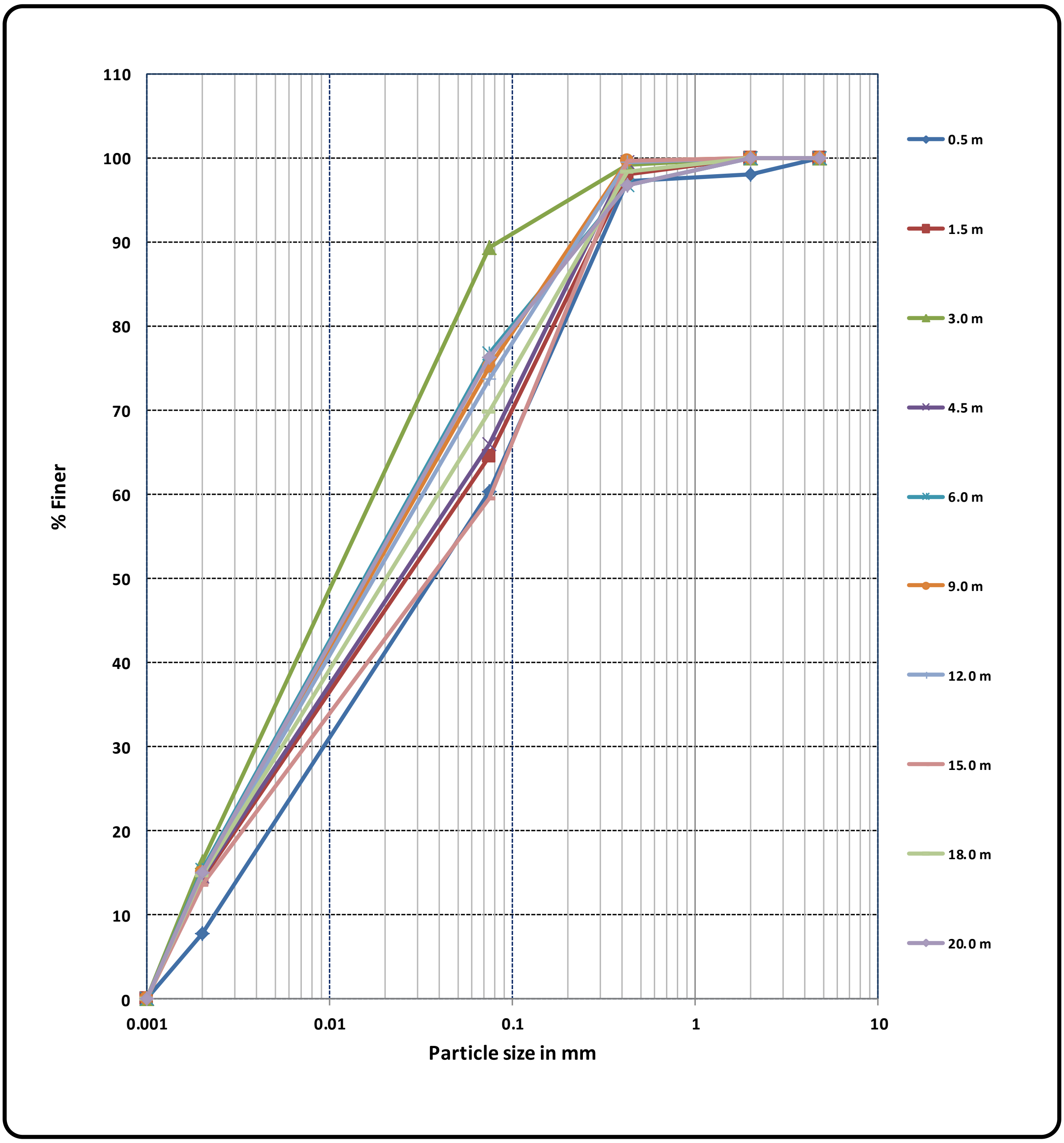
## GRAIN SIZE DISTRIBUTION CURVE OF BH NO-31



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& $\phi$) are calculated theoritically from N value.

1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

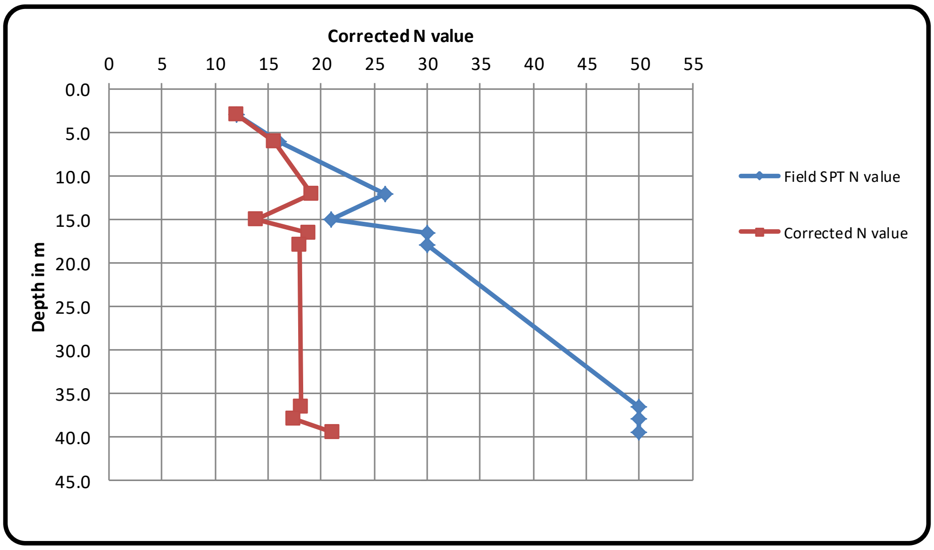
   Where N is the corrected N value.

2. In case of cohesionless, for angle of shearing resistance ($\phi$), 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

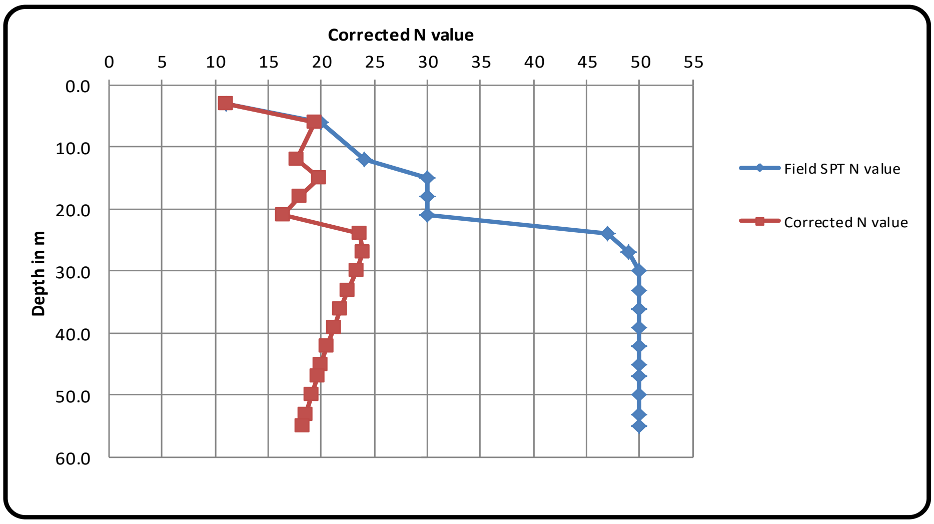
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) 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 ($\phi$), 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

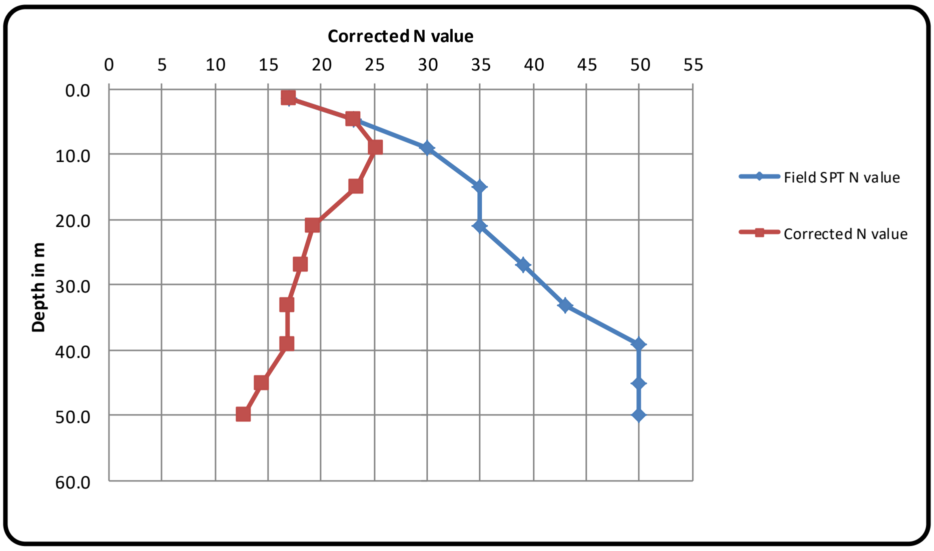
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

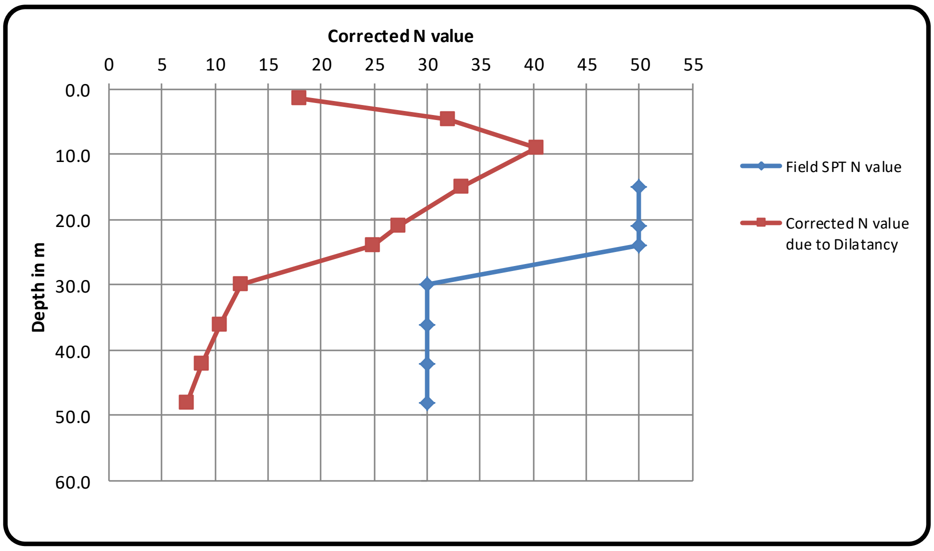
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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



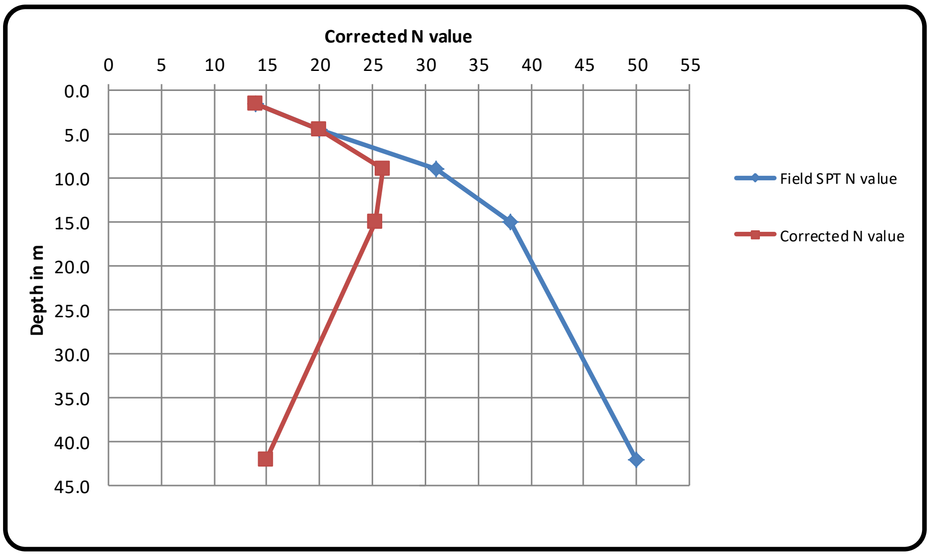
## COMPUTATION OF CORRECTED N VALUE

| 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

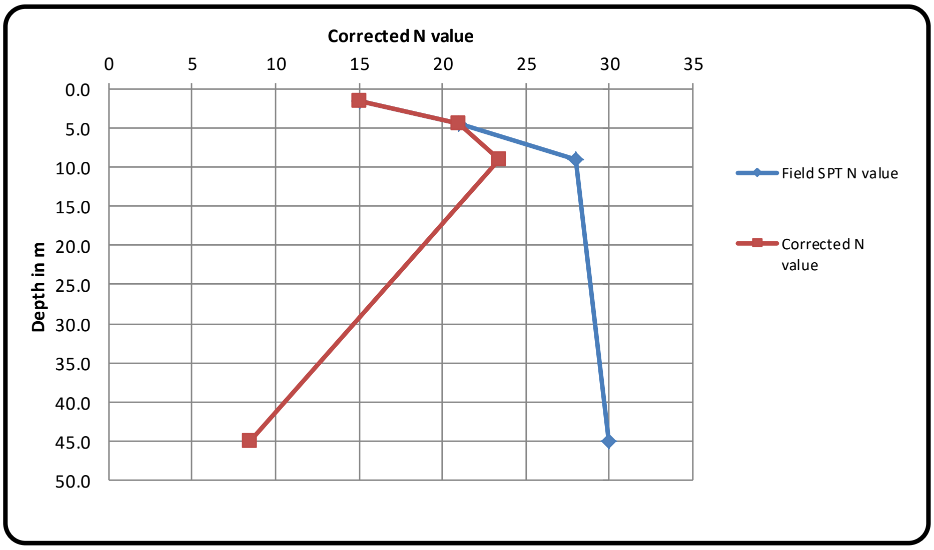
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) 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 ($\phi$), 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

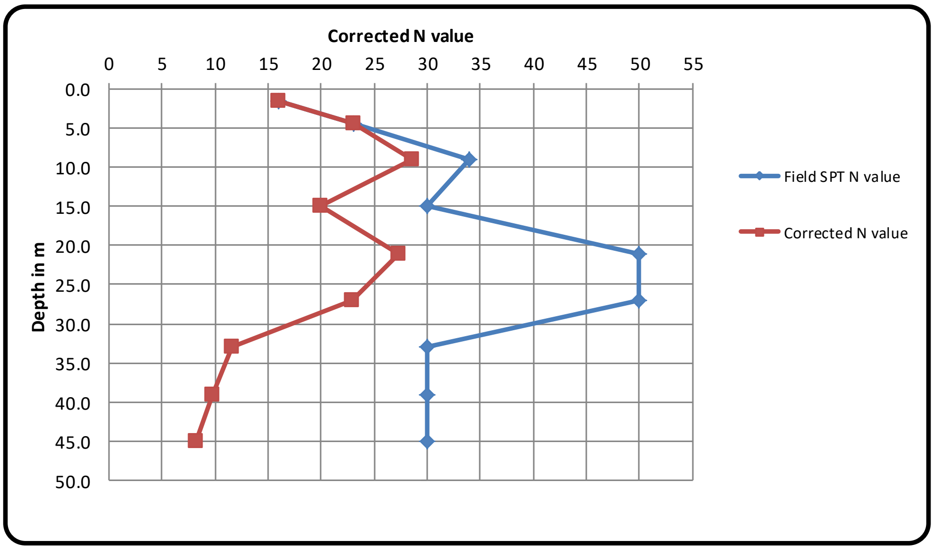
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) 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 ($\phi$), 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

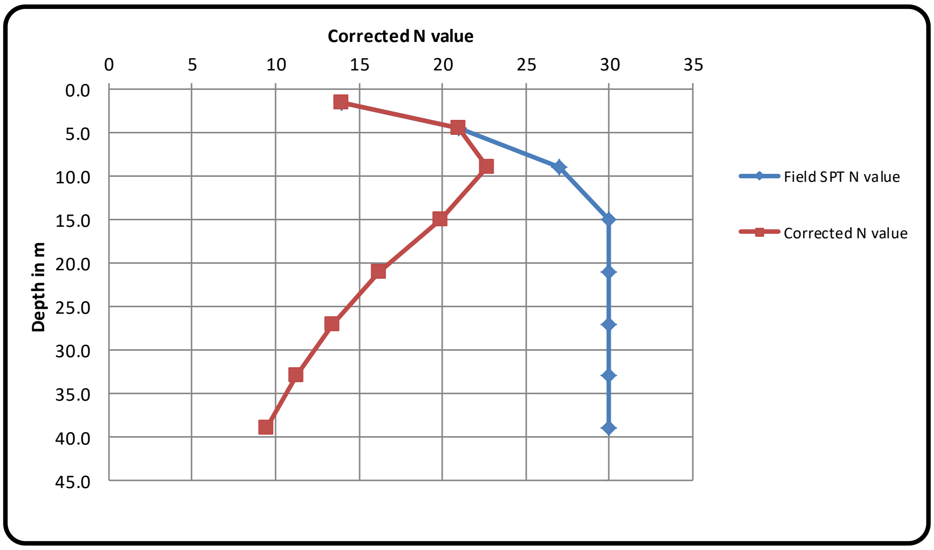
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) 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 ($\phi$), 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

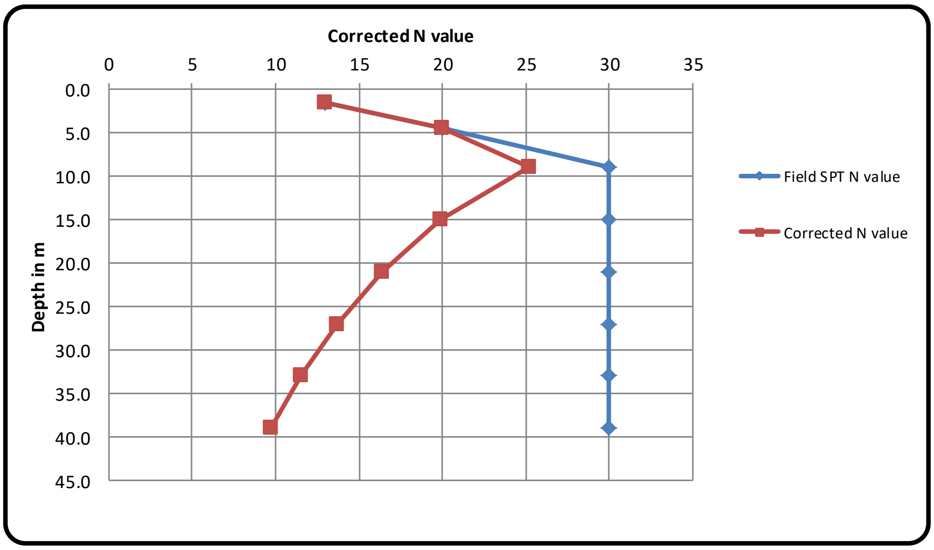
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) 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 ($\phi$), 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

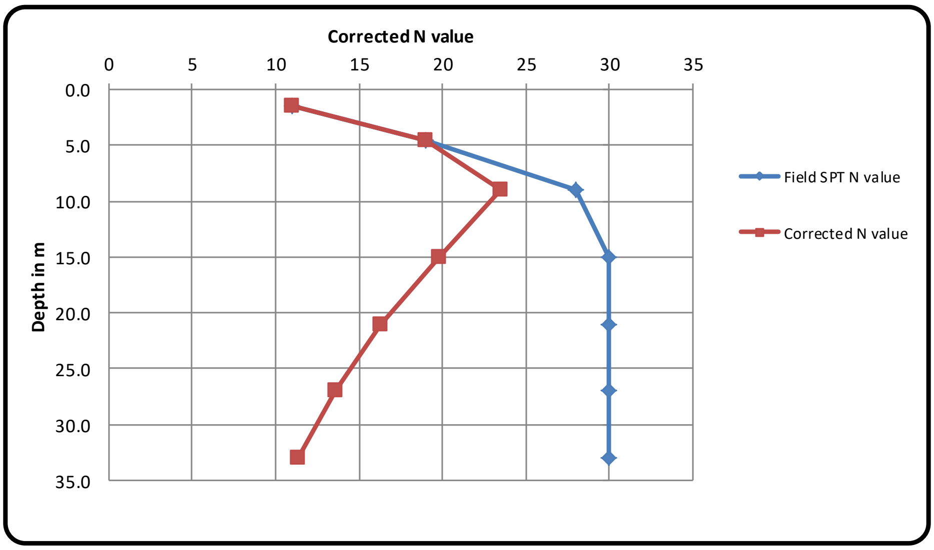
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

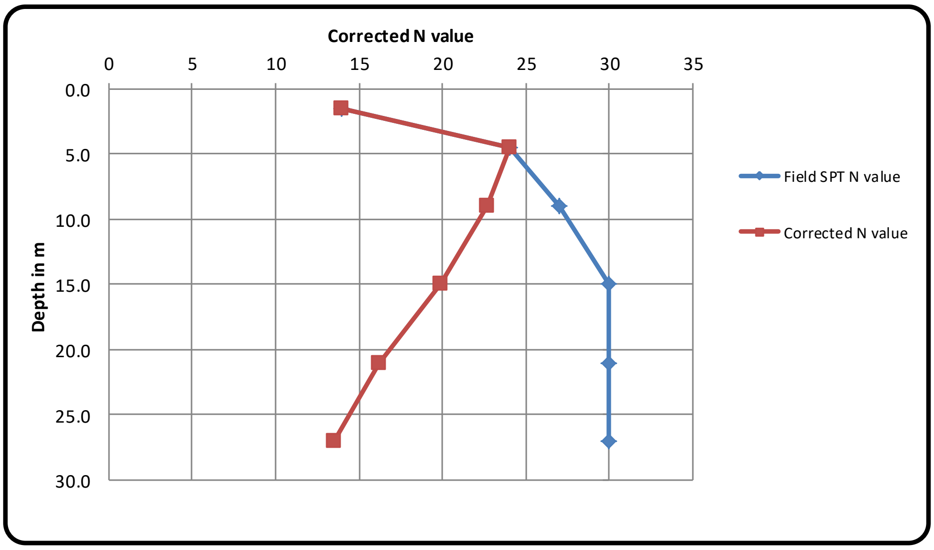
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) 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 ($\phi$), 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

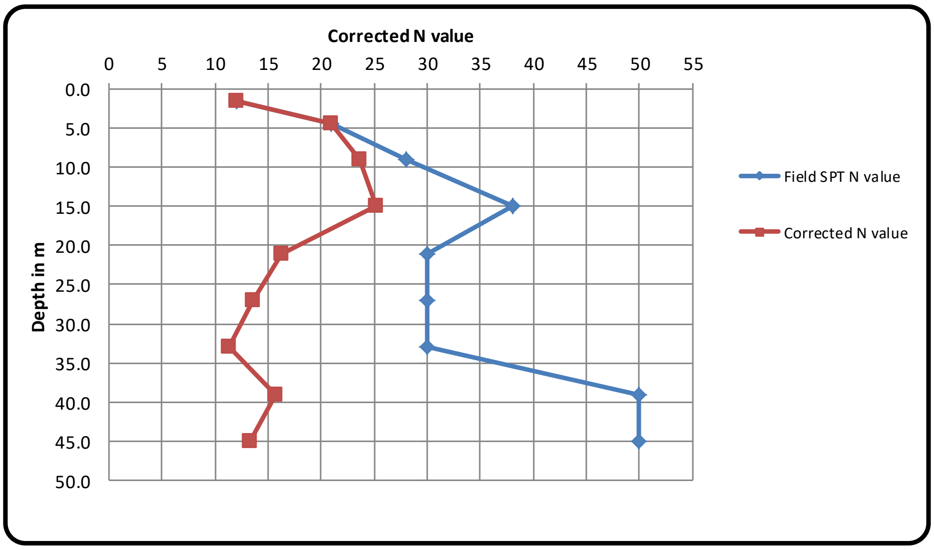
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) 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 ($\phi$), 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

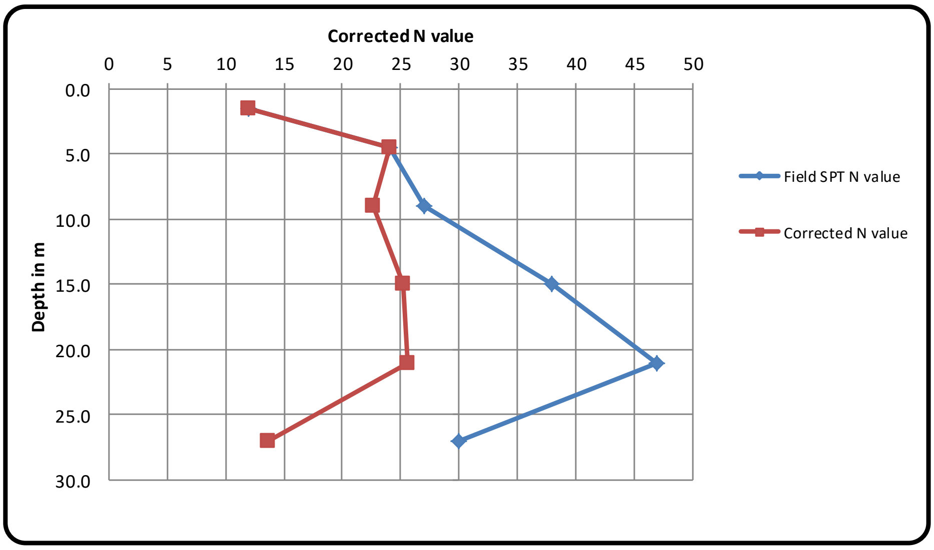
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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



## COMPUTATION OF CORRECTED N VALUE

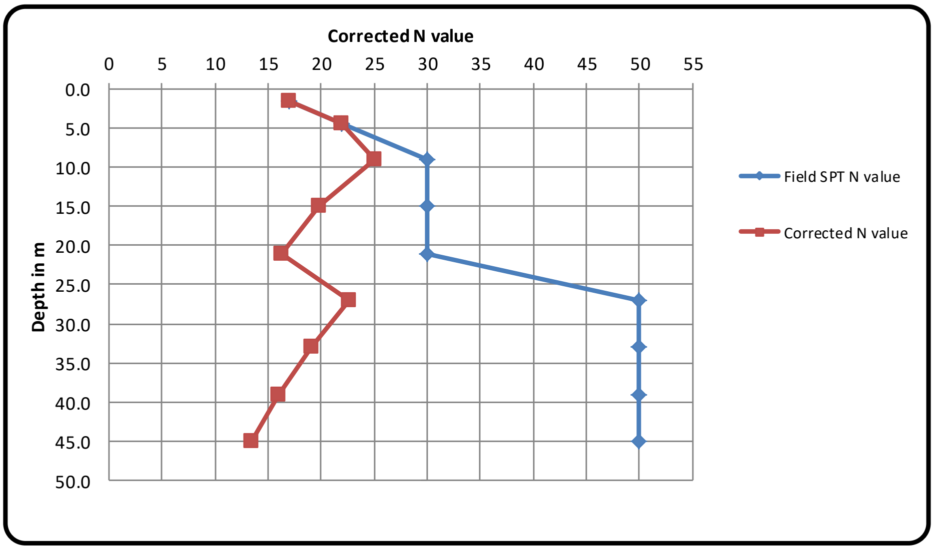
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

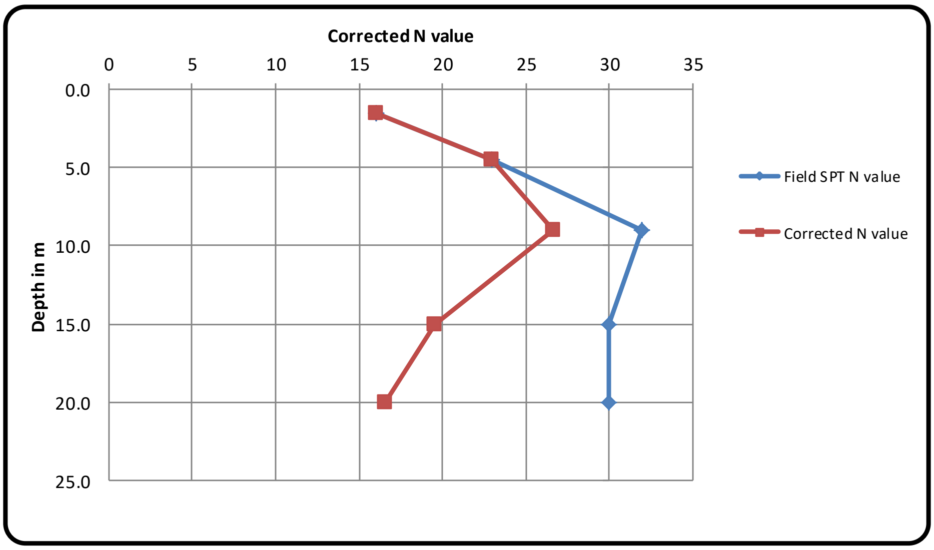
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) 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 ($\phi$), 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

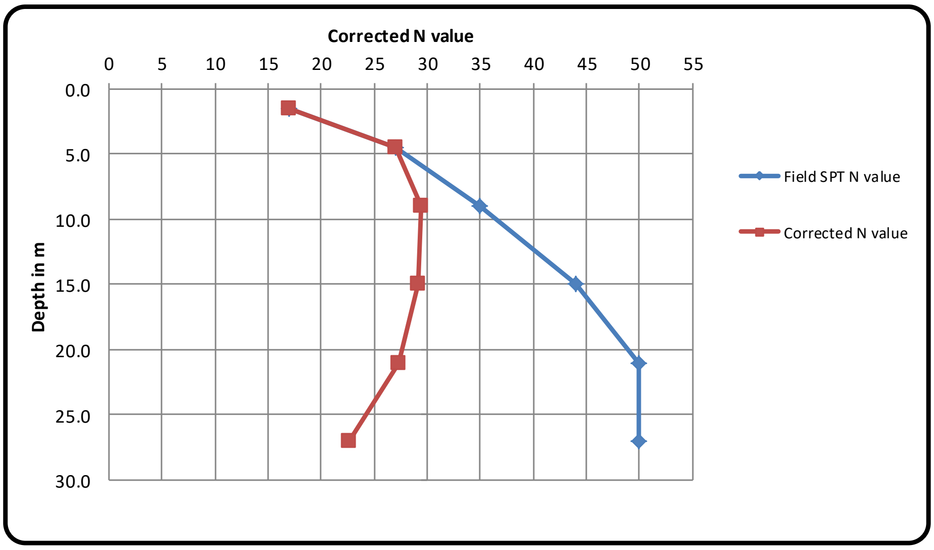
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

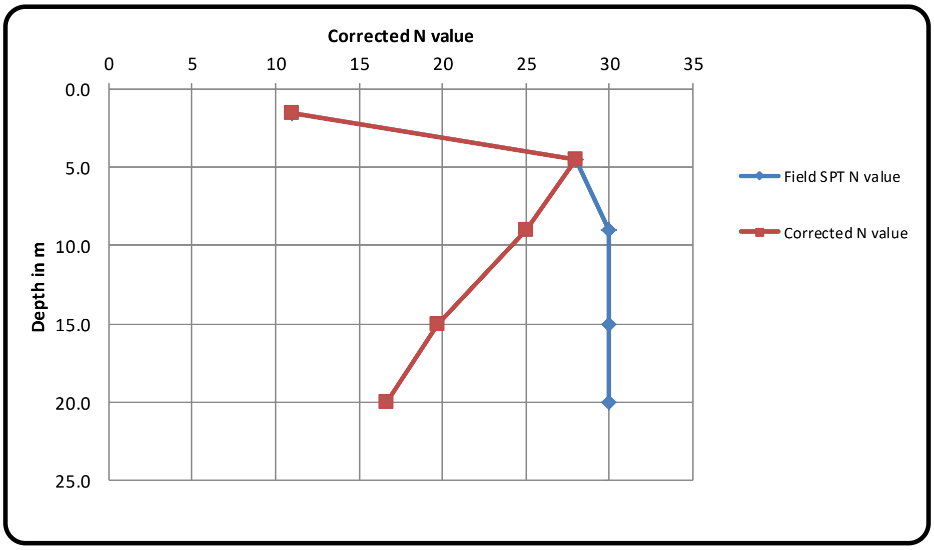
| Sl No. | Bridge No. | Depth from G.L in m. | Water table in m | Group of soil | Field SPT N value | | Density gm/cm$^3$ | overburden pressure in kg/cm$^2$ | overburden correction factor | Corrected N value due to overburden | Corrected N value due to Dilatancy |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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& $\phi$) are calculated theoritically from N value.

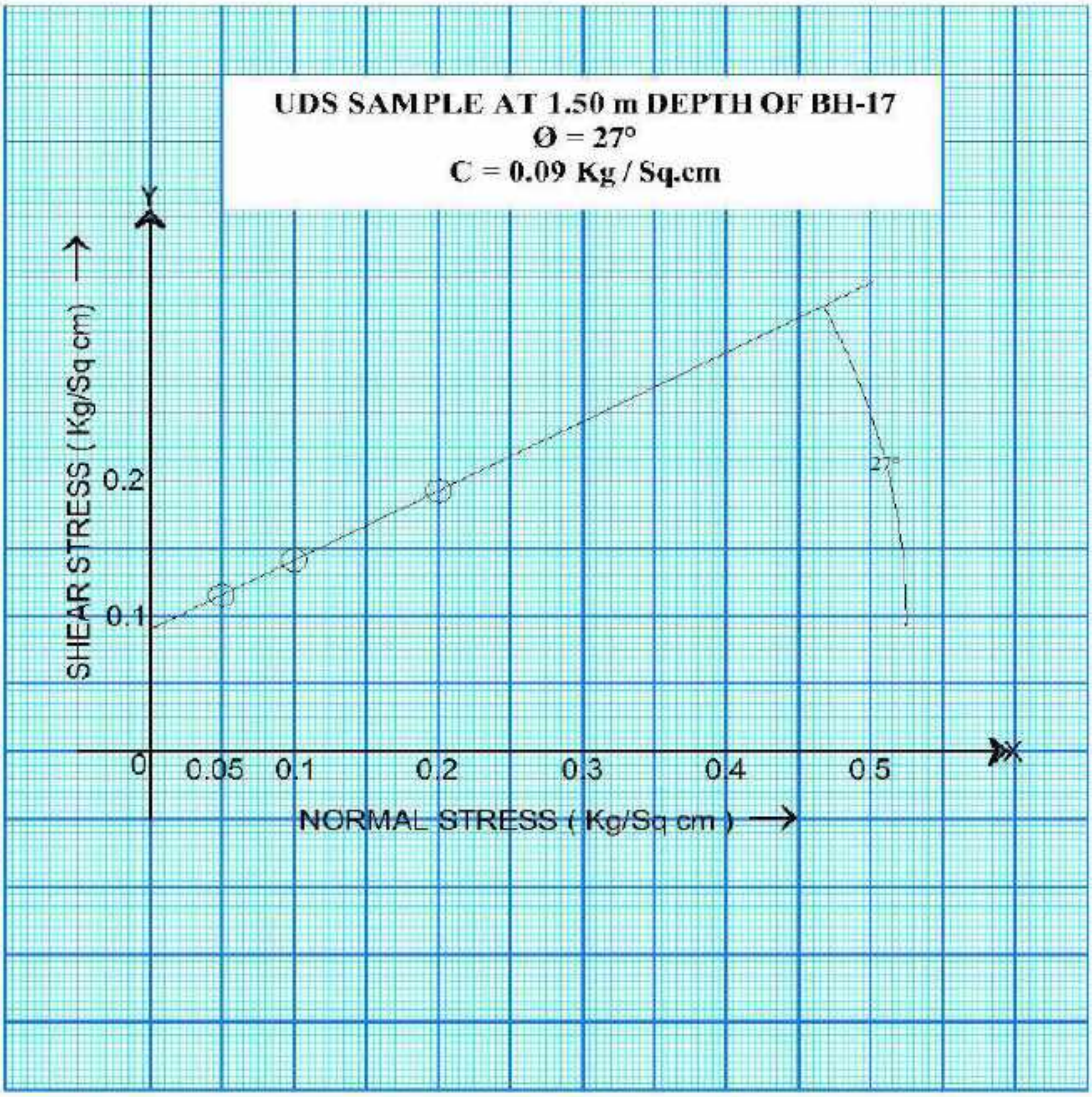
1. As per Terzaghi & Peck, in case of cohesive soil there is a relationship between N value & consistency.

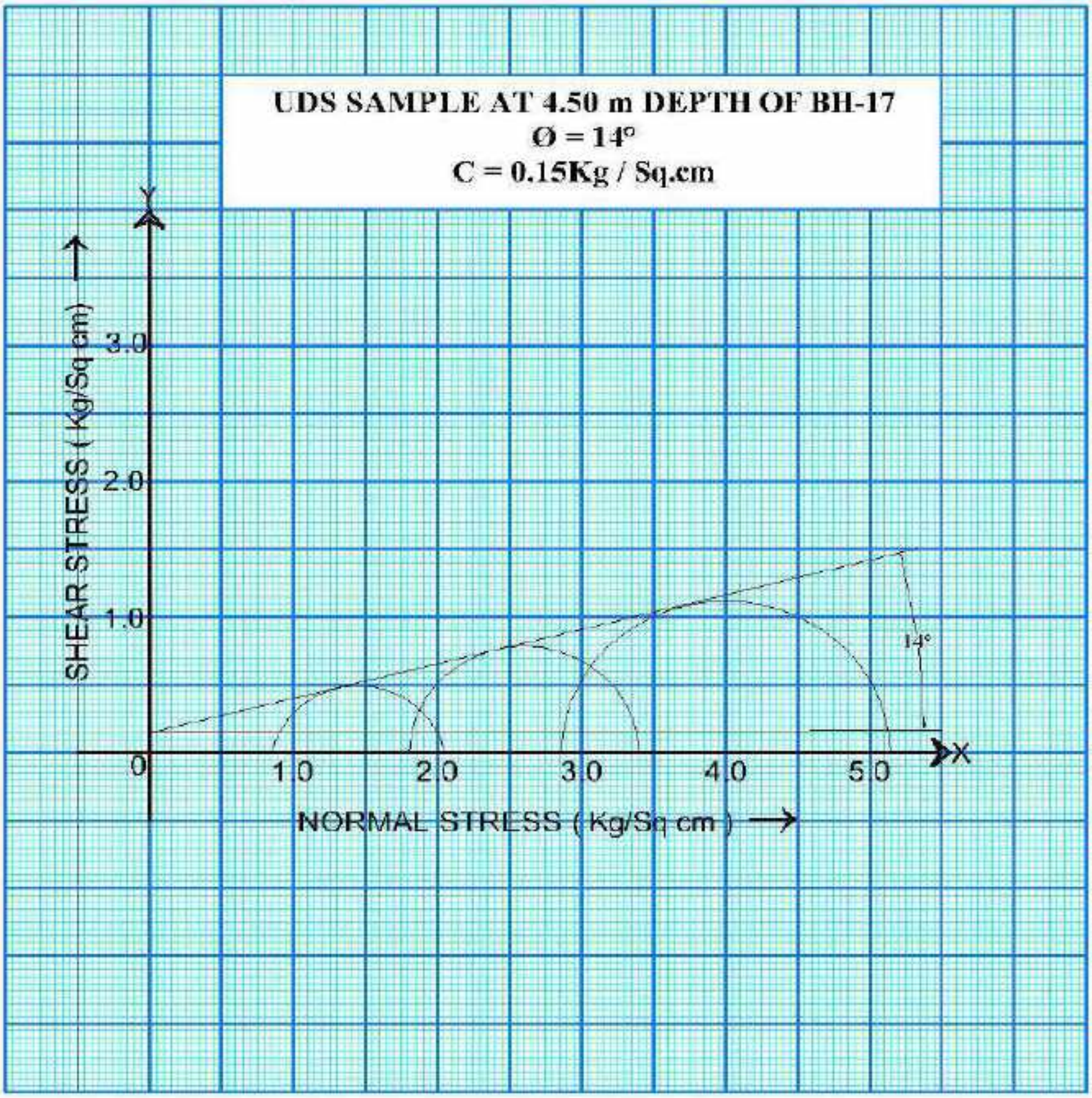
   Where N is the corrected N value.
2. In case of cohesionless, for angle of shearing resistance ($\phi$), fig - 1 of IS : 6403 was used.
3. In case of clay soil, if N>30 then it may be considered limited to 30.
4. Overburden correction factor is considered as1 whereever its value is greater than 1.

## STANDARD PENETRATION TEST OF BH NO-33



# ANNEXURE –J
# GRAPHICAL REPRESENTATION OF SHEAR STRENGTH PARAMETER

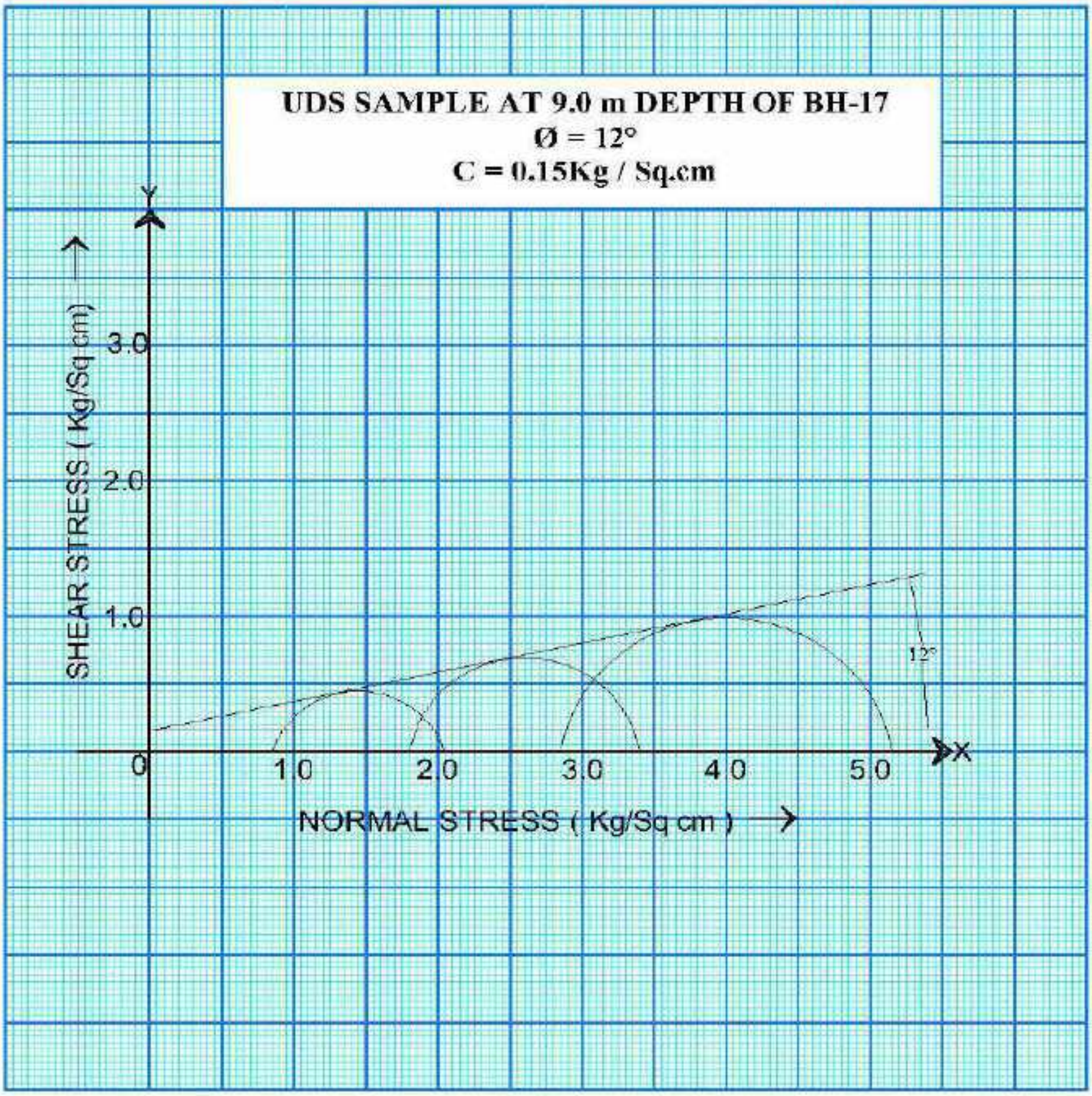

UDS SAMPLE AT 1.50 m DEPTH OF BH-17
Ø = 27°
C = 0.09 Kg / Sq.cm



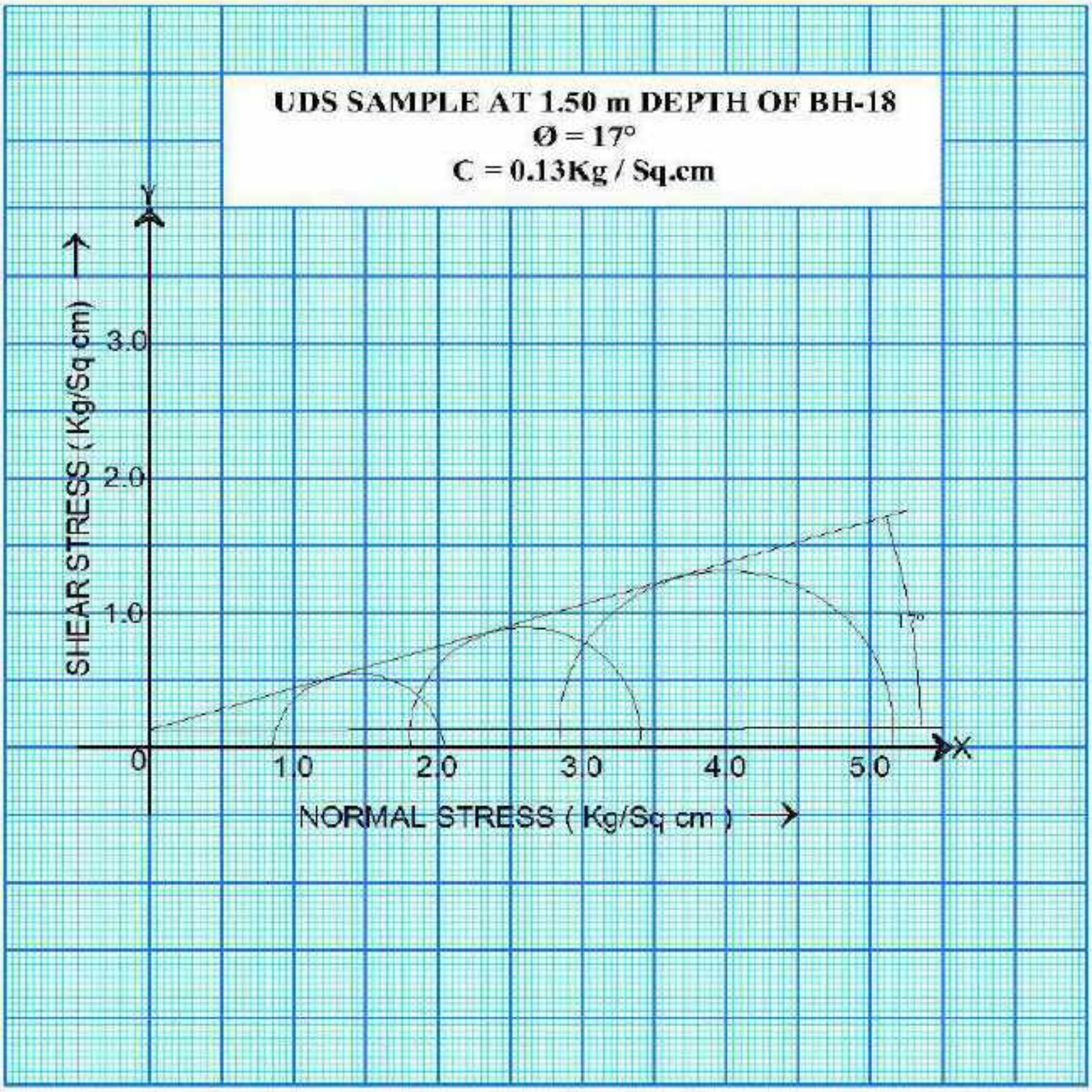
UDS SAMPLE AT 4.50 m DEPTH OF BH-17

Ø = 14°

C = 0.15Kg / Sq.cm

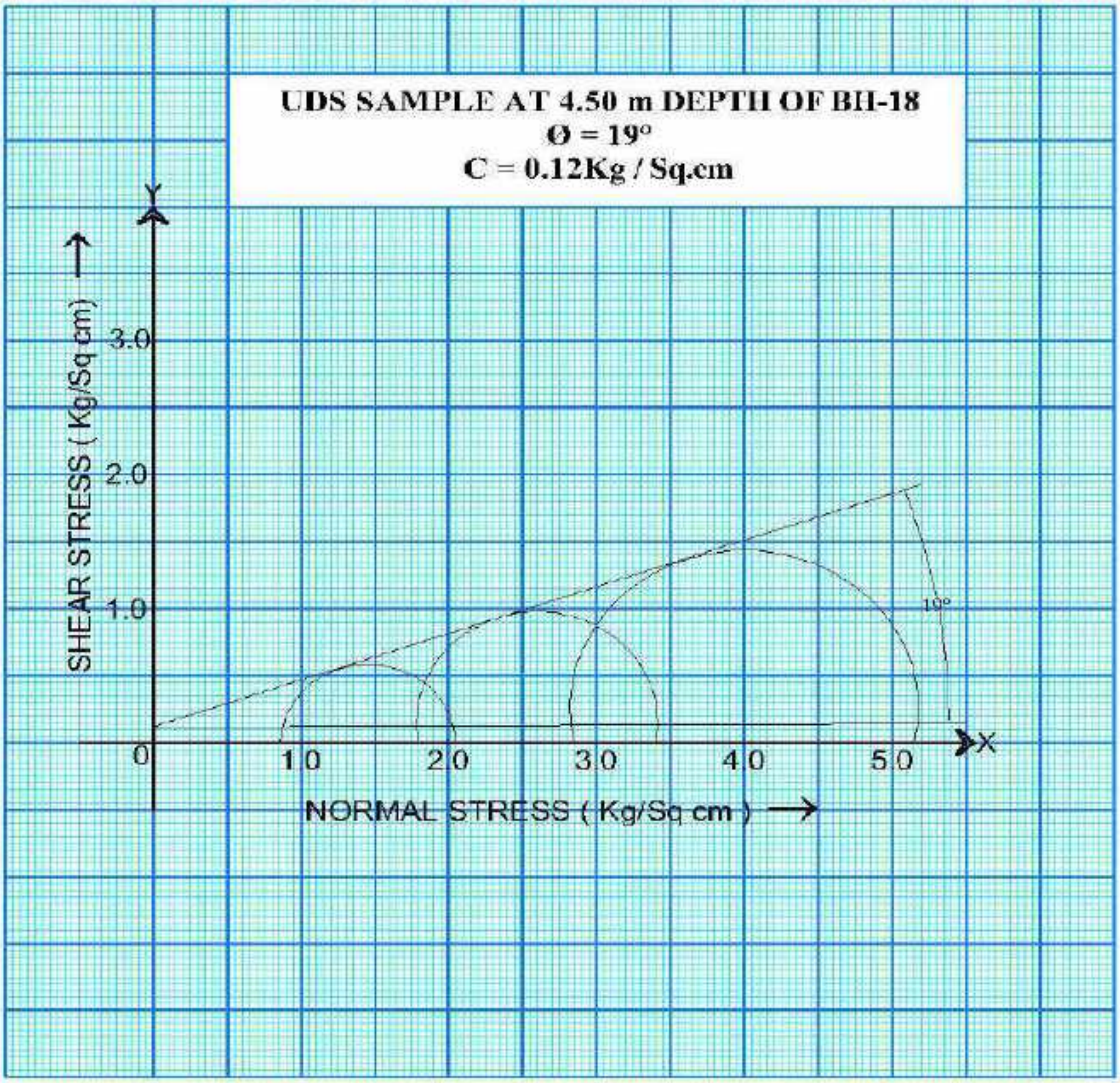


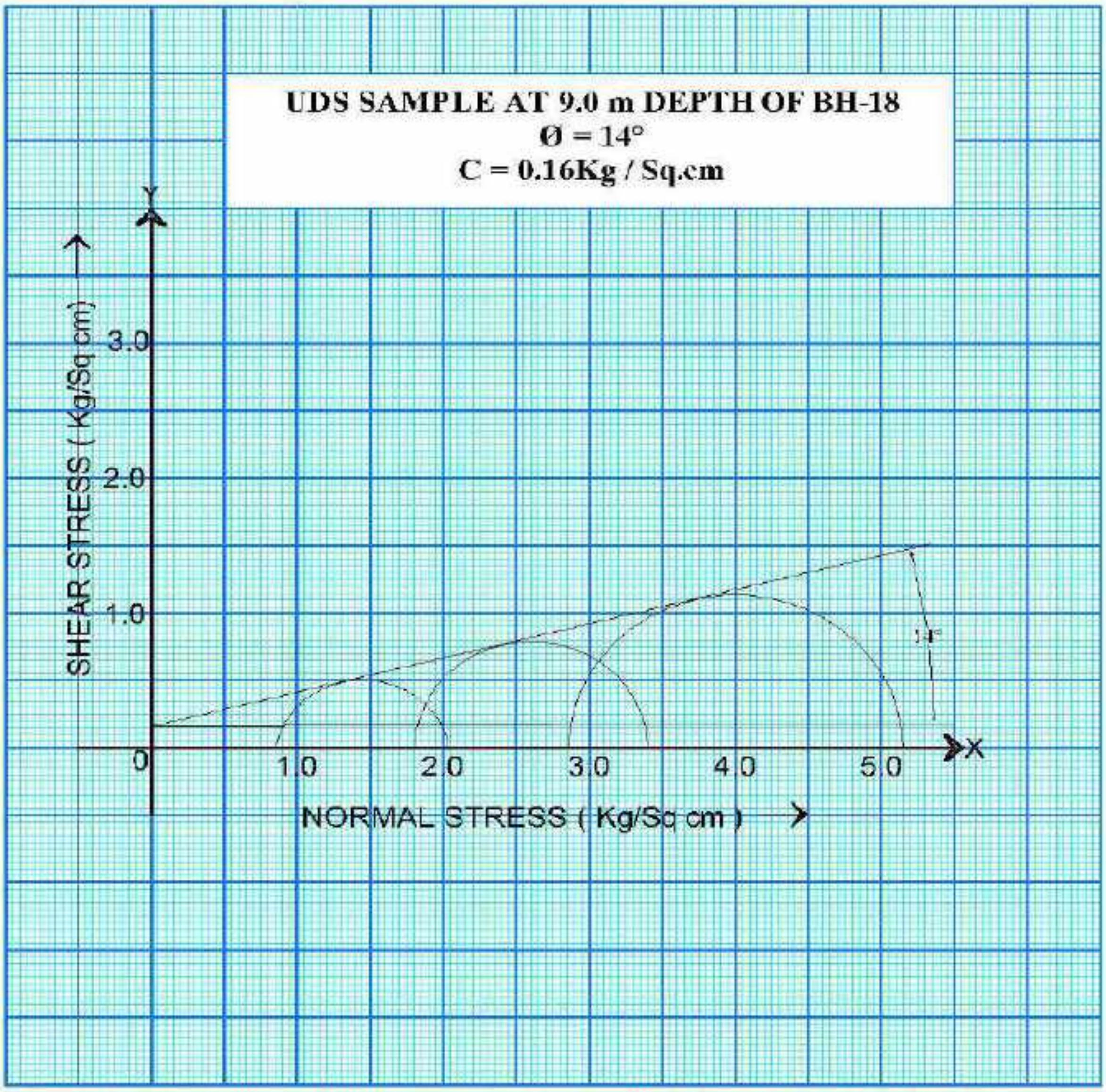
UDS SAMPLE AT 9.0 m DEPTH OF BH-17
Ø = 12°
C = 0.15Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
12°
NORMAL STRESS ( Kg/Sq cm )

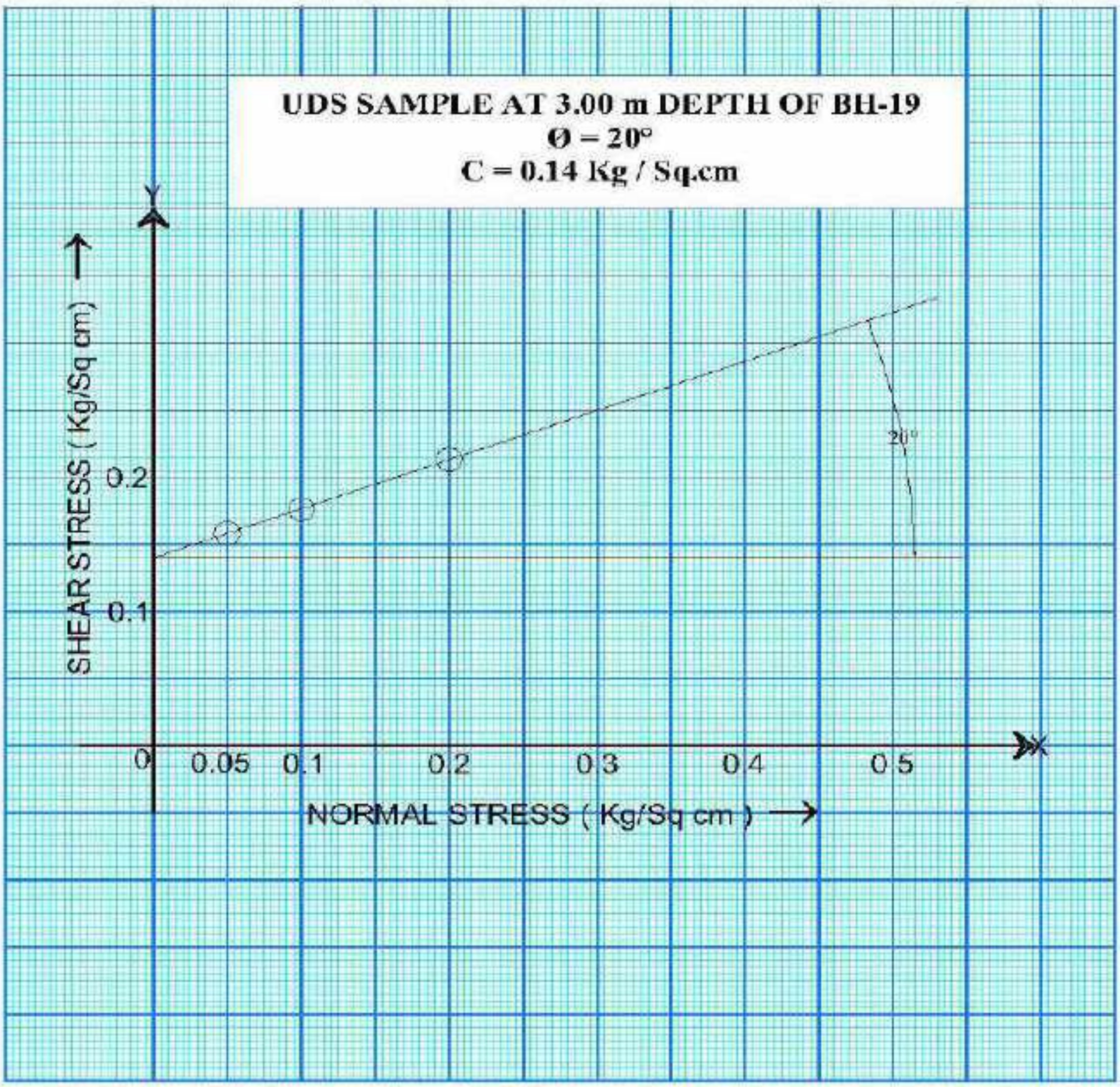

UDS SAMPLE AT 1.50 m DEPTH OF BH-18

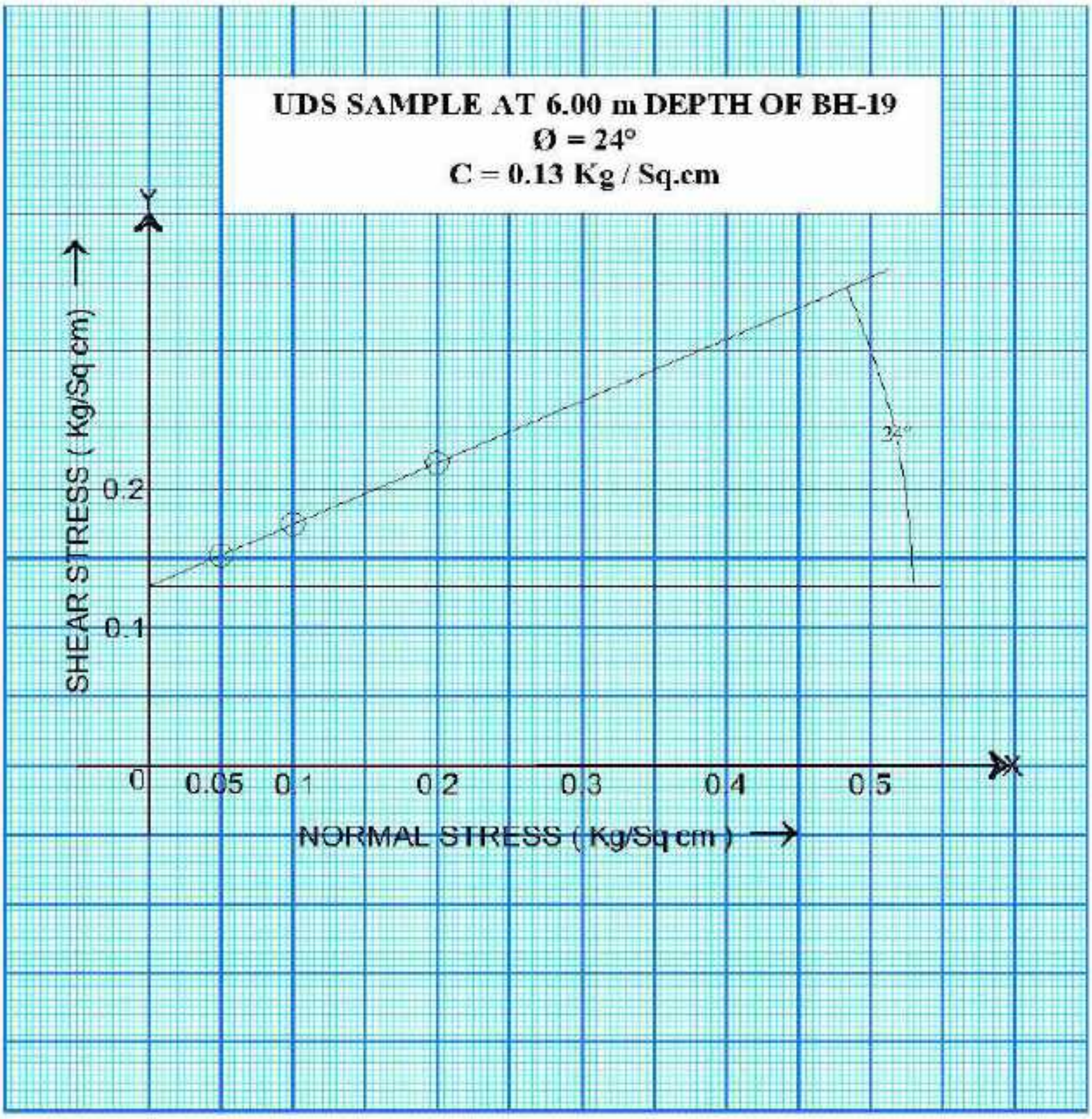
Ø = 17°

C = 0.13Kg / Sq.cm

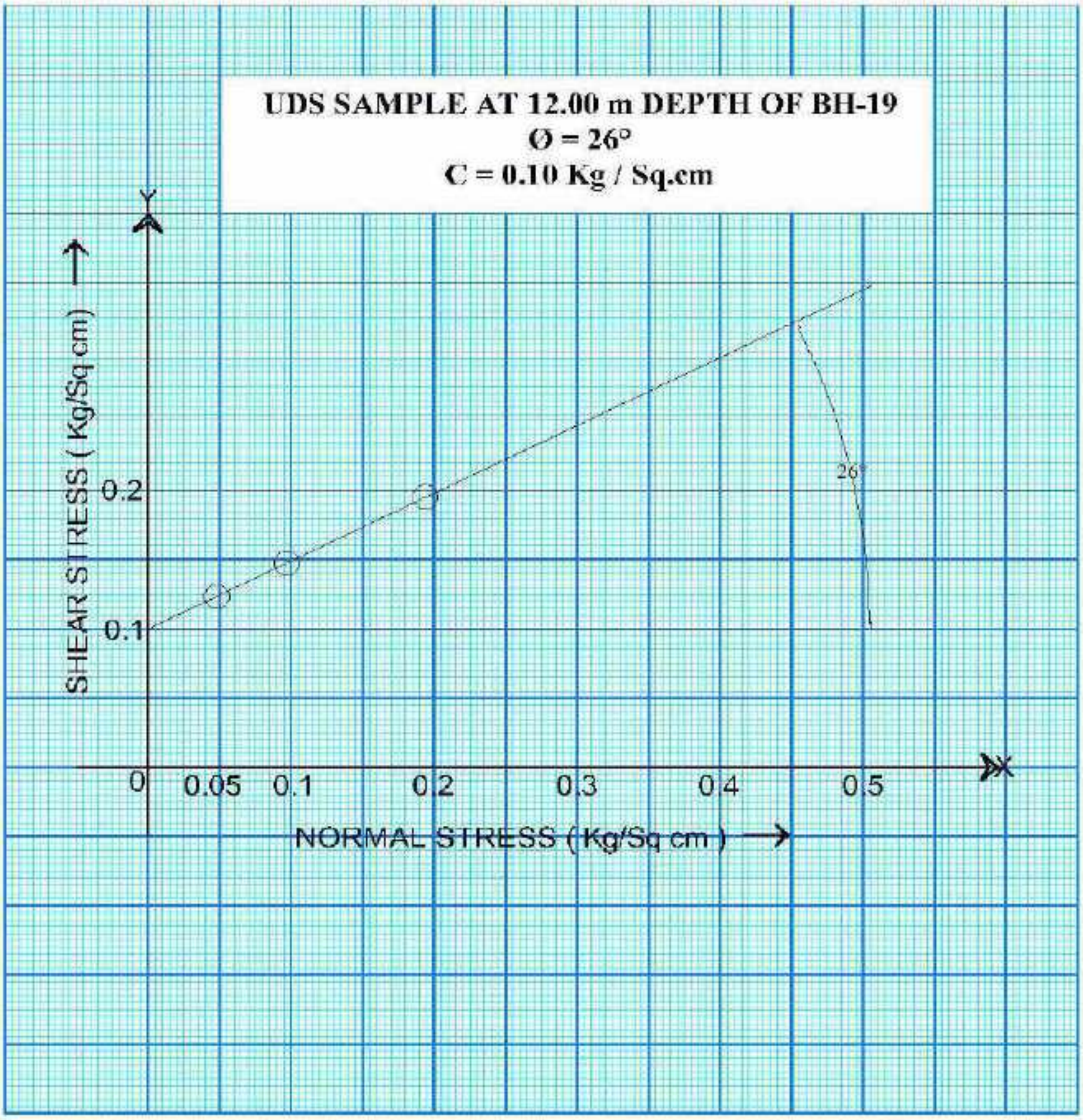

UDS SAMPLE AT 4.50 m DEPTH OF BH-18
Ø = 19°
C = 0.12Kg / Sq.cm
Y
X
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
NORMAL STRESS ( Kg/Sq cm )
19°


UDS SAMPLE AT 9.0 m DEPTH OF BH-18
Ø = 14°
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
14°
NORMAL STRESS ( Kg/Sq cm )


UDS SAMPLE AT 3.00 m DEPTH OF BH-19
Ø = 20°
C = 0.14 Kg / Sq.cm



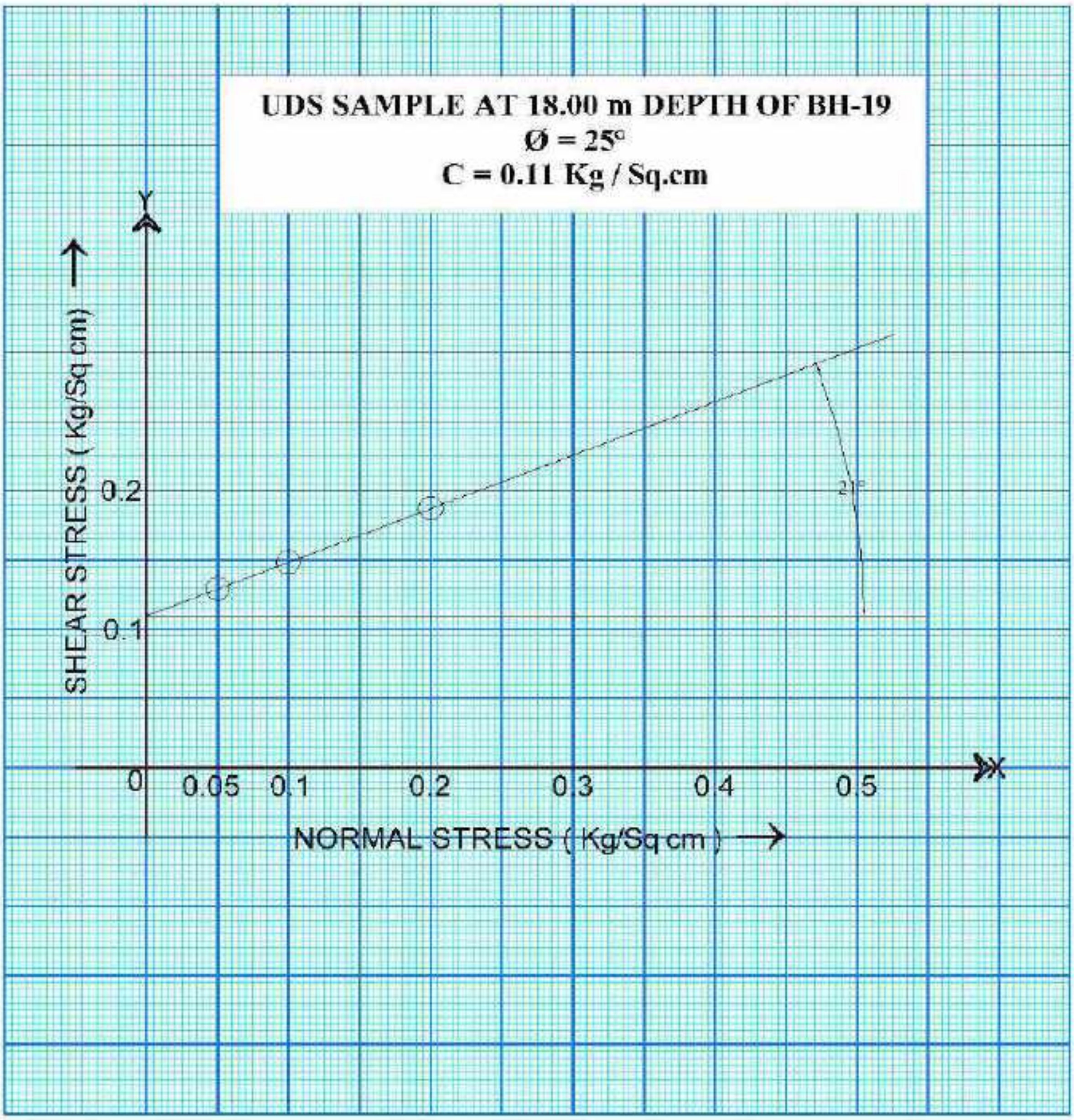
UDS SAMPLE AT 6.00 m DEPTH OF BH-19
Ø = 24°
C = 0.13 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
24°
NORMAL STRESS ( Kg/Sq cm )



**UDS SAMPLE AT 12.00 m DEPTH OF BH-19**

**Ø = 26°**

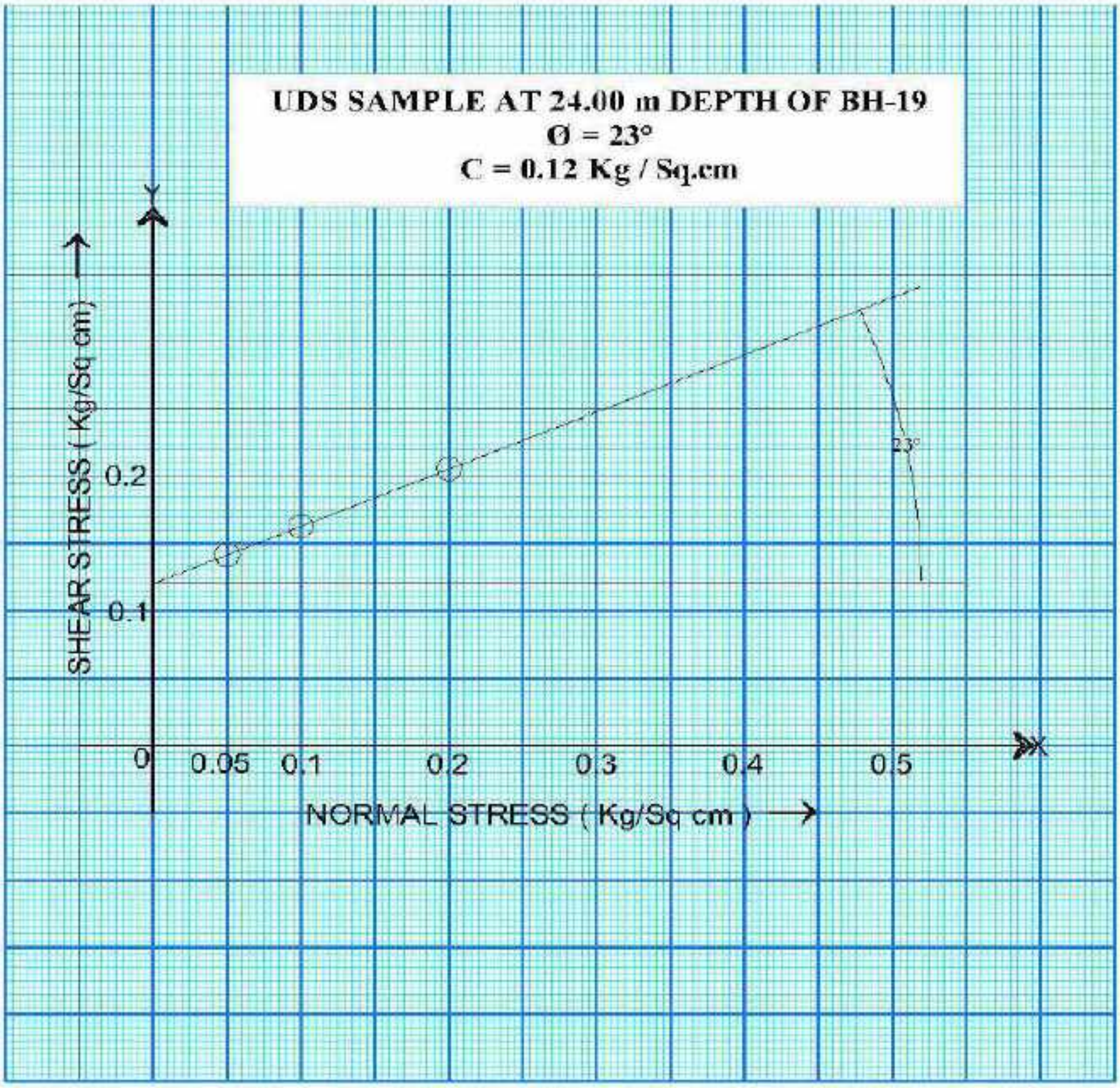
**C = 0.10 Kg / Sq.cm**



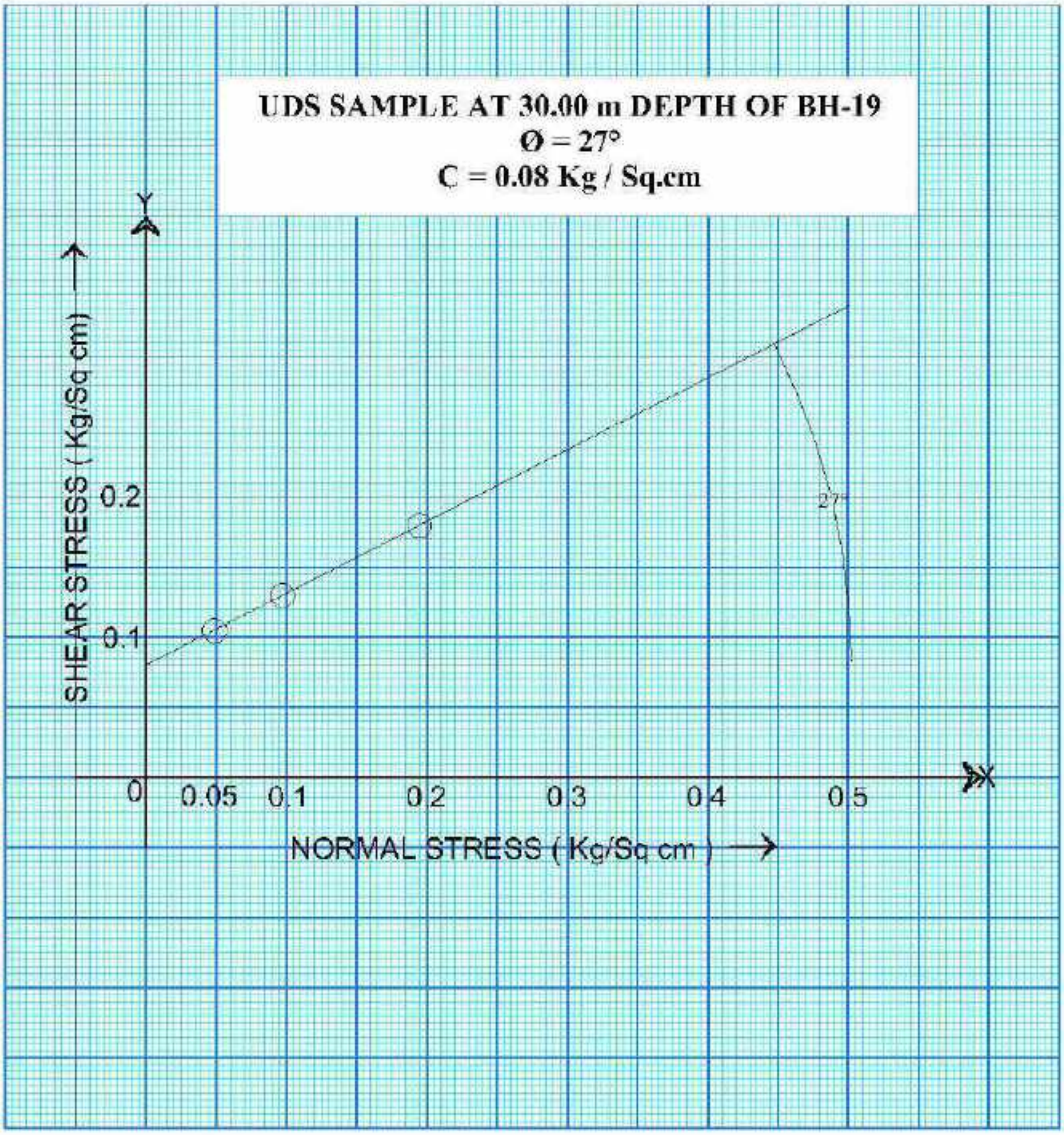
**UDS SAMPLE AT 18.00 m DEPTH OF BH-19**

**Ø = 25°**

**C = 0.11 Kg / Sq.cm**



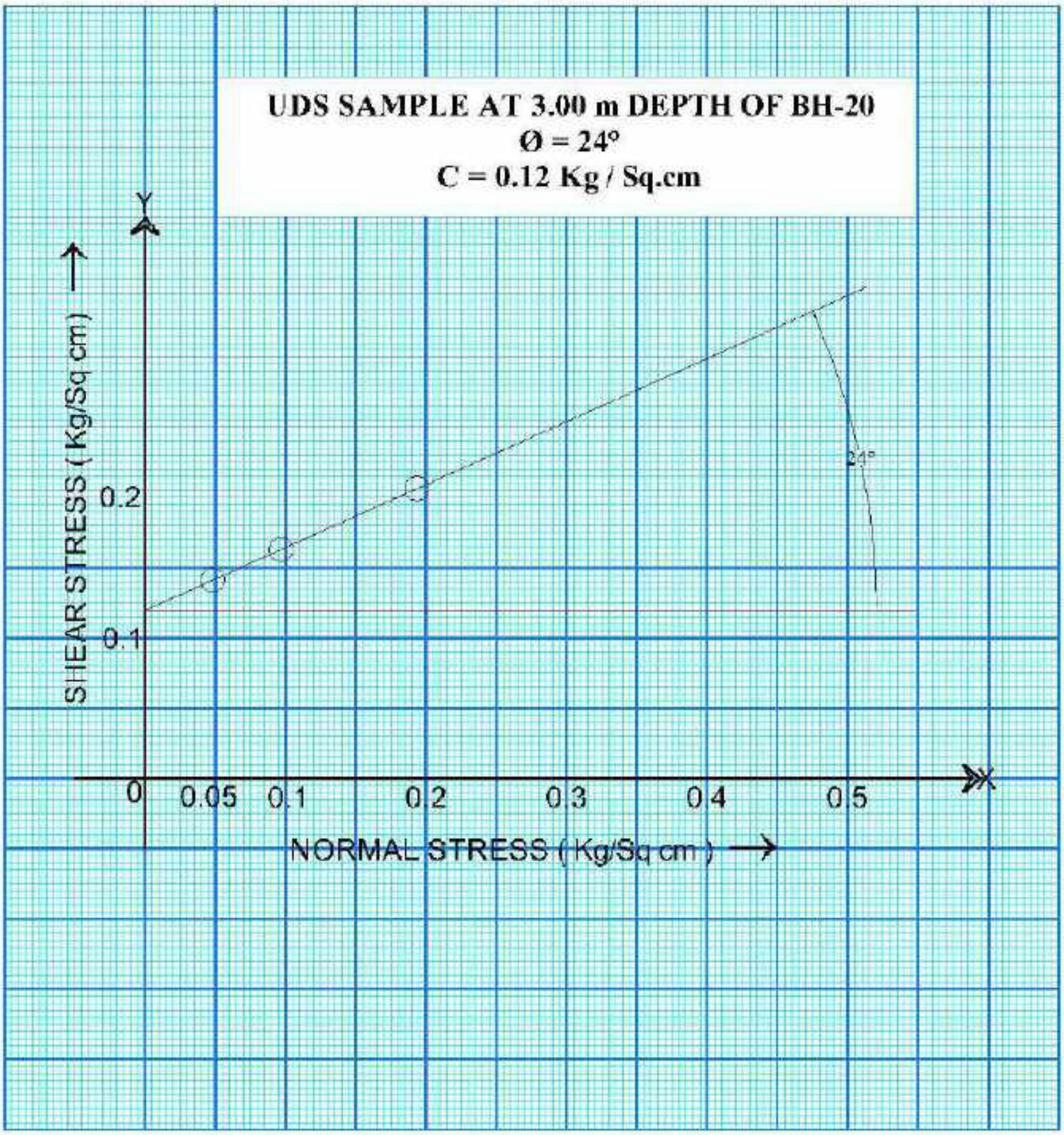
UDS SAMPLE AT 24.00 m DEPTH OF BH-19
Ø = 23°
C = 0.12 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm )
23°



UDS SAMPLE AT 30.00 m DEPTH OF BH-19

Ø = 27°

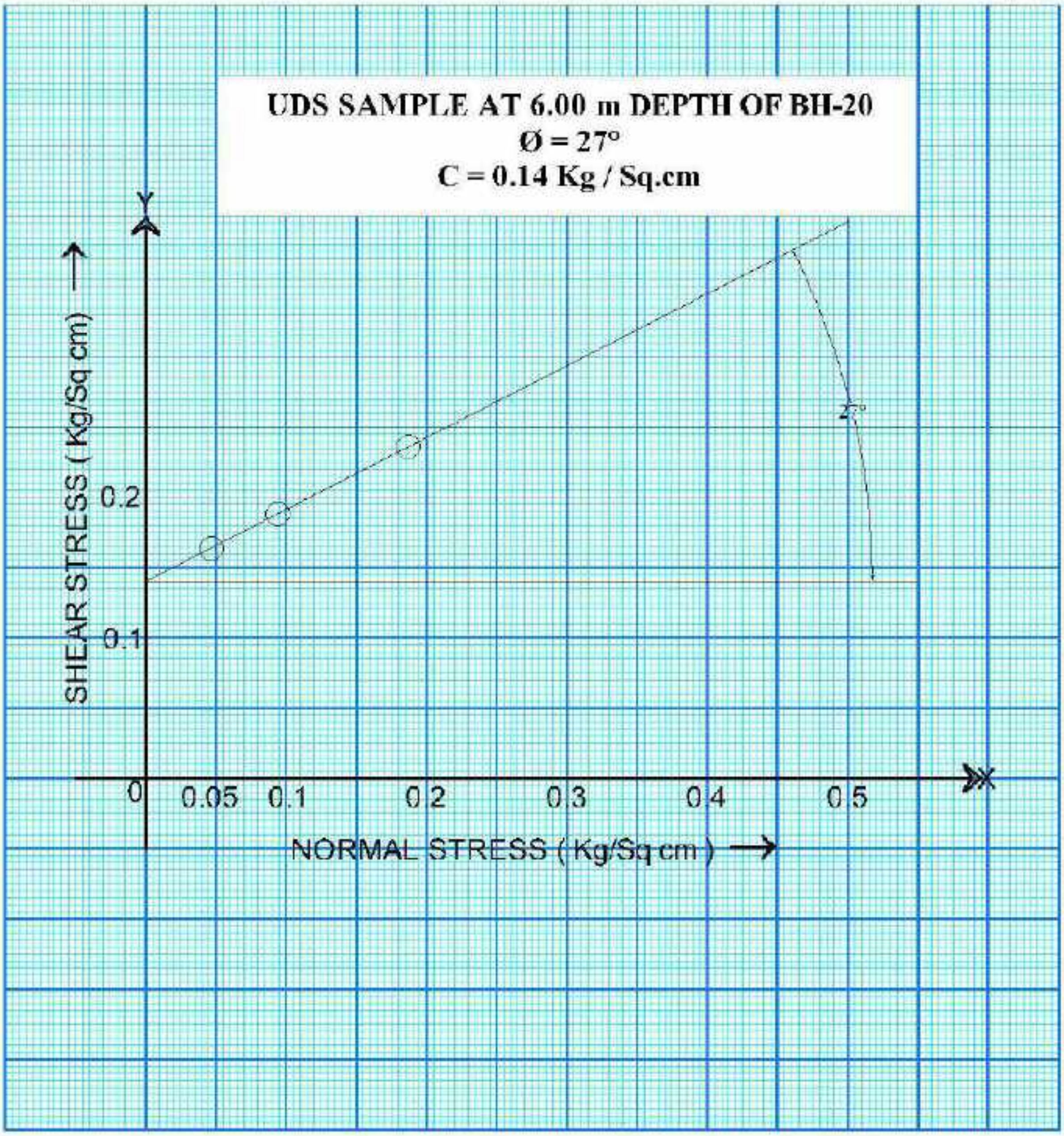
C = 0.08 Kg / Sq.cm



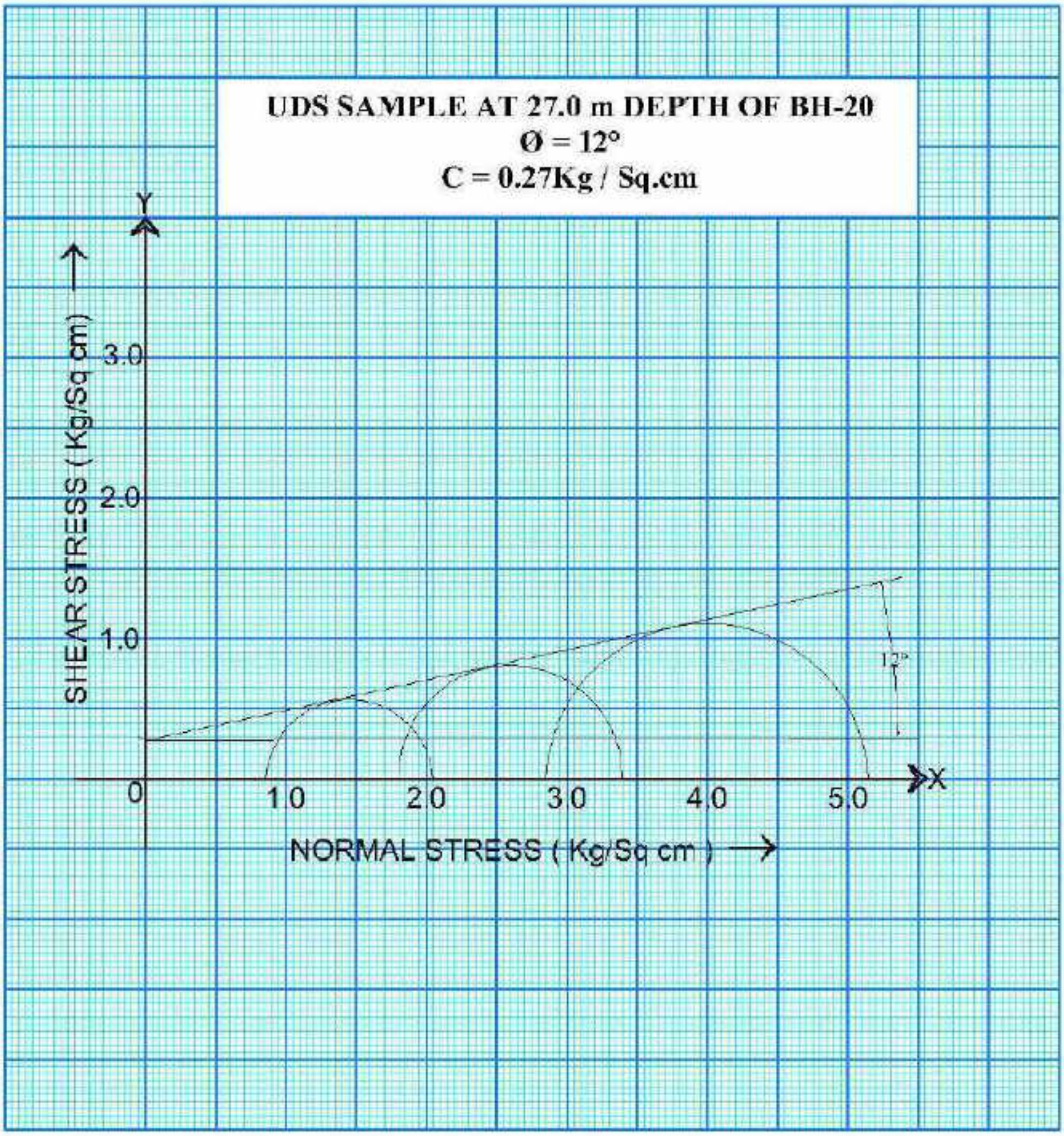
**UDS SAMPLE AT 3.00 m DEPTH OF BH-20**

**Ø = 24°**

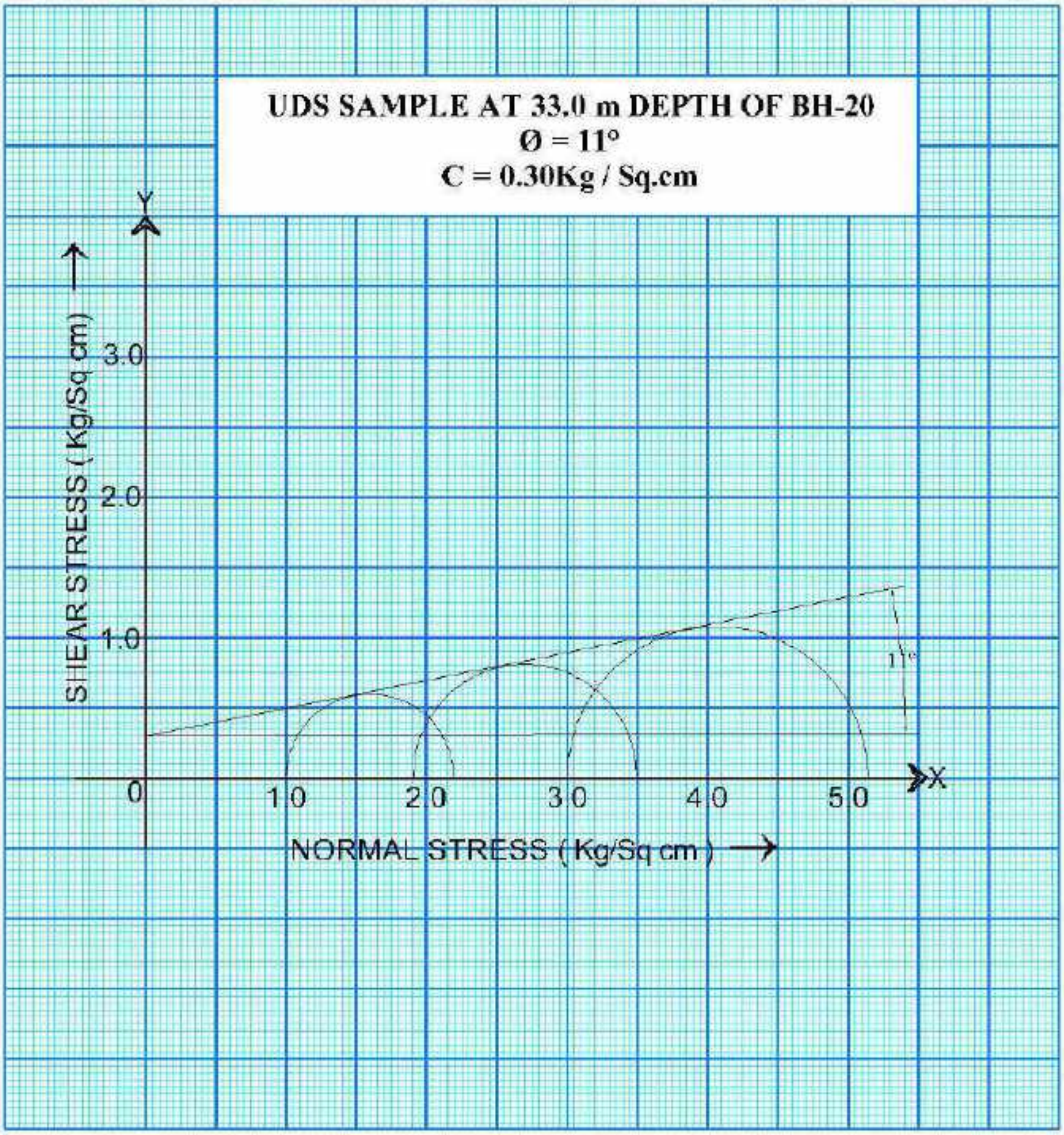
**C = 0.12 Kg / Sq.cm**



UDS SAMPLE AT 6.00 m DEPTH OF BH-20
Ø = 27°
C = 0.14 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 ) →
27°

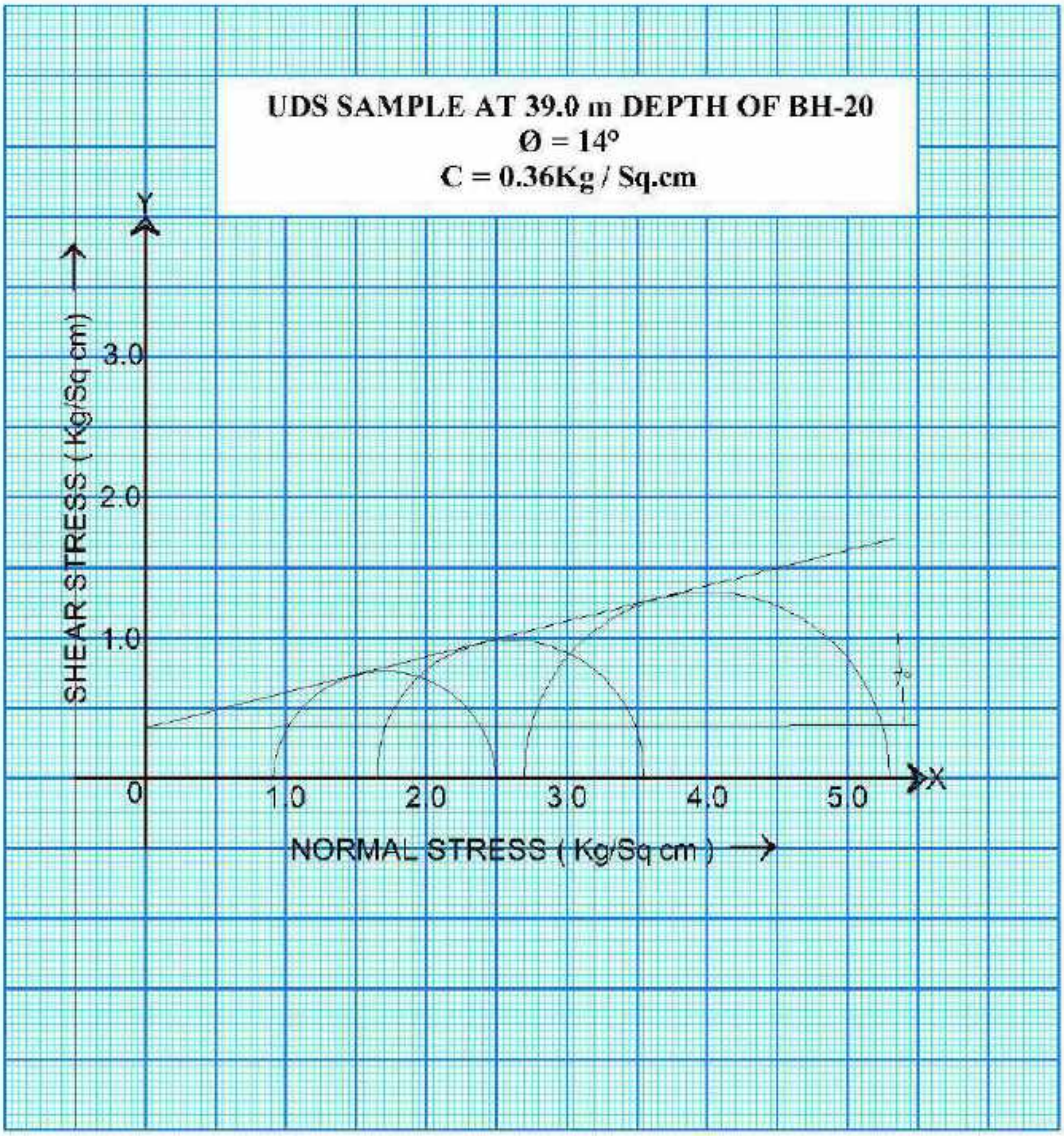


UDS SAMPLE AT 27.0 m DEPTH OF BH-20
Ø = 12°
C = 0.27Kg / Sq.cm


UDS SAMPLE AT 33.0 m DEPTH OF BH-20

Ø = 11°

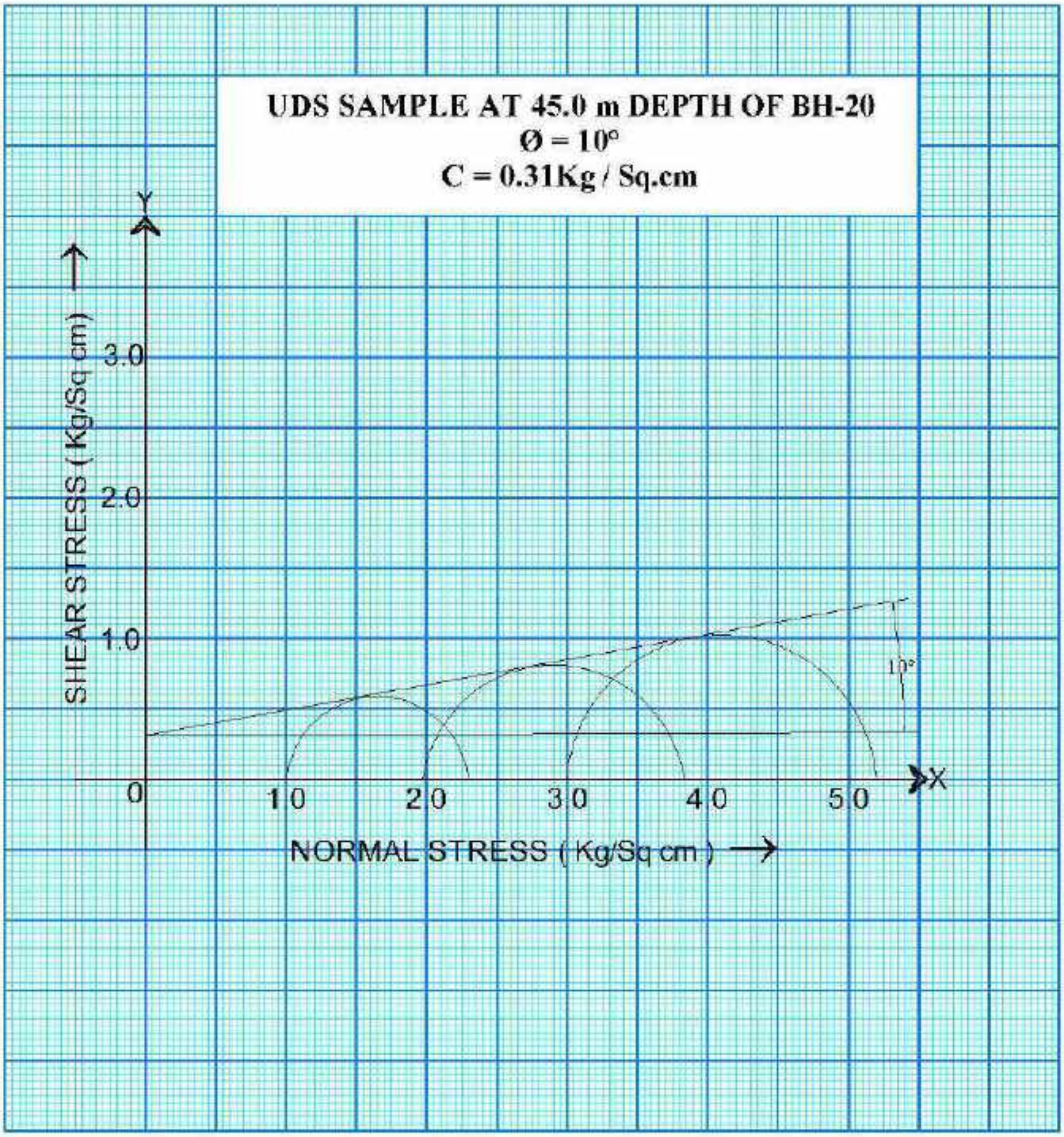
C = 0.30Kg / Sq.cm



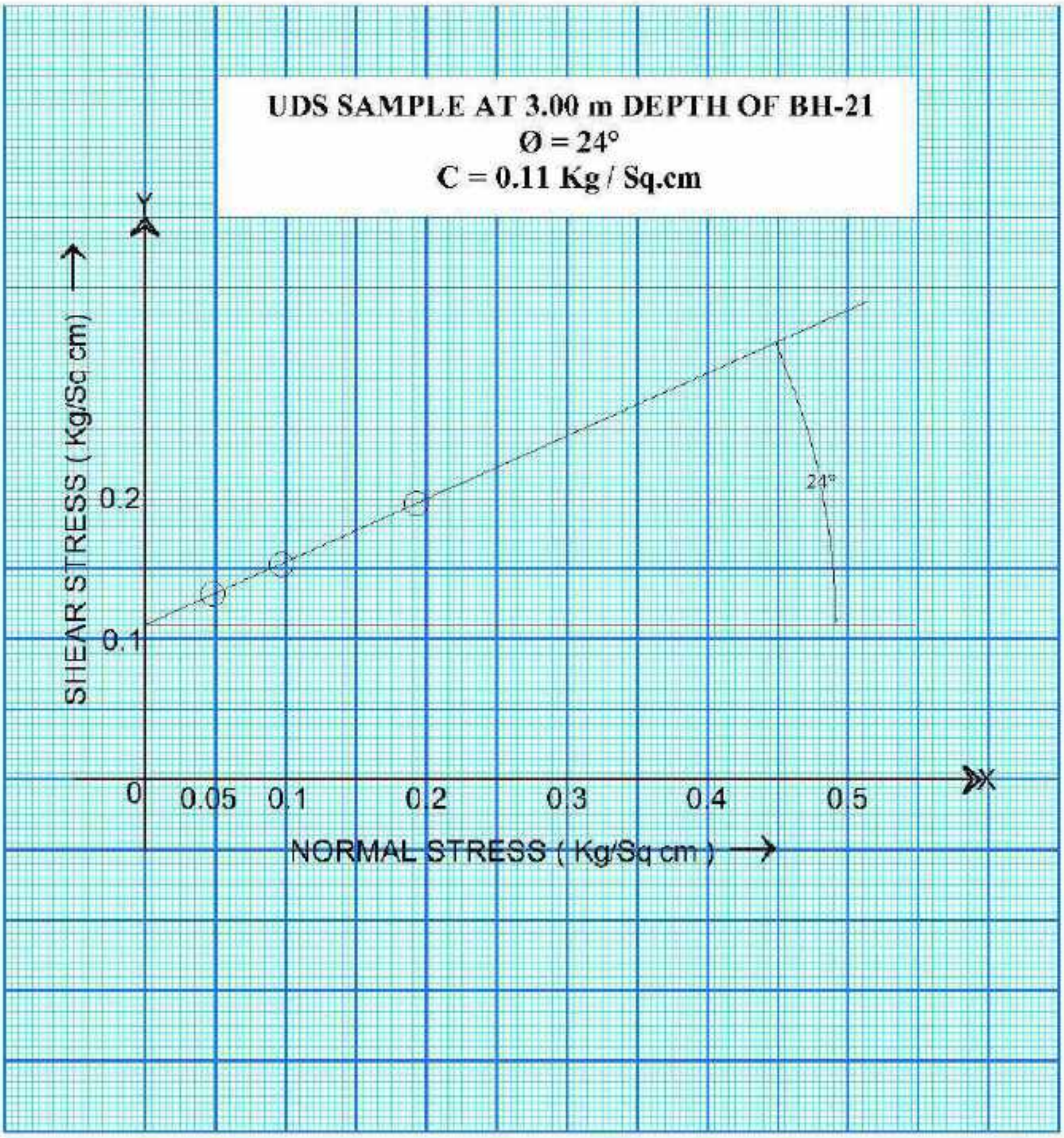
UDS SAMPLE AT 39.0 m DEPTH OF BH-20

Ø = 14°

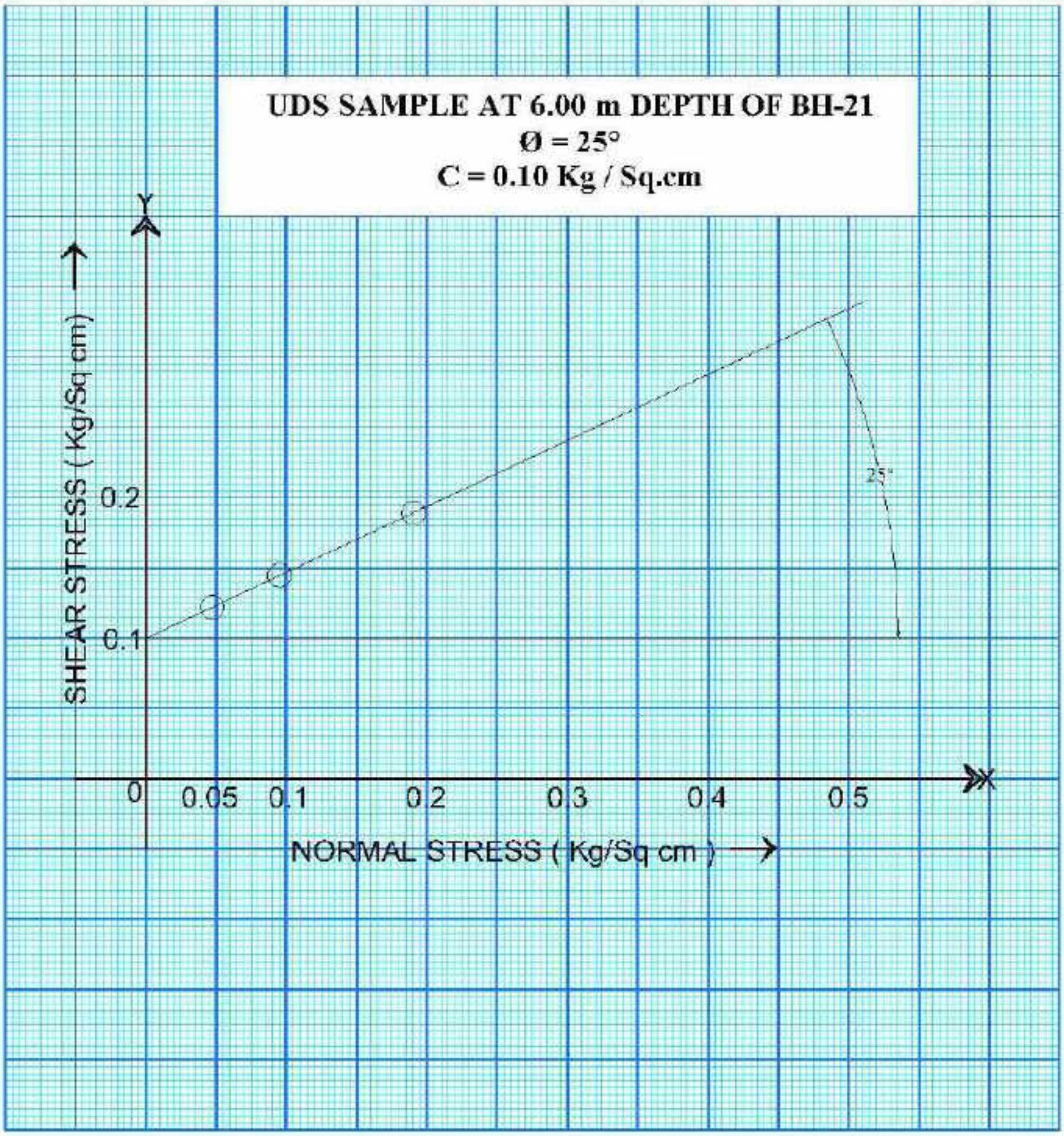
C = 0.36Kg / Sq.cm

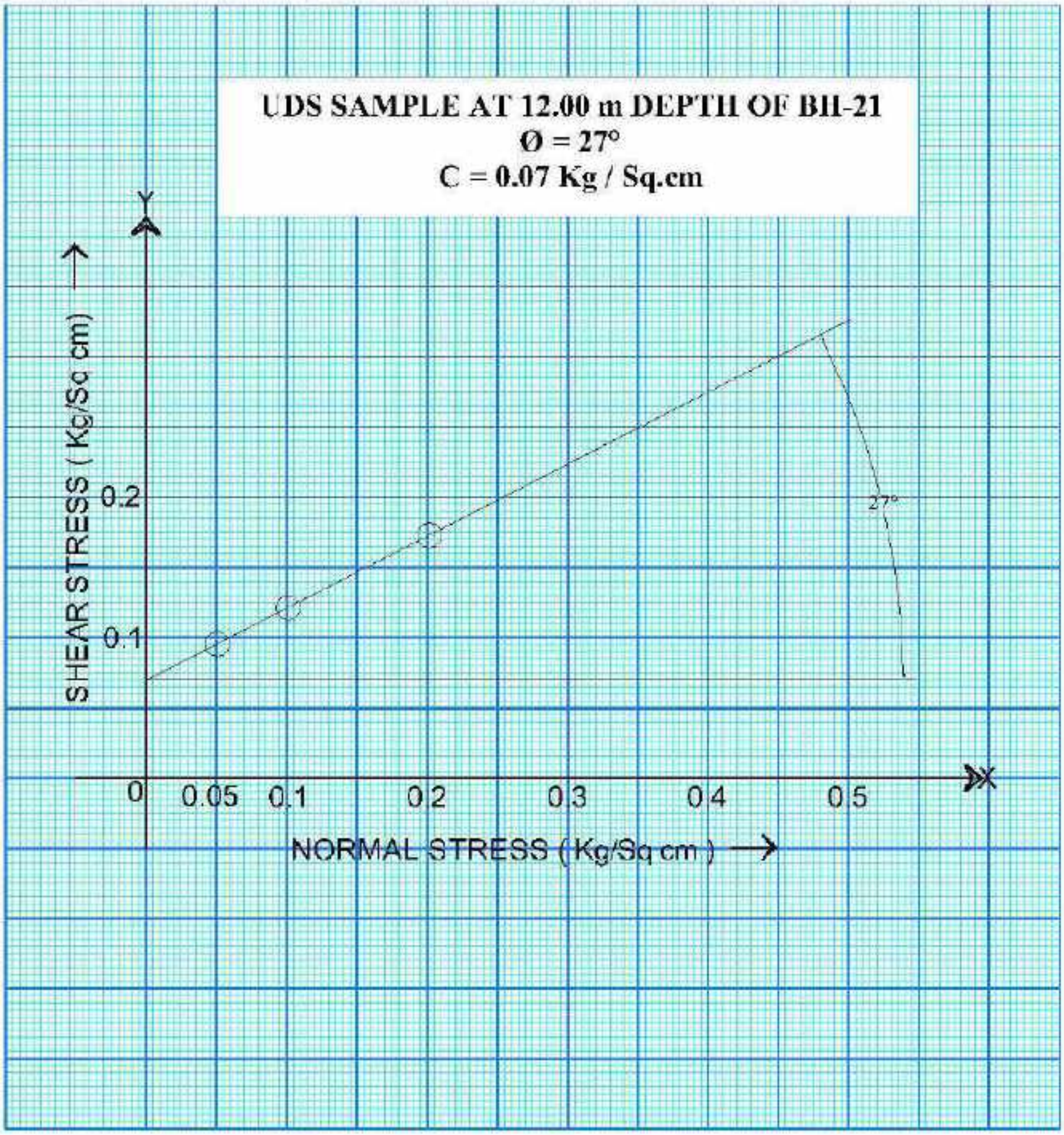


UDS SAMPLE AT 45.0 m DEPTH OF BH-20
Ø = 10°
C = 0.31Kg / Sq.cm

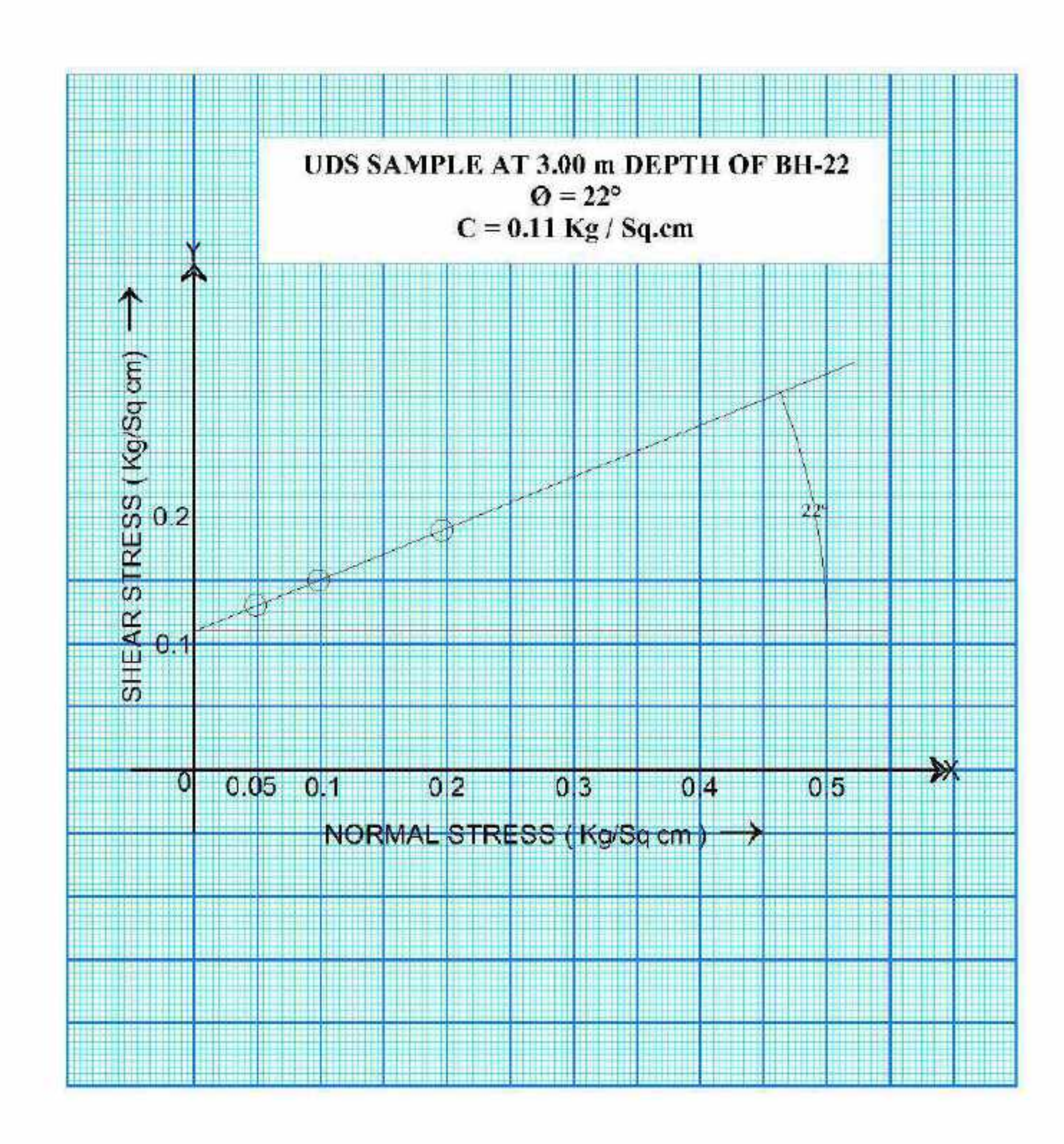


UDS SAMPLE AT 3.00 m DEPTH OF BH-21
Ø = 24°
C = 0.11 Kg / Sq.cm
Y
X
SHEAR STRESS ( Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS ( Kg/Sq cm )
24°

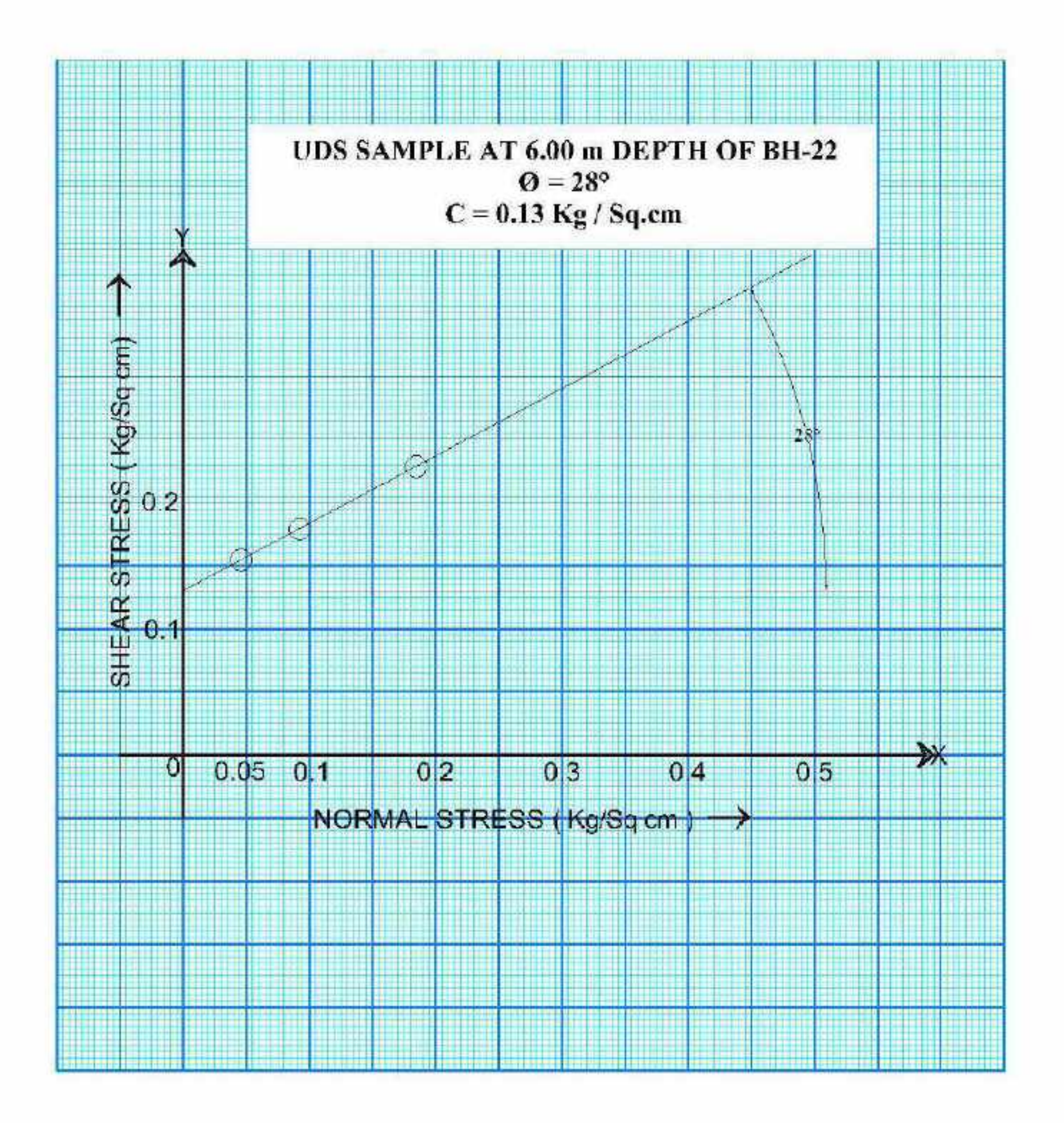

UDS SAMPLE AT 6.00 m DEPTH OF BH-21
Ø = 25°
C = 0.10 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm )
25°



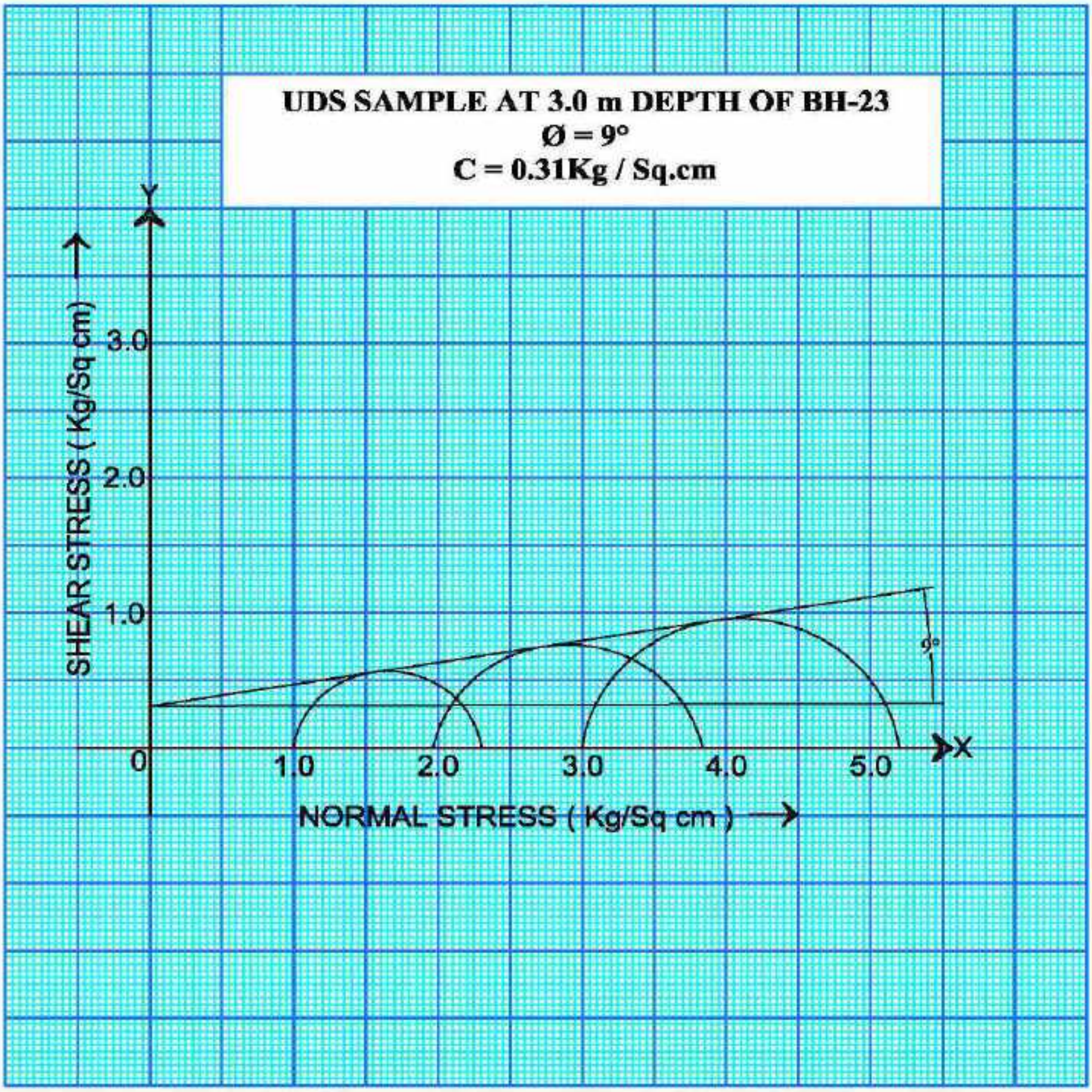
UDS SAMPLE AT 12.00 m DEPTH OF BH-21
Ø = 27°
C = 0.07 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
0.2
0.1
27°
X
0
0.05
0.1
0.2
0.3
0.4
0.5
NORMAL STRESS ( Kg/Sq cm ) →



**UDS SAMPLE AT 3.00 m DEPTH OF BH-22**
**Ø = 22°**
**C = 0.11 Kg / Sq.cm**



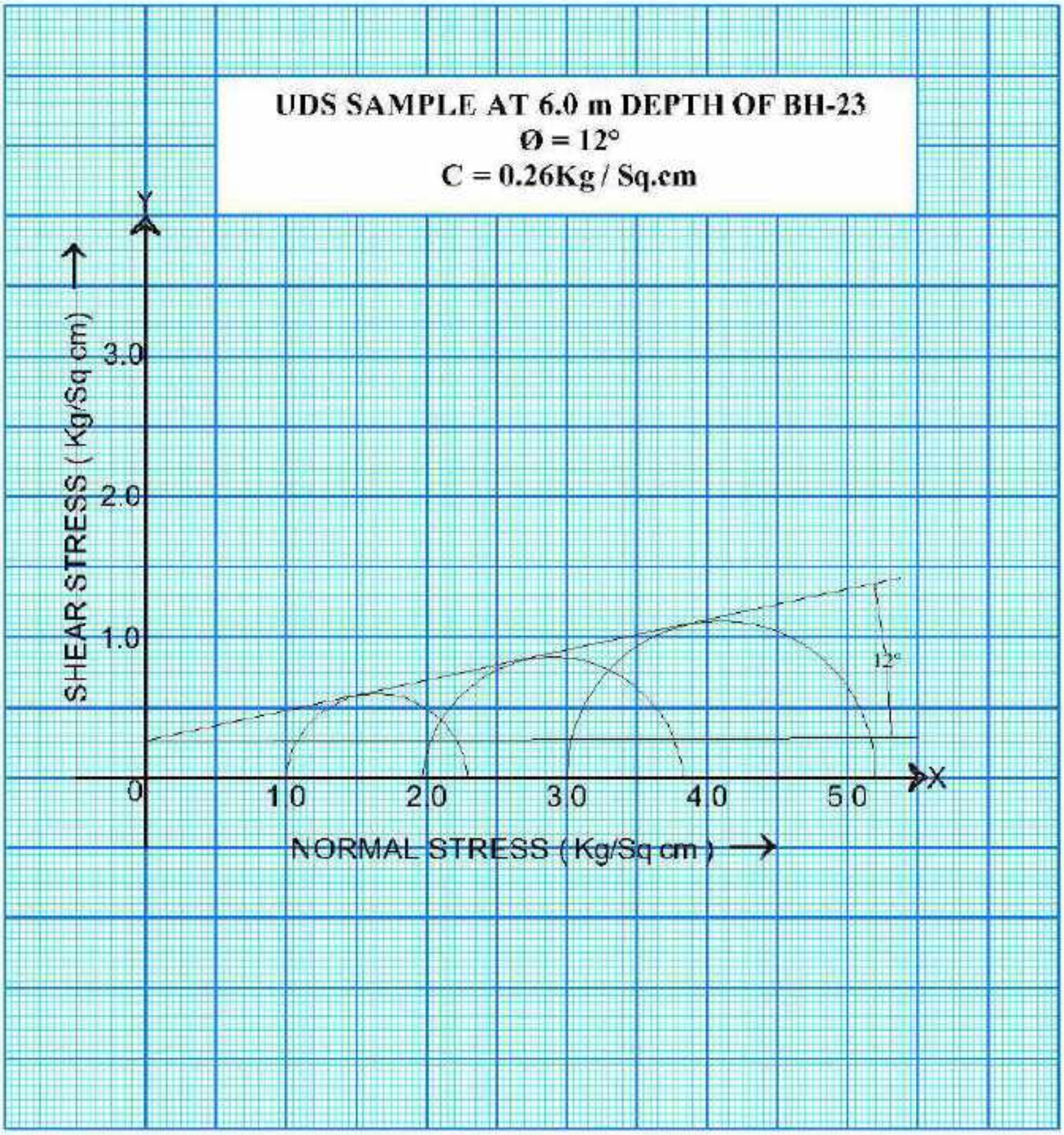
UDS SAMPLE AT 6.00 m DEPTH OF BH-22
Ø = 28°
C = 0.13 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm ) →
28°



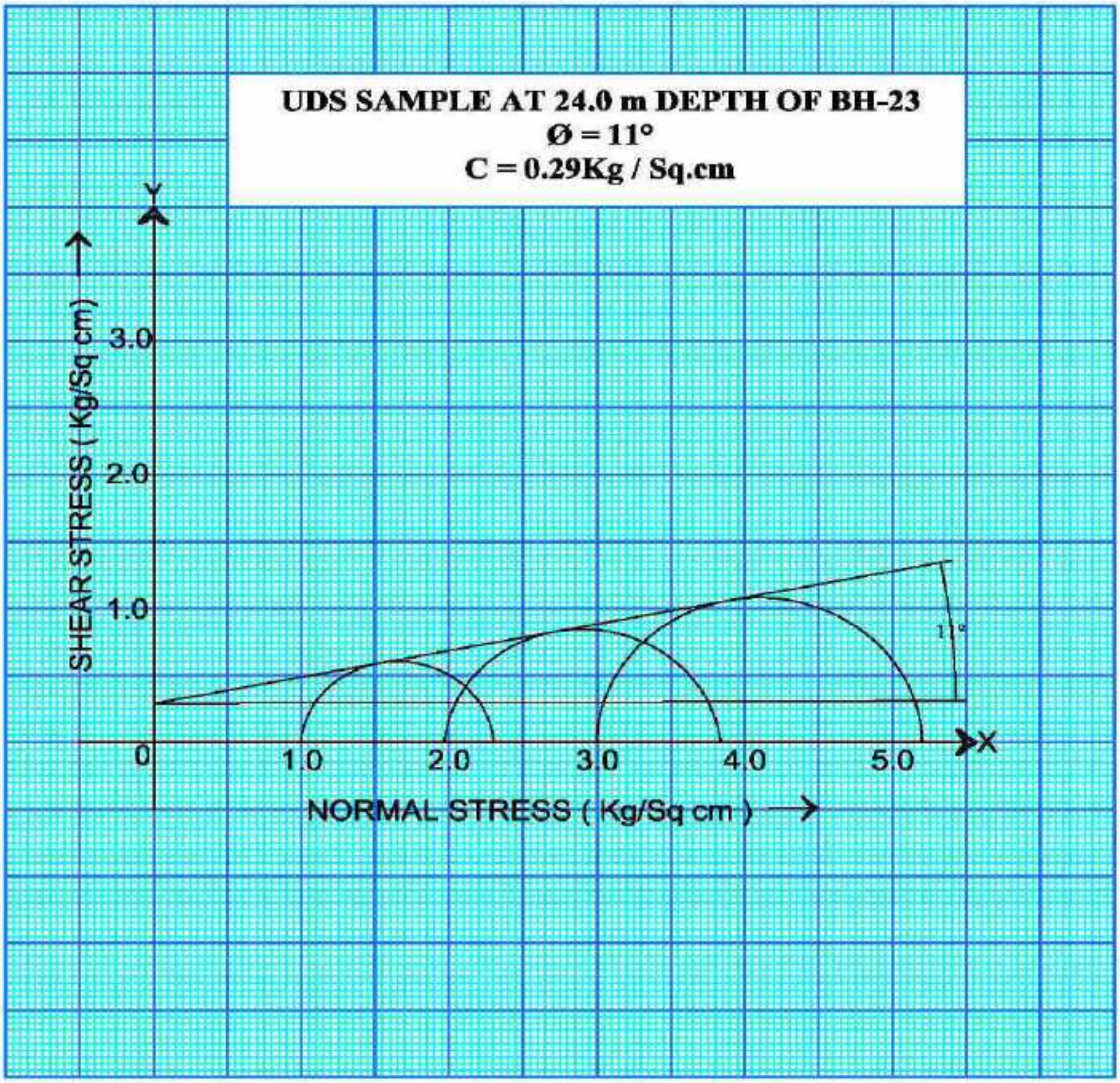
**UDS SAMPLE AT 3.0 m DEPTH OF BH-23**

**Ø = 9°**

**C = 0.31Kg / Sq.cm**



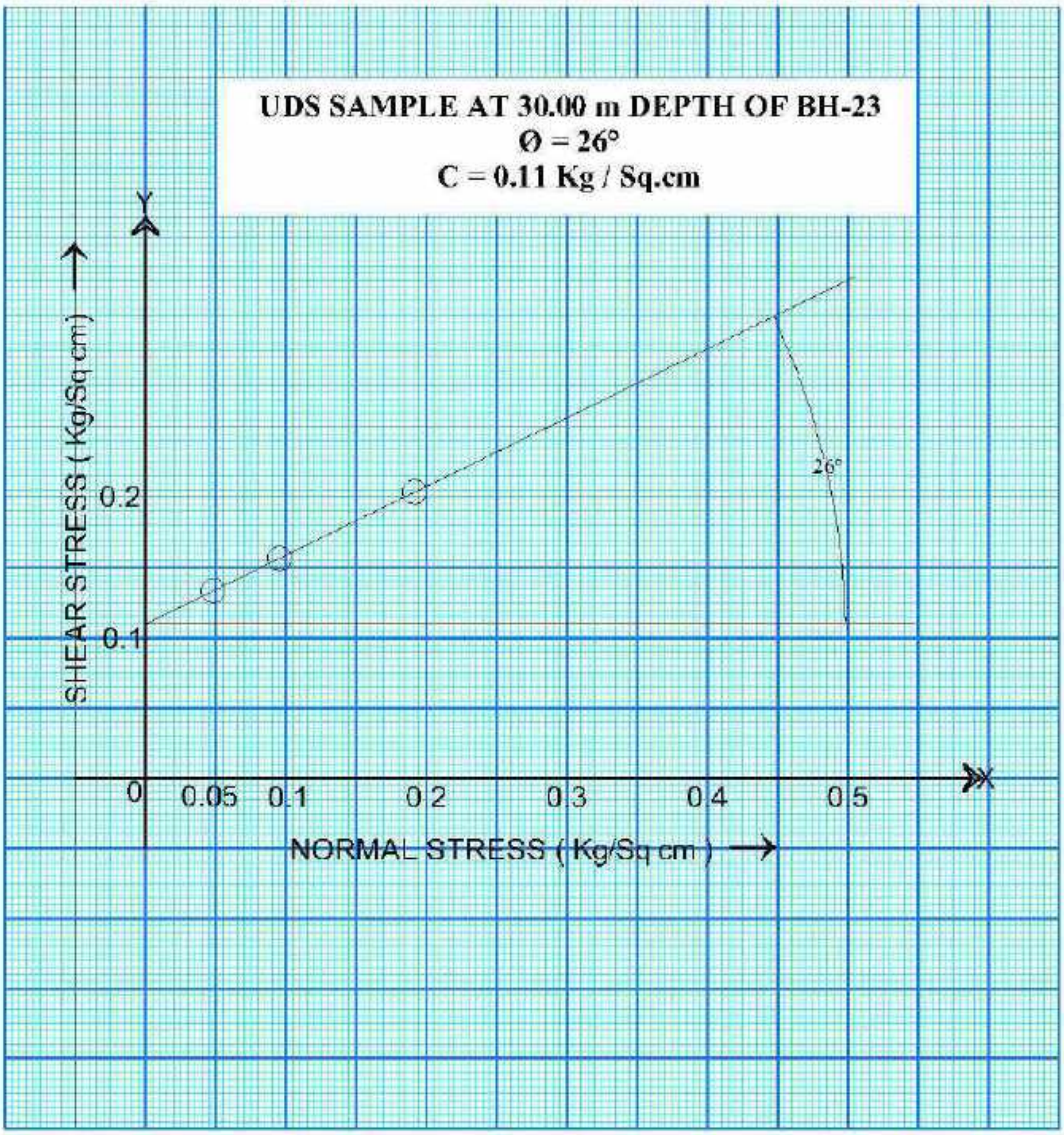
UDS SAMPLE AT 6.0 m DEPTH OF BH-23
Ø = 12°
C = 0.26Kg / Sq.cm

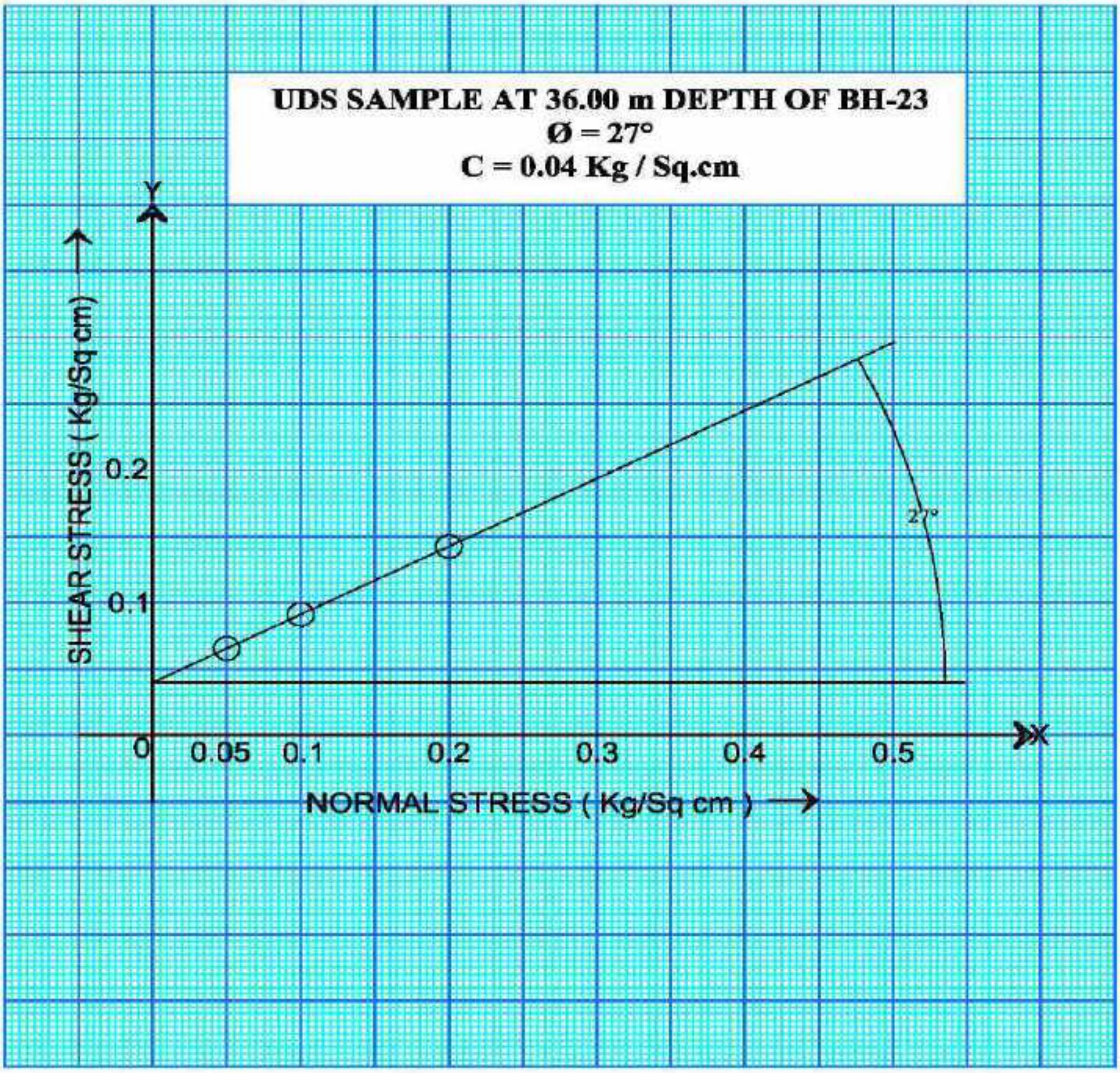


**UDS SAMPLE AT 24.0 m DEPTH OF BH-23**

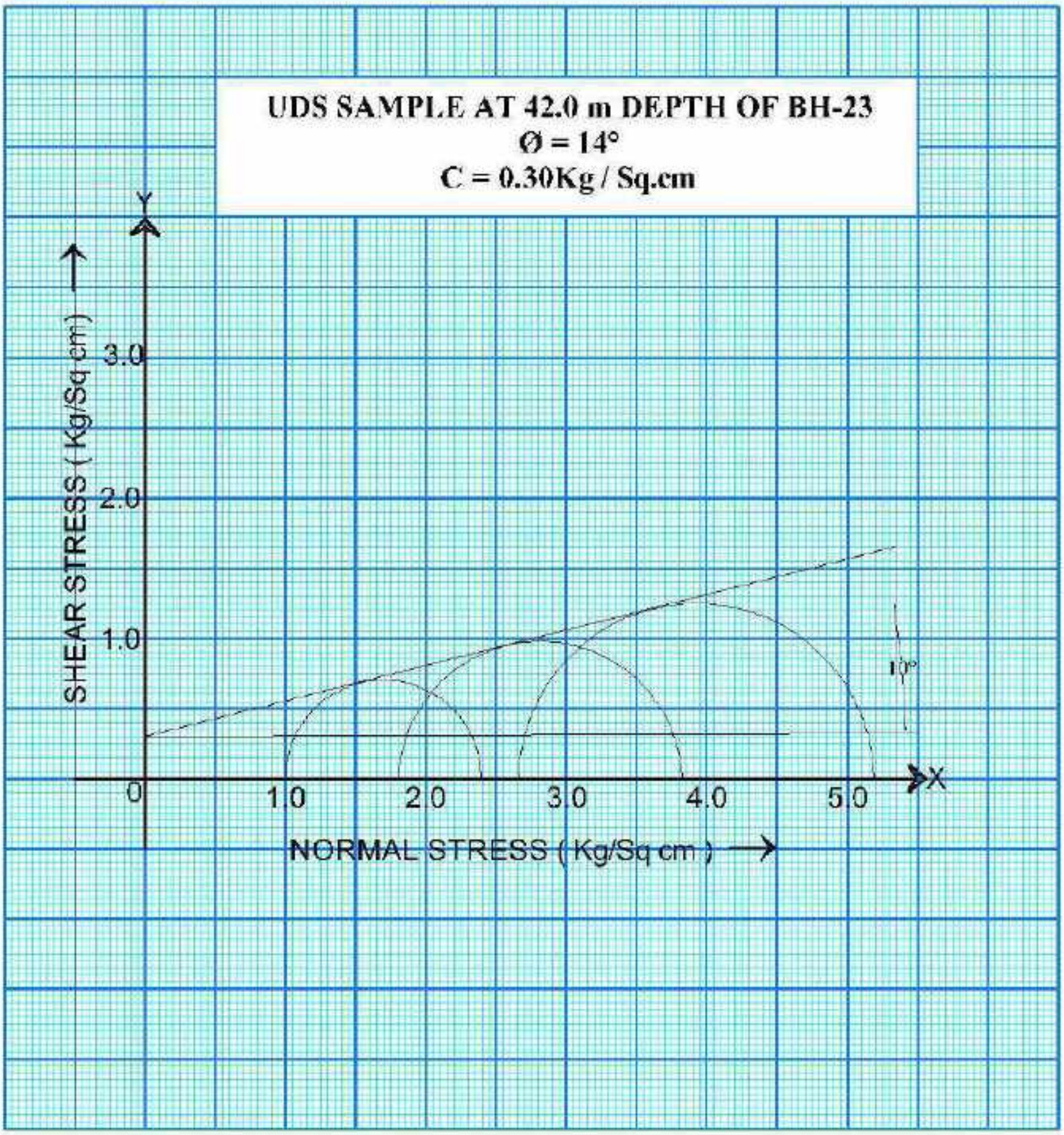
**Ø = 11°**

**C = 0.29Kg / Sq.cm**

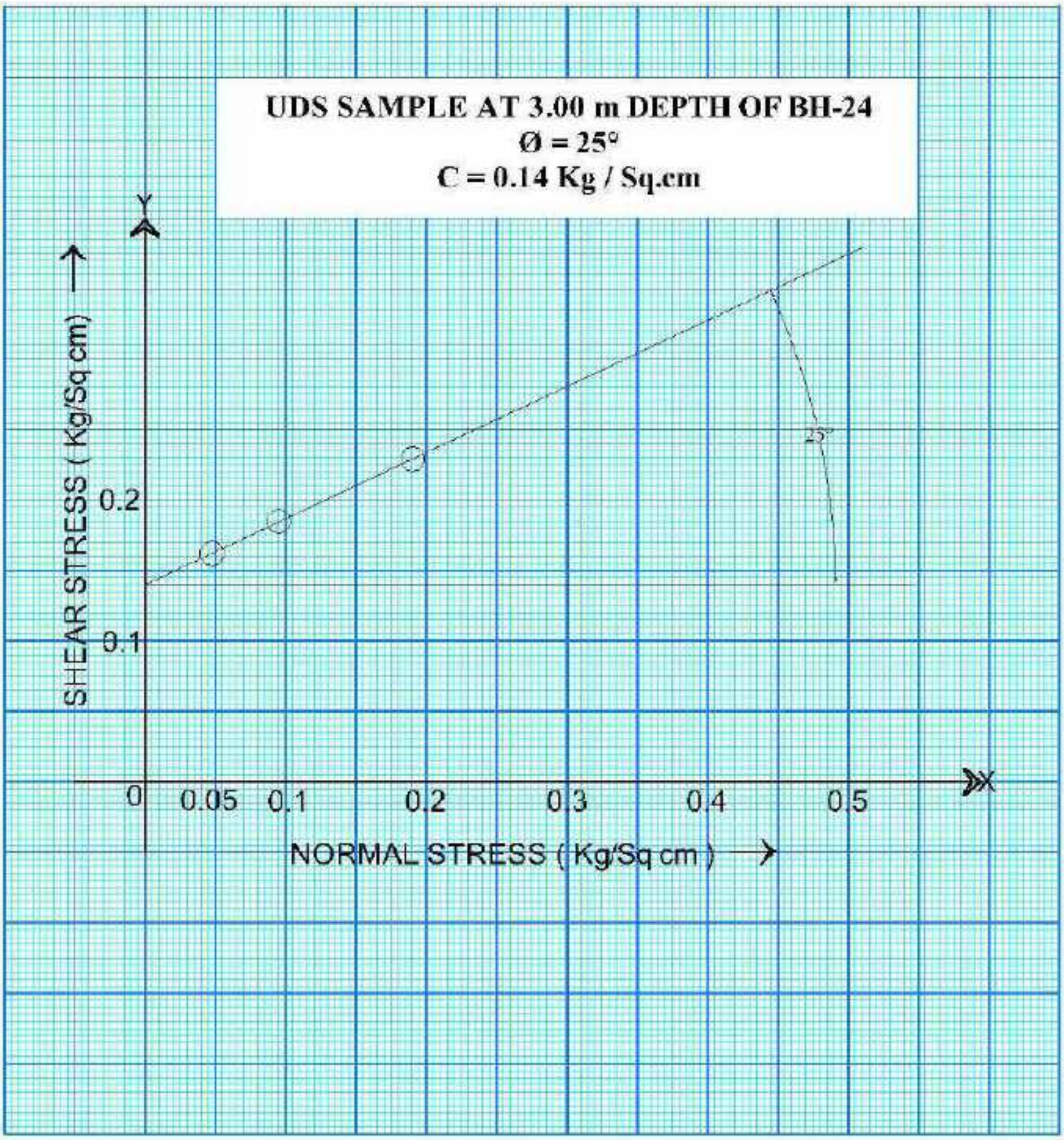

UDS SAMPLE AT 30.00 m DEPTH OF BH-23
Ø = 26°
C = 0.11 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
0.2
0.1
26°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm ) →



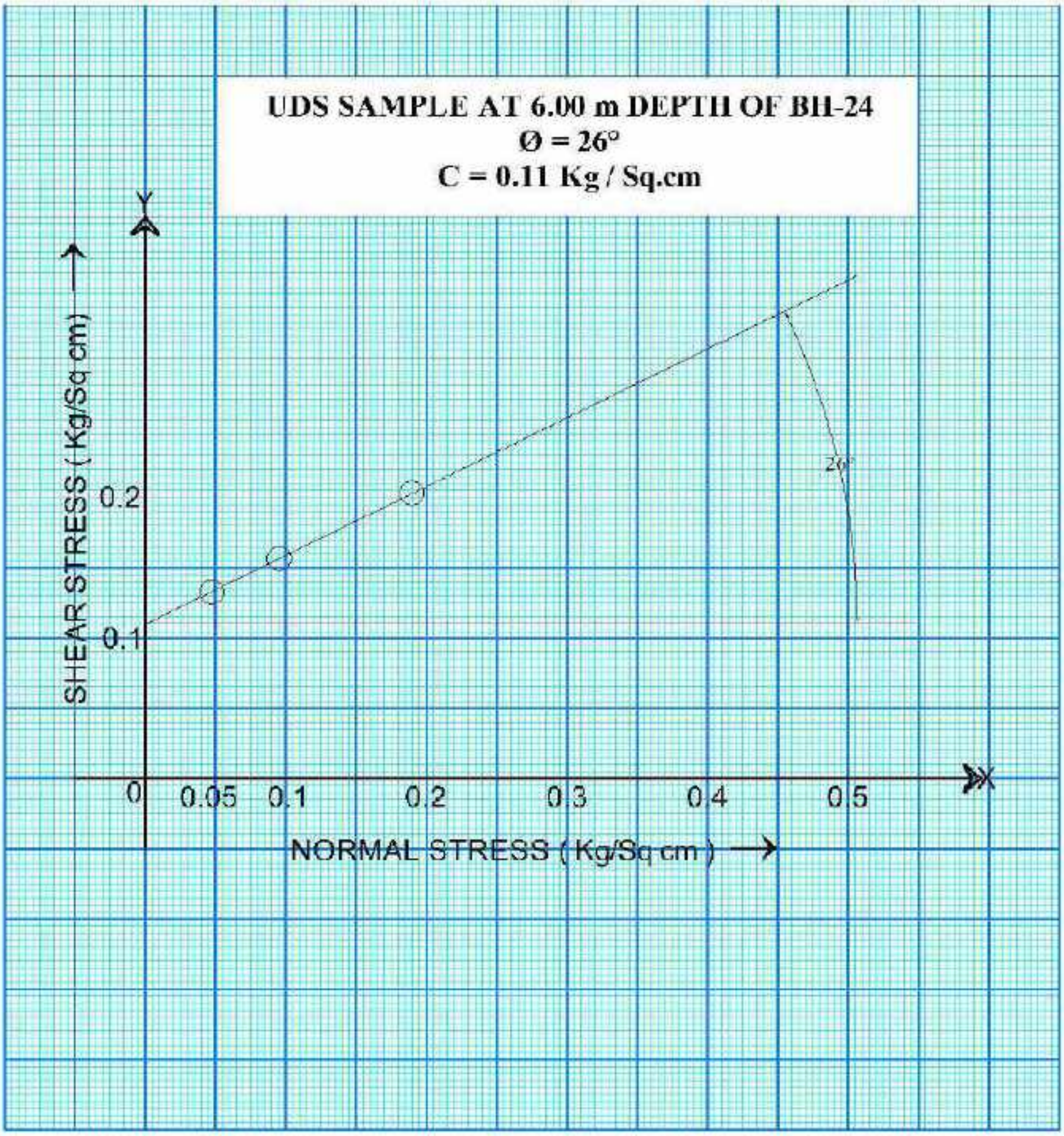
UDS SAMPLE AT 36.00 m DEPTH OF BH-23
Ø = 27°
C = 0.04 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
0.2
0.1
27°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm )



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 )
10°



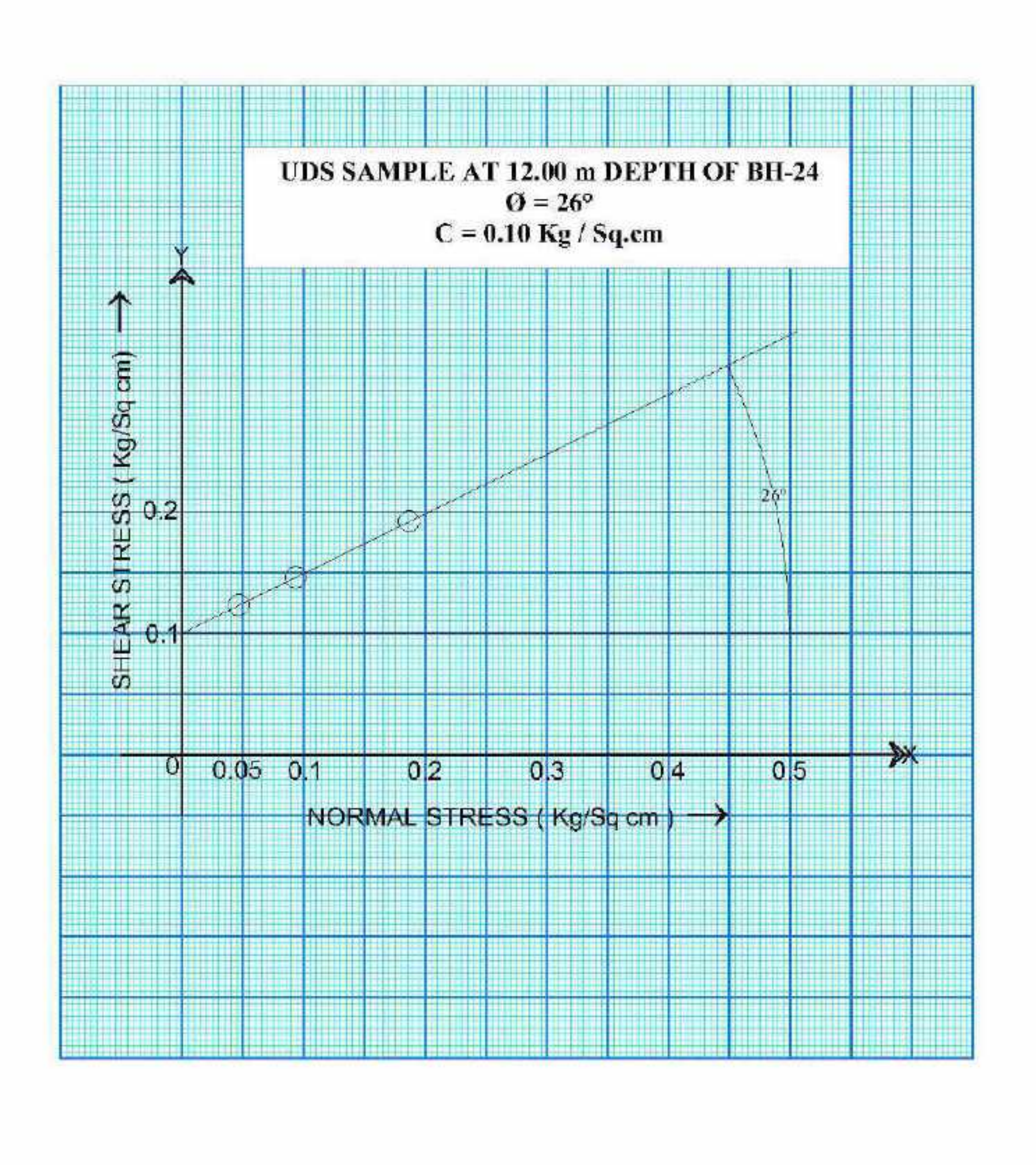
UDS SAMPLE AT 3.00 m DEPTH OF BH-24
Ø = 25°
C = 0.14 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm ) →
25°



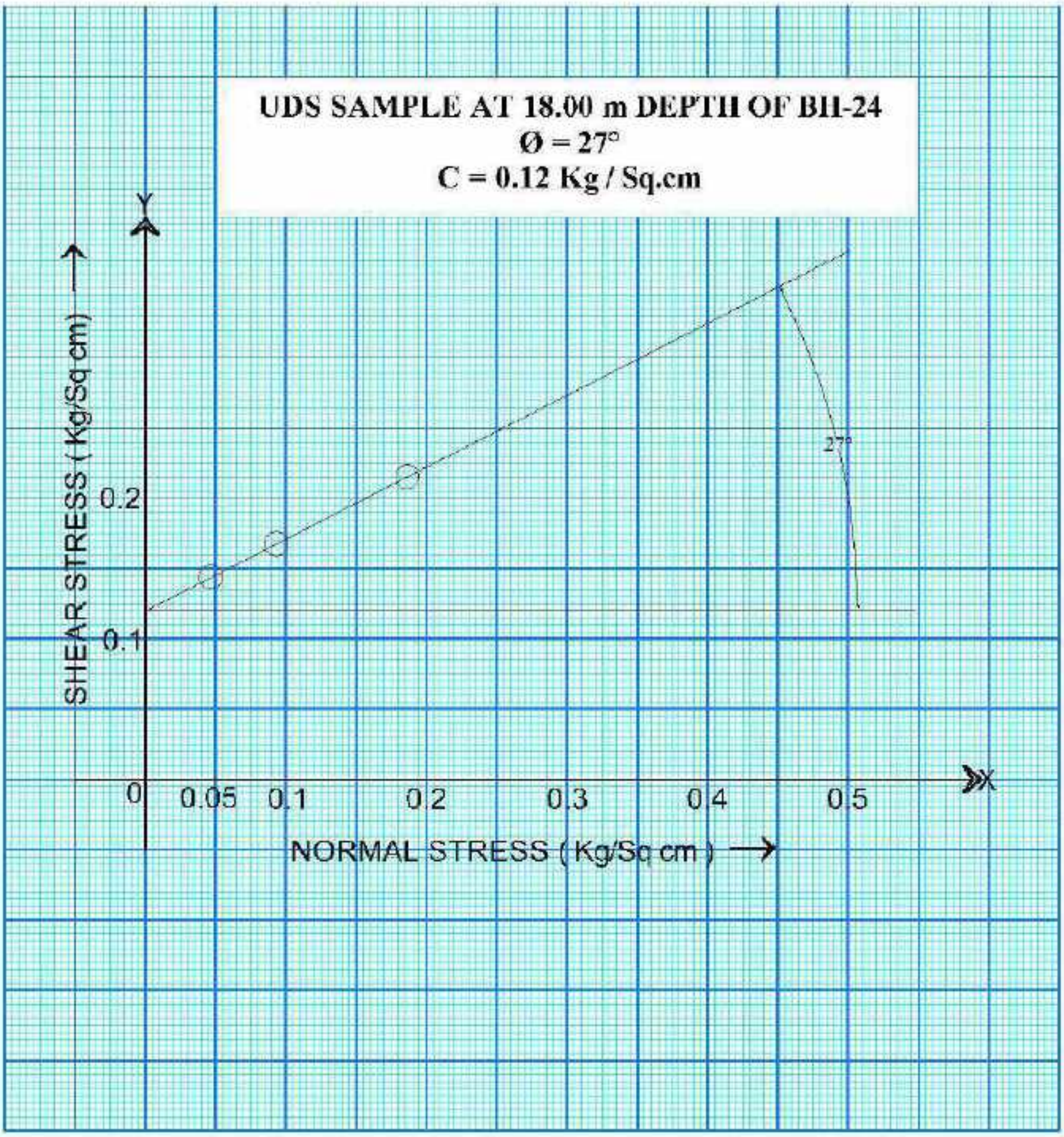
**UDS SAMPLE AT 6.00 m DEPTH OF BH-24**

**Ø = 26°**

**C = 0.11 Kg / Sq.cm**

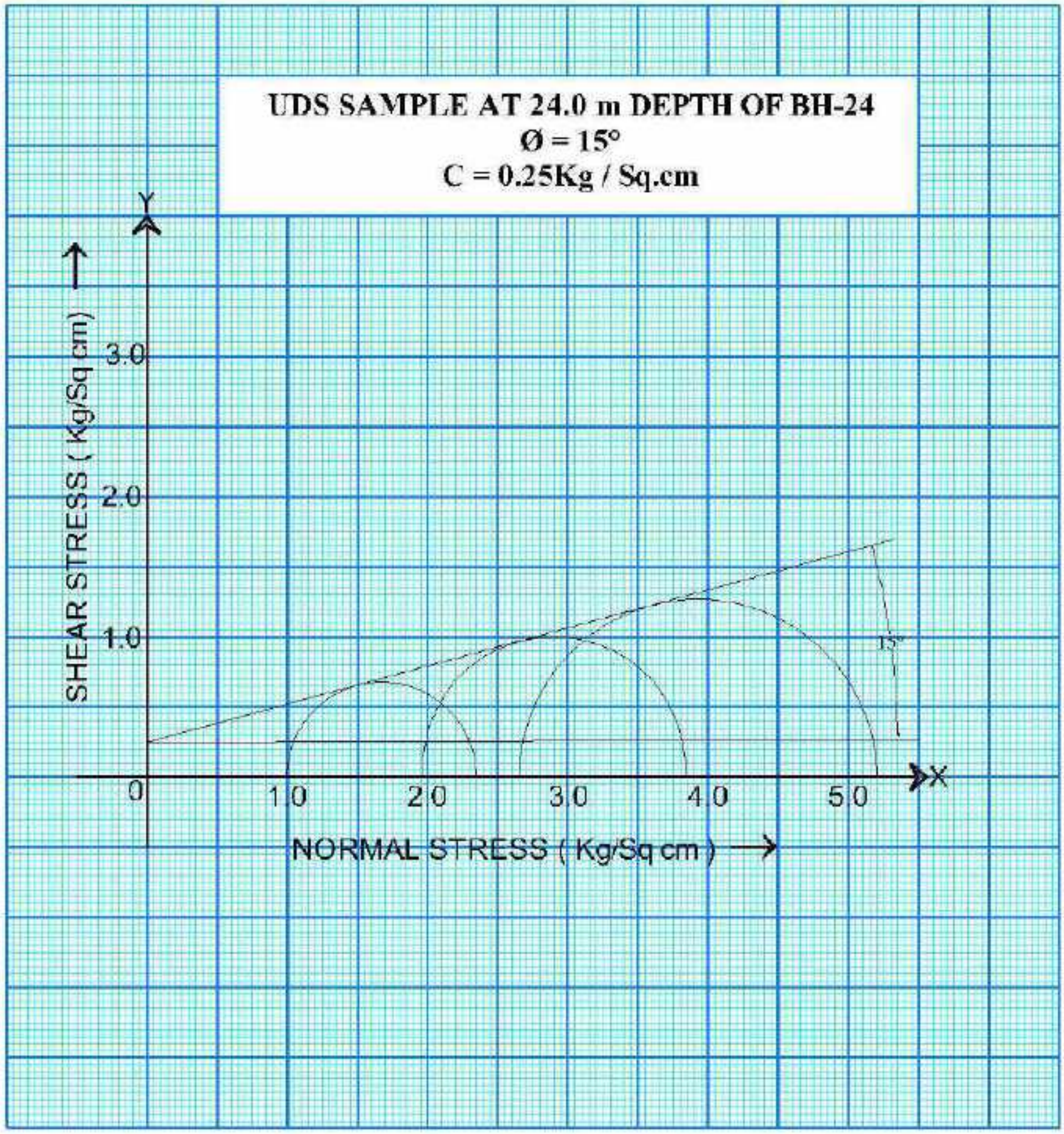


UDS SAMPLE AT 12.00 m DEPTH OF BH-24
Ø = 26°
C = 0.10 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm ) →
26°

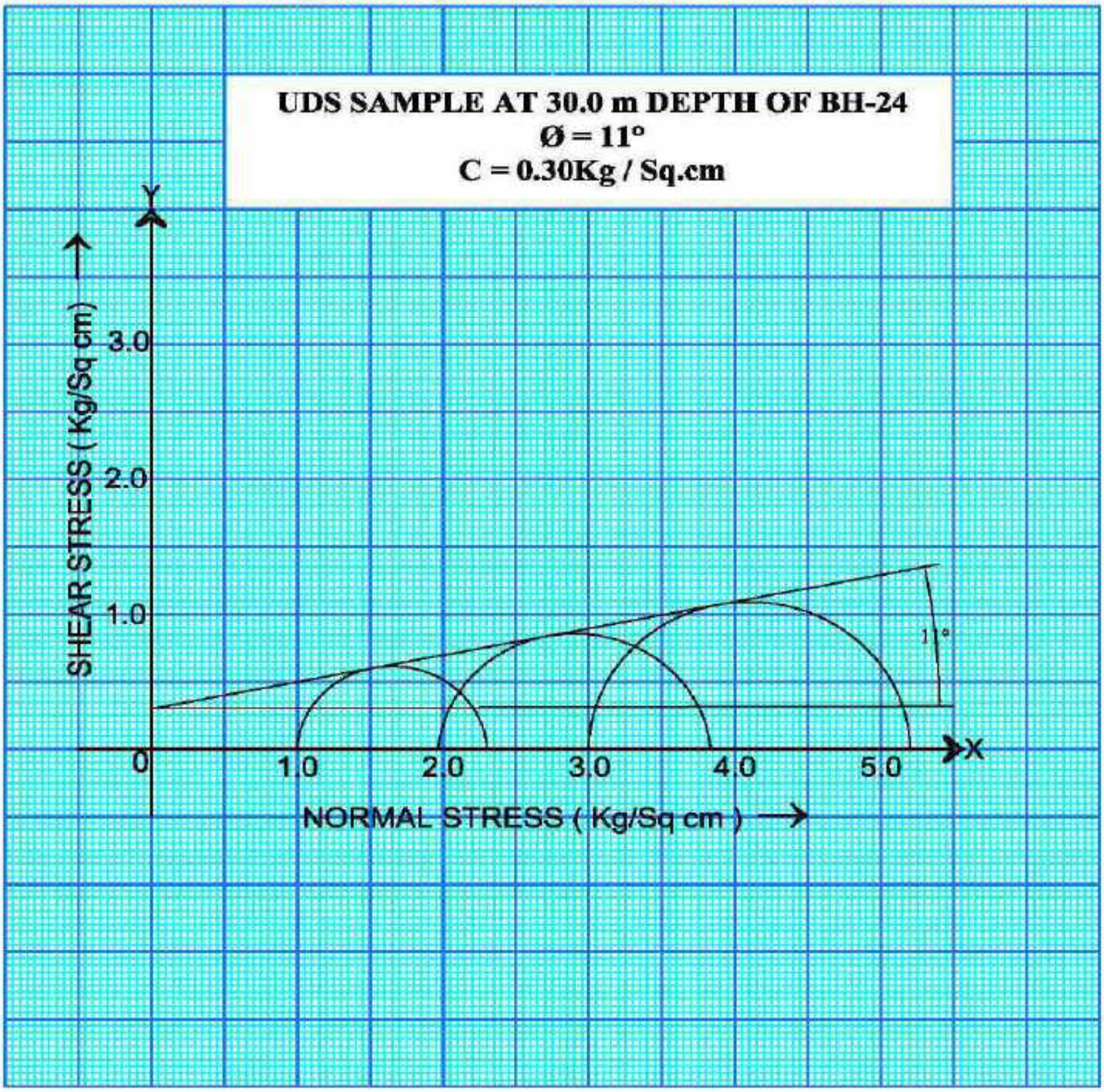

UDS SAMPLE AT 18.00 m DEPTH OF BH-24

Ø = 27°

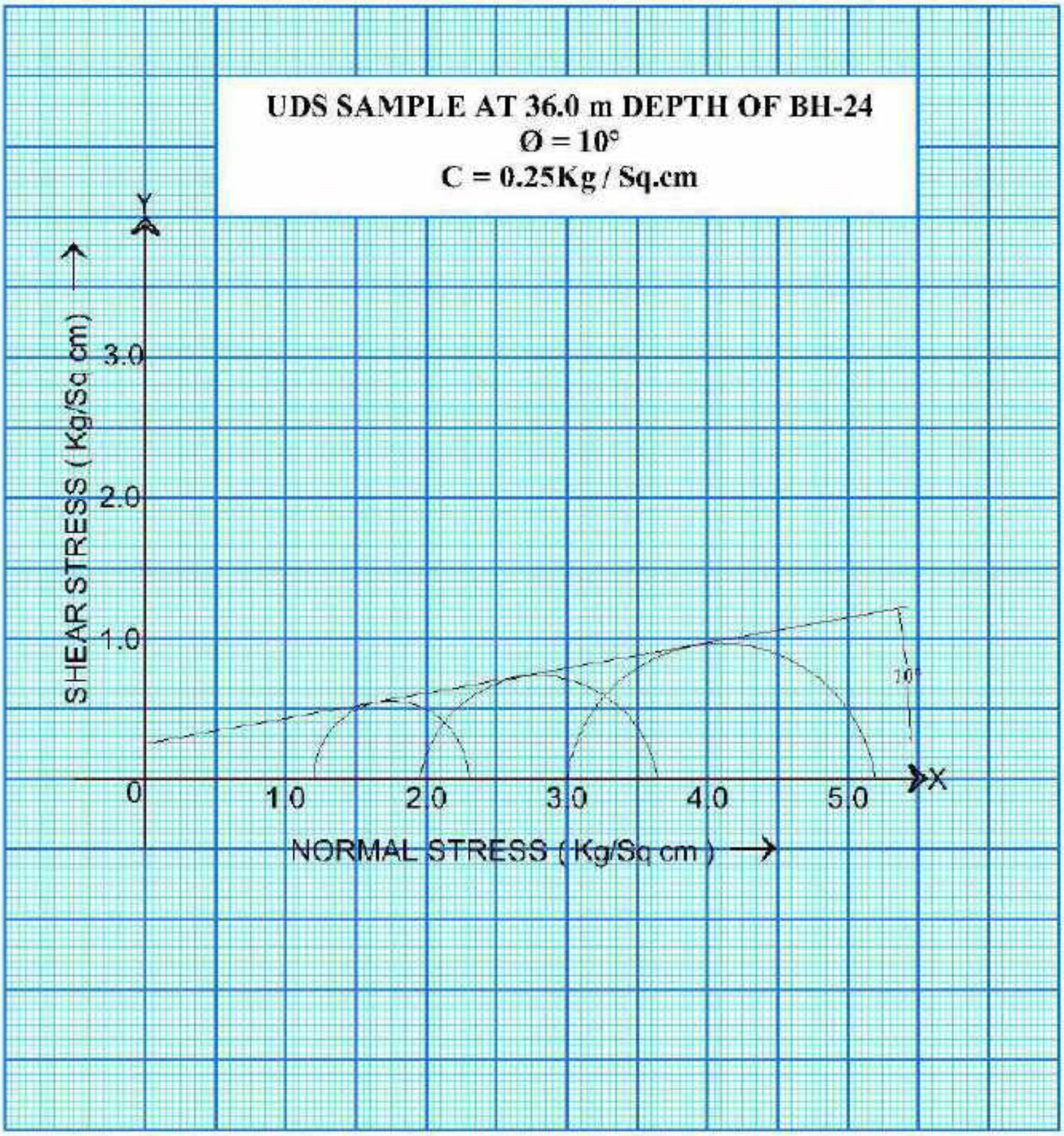
C = 0.12 Kg / Sq.cm



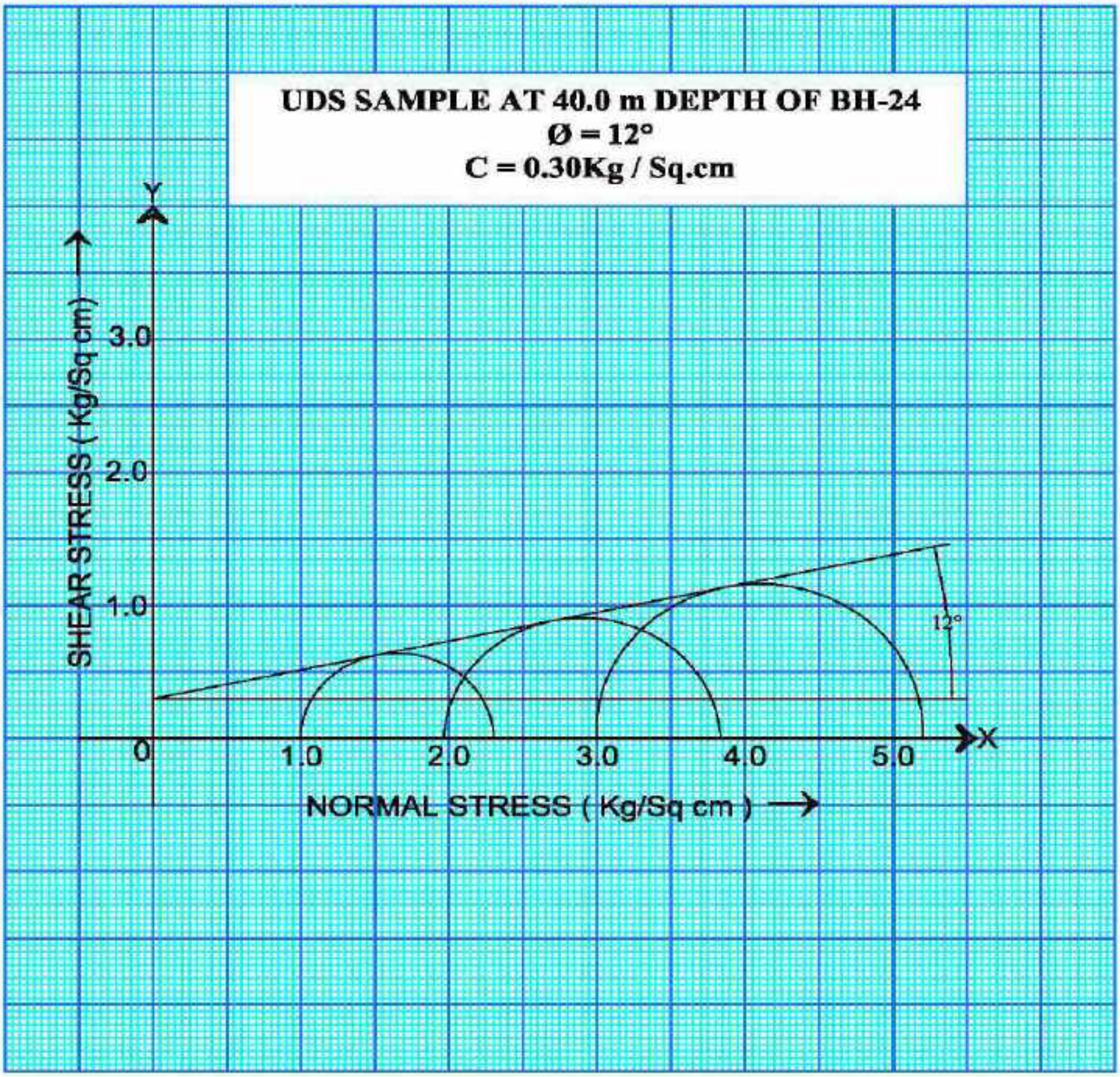
UDS SAMPLE AT 24.0 m DEPTH OF BH-24
Ø = 15°
C = 0.25Kg / Sq.cm

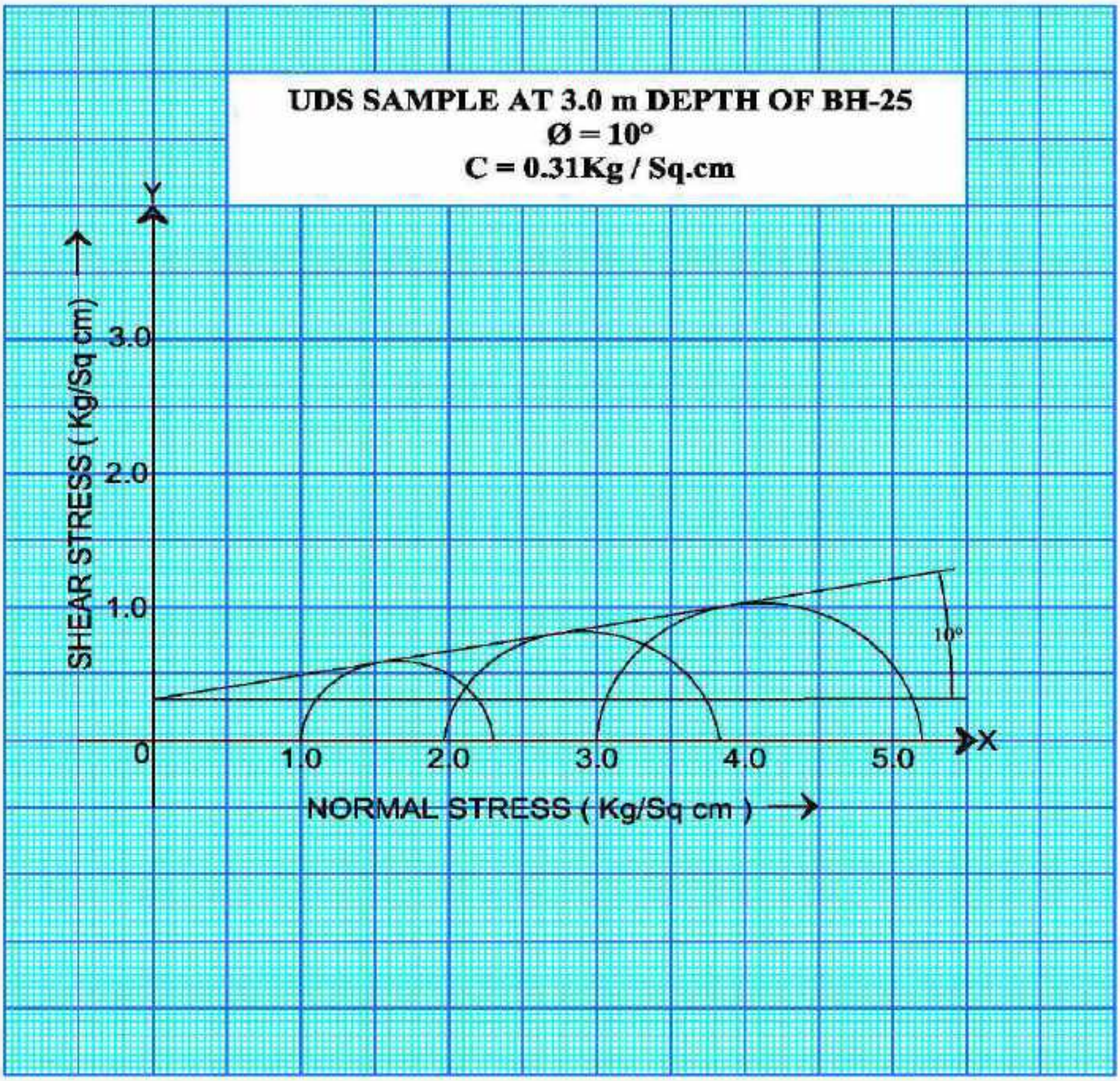


UDS SAMPLE AT 30.0 m DEPTH OF BH-24
Ø = 11°
C = 0.30Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
11°
NORMAL STRESS ( Kg/Sq cm ) →

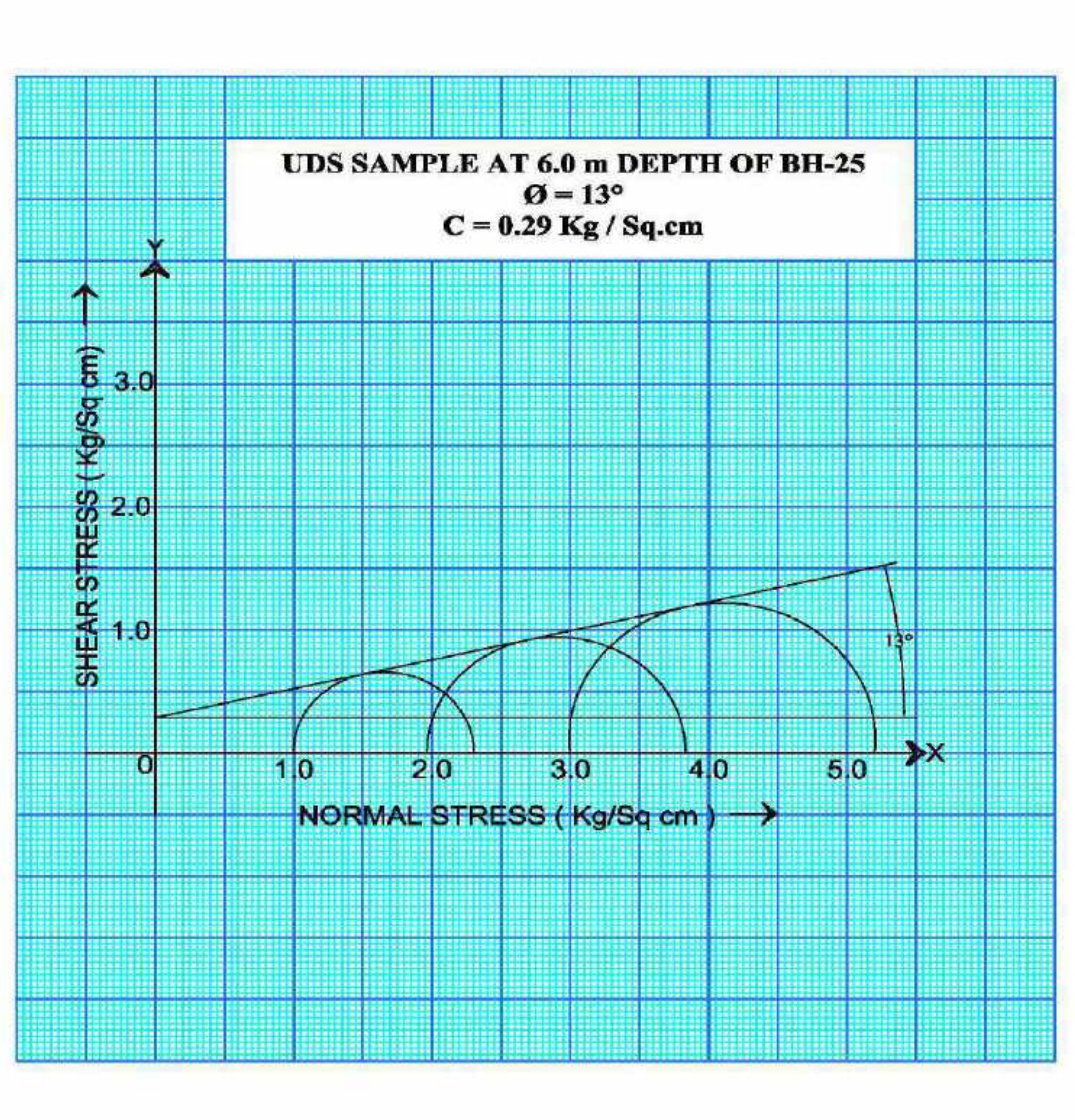


UDS SAMPLE AT 36.0 m DEPTH OF BH-24
Ø = 10°
C = 0.25Kg / Sq.cm

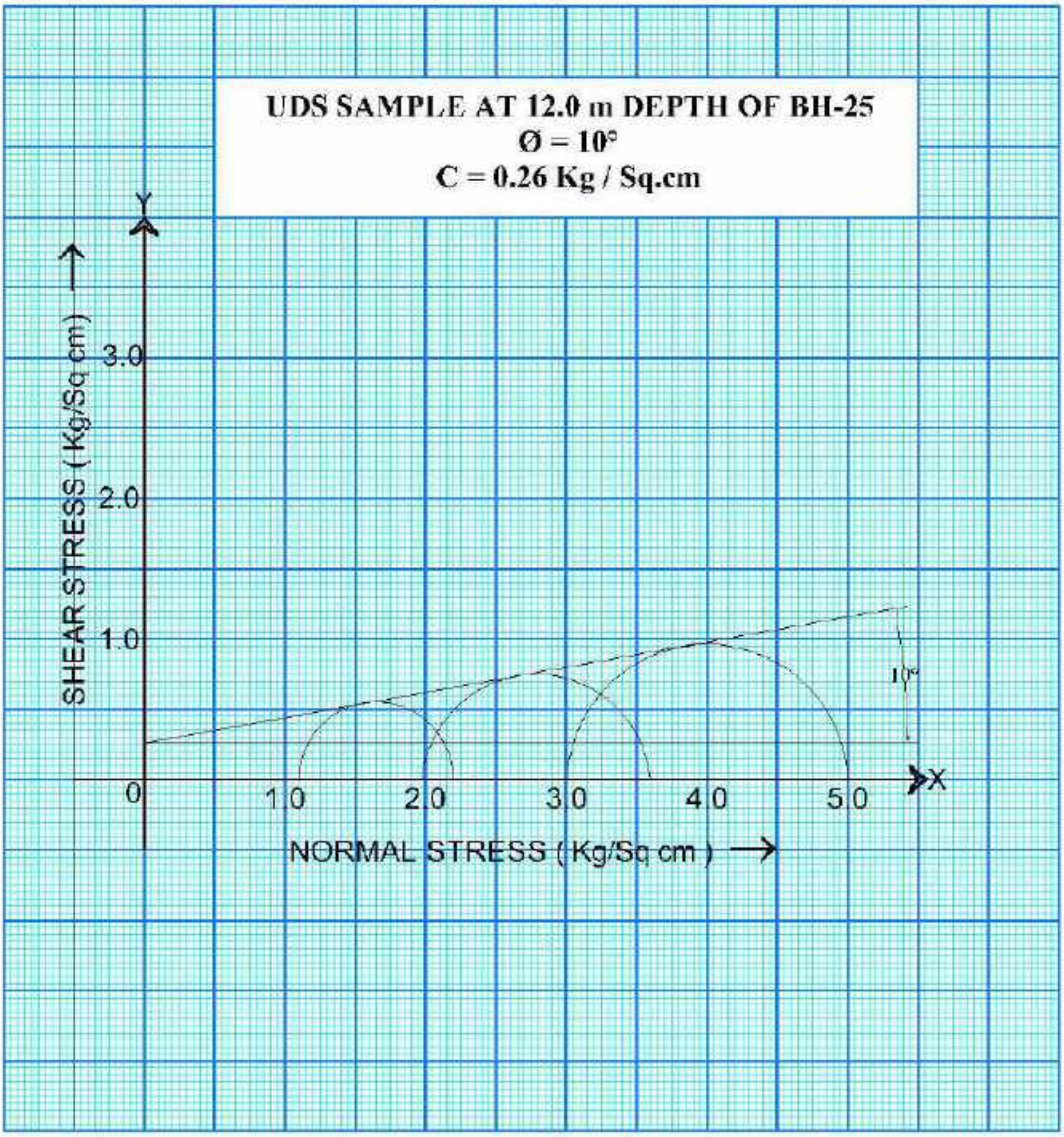

UDS SAMPLE AT 40.0 m DEPTH OF BH-24
Ø = 12°
C = 0.30Kg / Sq.cm

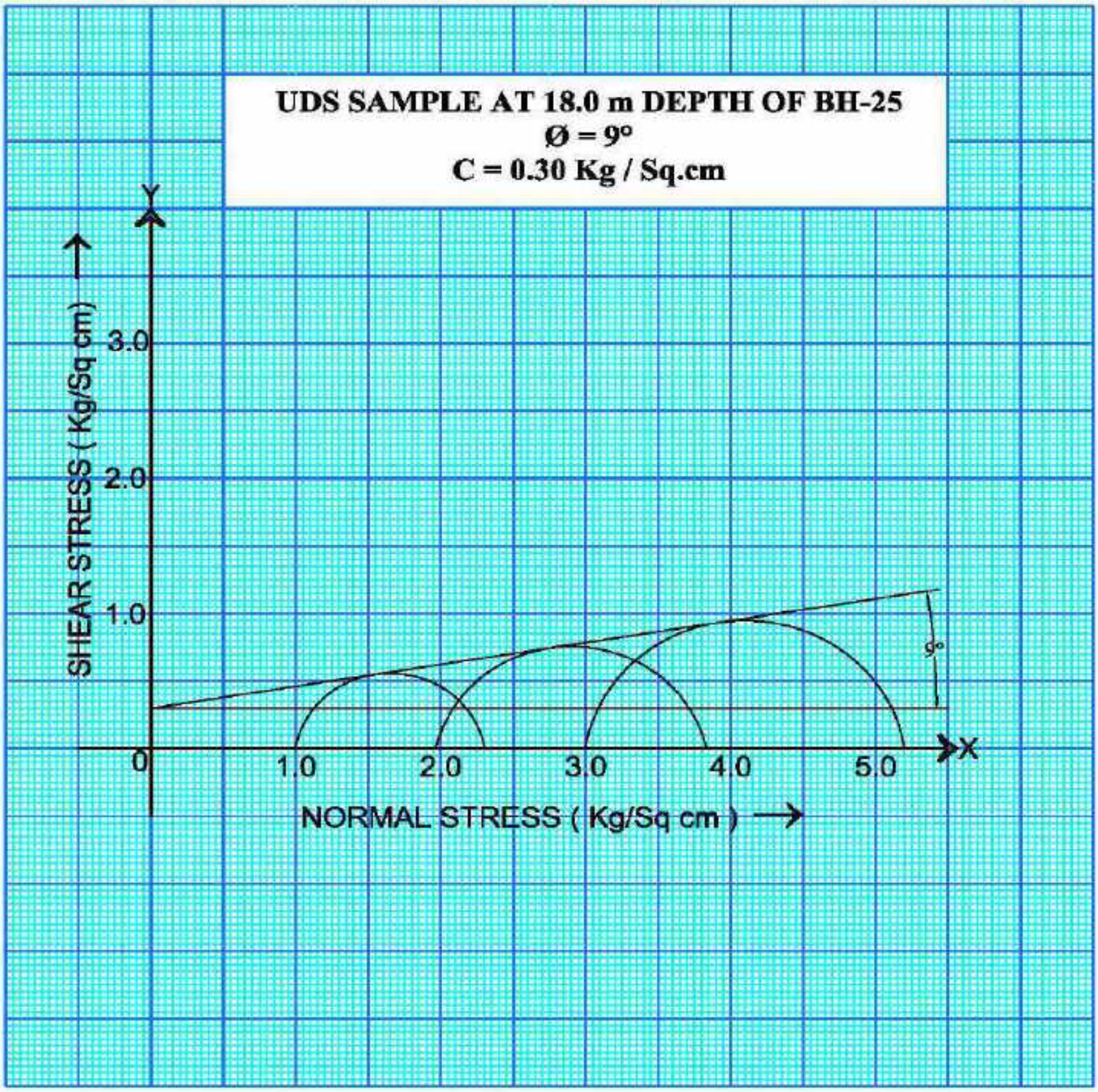


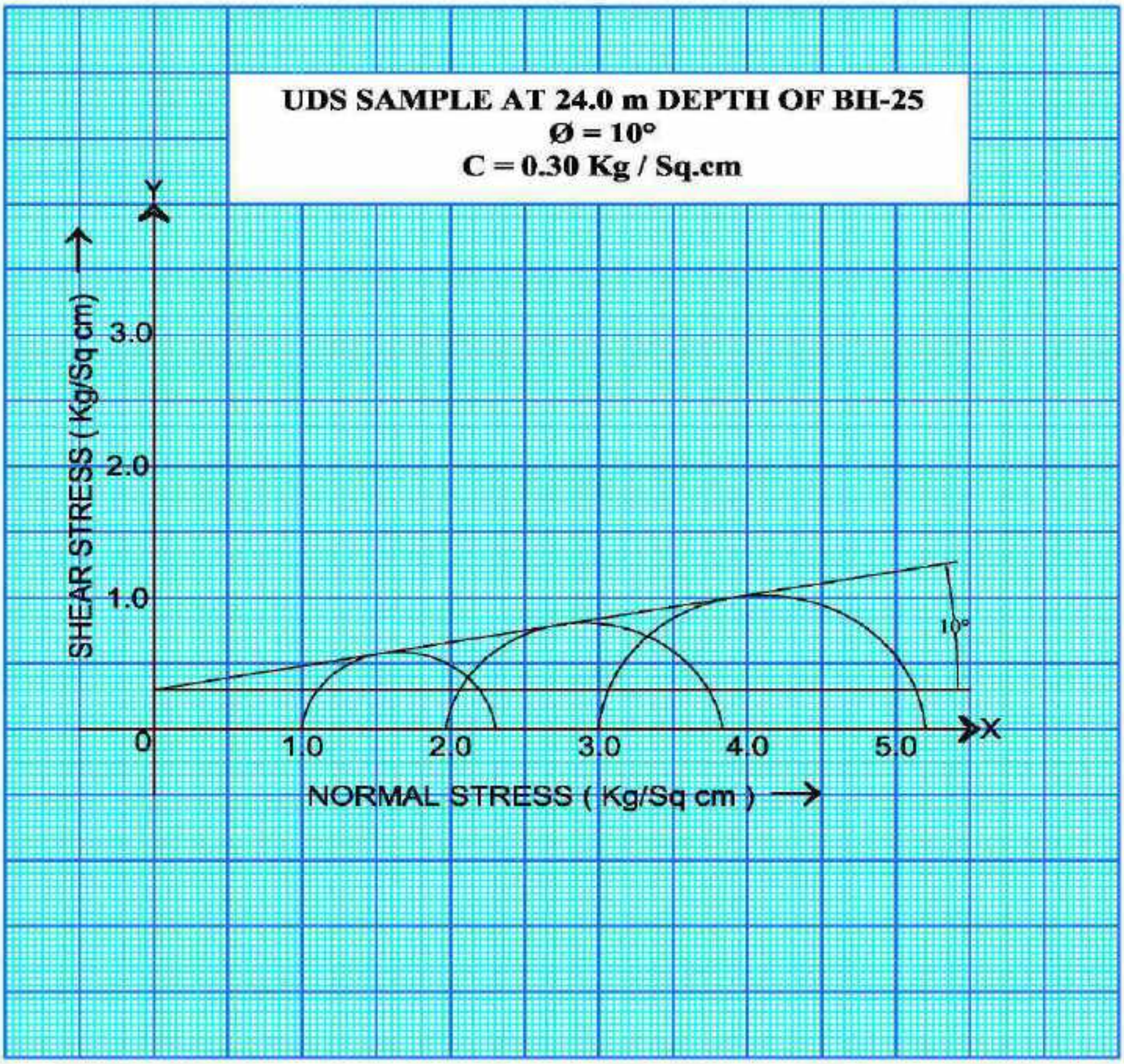
UDS SAMPLE AT 3.0 m DEPTH OF BH-25
Ø = 10°
C = 0.31Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
10°
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS ( Kg/Sq cm )



**UDS SAMPLE AT 6.0 m DEPTH OF BH-25**
**Ø = 13°**
**C = 0.29 Kg / Sq.cm**

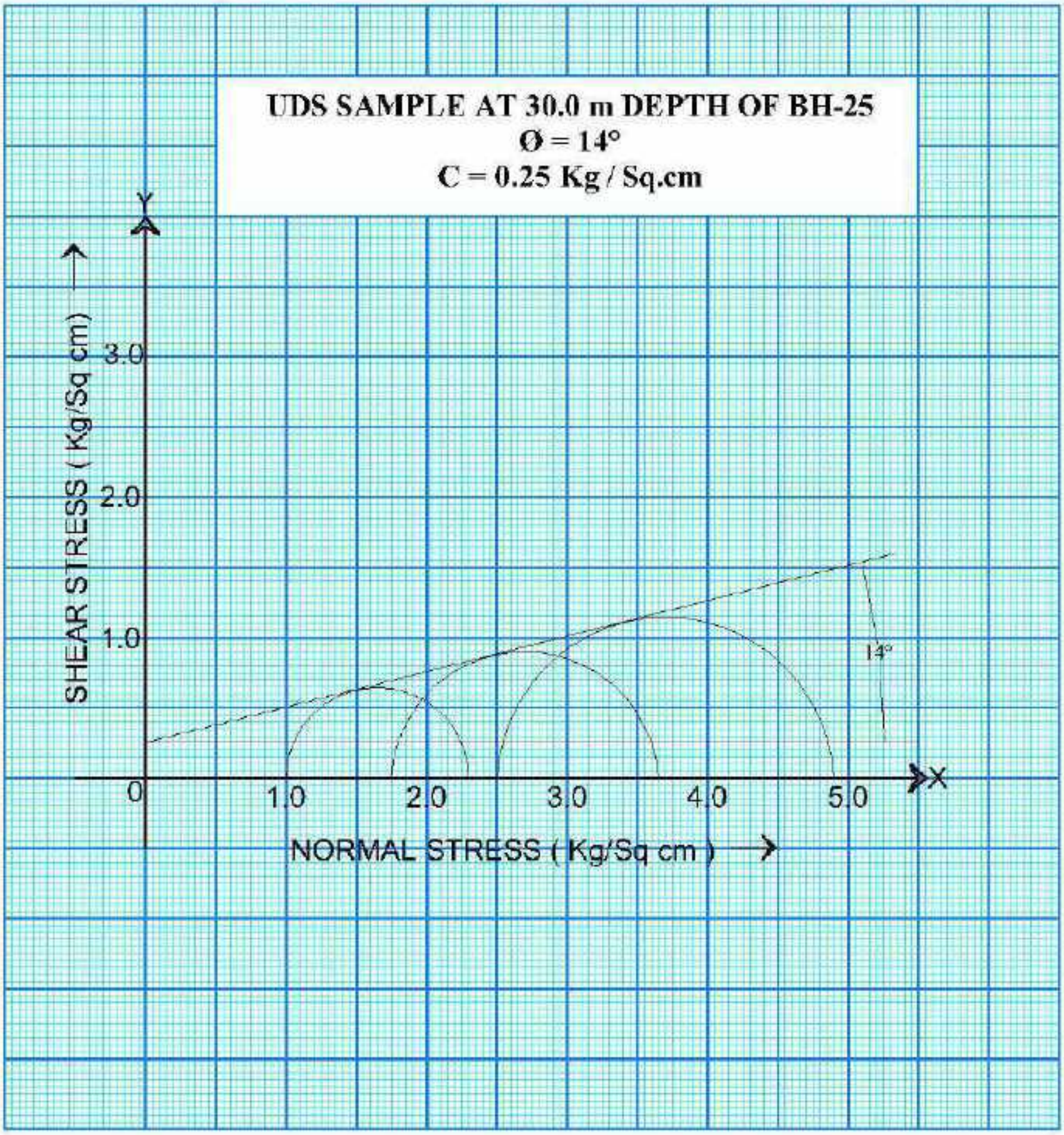

UDS SAMPLE AT 12.0 m DEPTH OF BH-25
Ø = 10°
C = 0.26 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
10°
NORMAL STRESS ( Kg/Sq cm ) →


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
9°
NORMAL STRESS ( Kg/Sq cm )

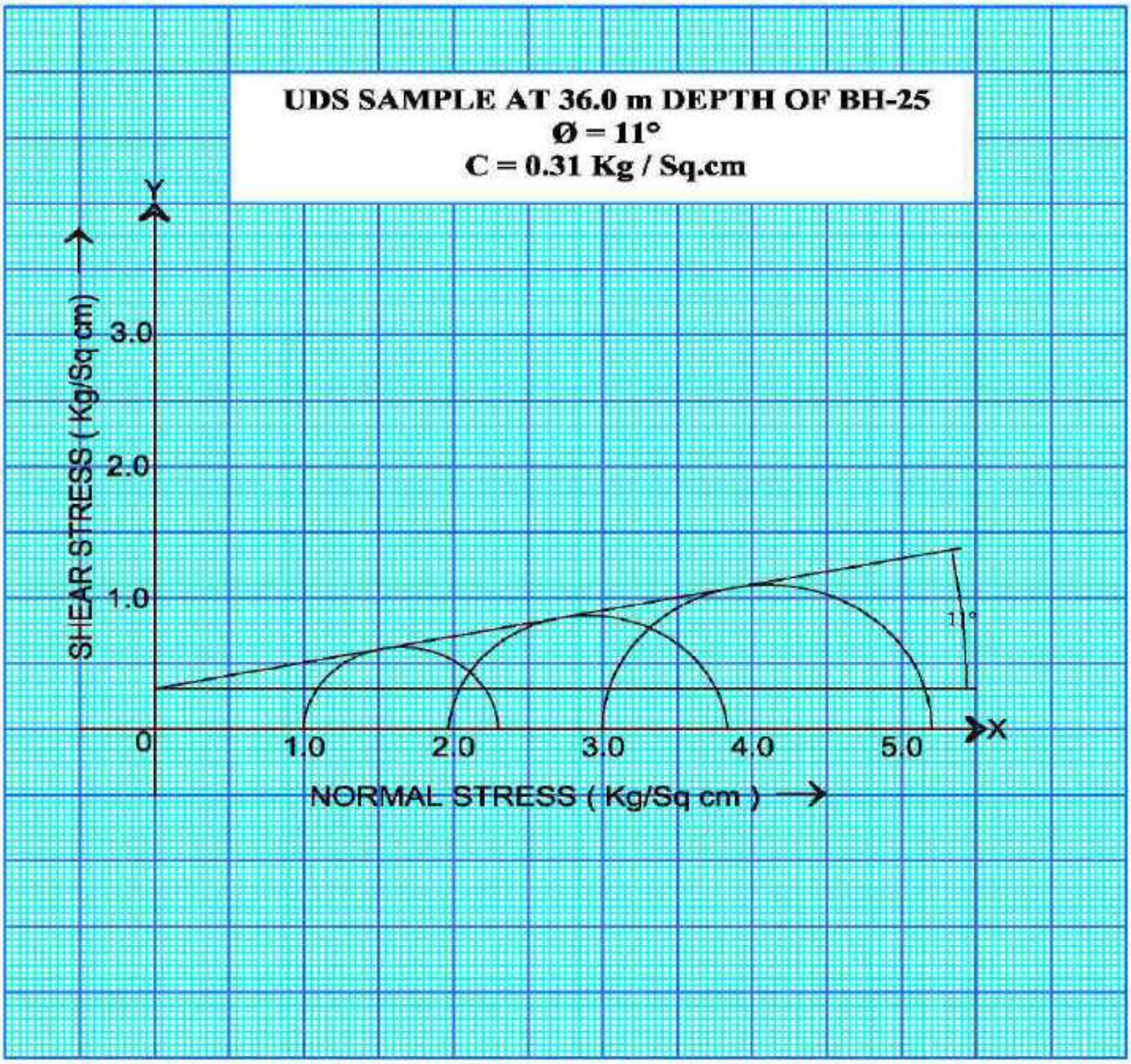

UDS SAMPLE AT 24.0 m DEPTH OF BH-25

Ø = 10°

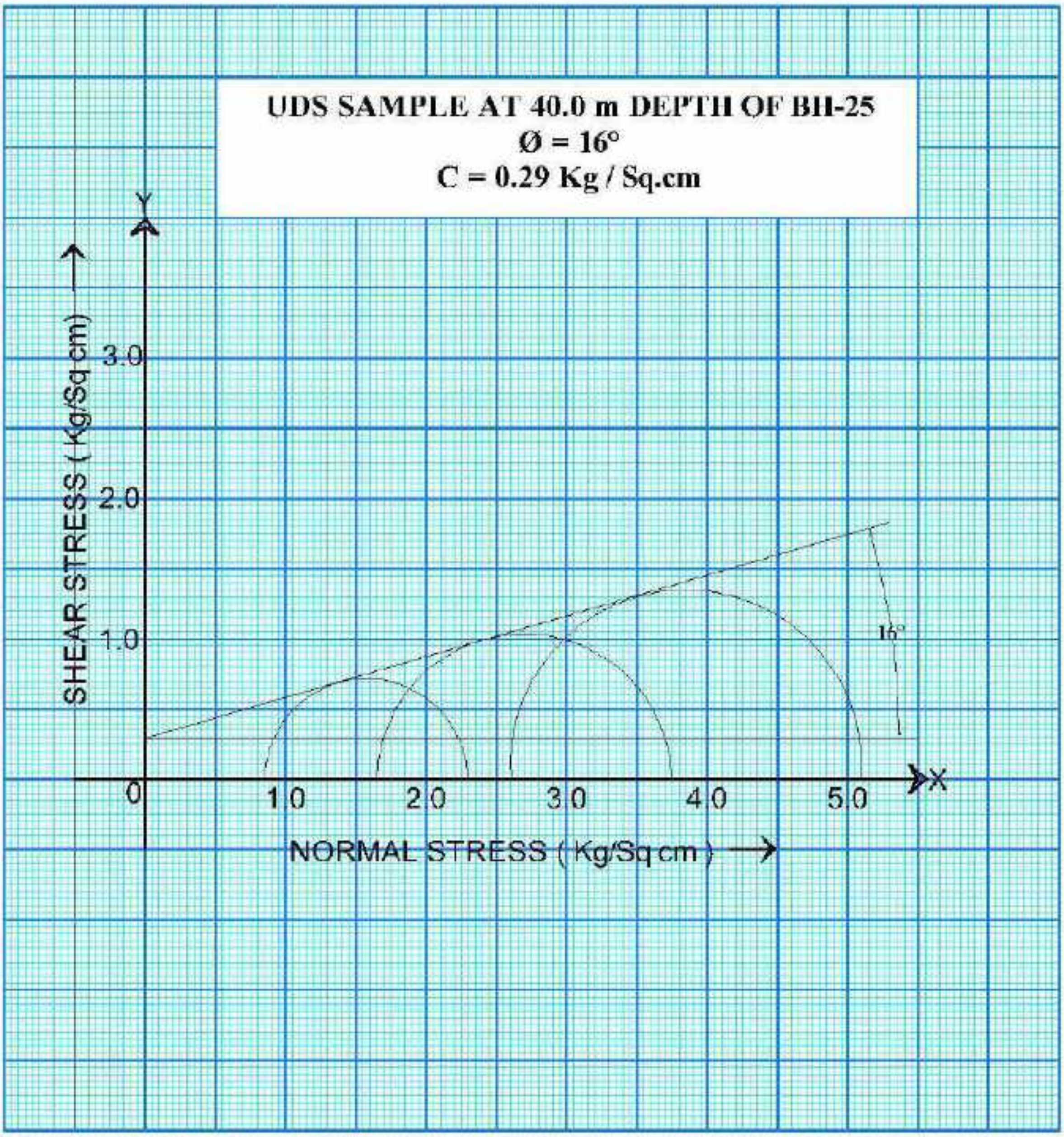
C = 0.30 Kg / Sq.cm

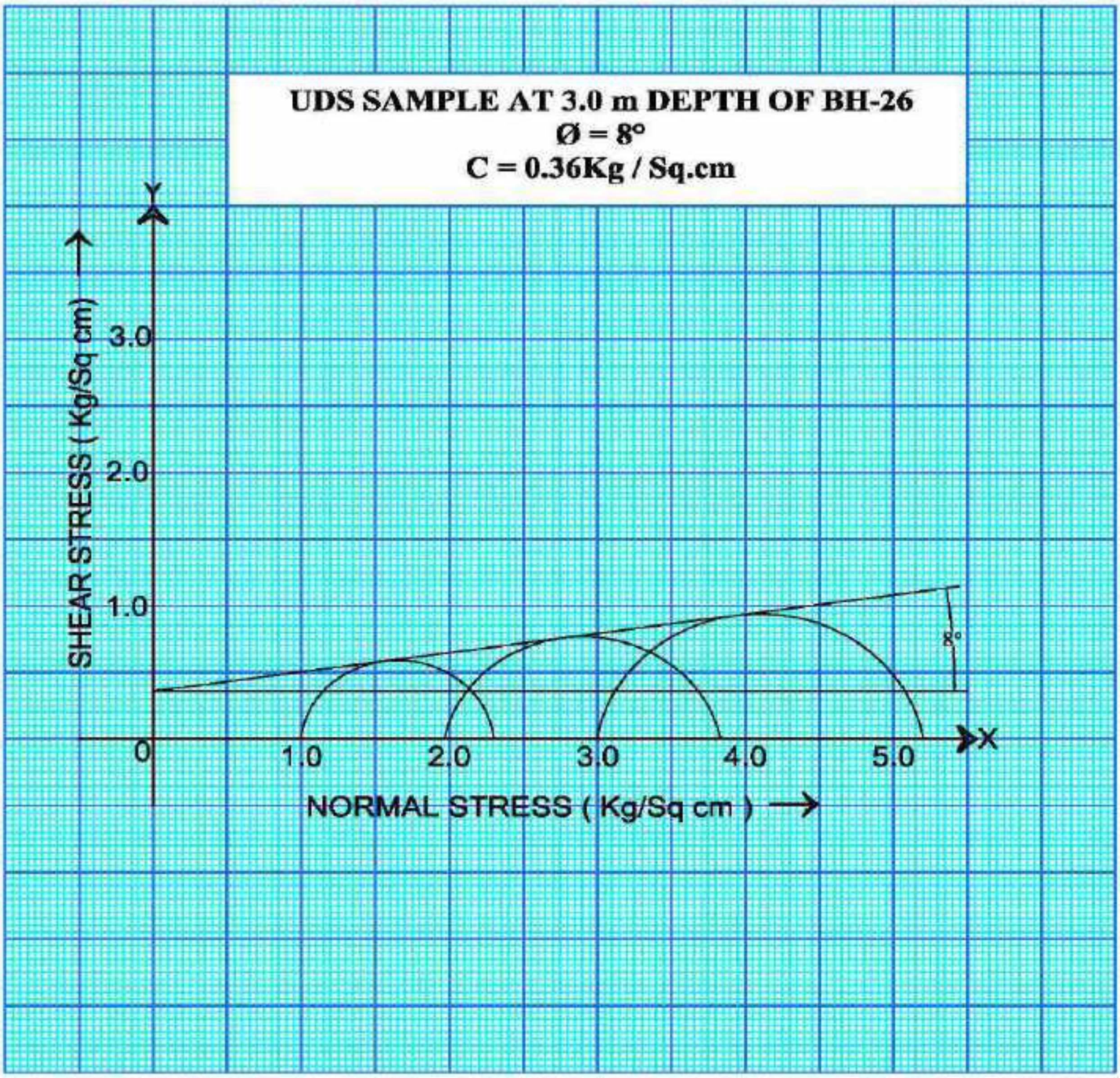


UDS SAMPLE AT 30.0 m DEPTH OF BH-25
Ø = 14°
C = 0.25 Kg / Sq.cm
Y
X
SHEAR STRESS ( Kg/Sq cm)
NORMAL STRESS ( Kg/Sq cm )
0
1.0
2.0
3.0
4.0
5.0
14°

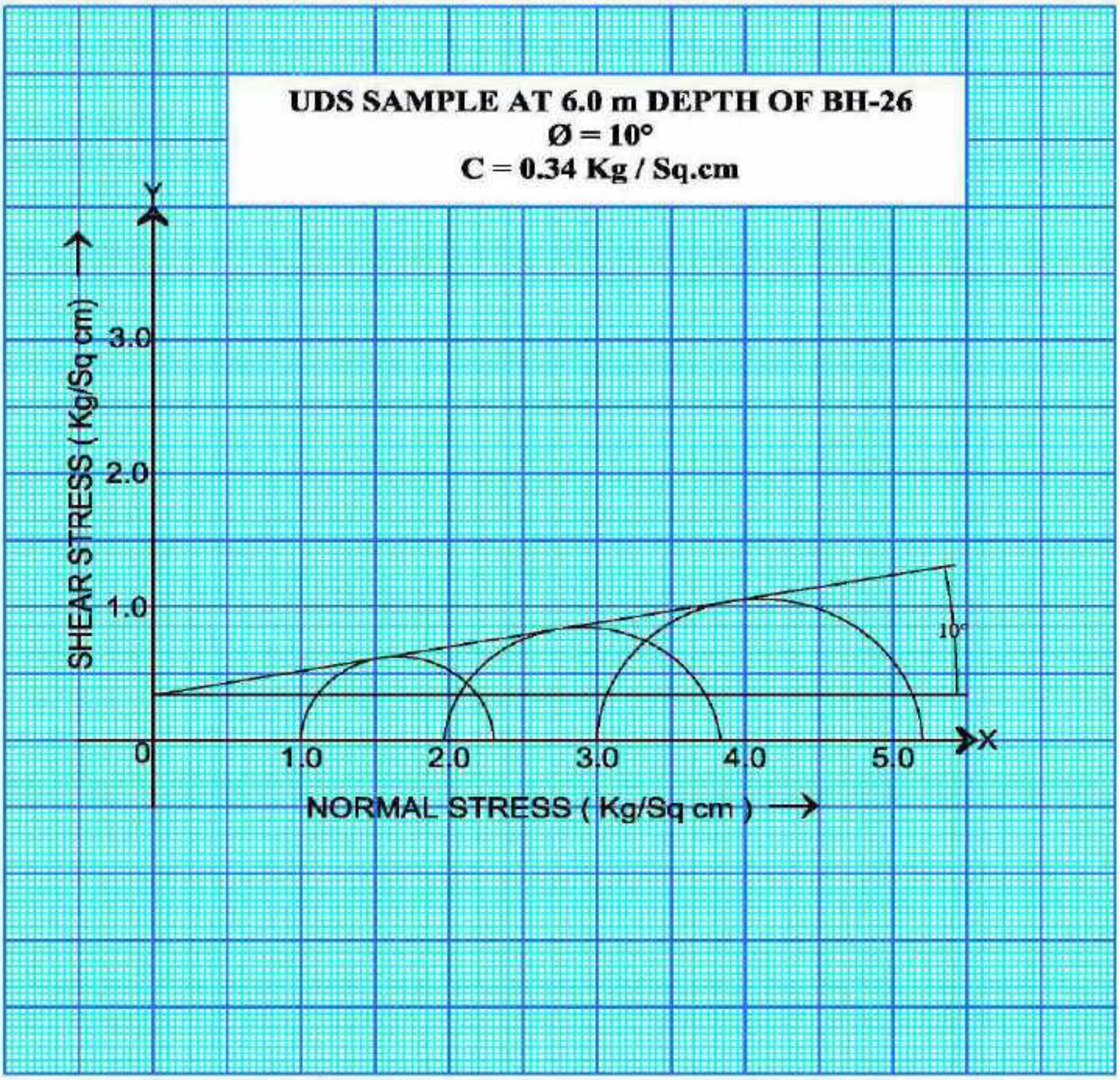


UDS SAMPLE AT 36.0 m DEPTH OF BH-25
Ø = 11°
C = 0.31 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS ( Kg/Sq cm )
11°


UDS SAMPLE AT 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
16°
NORMAL STRESS ( Kg/Sq cm )



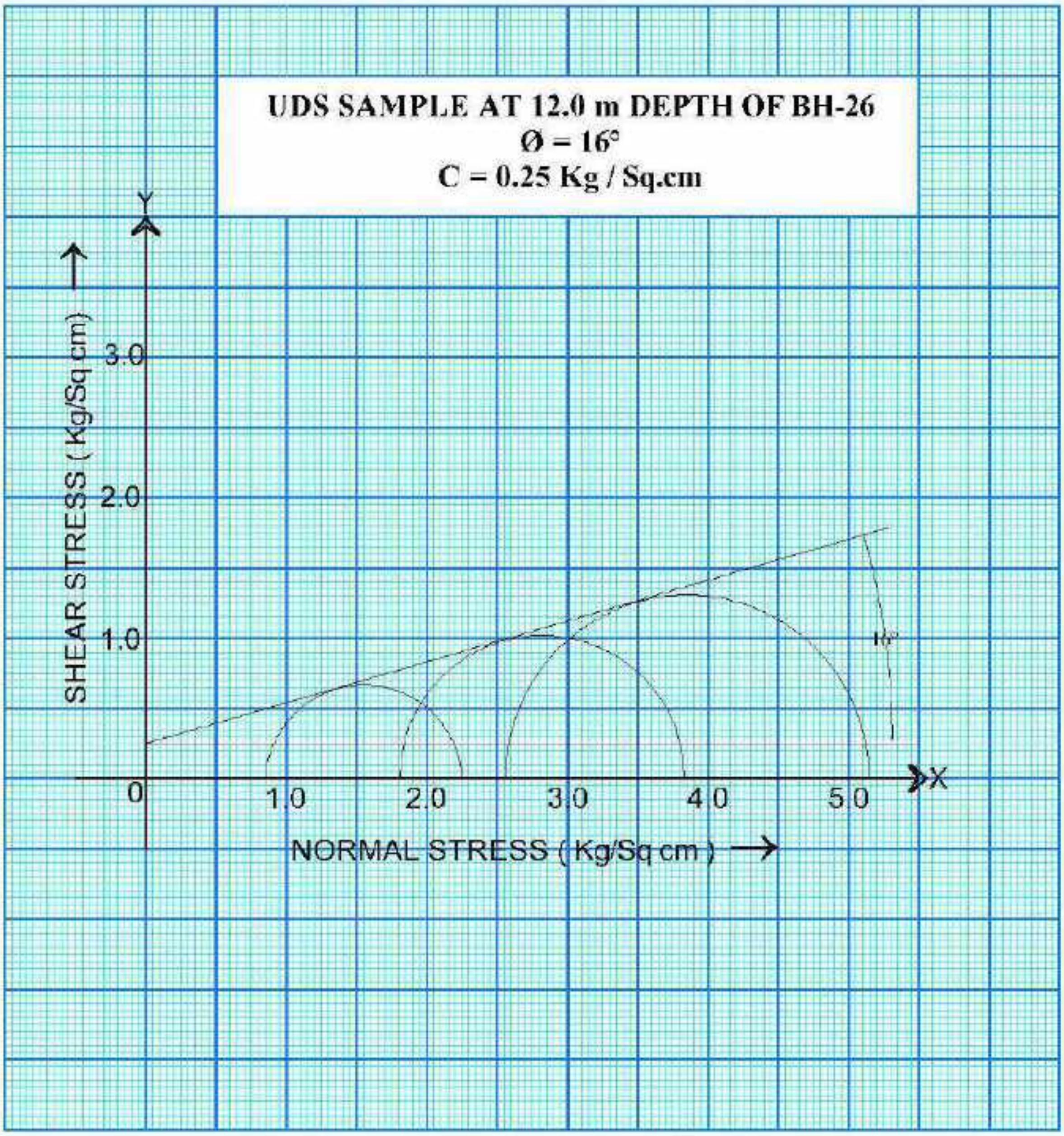
UDS SAMPLE AT 3.0 m DEPTH OF BH-26
Ø = 8°
C = 0.36Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
8°
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS ( Kg/Sq cm )



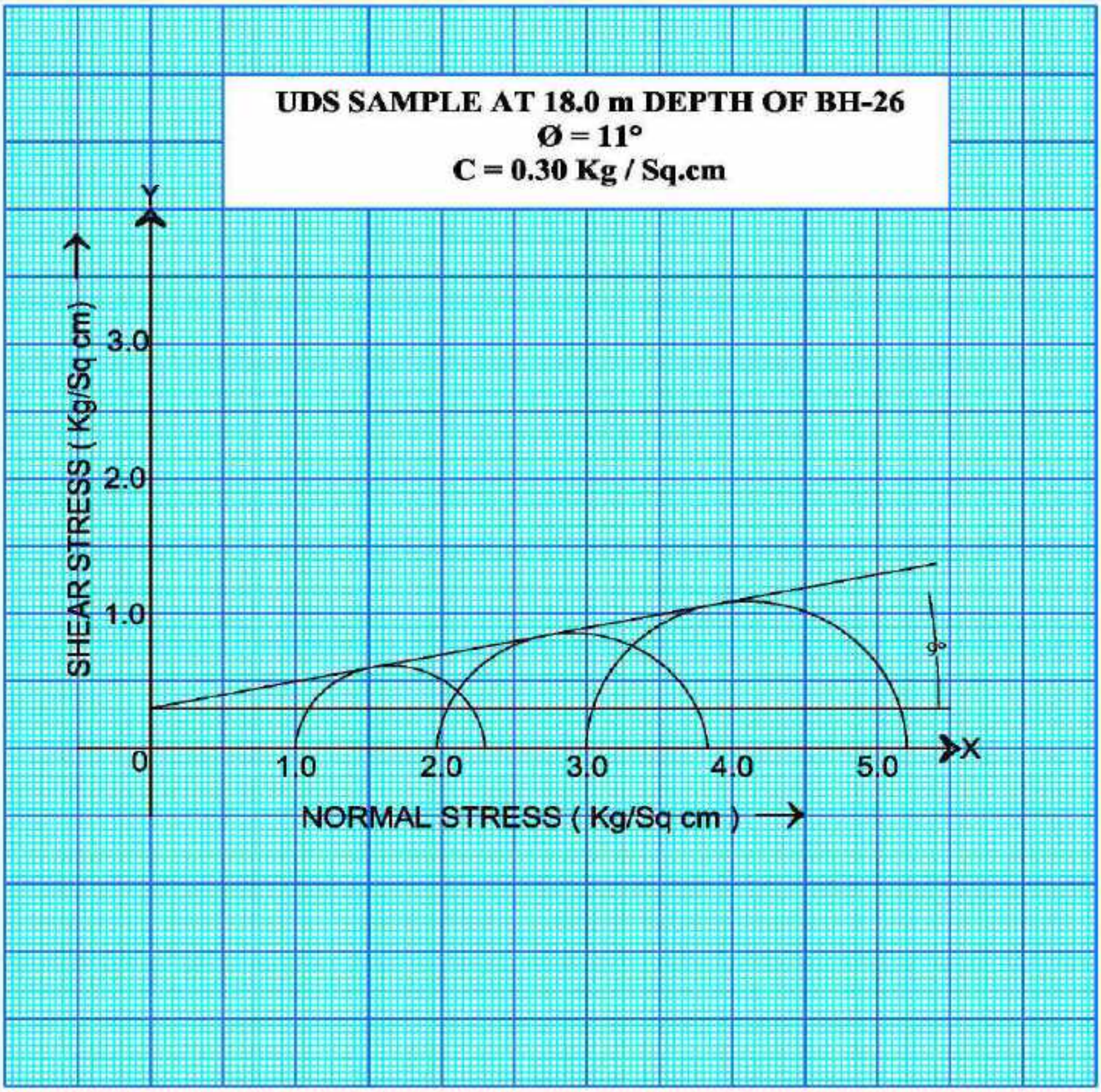
**UDS SAMPLE AT 6.0 m DEPTH OF BH-26**

**Ø = 10°**

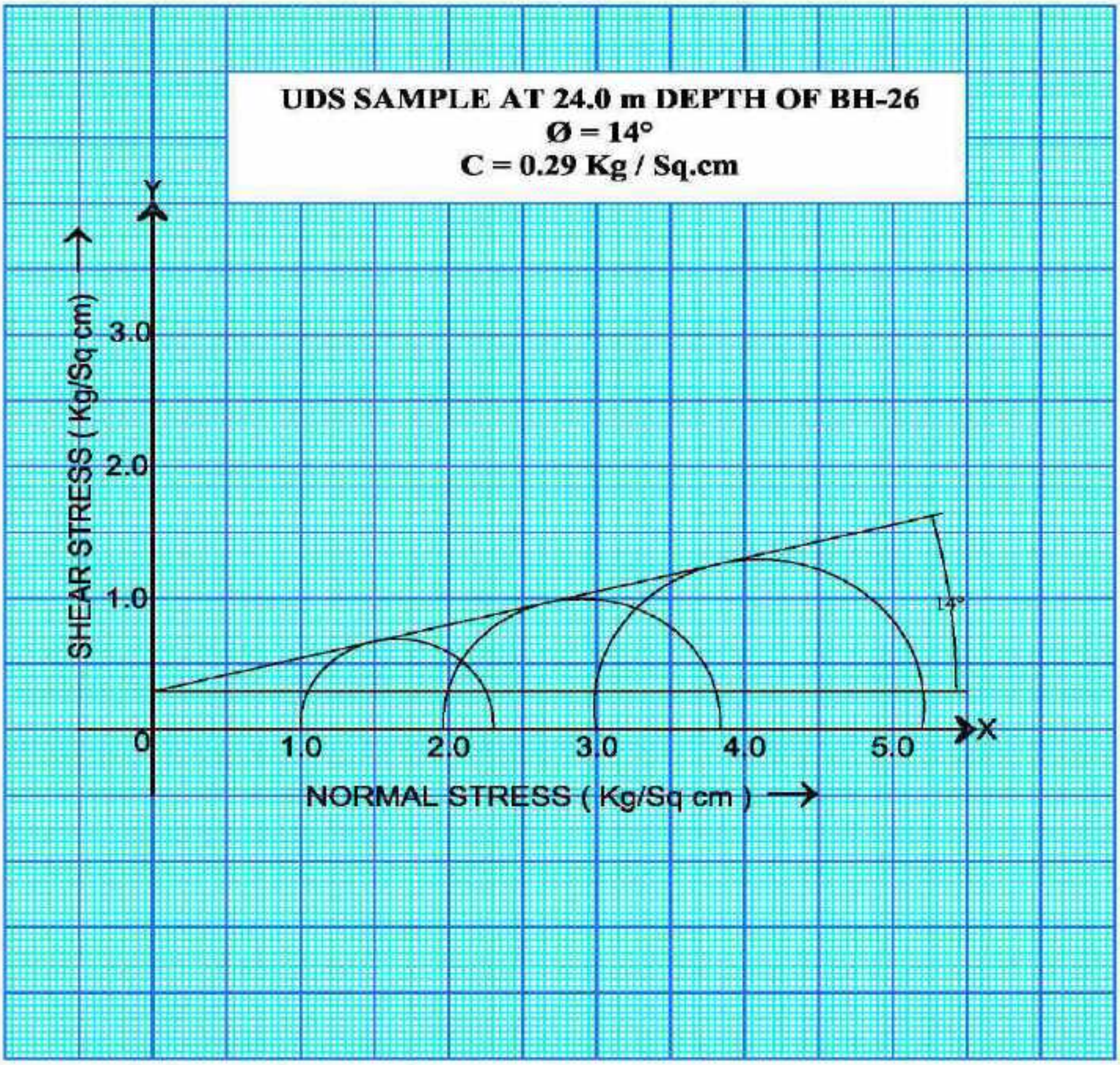
**C = 0.34 Kg / Sq.cm**

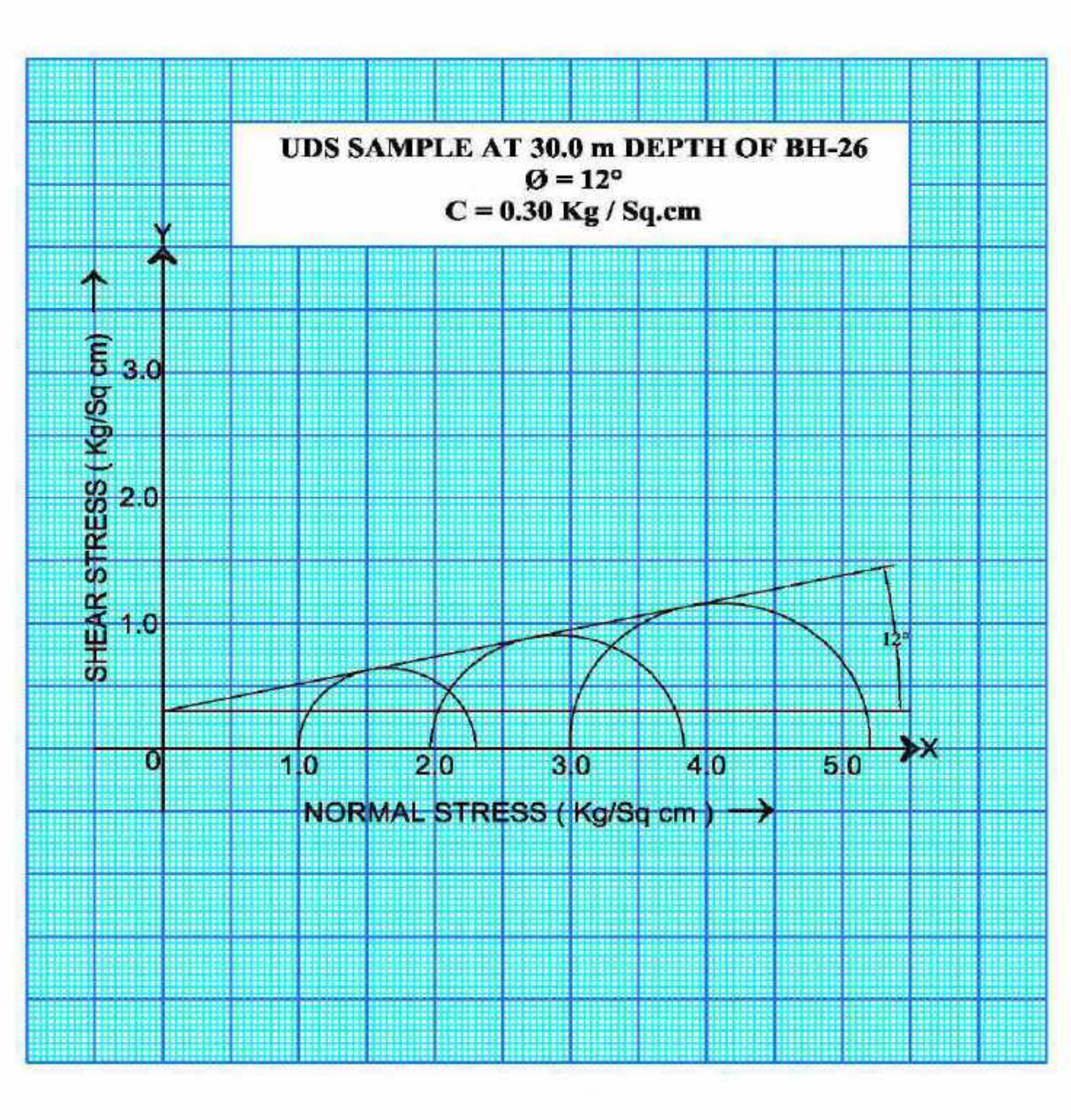


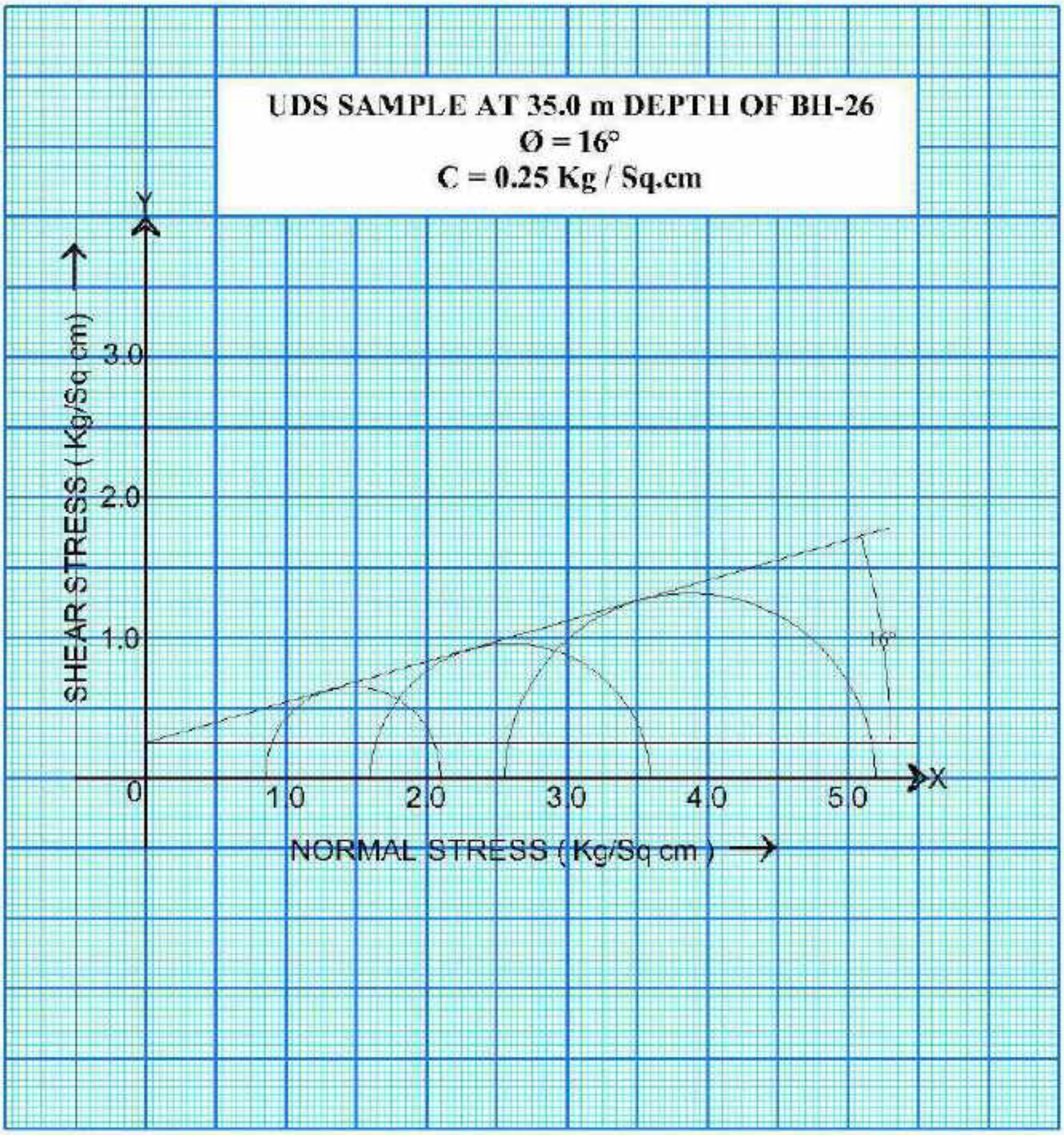
UDS SAMPLE AT 12.0 m DEPTH OF BH-26
Ø = 16°
C = 0.25 Kg / Sq.cm

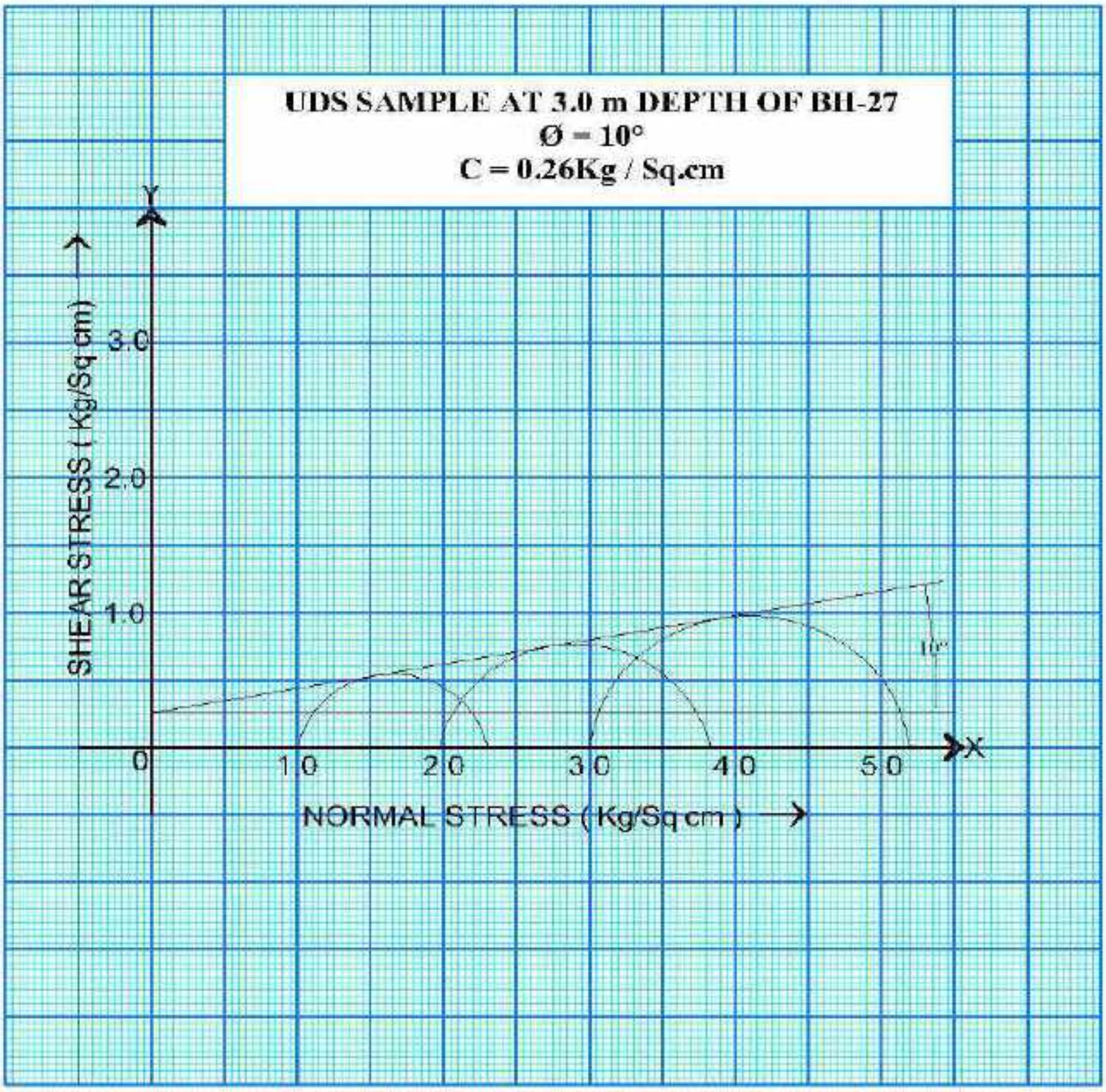


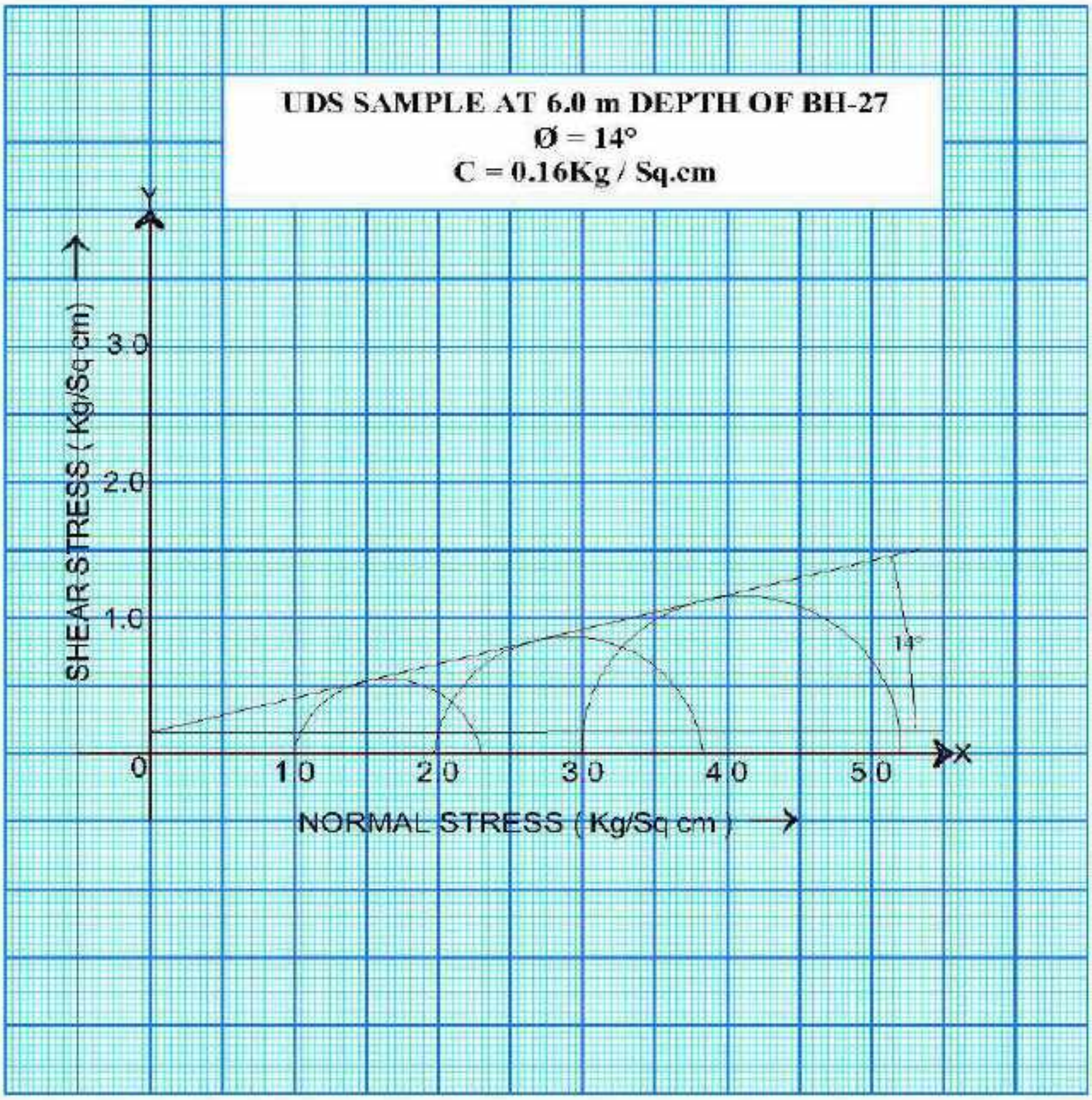
UDS SAMPLE AT 18.0 m DEPTH OF BH-26
Ø = 11°
C = 0.30 Kg / Sq.cm
Y
X
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
NORMAL STRESS ( Kg/Sq cm )
ø


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°

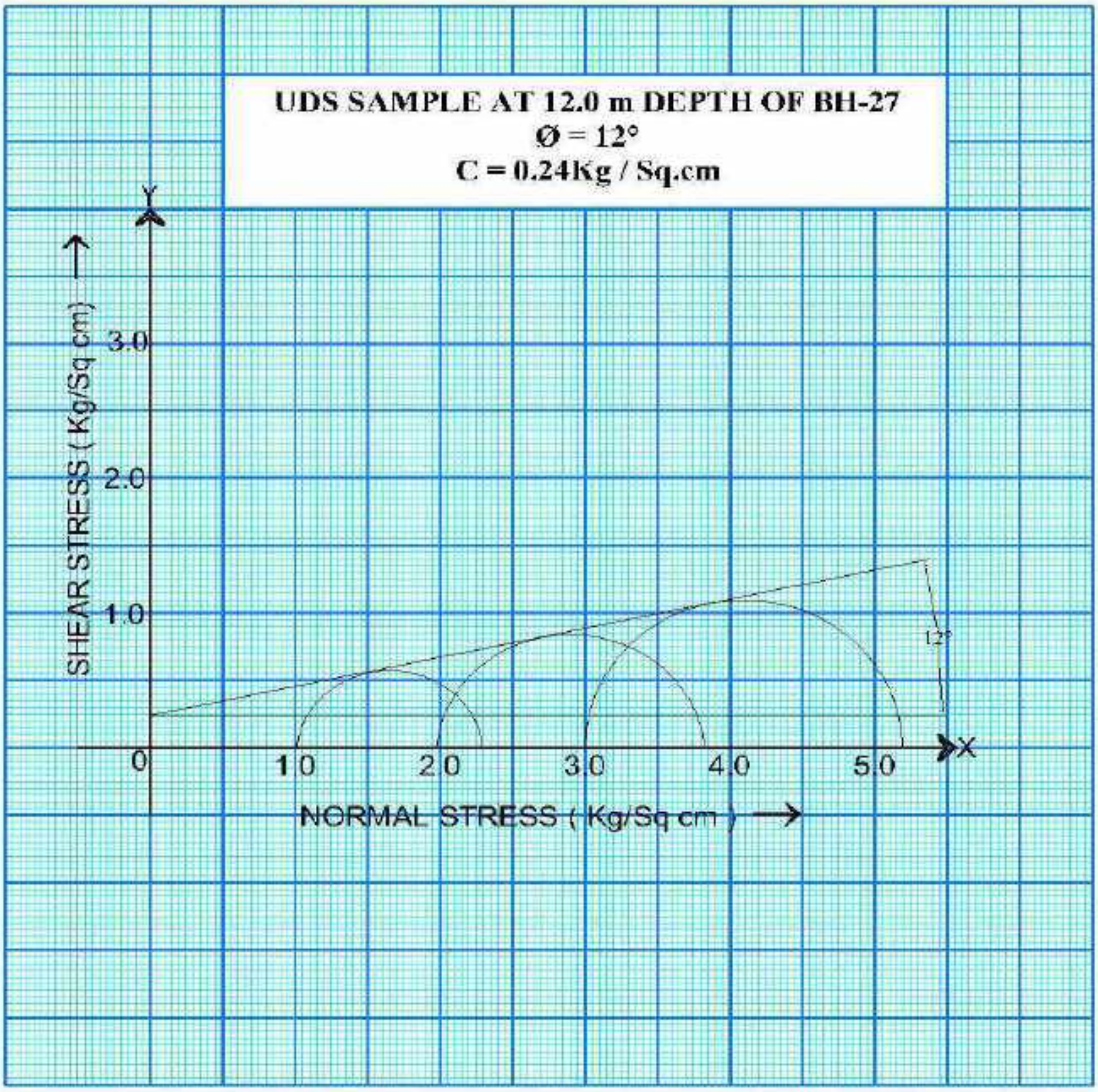

UDS SAMPLE AT 30.0 m DEPTH OF BH-26
Ø = 12°
C = 0.30 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm ) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS ( Kg/Sq cm ) →
12°

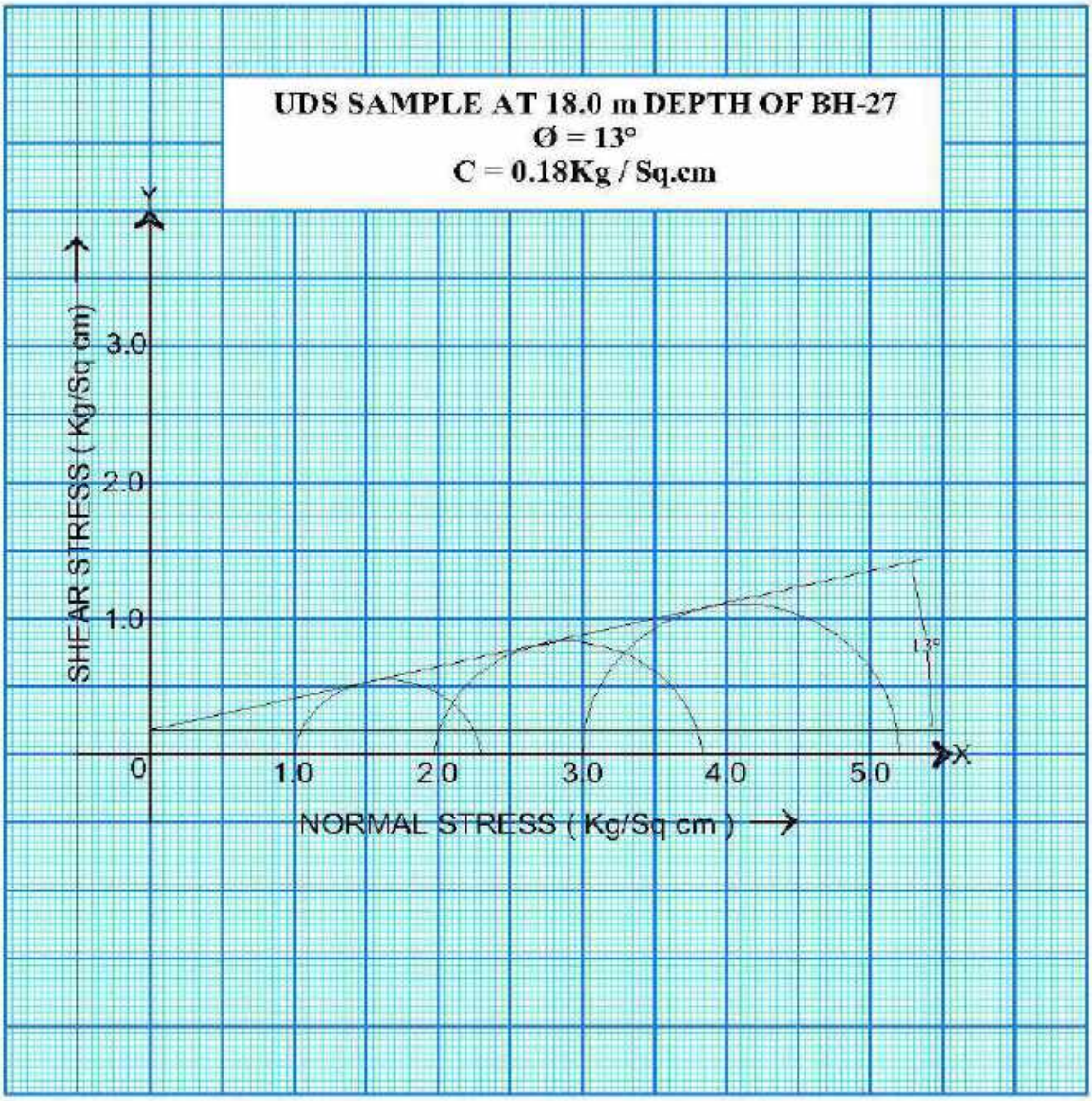

UDS SAMPLE AT 35.0 m DEPTH OF BH-26
Ø = 16°
C = 0.25 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
NORMAL STRESS ( Kg/Sq cm )
16°

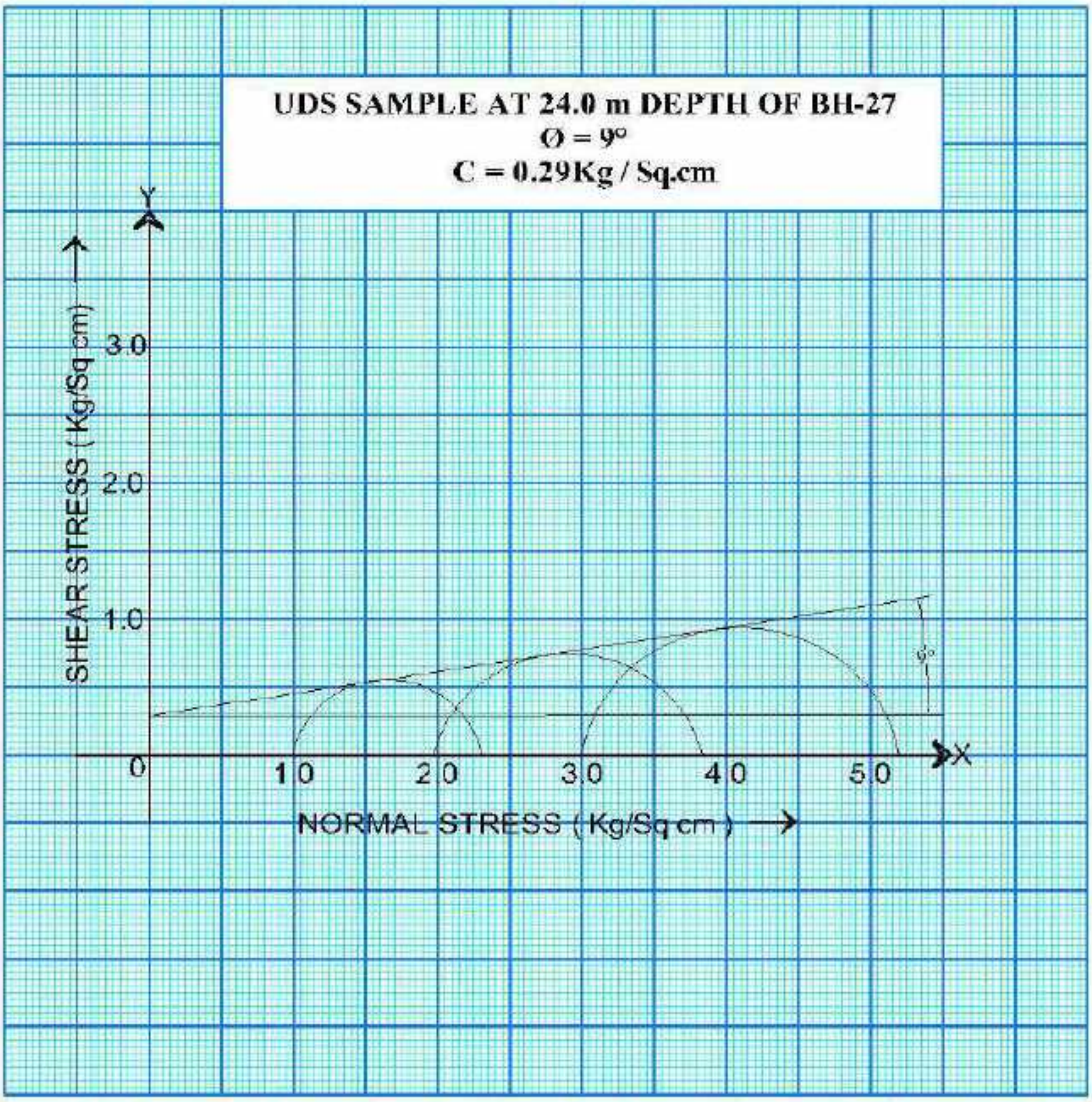

UDS SAMPLE AT 3.0 m DEPTH OF BH-27
Ø = 10°
C = 0.26Kg / Sq.cm

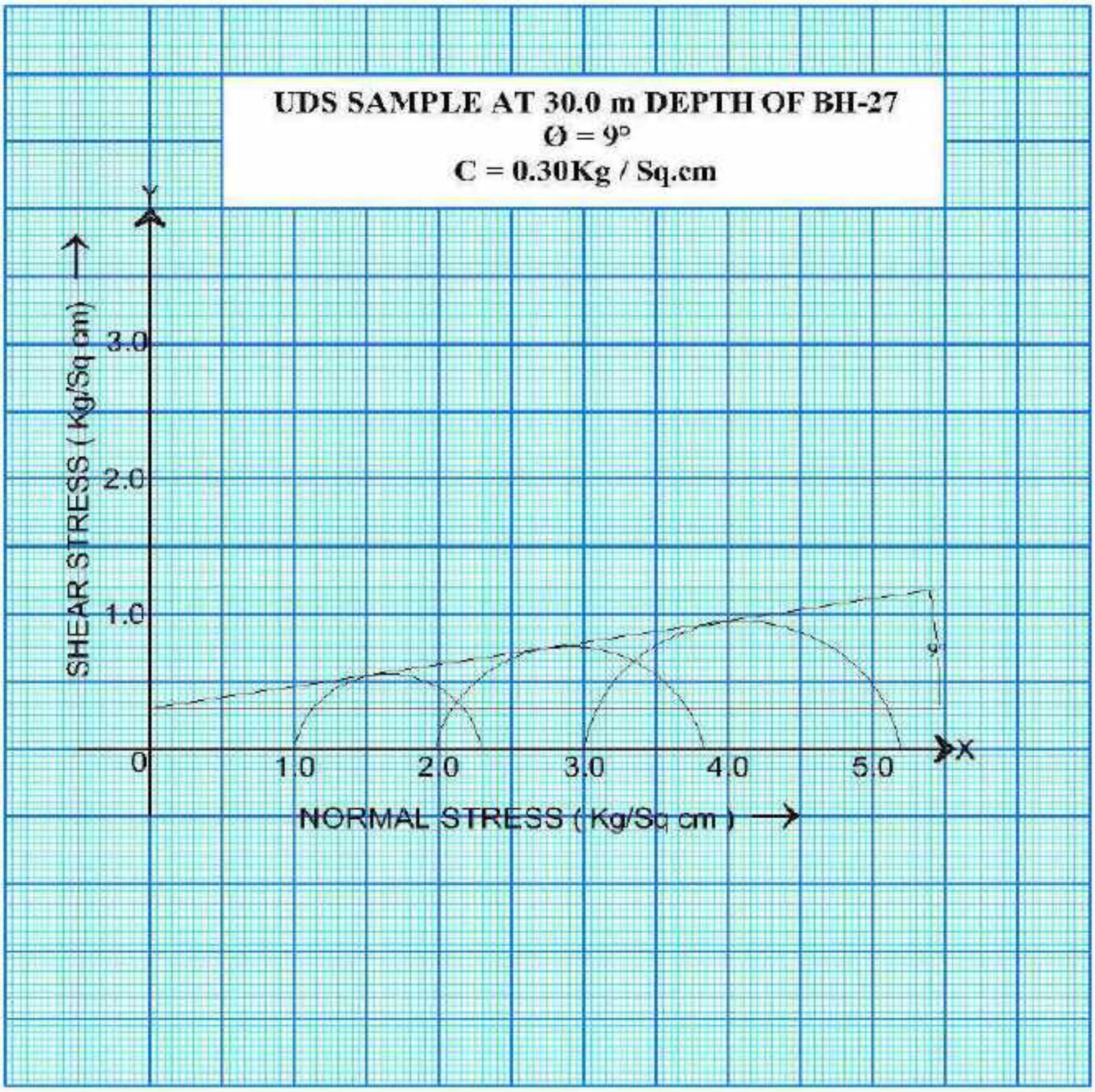


UDS SAMPLE AT 6.0 m DEPTH OF BH-27
Ø = 14°
C = 0.16Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS ( Kg/Sq cm )

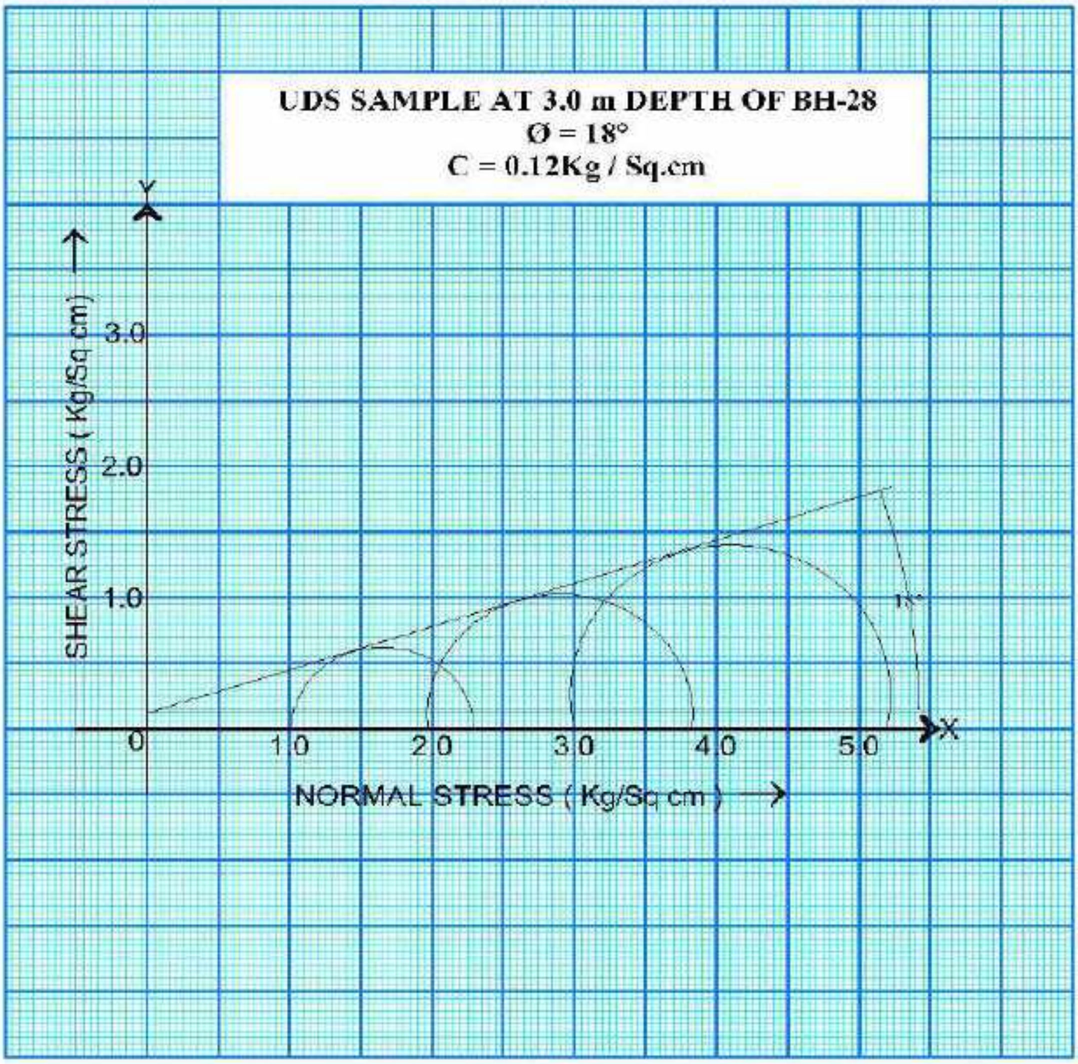

UDS SAMPLE AT 12.0 m DEPTH OF BH-27
Ø = 12°
C = 0.24Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
12°
NORMAL STRESS ( Kg/Sq cm ) →


UDS SAMPLE AT 18.0 m DEPTH OF BH-27
Ø = 13°
C = 0.18Kg / Sq.cm

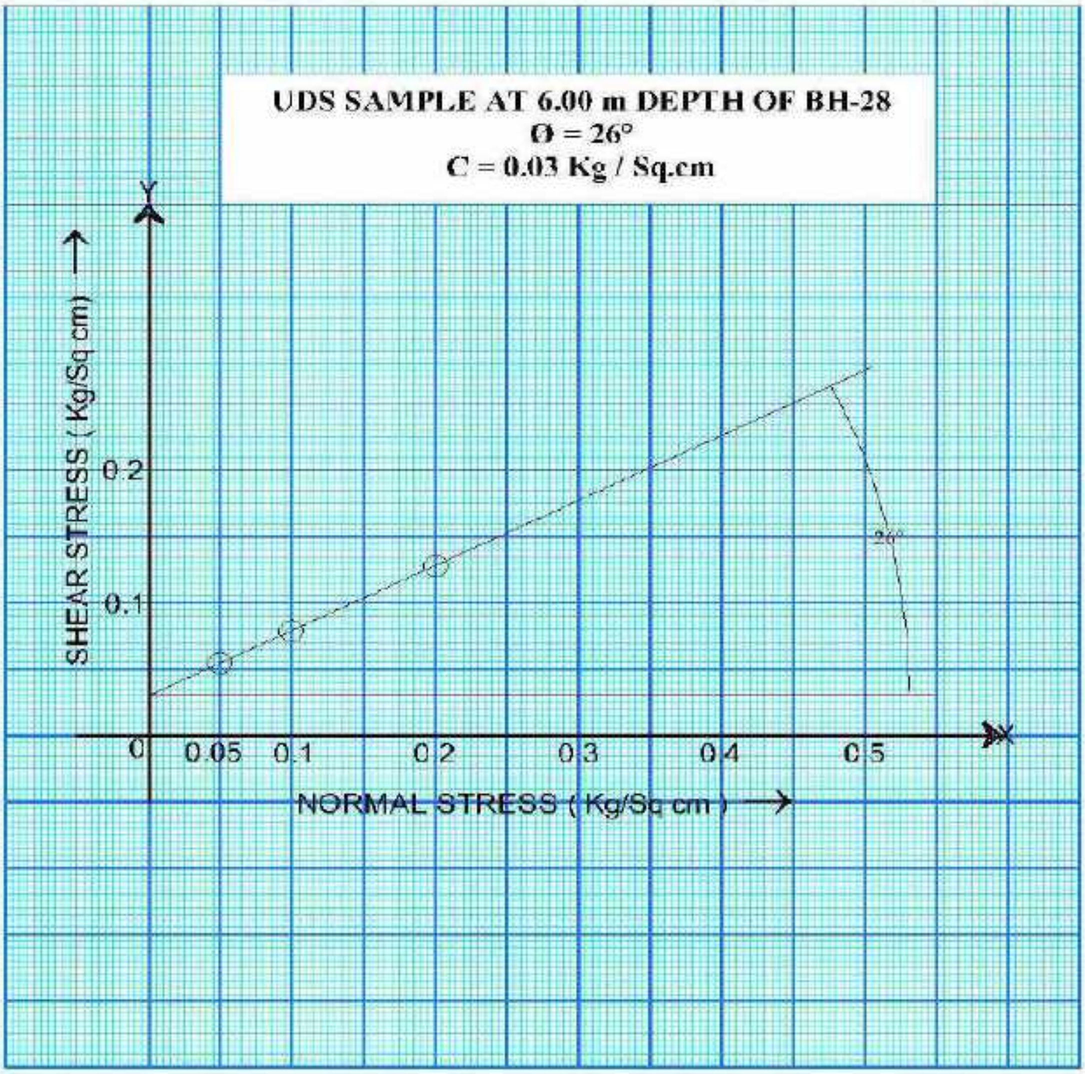

UDS SAMPLE AT 24.0 m DEPTH OF BH-27
Ø = 9°
C = 0.29Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
9°
NORMAL STRESS ( Kg/Sq cm ) →

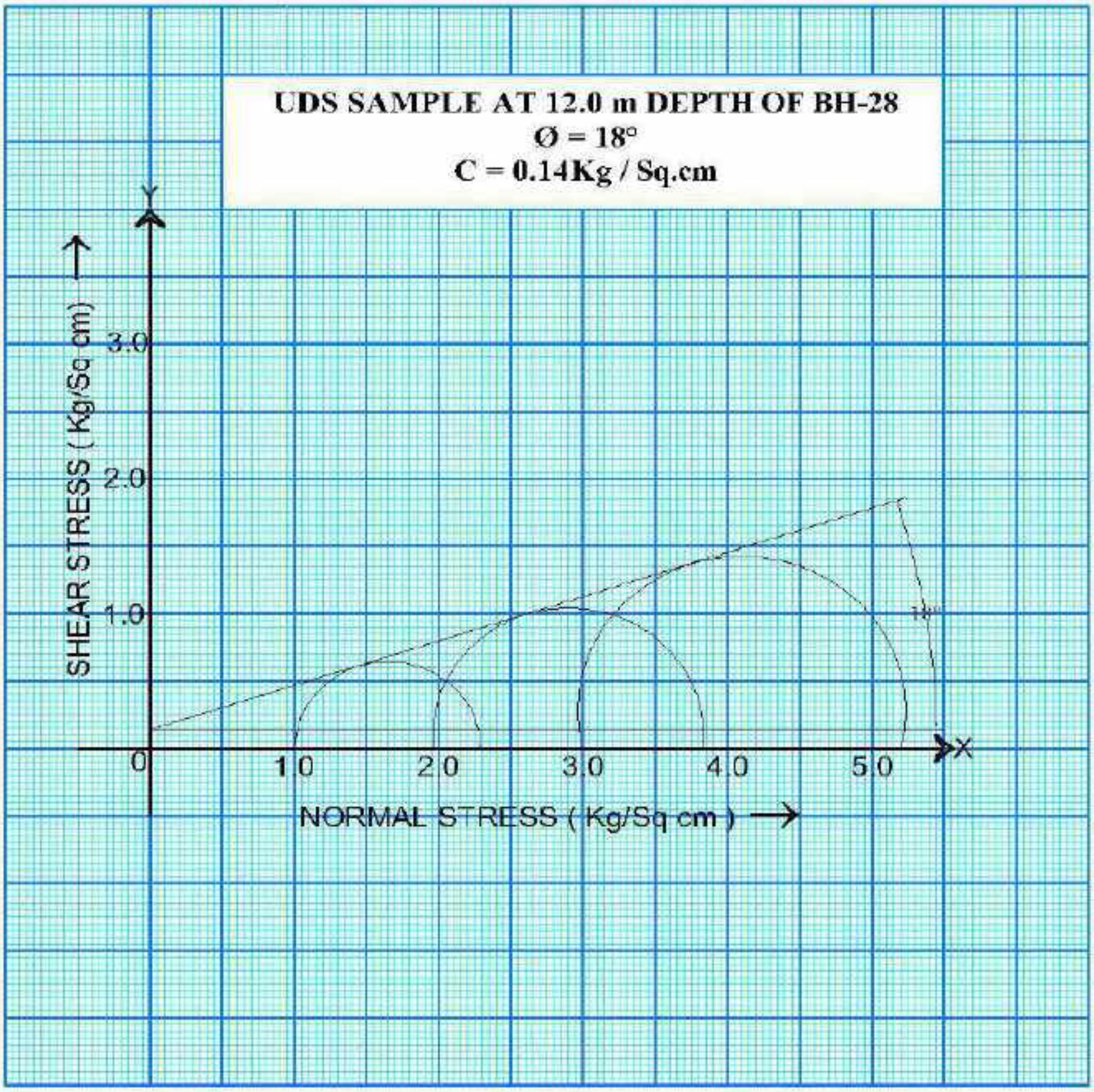


UDS SAMPLE AT 30.0 m DEPTH OF BH-27
Ø = 9°
C = 0.30Kg / Sq.cm

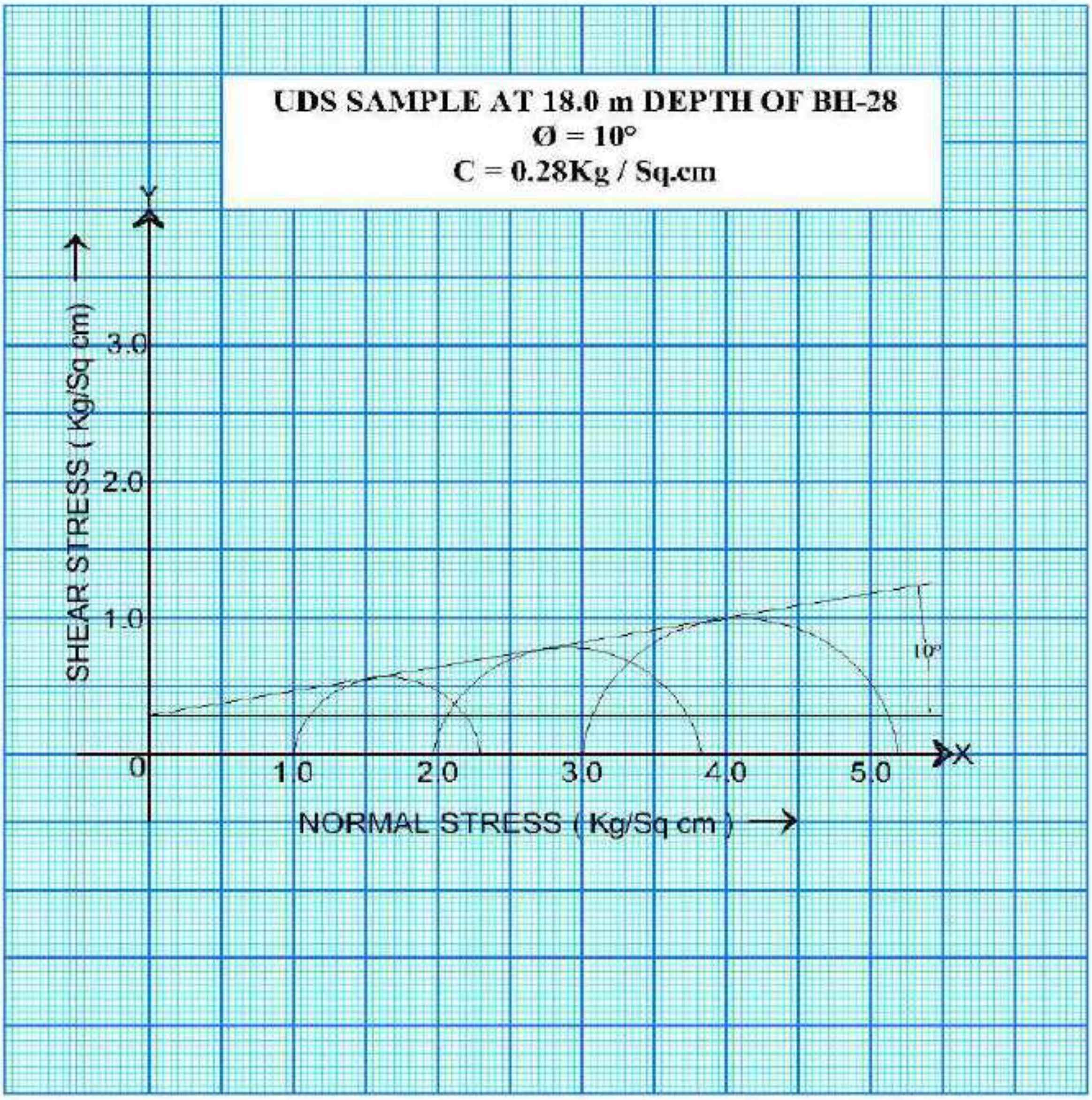


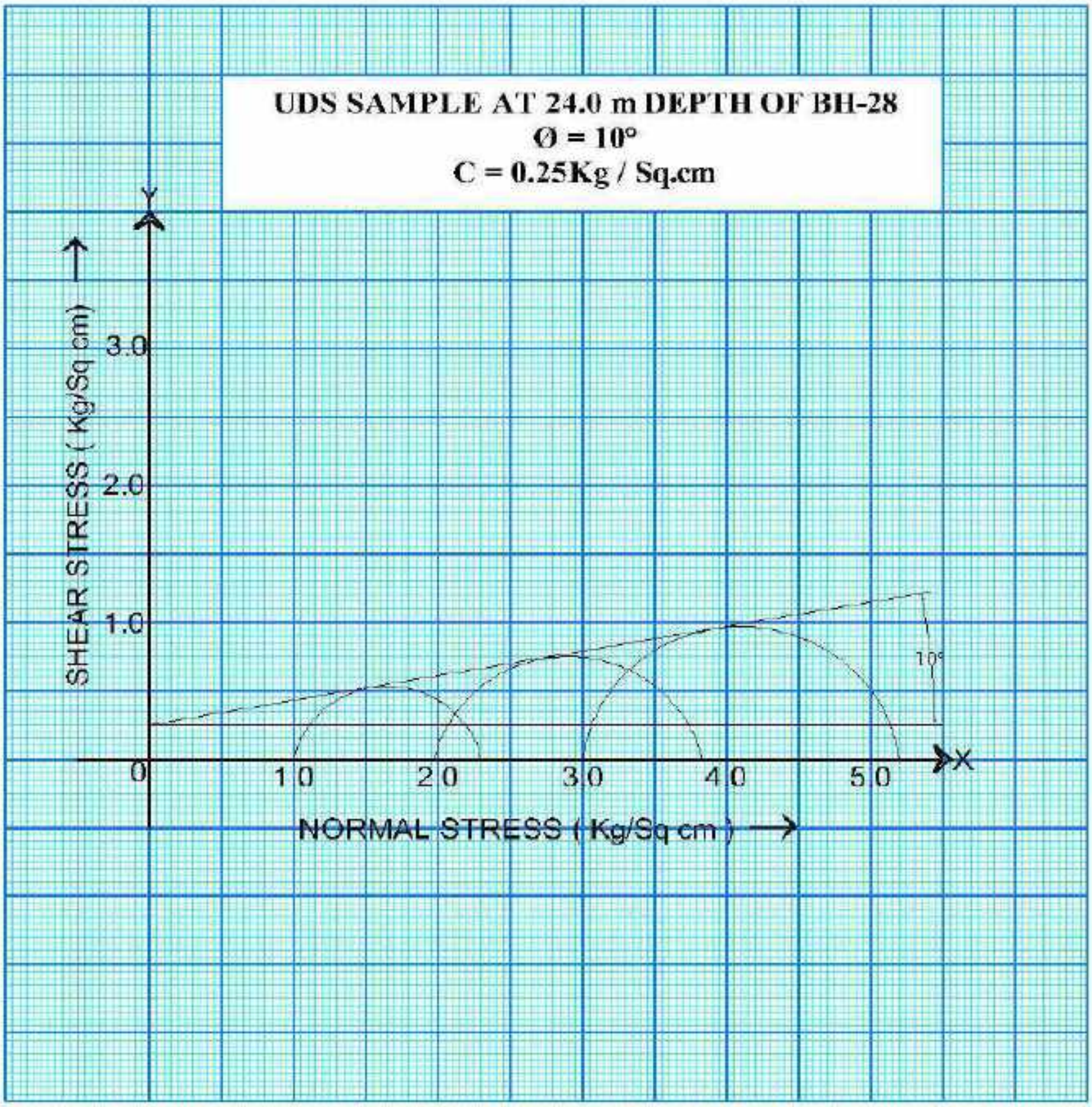
UDS SAMPLE AT 3.0 m DEPTH OF BH-28
Ø = 18°
C = 0.12Kg / Sq.cm

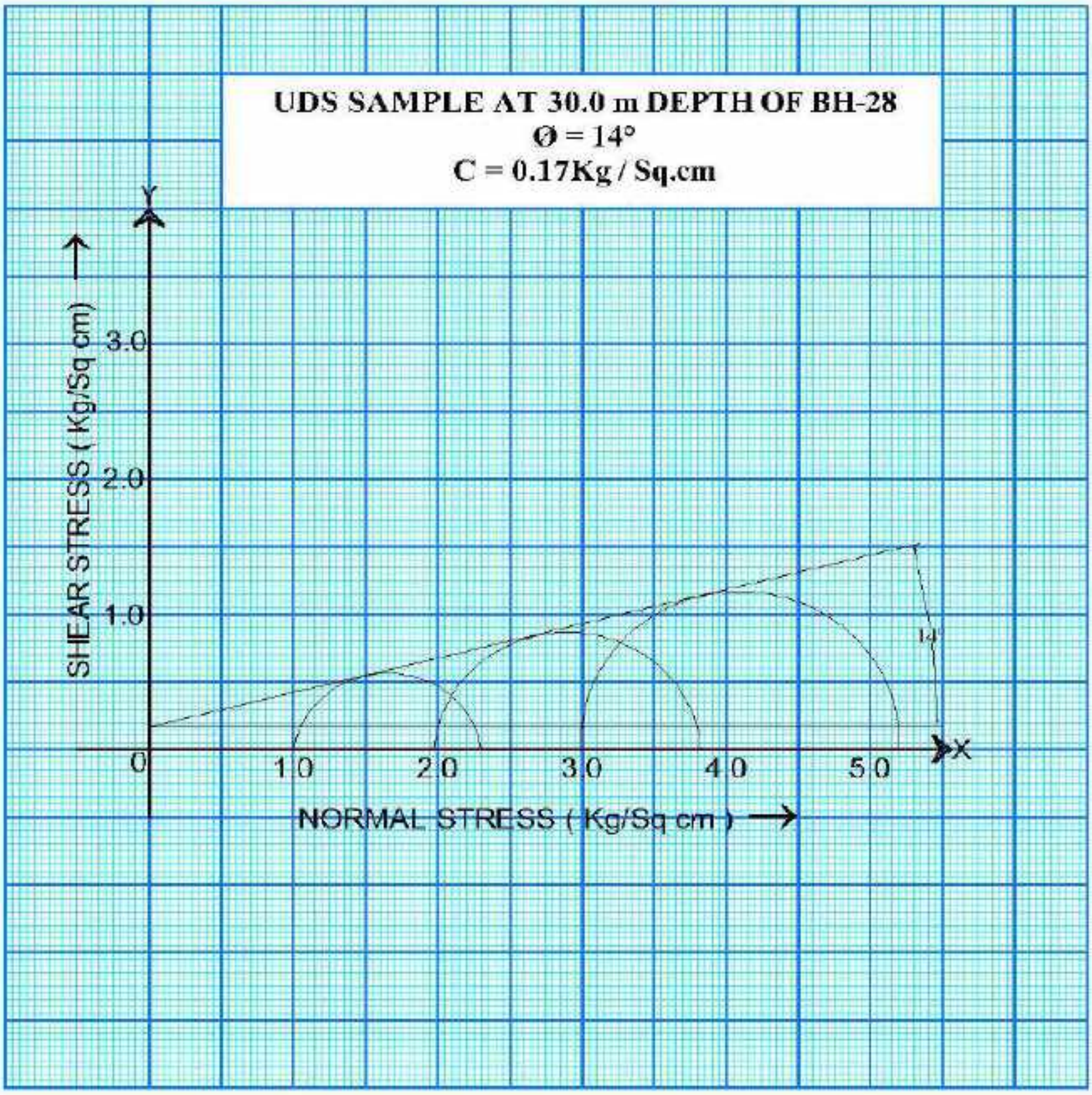

UDS SAMPLE AT 6.00 m DEPTH OF BH-28
Ø = 26°
C = 0.03 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm ) →
26°



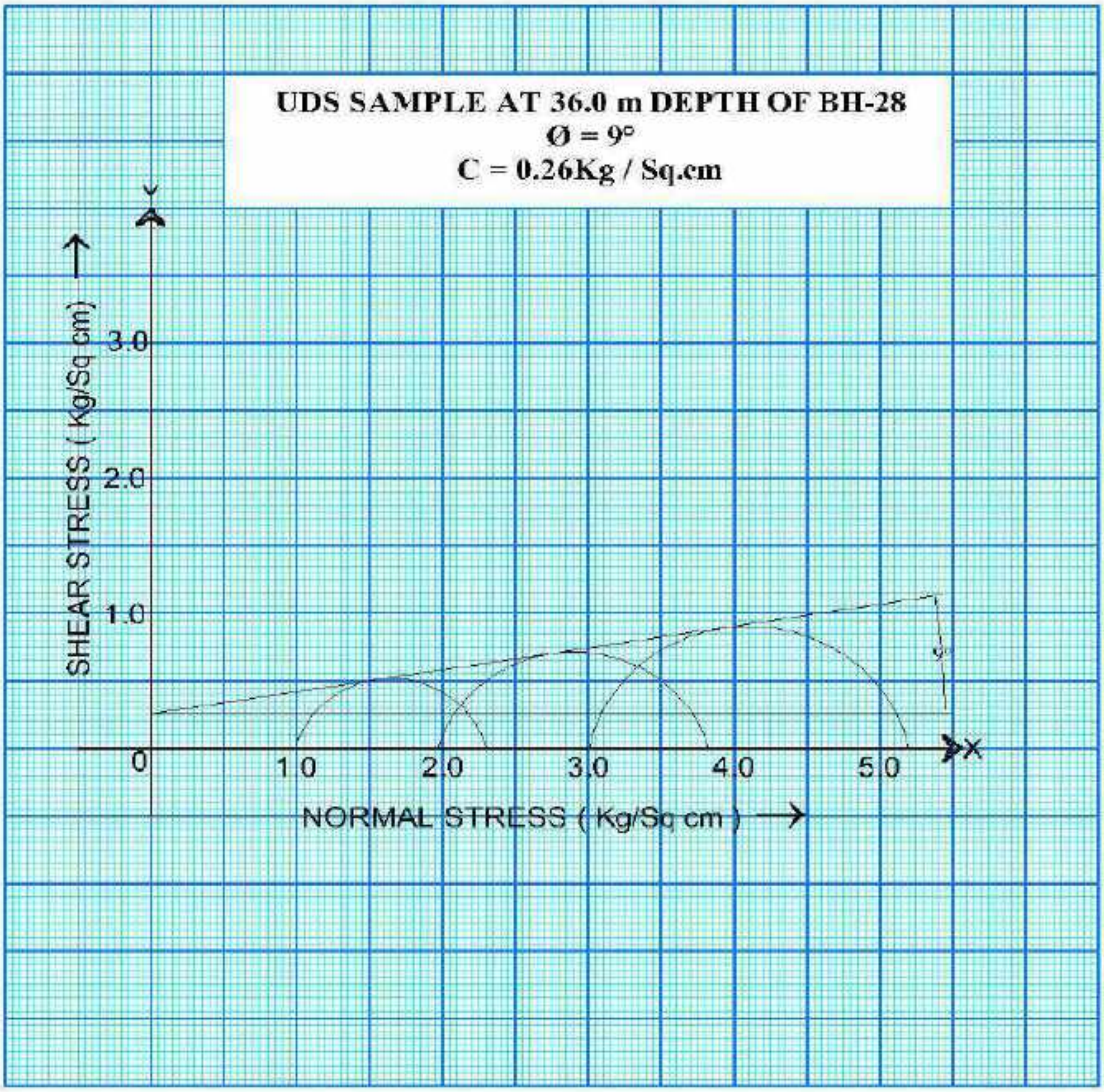
**UDS SAMPLE AT 12.0 m DEPTH OF BH-28**
**Ø = 18°**
**C = 0.14Kg / Sq.cm**


UDS SAMPLE AT 18.0 m DEPTH OF BH-28
Ø = 10°
C = 0.28Kg / Sq.cm


UDS SAMPLE AT 24.0 m DEPTH OF BH-28
Ø = 10°
C = 0.25Kg / Sq.cm



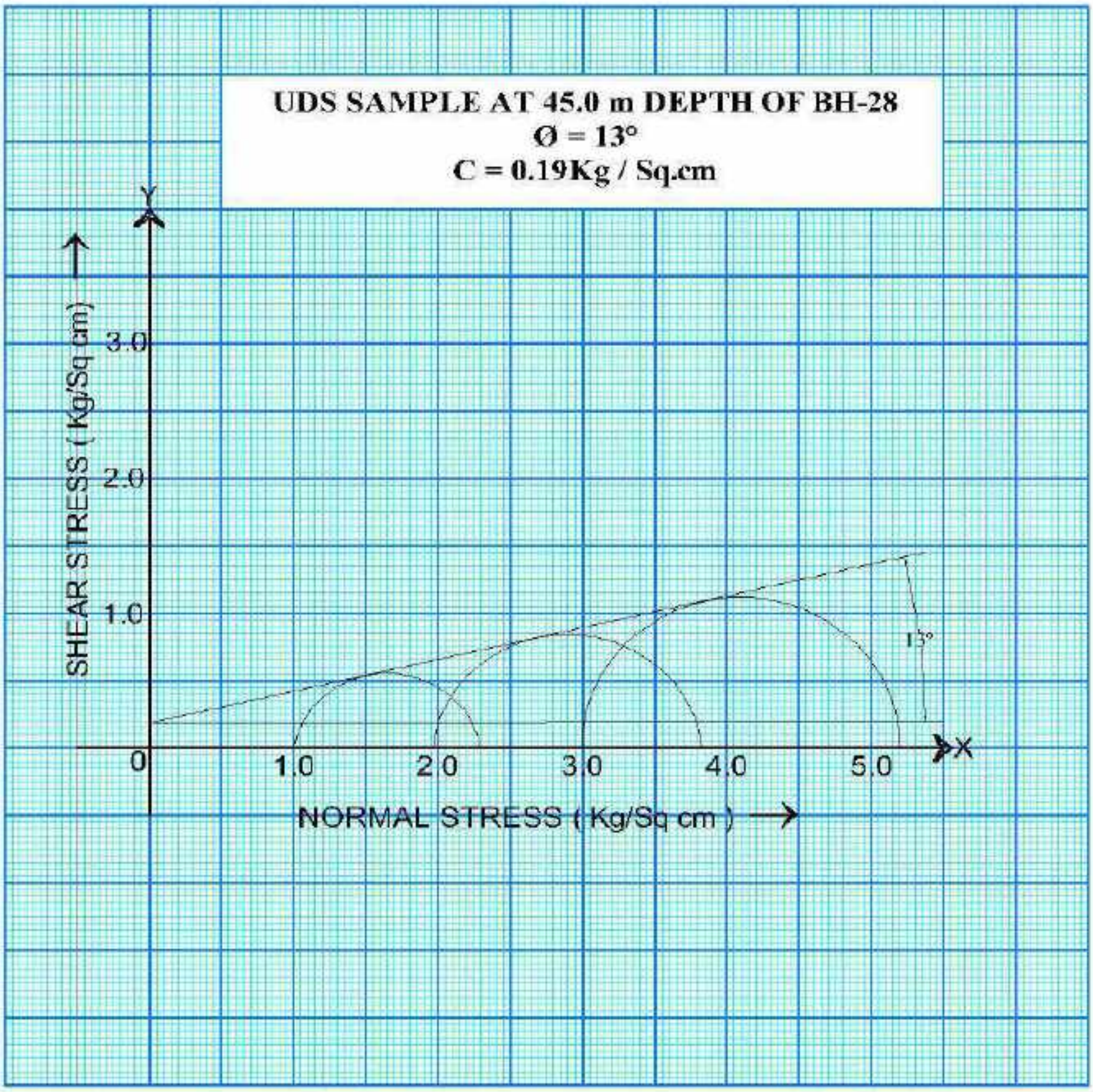
**UDS SAMPLE AT 30.0 m DEPTH OF BH-28**
**Ø = 14°**
**C = 0.17Kg / Sq.cm**



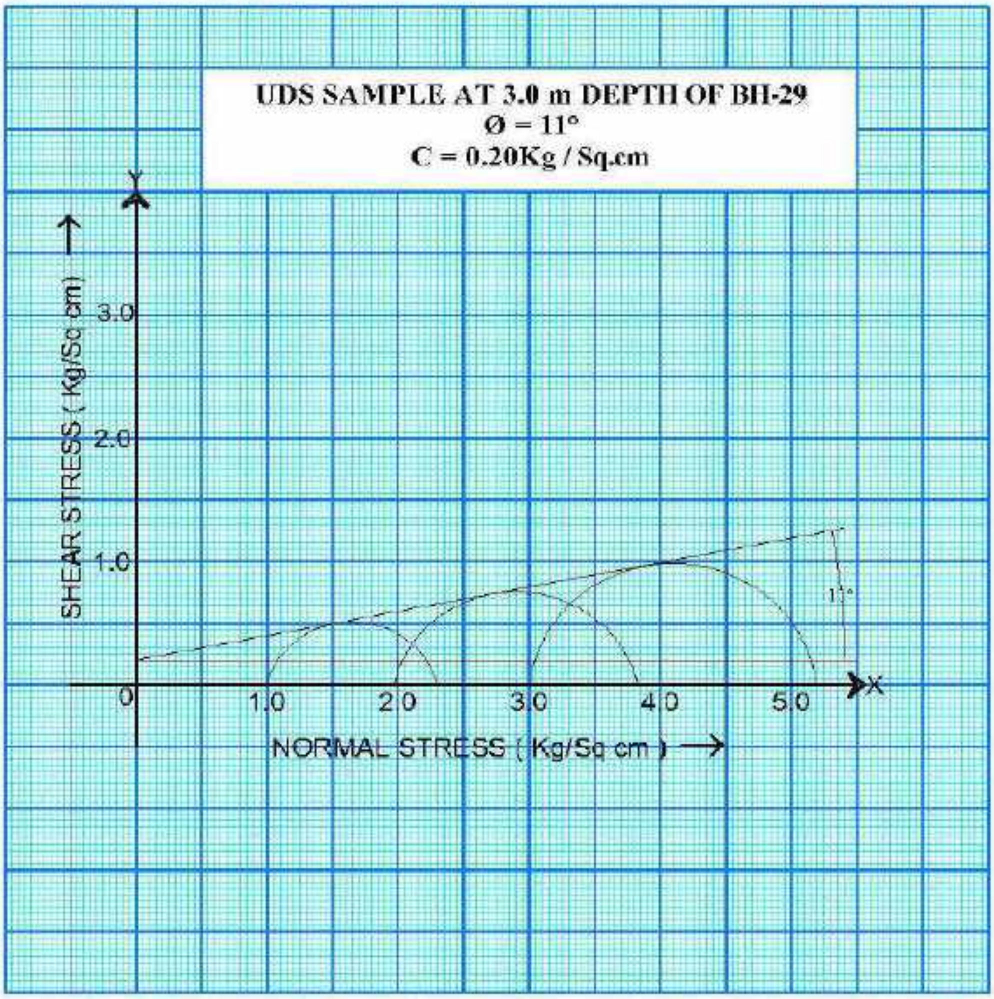
**UDS SAMPLE AT 36.0 m DEPTH OF BH-28**

Ø = 9°

C = 0.26Kg / Sq.cm



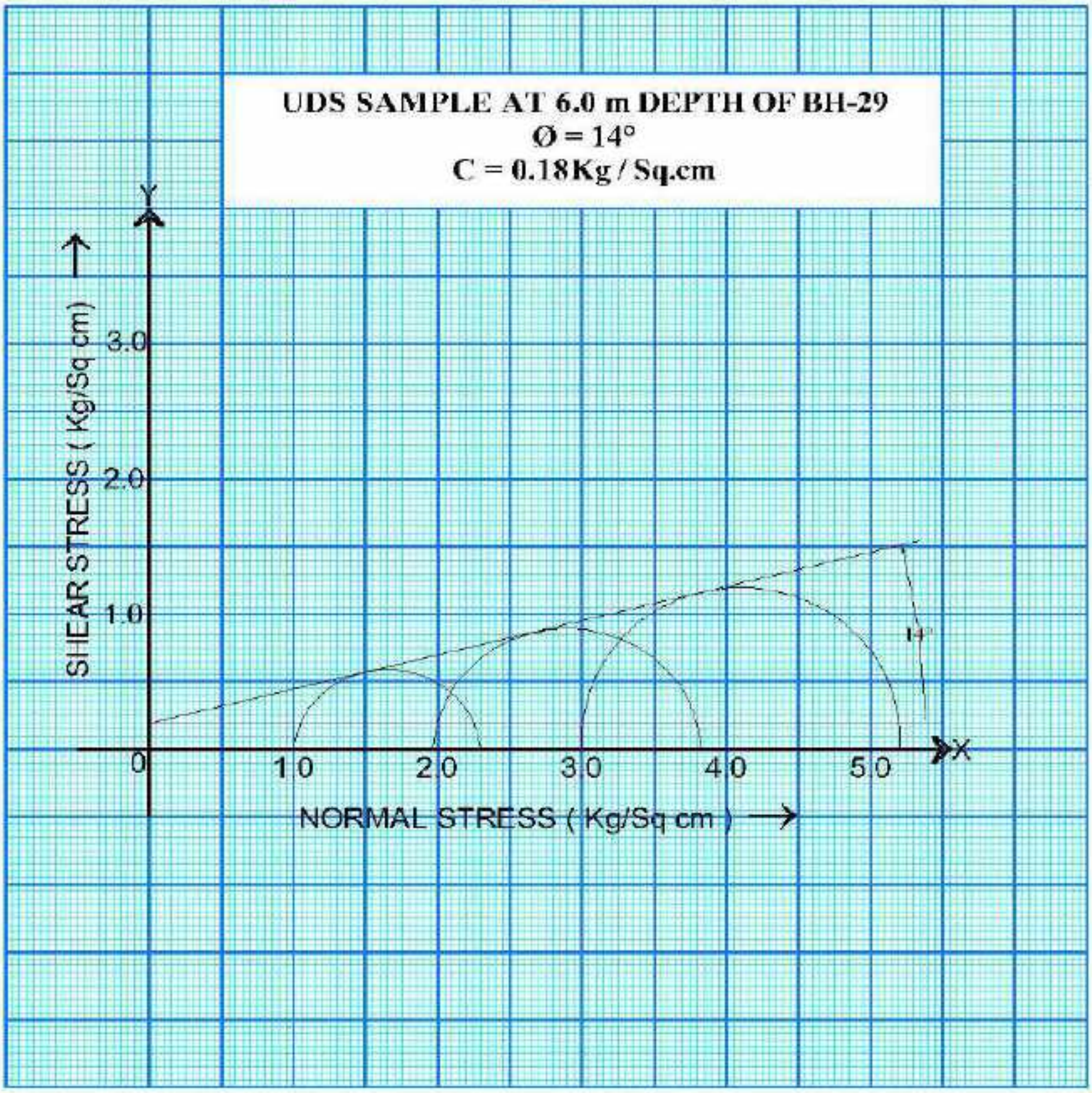
UDS SAMPLE AT 45.0 m DEPTH OF BH-28
Ø = 13°
C = 0.19Kg / Sq.cm



UDS SAMPLE AT 3.0 m DEPTH OF BH-29

Ø = 11°

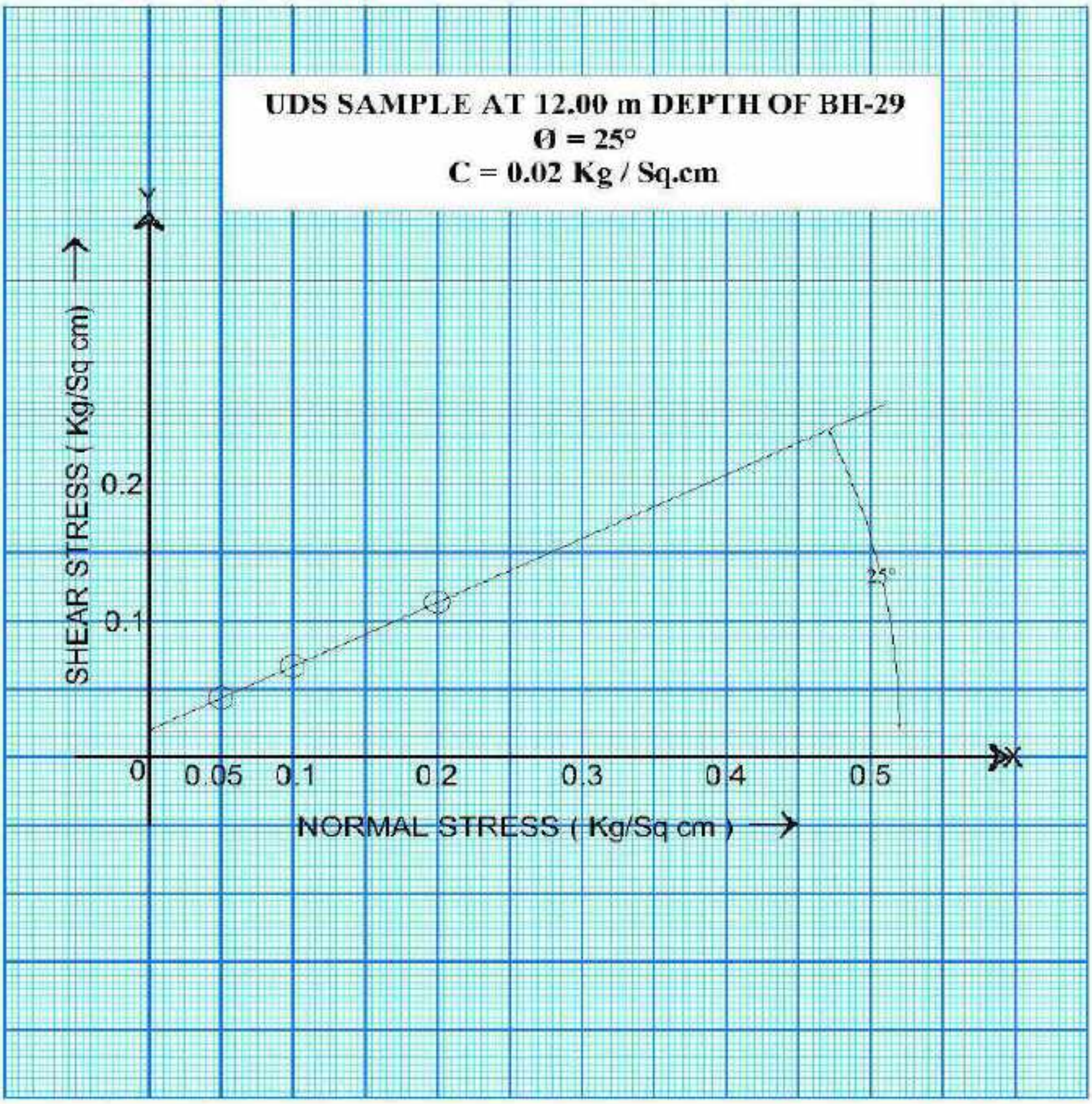
C = 0.20Kg / Sq.cm

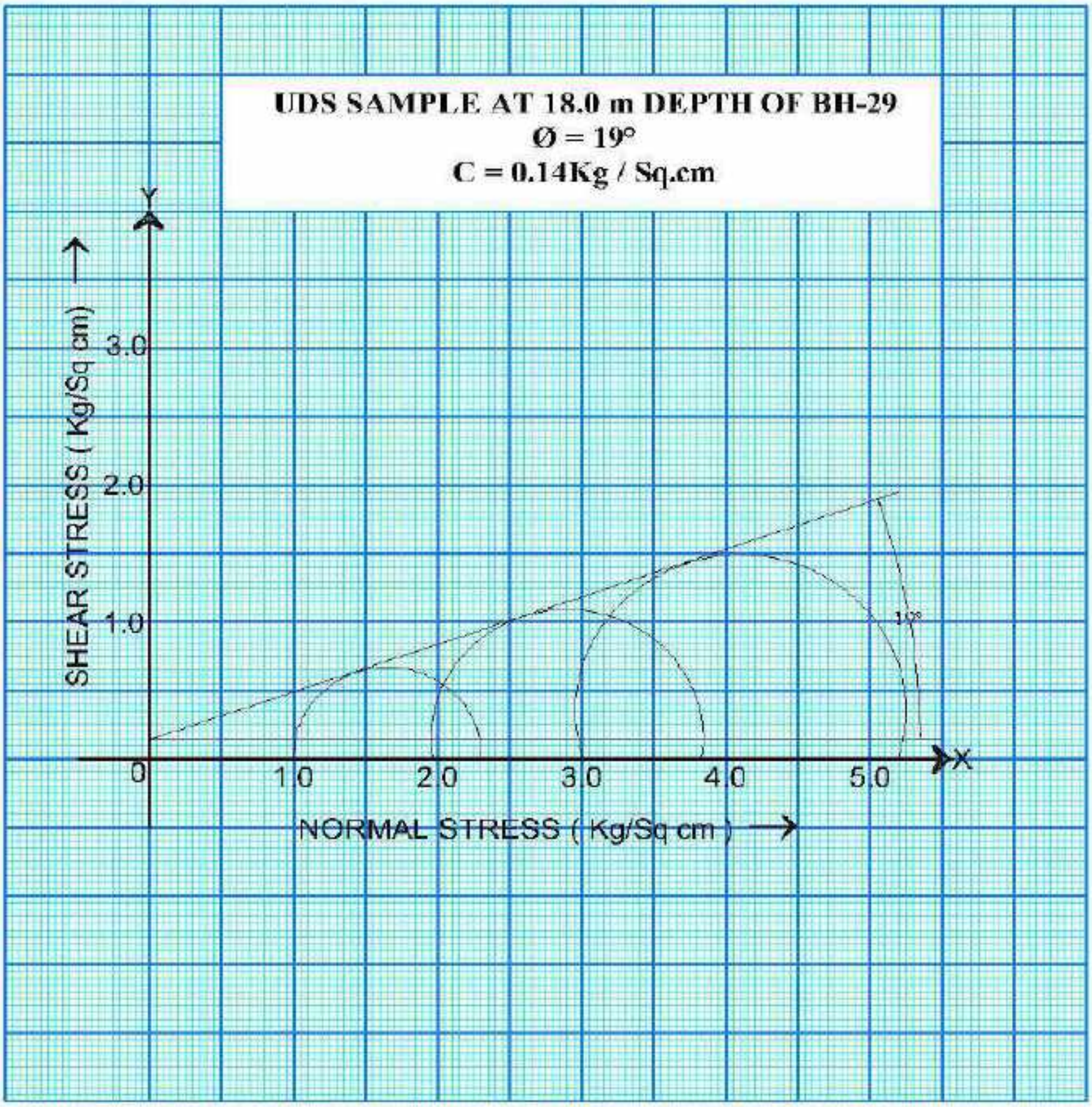


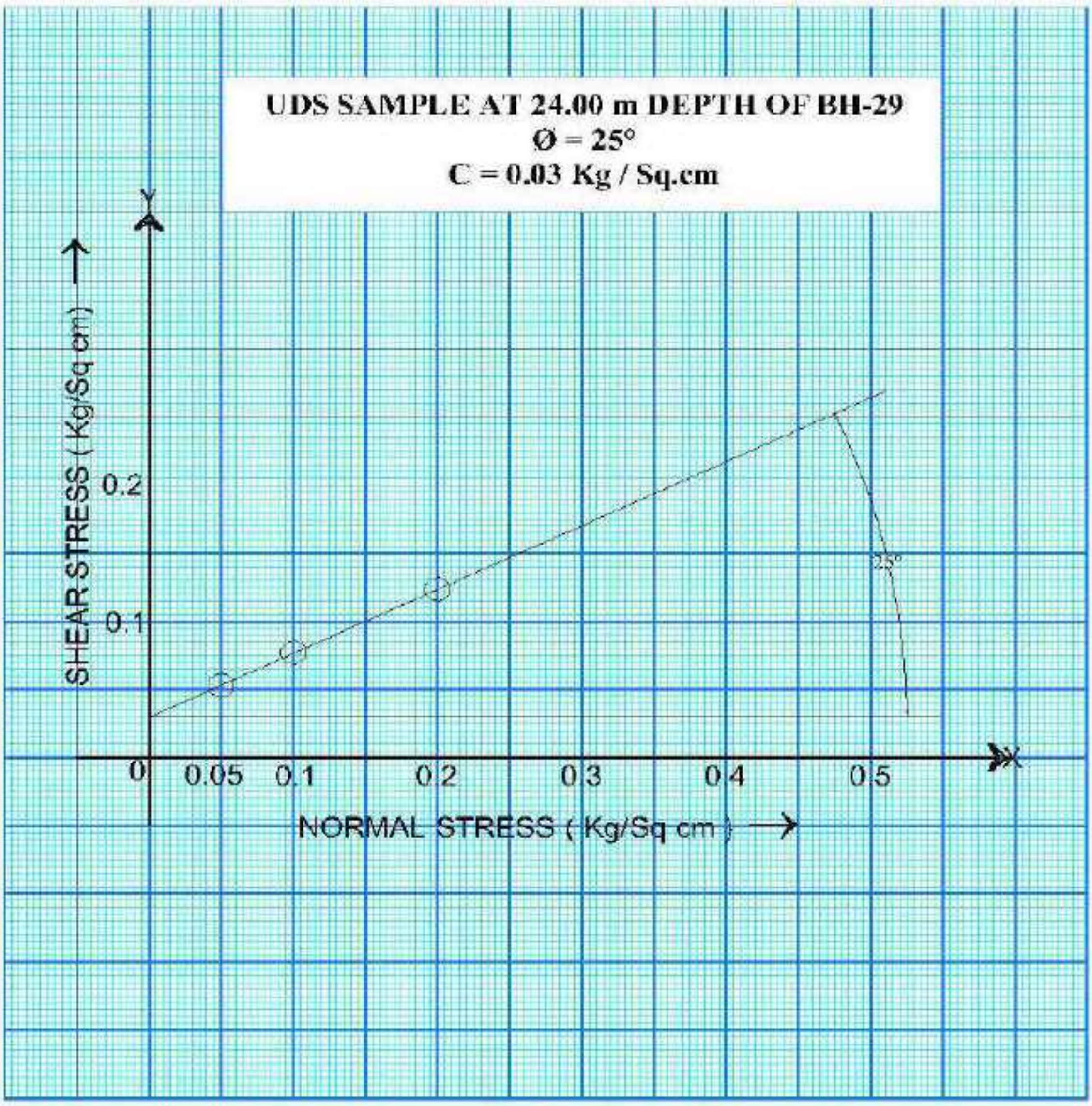
UDS SAMPLE AT 6.0 m DEPTH OF BH-29

Ø = 14°

C = 0.18Kg / Sq.cm


UDS SAMPLE AT 12.00 m DEPTH OF BH-29
Ø = 25°
C = 0.02 Kg / Sq.cm
Y
X
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°

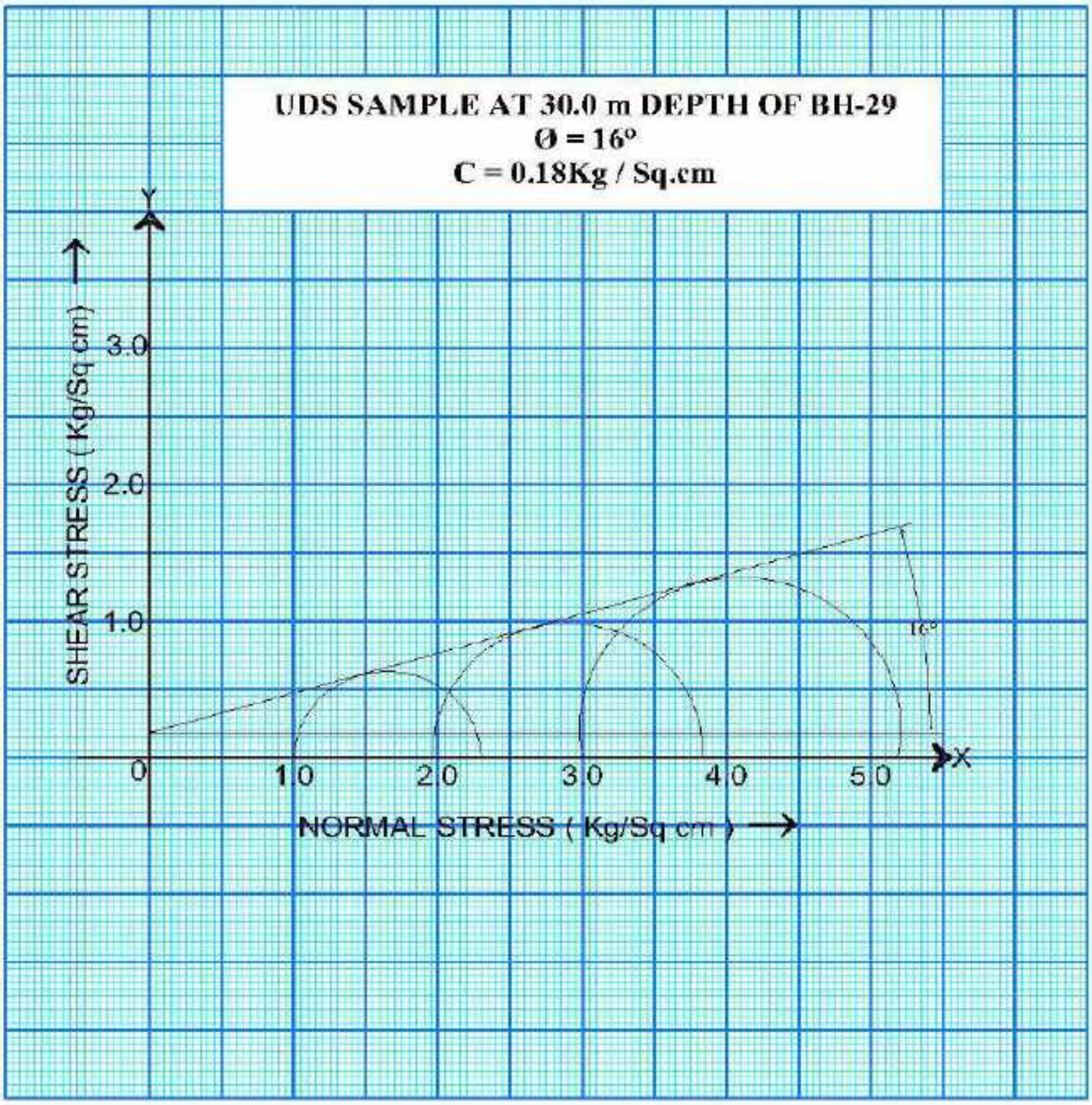

UDS SAMPLE AT 18.0 m DEPTH OF BH-29
Ø = 19°
C = 0.14Kg / Sq.cm



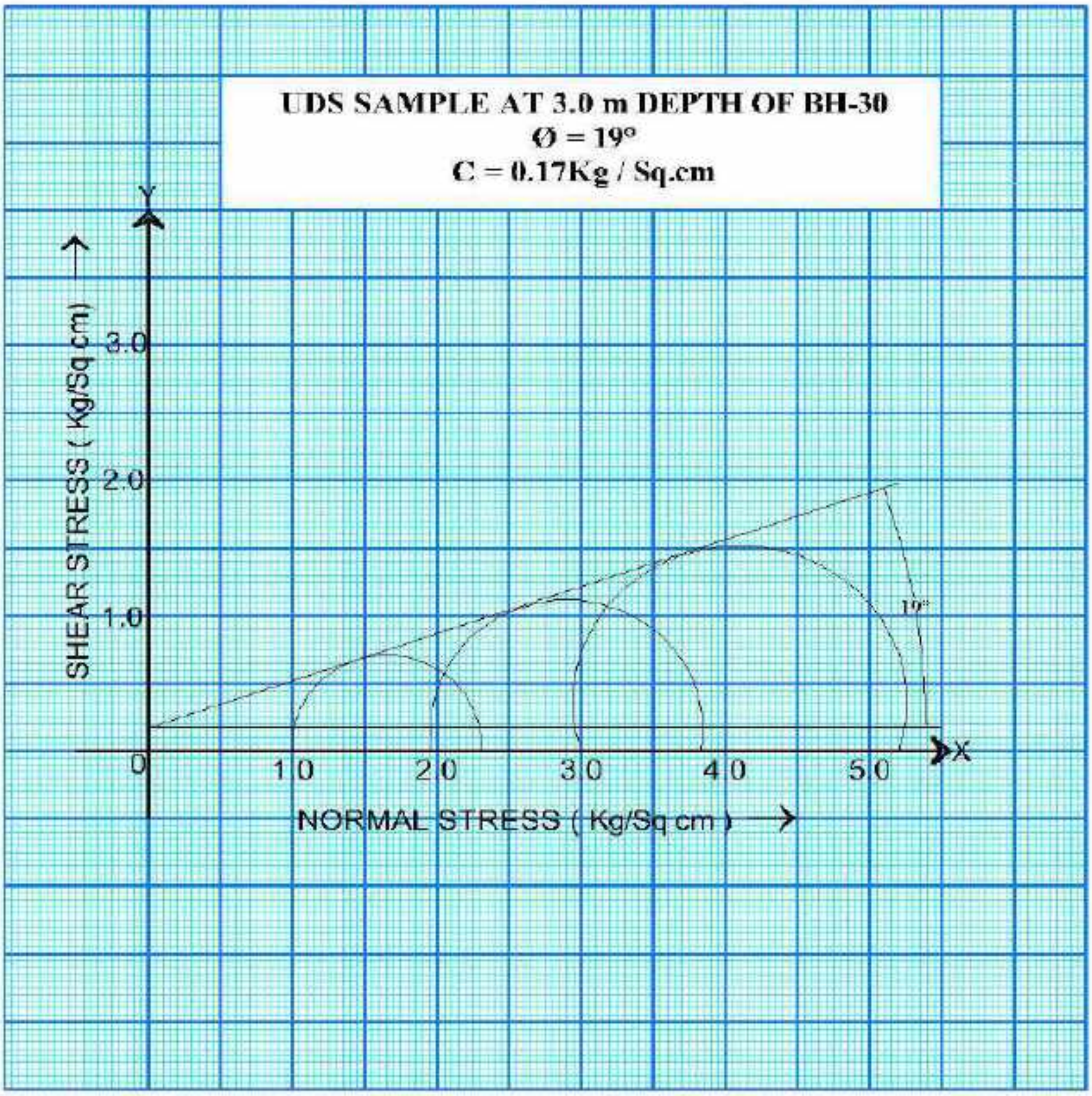
UDS SAMPLE AT 24.00 m DEPTH OF BH-29

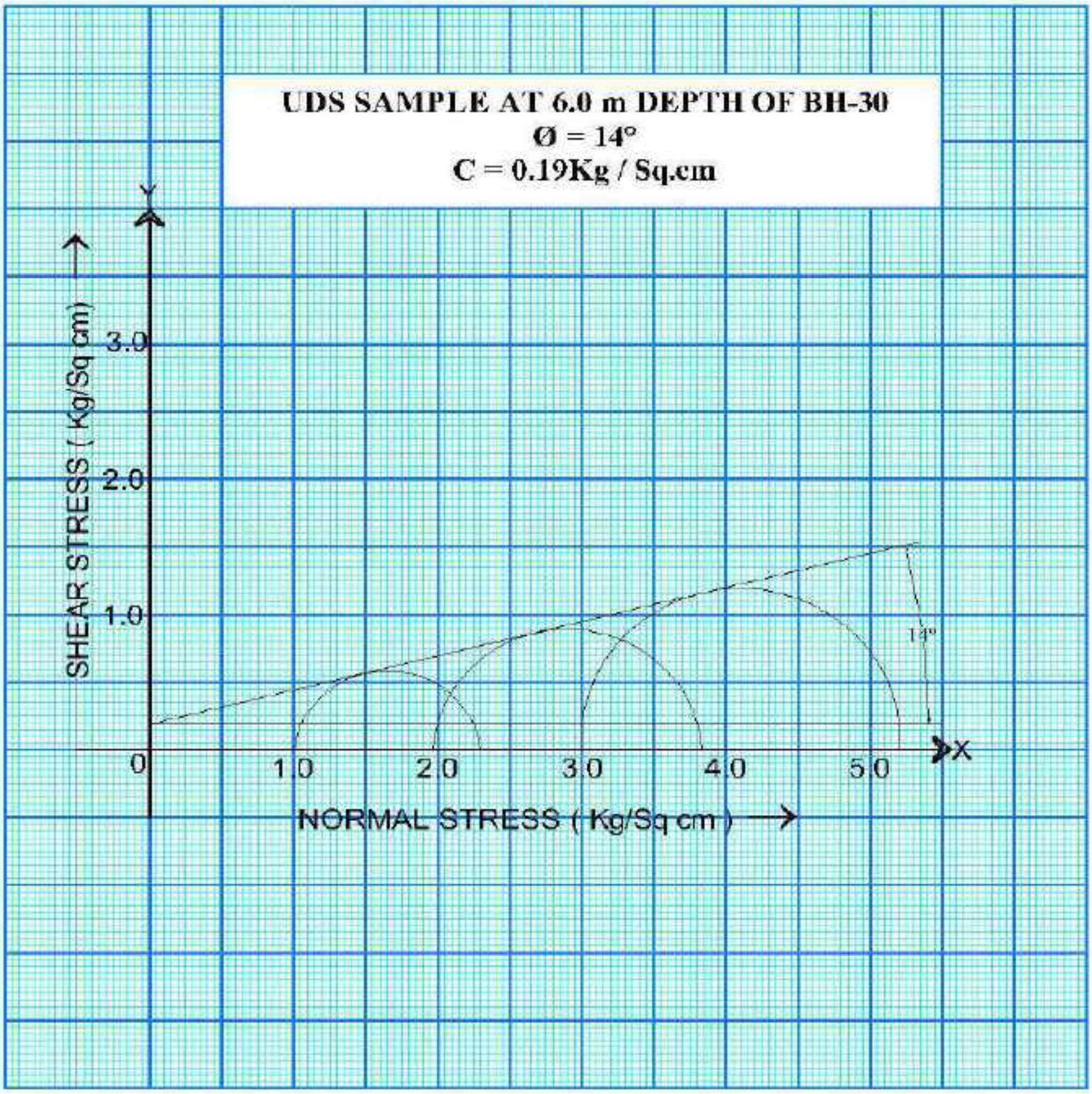
Ø = 25°

C = 0.03 Kg / Sq.cm

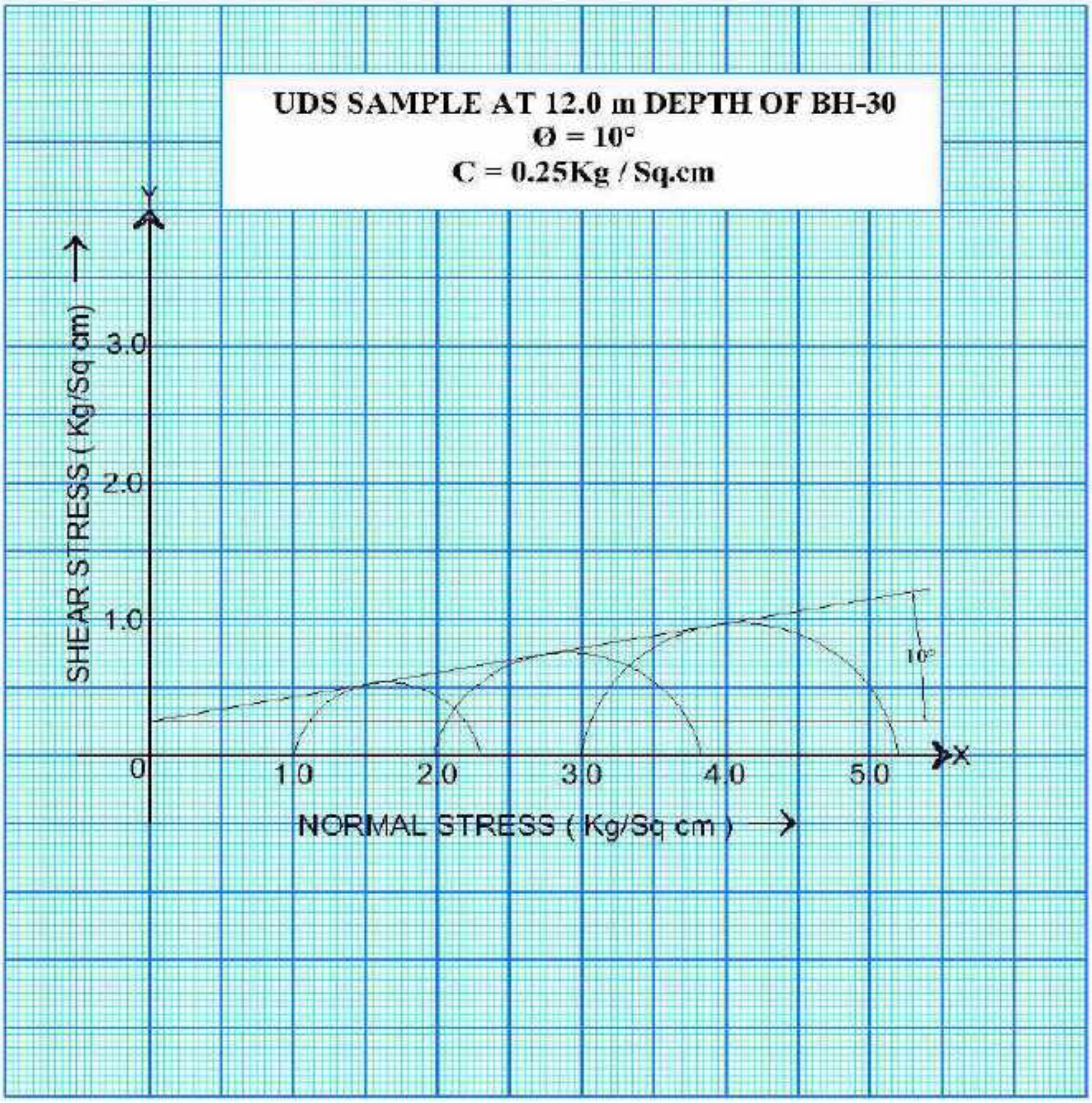


UDS SAMPLE AT 30.0 m DEPTH OF BH-29
Ø = 16°
C = 0.18Kg / Sq.cm

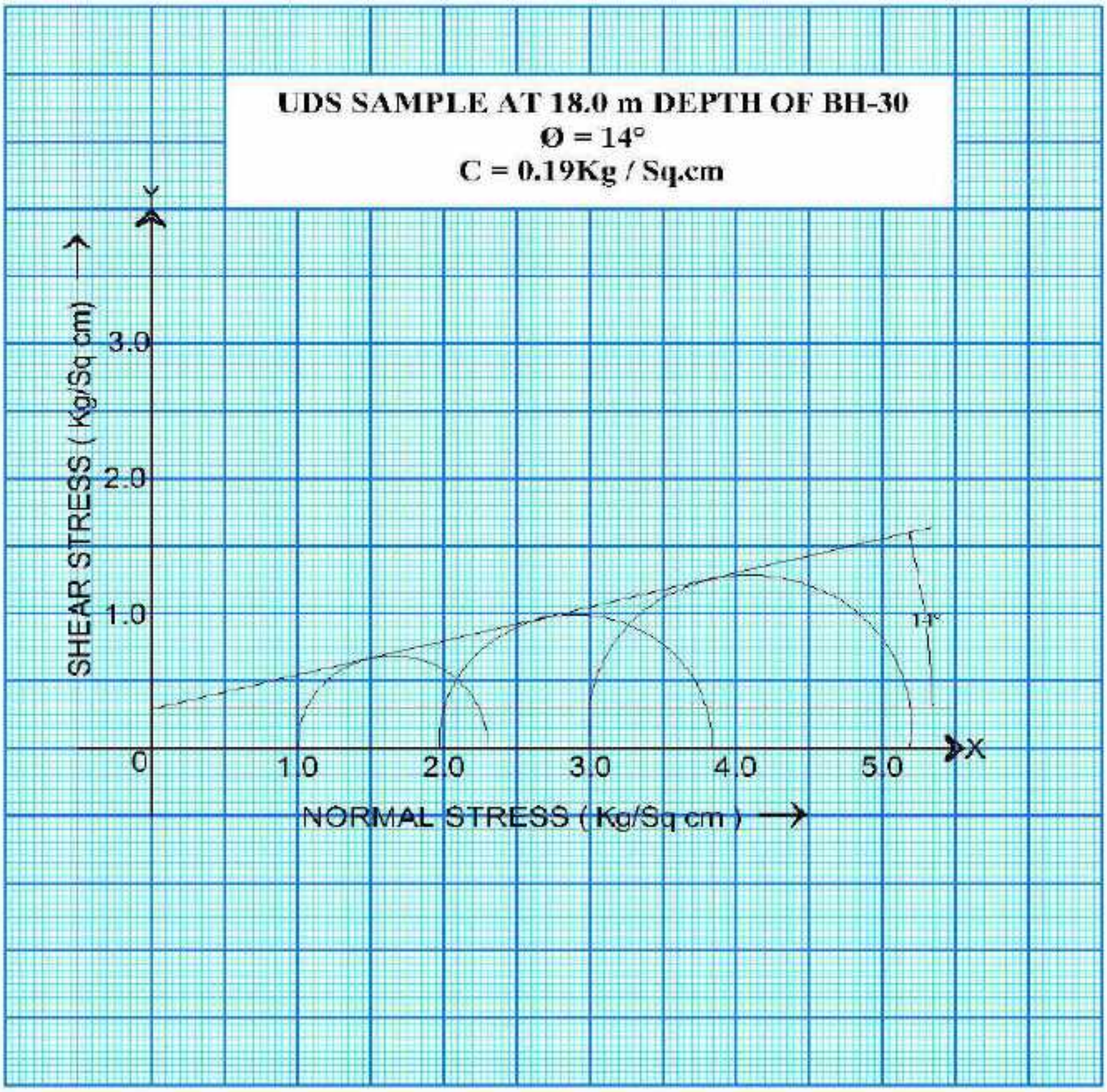

UDS SAMPLE AT 3.0 m DEPTH OF BH-30
Ø = 19°
C = 0.17Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
19°
NORMAL STRESS ( Kg/Sq cm )

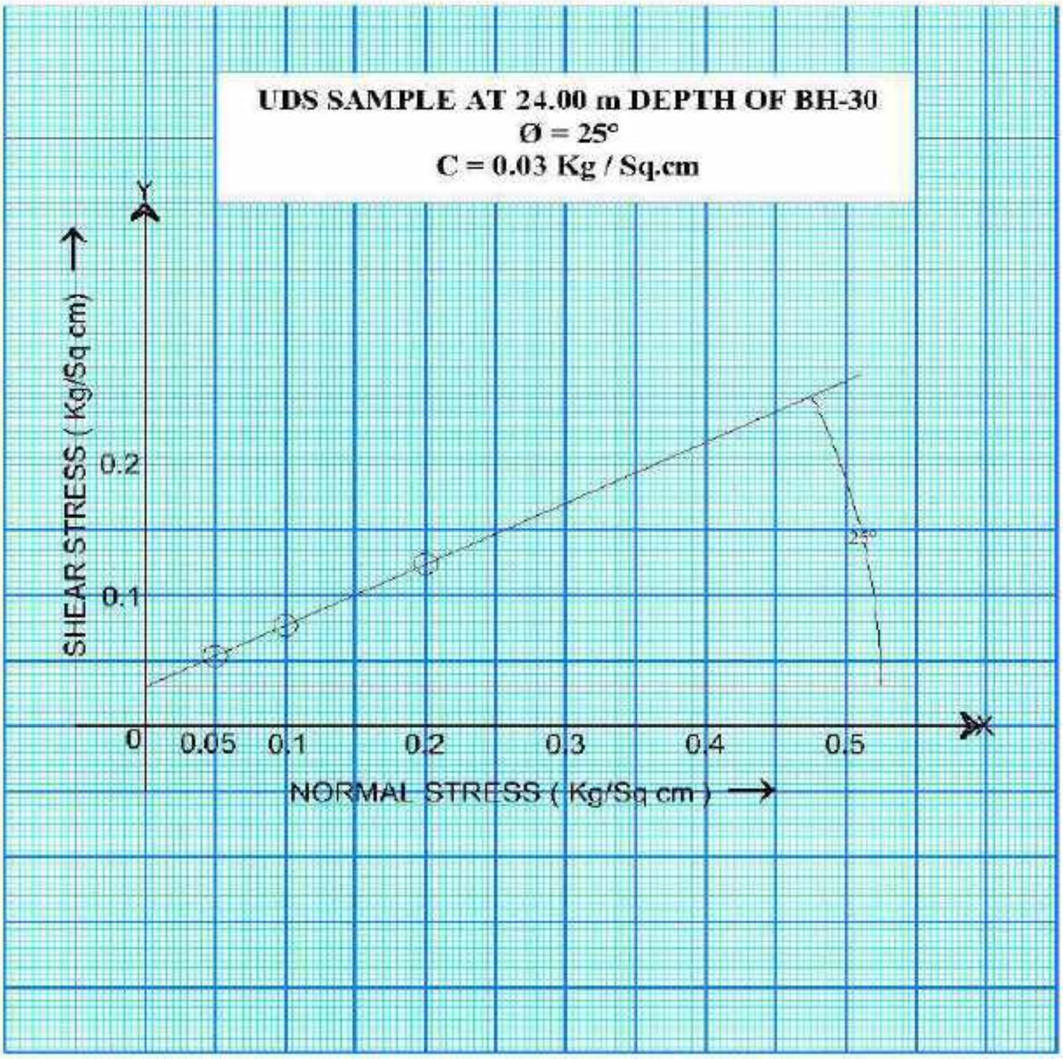


UDS SAMPLE AT 6.0 m DEPTH OF BH-30
Ø = 14°
C = 0.19Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS ( Kg/Sq cm )

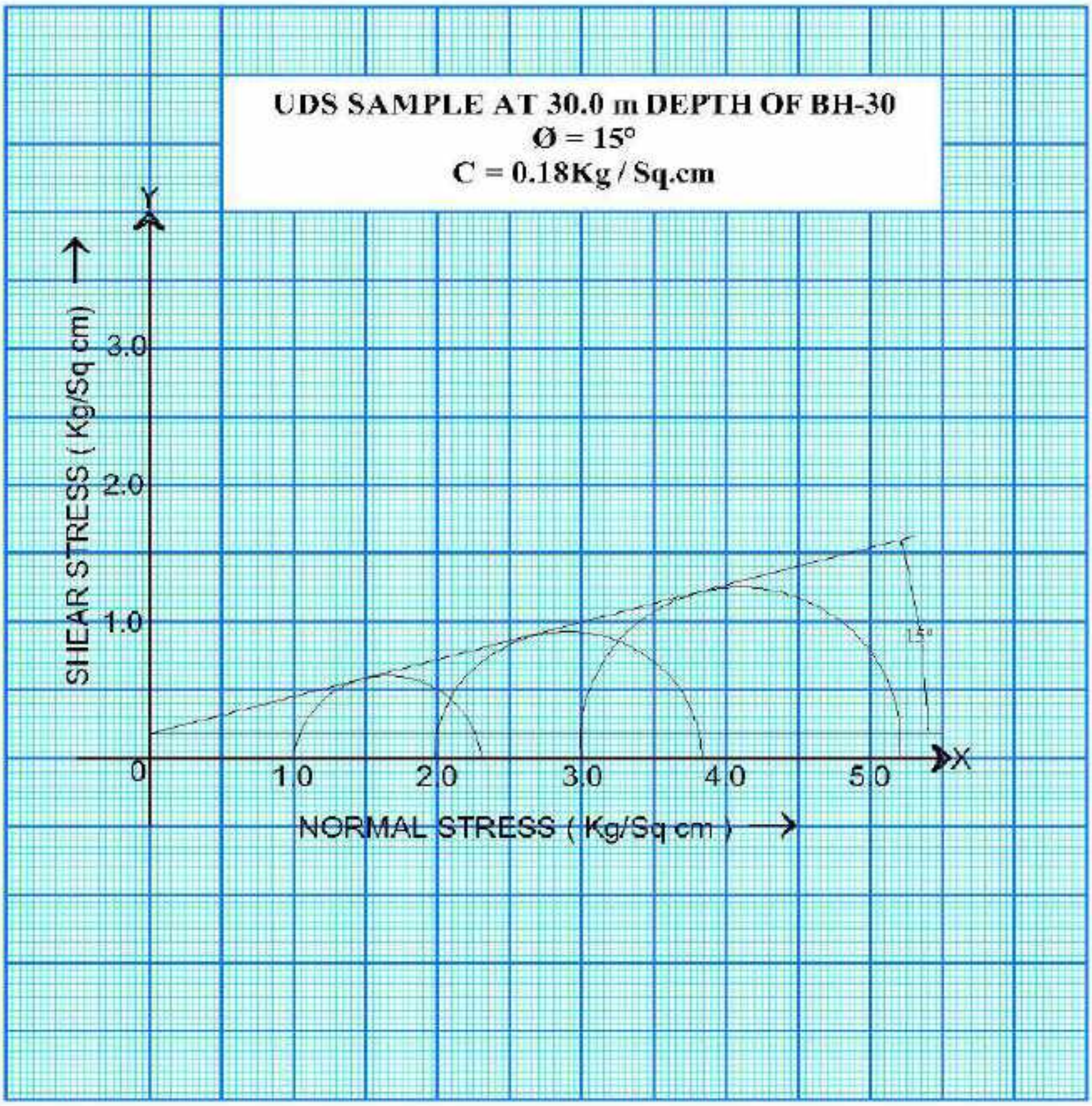


UDS SAMPLE AT 12.0 m DEPTH OF BH-30
Ø = 10°
C = 0.25Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
10°
NORMAL STRESS ( Kg/Sq cm )

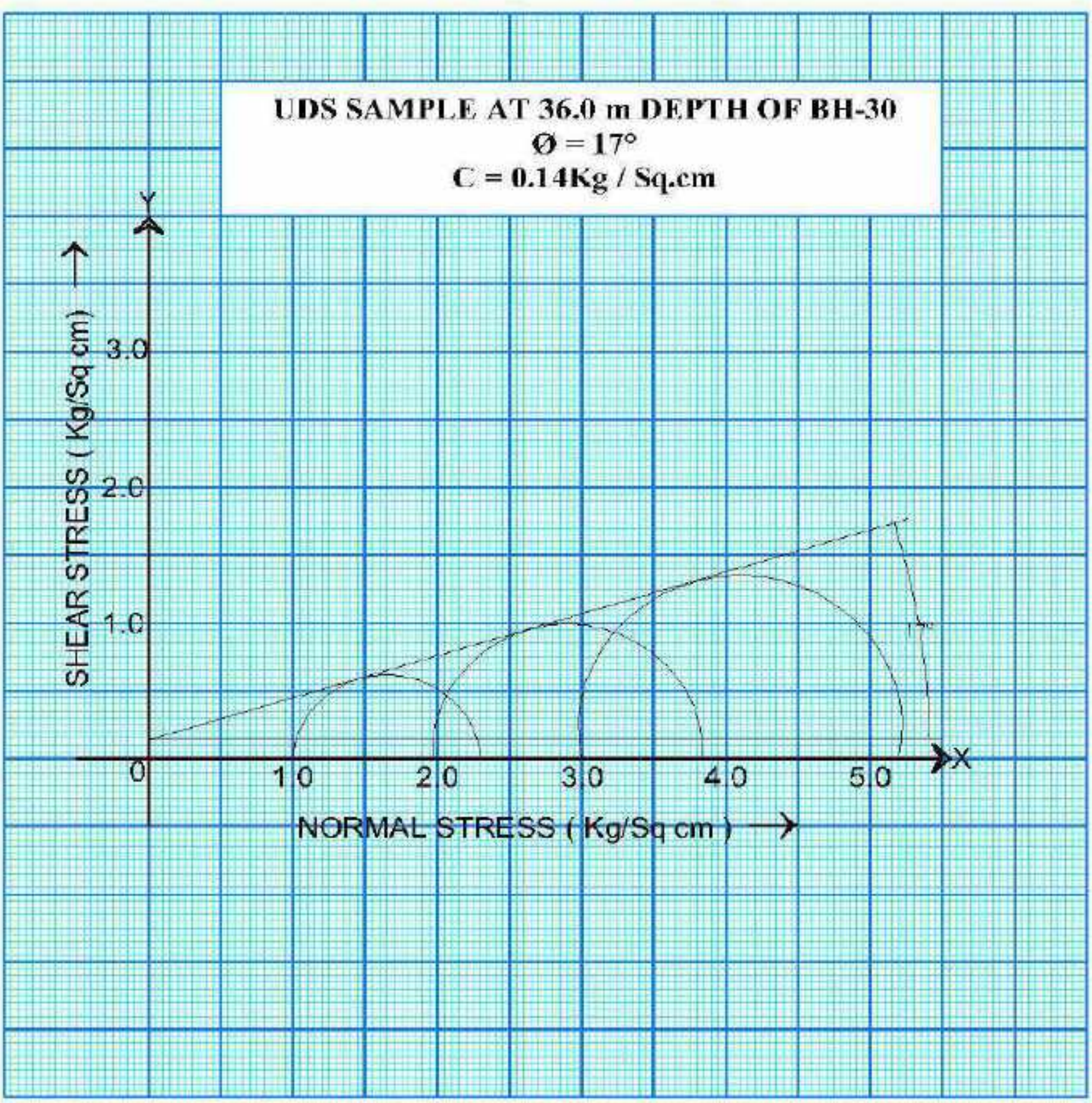

UDS SAMPLE AT 18.0 m DEPTH OF BH-30
Ø = 14°
C = 0.19Kg / Sq.cm
Y
X
SHEAR STRESS ( Kg/Sq cm)
NORMAL STRESS ( Kg/Sq cm )
0
1.0
2.0
3.0
4.0
5.0
14°



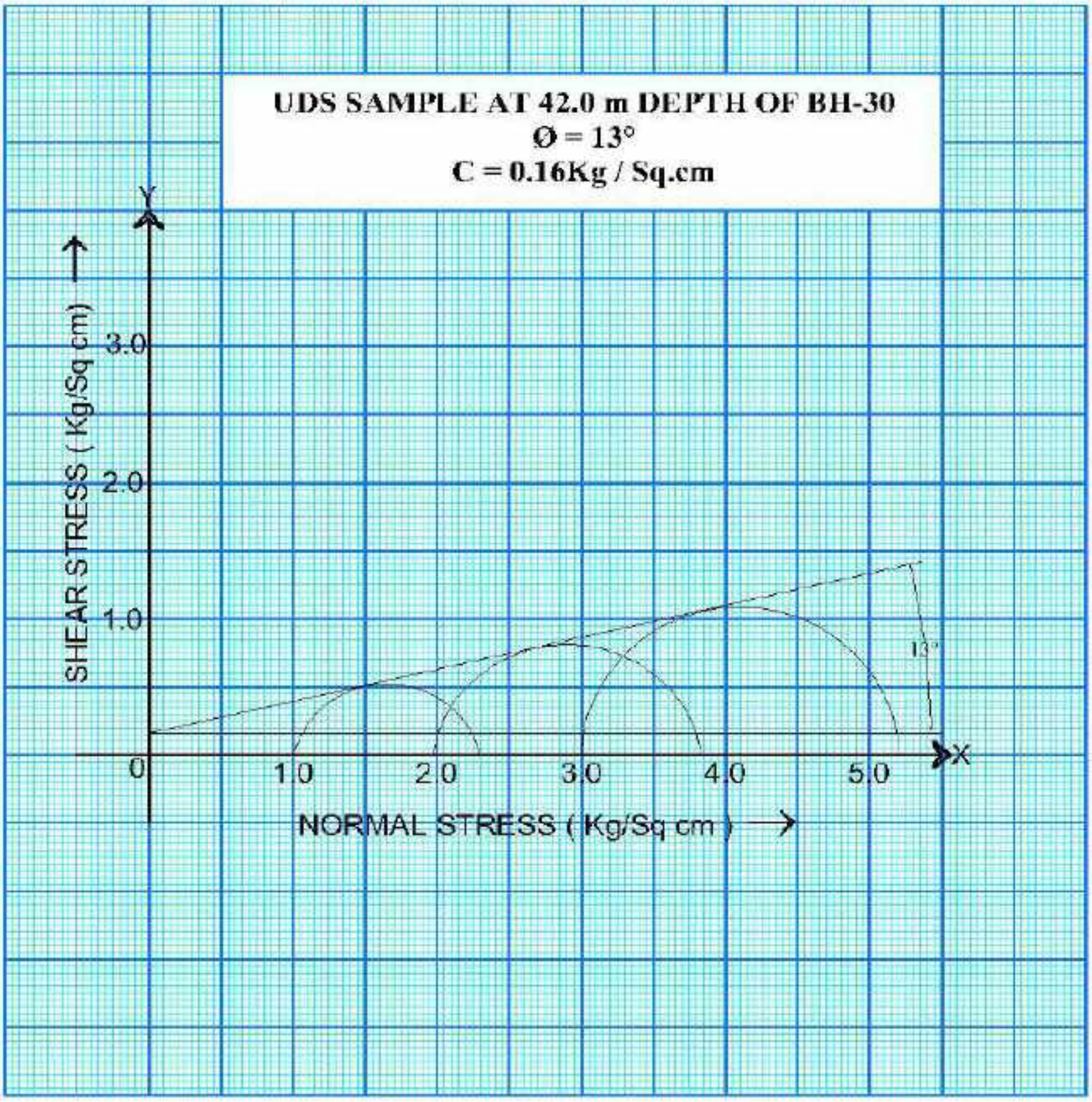
UDS SAMPLE AT 24.00 m DEPTH OF BH-30
Ø = 25°
C = 0.03 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm) →
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
25°
NORMAL STRESS ( Kg/Sq cm ) →



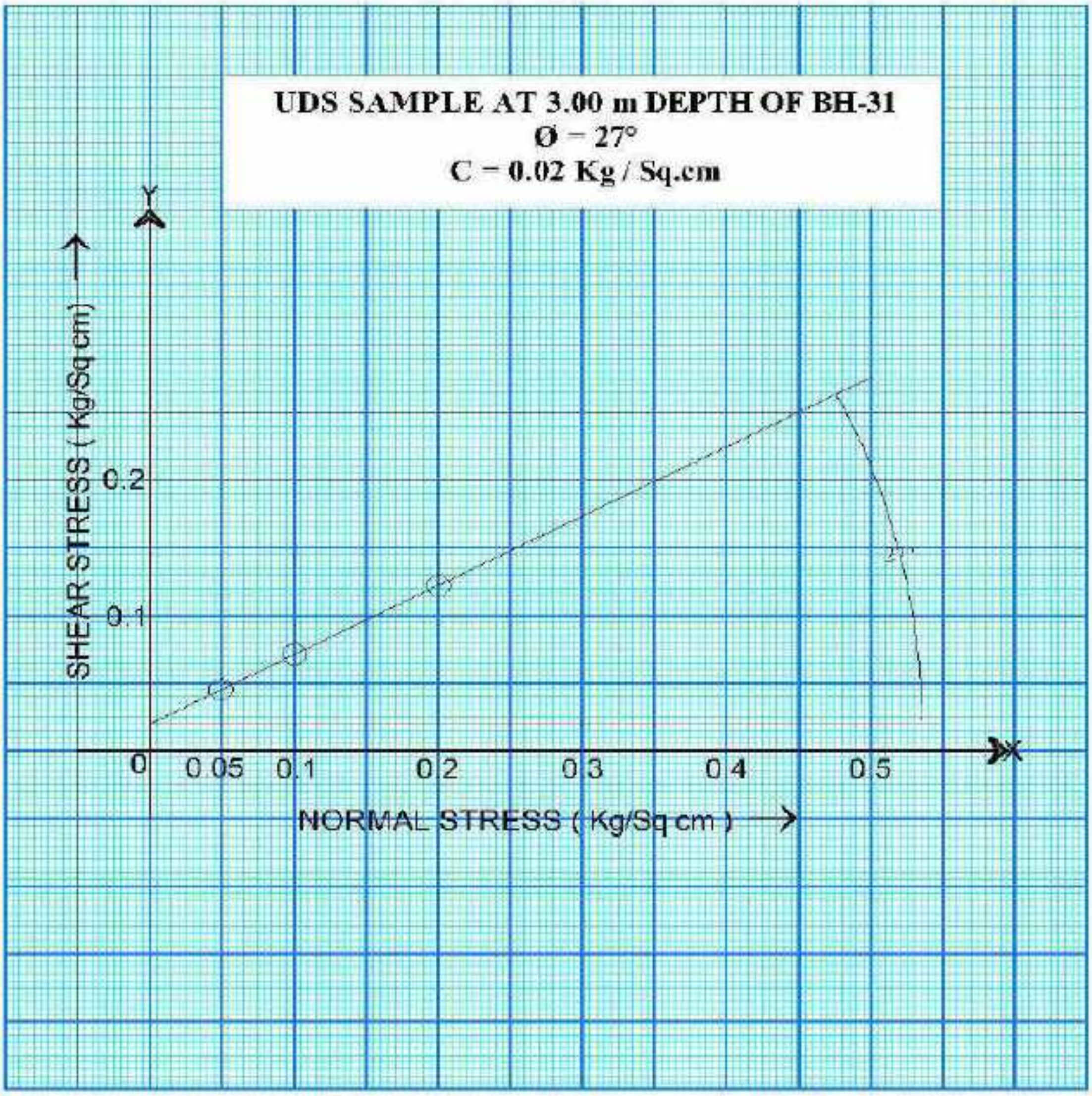
UDS SAMPLE AT 30.0 m DEPTH OF BH-30
Ø = 15°
C = 0.18Kg / Sq.cm



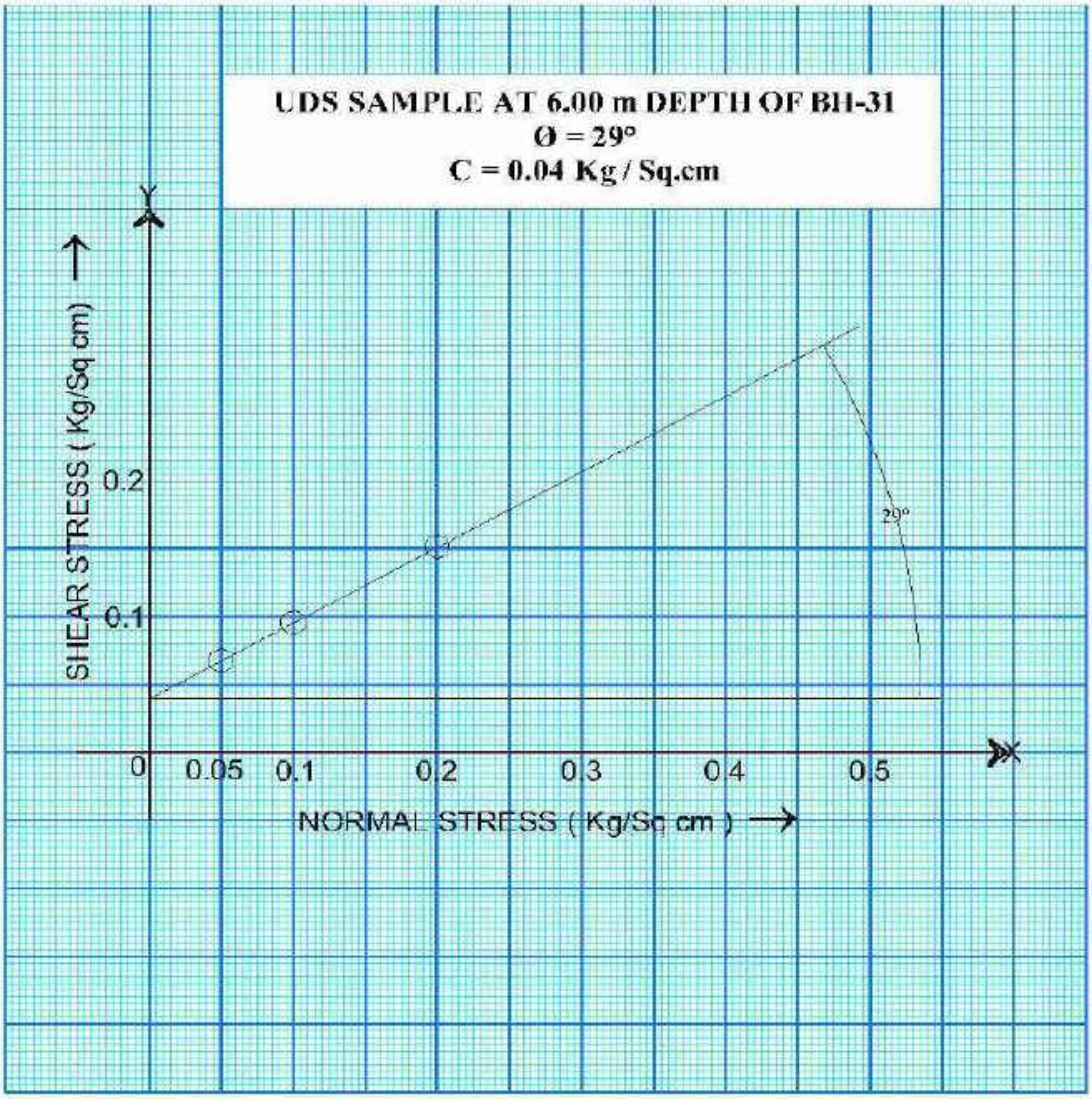
UDS SAMPLE AT 36.0 m DEPTH OF BH-30
Ø = 17°
C = 0.14Kg / Sq.cm



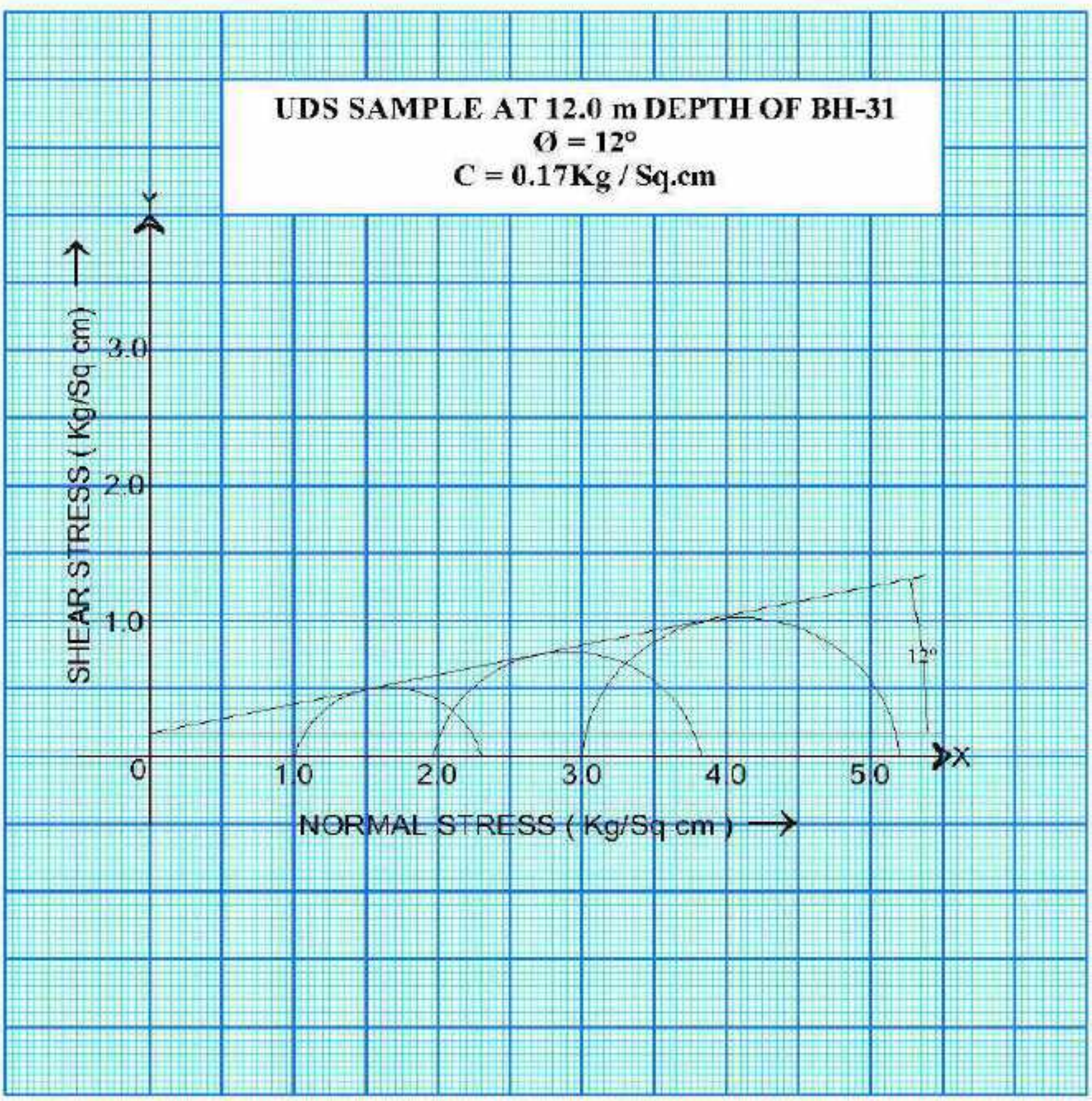
UDS SAMPLE AT 42.0 m DEPTH OF BH-30
Ø = 13°
C = 0.16Kg / Sq.cm



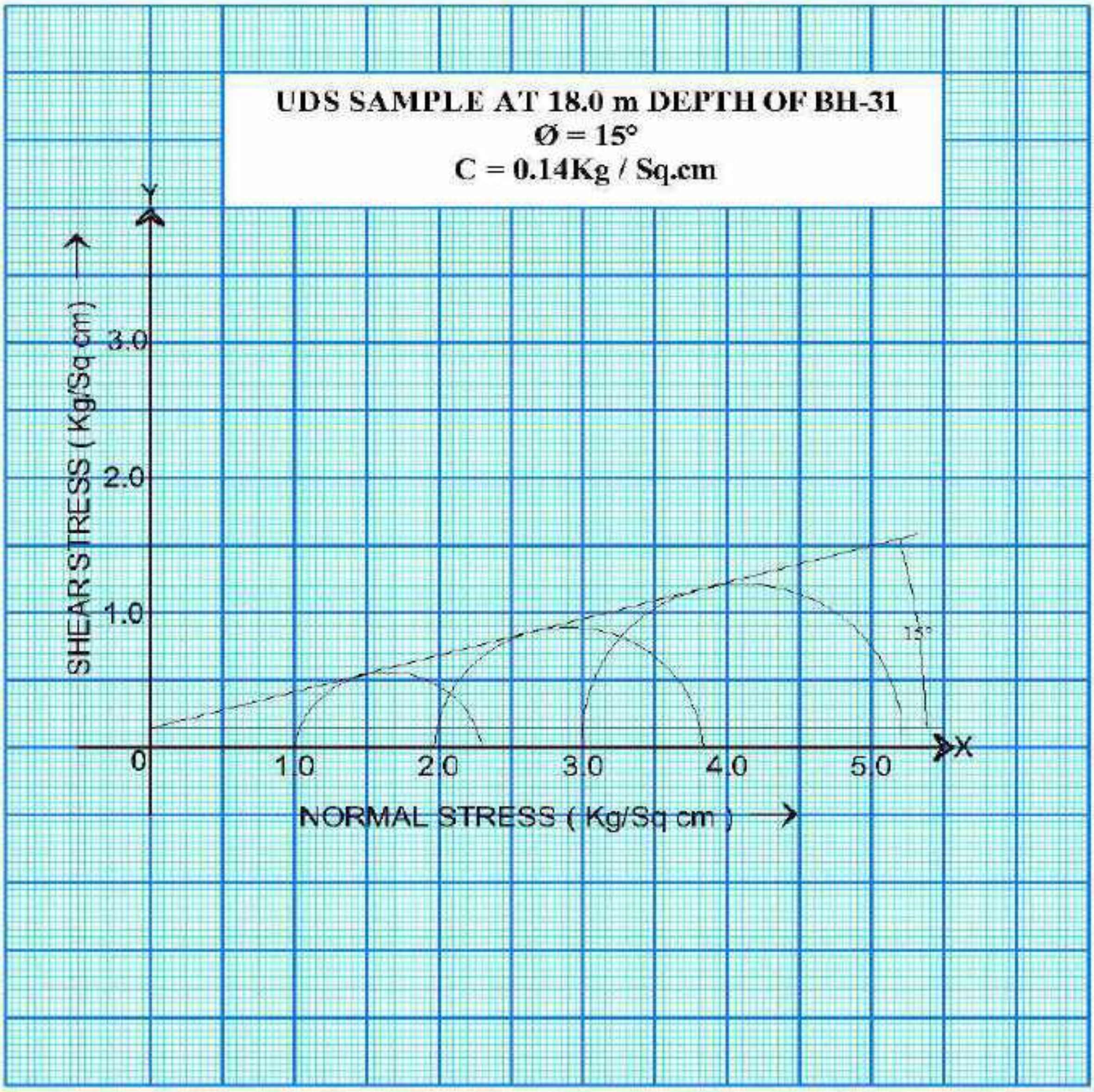
UDS SAMPLE AT 3.00 m DEPTH OF BH-31
Ø = 27°
C = 0.02 Kg / Sq.cm

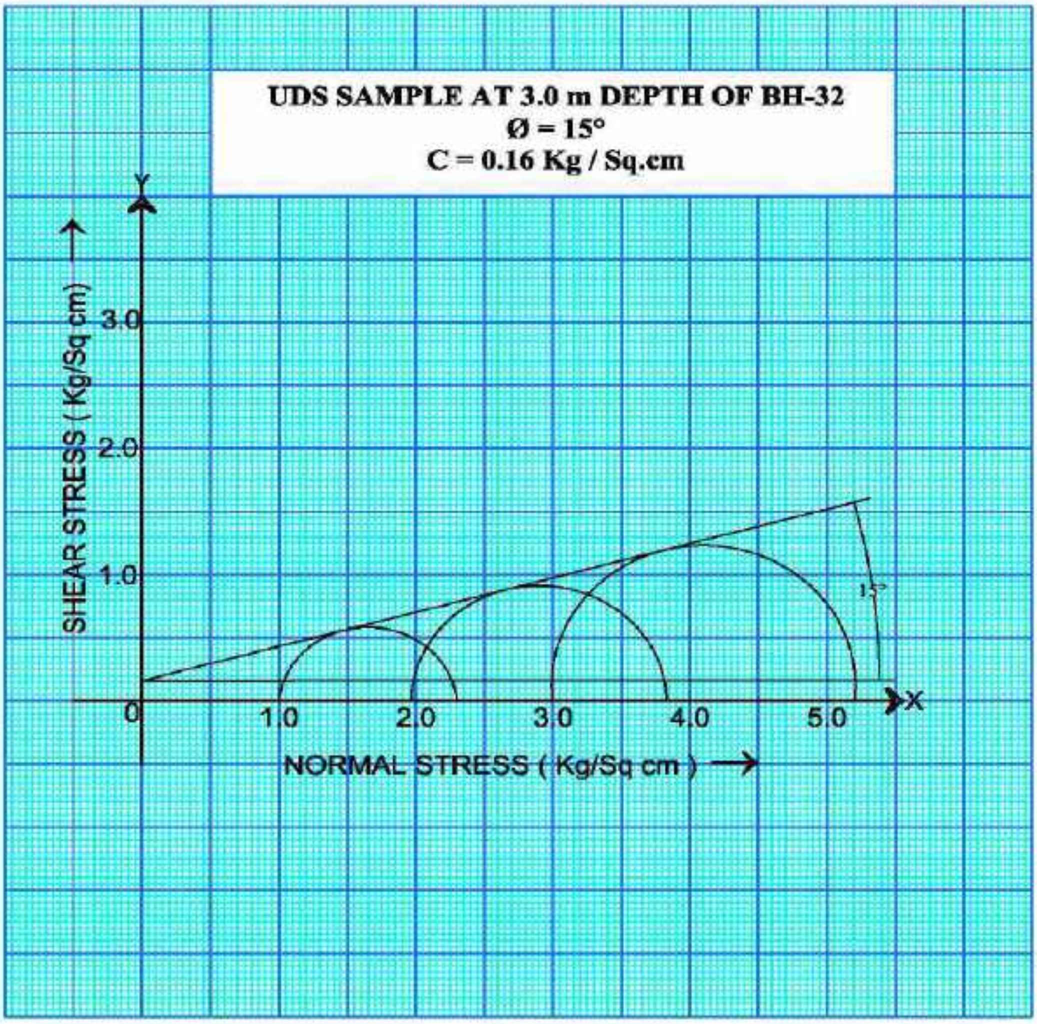


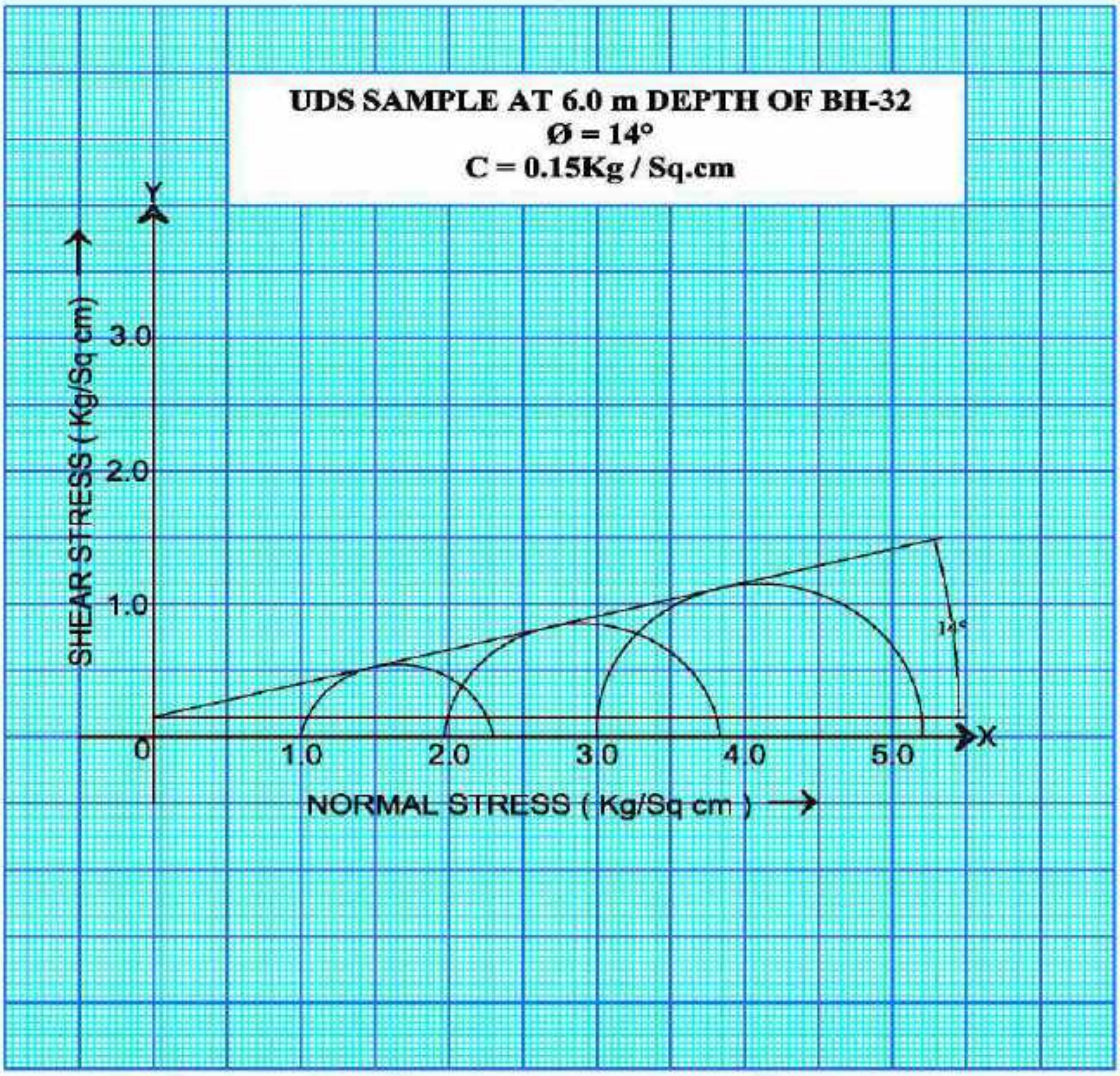
**UDS SAMPLE AT 6.00 m DEPTH OF BH-31**
Ø = 29°
C = 0.04 Kg / Sq.cm

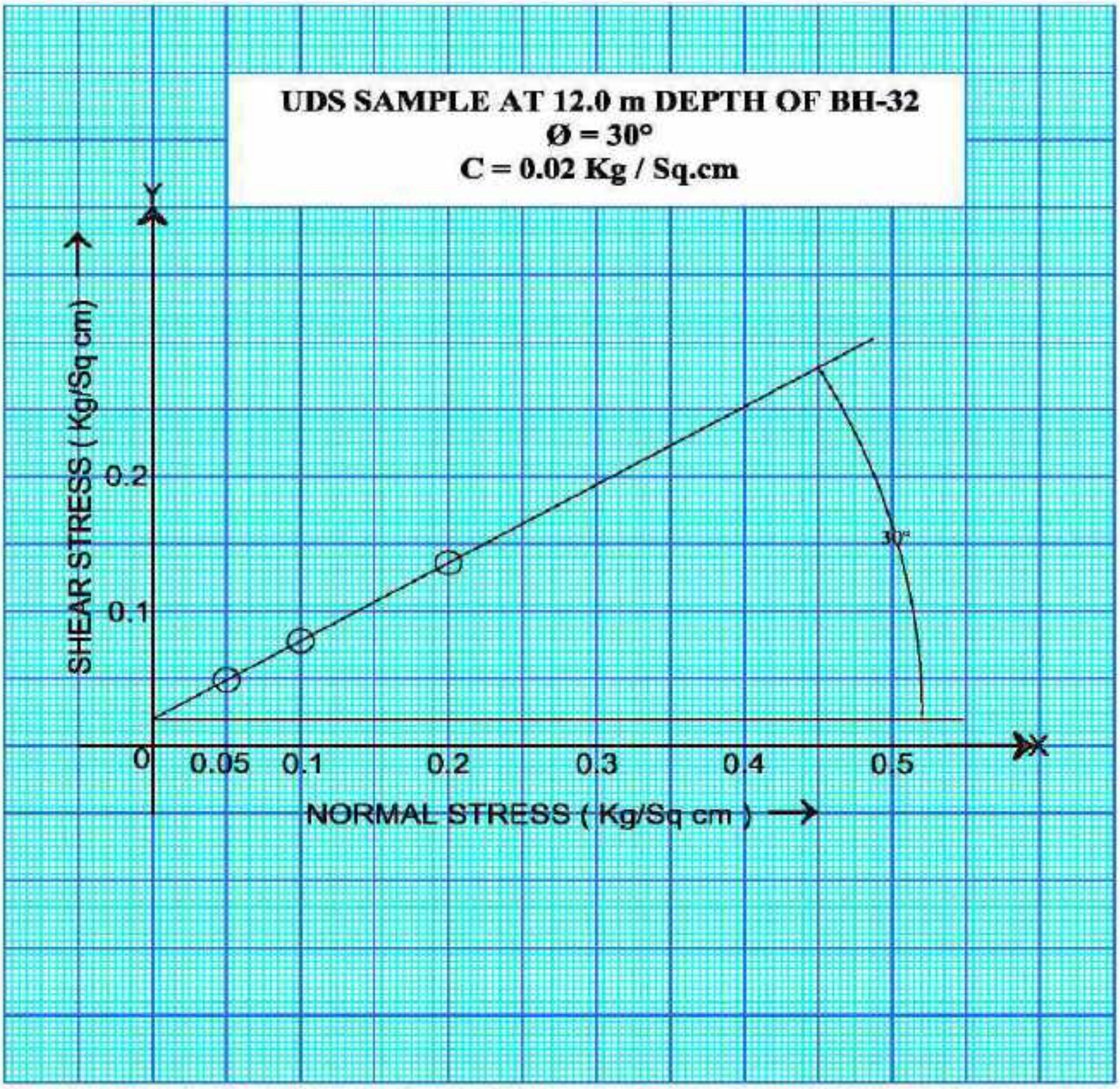


UDS SAMPLE AT 12.0 m DEPTH OF BH-31
Ø = 12°
C = 0.17Kg / Sq.cm

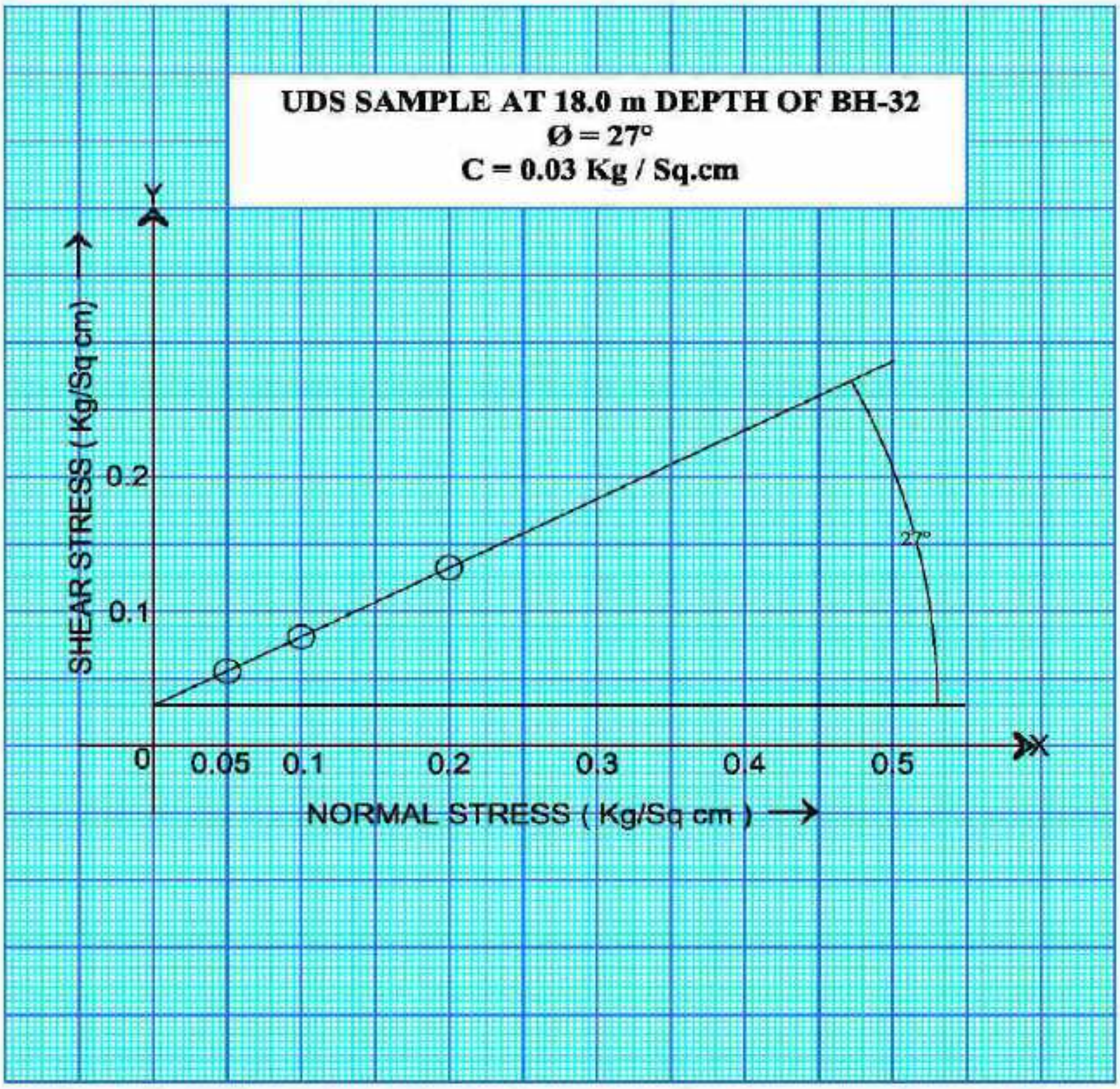

UDS SAMPLE AT 18.0 m DEPTH OF BH-31
Ø = 15°
C = 0.14Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
15°
NORMAL STRESS ( Kg/Sq cm )


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
15°
NORMAL STRESS ( Kg/Sq cm ) →

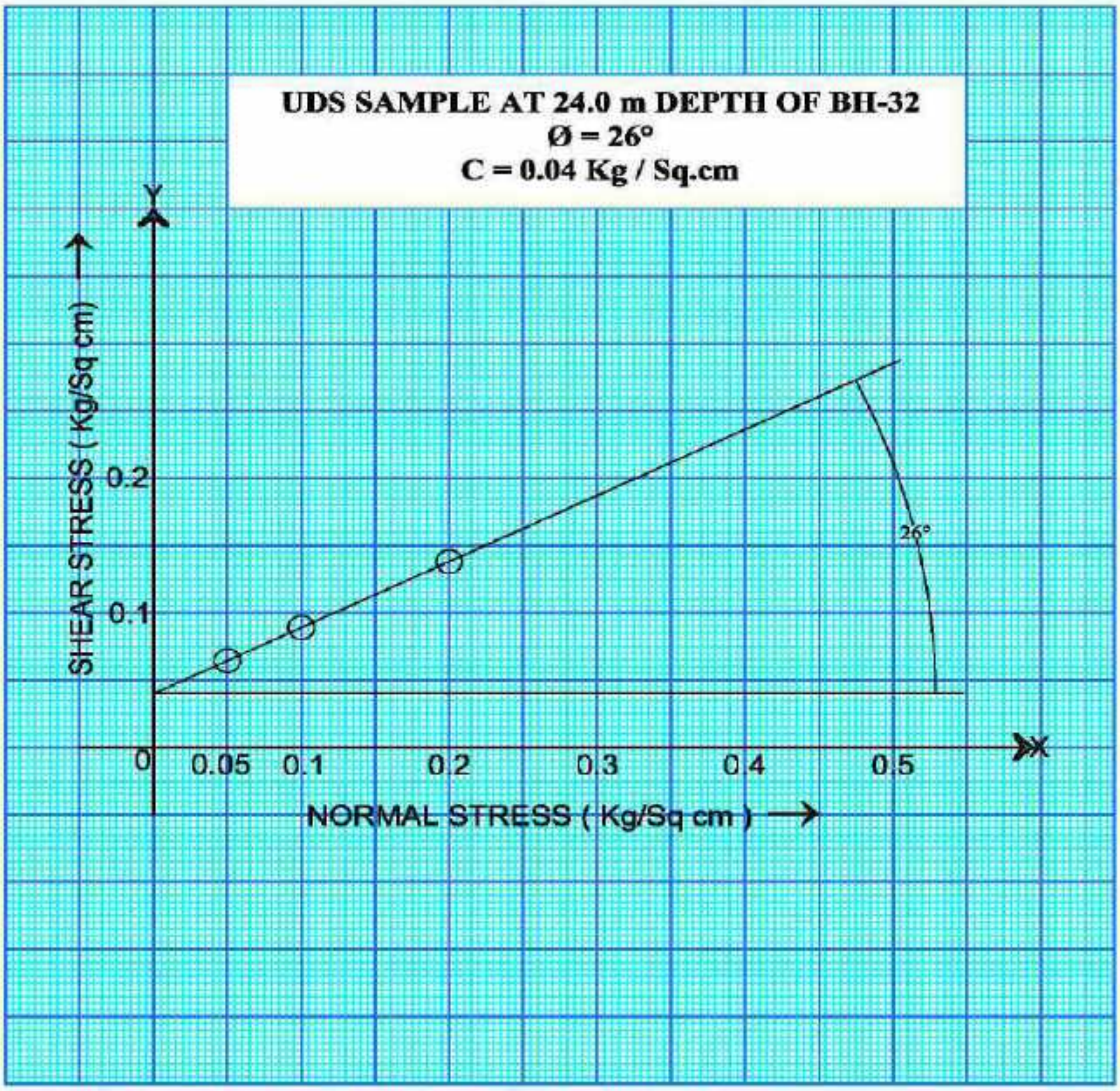

UDS SAMPLE AT 6.0 m DEPTH OF BH-32
Ø = 14°
C = 0.15Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS ( Kg/Sq cm )



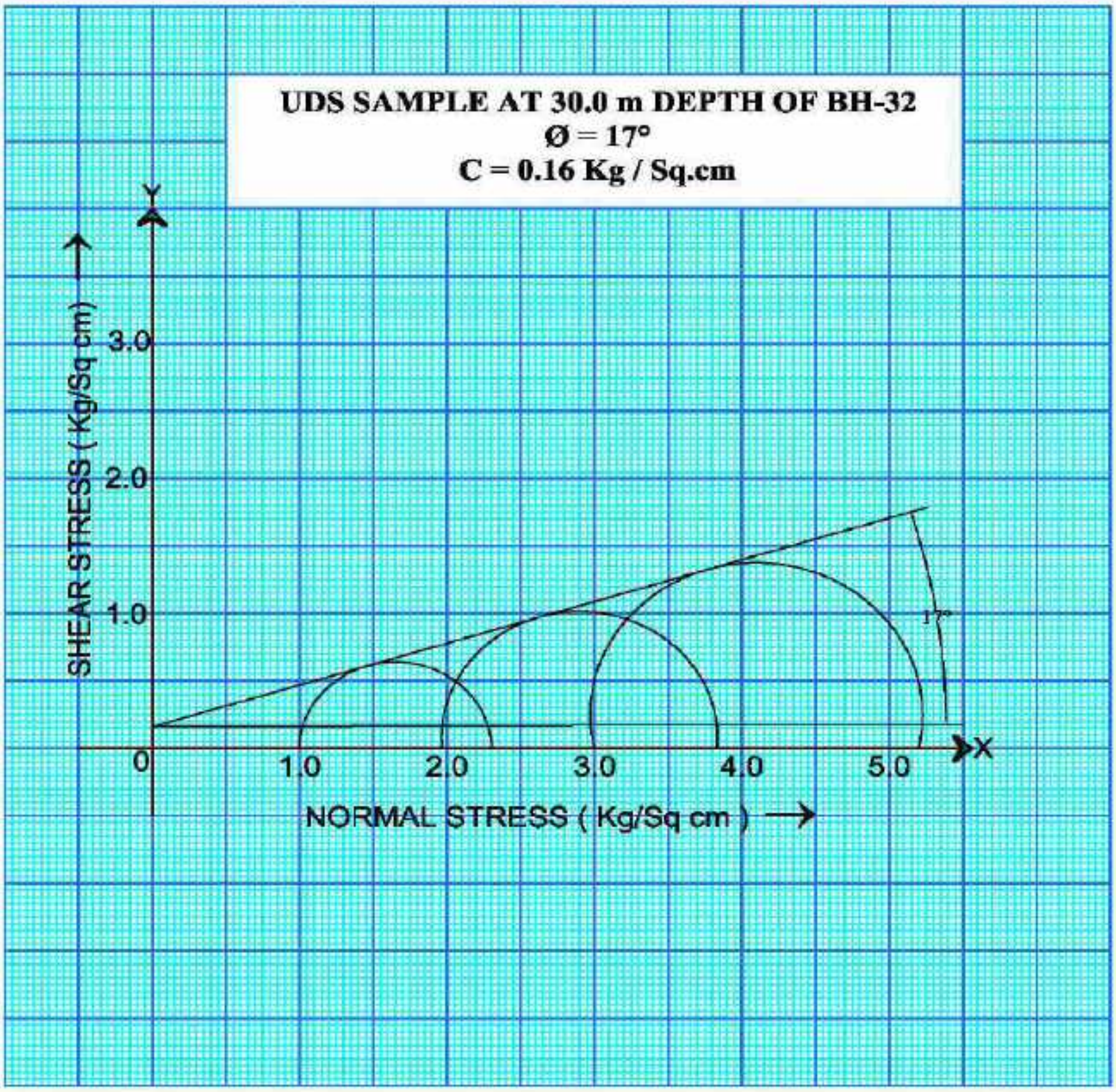
UDS SAMPLE AT 12.0 m DEPTH OF BH-32
Ø = 30°
C = 0.02 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
0.2
0.1
30°
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm )

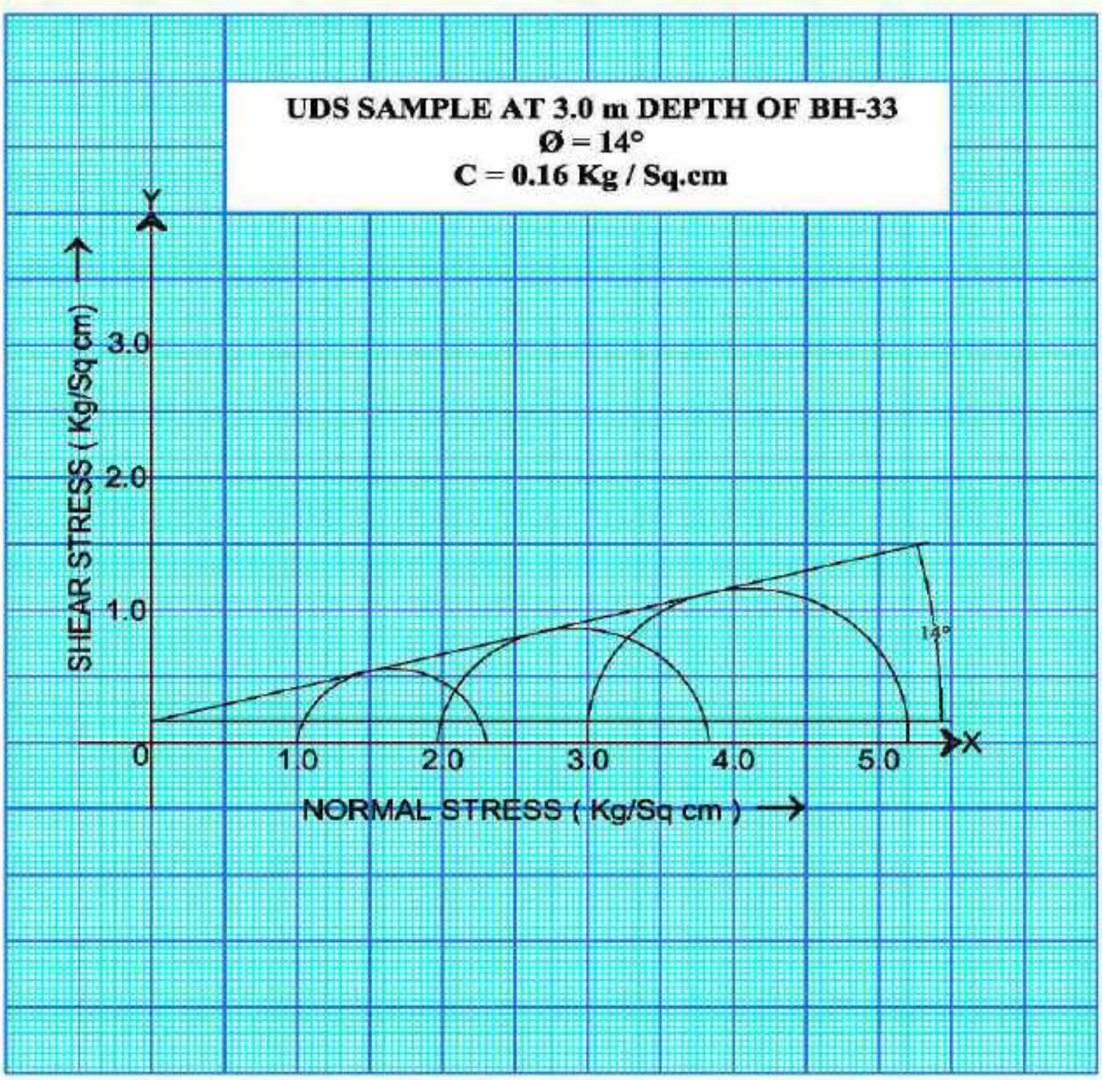


UDS SAMPLE AT 18.0 m DEPTH OF BH-32
Ø = 27°
C = 0.03 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
0.2
0.1
0
0.05
0.1
0.2
0.3
0.4
0.5
X
NORMAL STRESS ( Kg/Sq cm )
27°

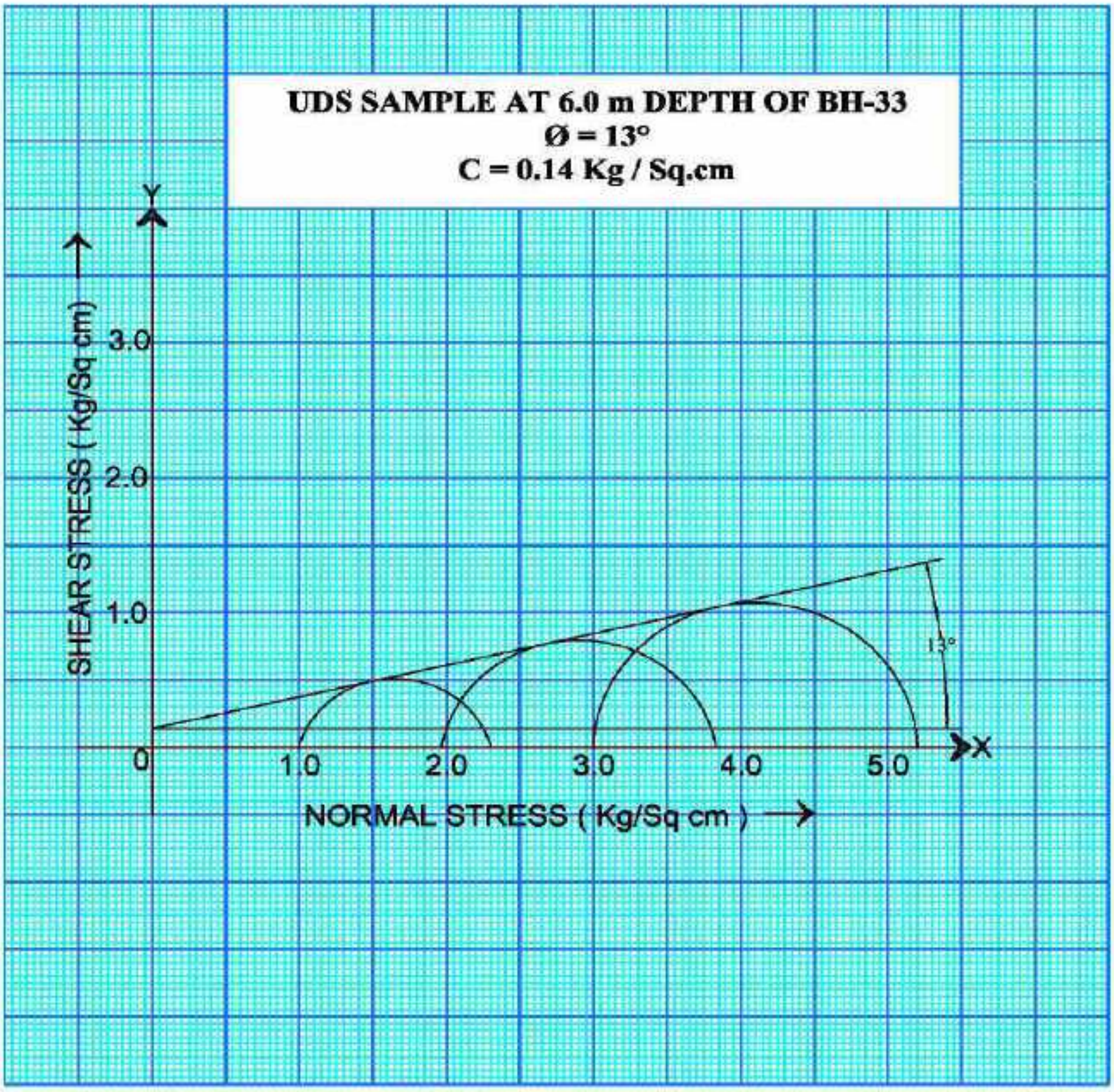


UDS SAMPLE AT 24.0 m DEPTH OF BH-32
Ø = 26°
C = 0.04 Kg / Sq.cm


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
17°
NORMAL STRESS ( Kg/Sq cm )



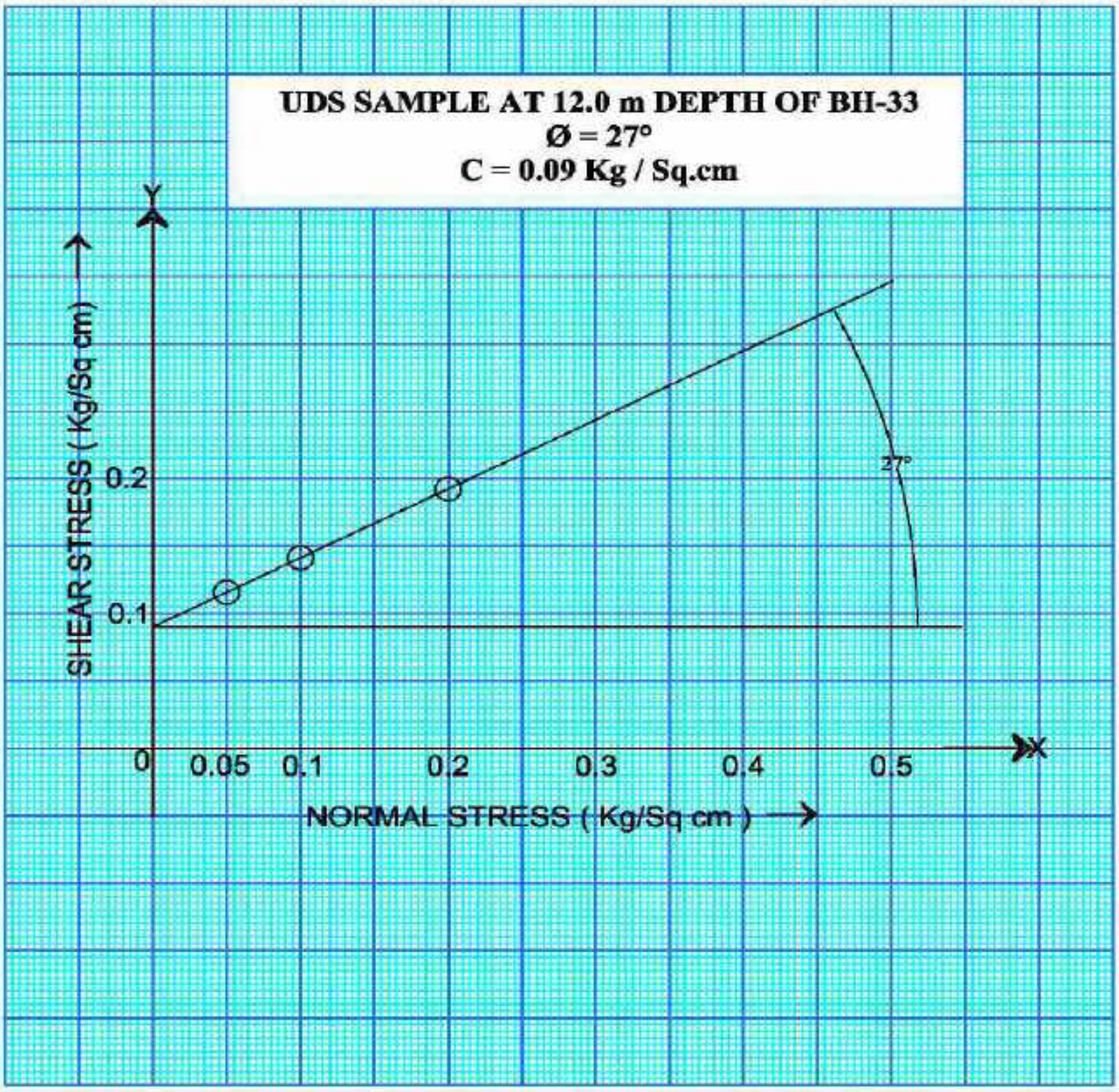
UDS SAMPLE AT 3.0 m DEPTH OF BH-33
Ø = 14°
C = 0.16 Kg / Sq.cm
Y
SHEAR STRESS ( Kg/Sq cm)
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
X
14°
NORMAL STRESS ( Kg/Sq cm )

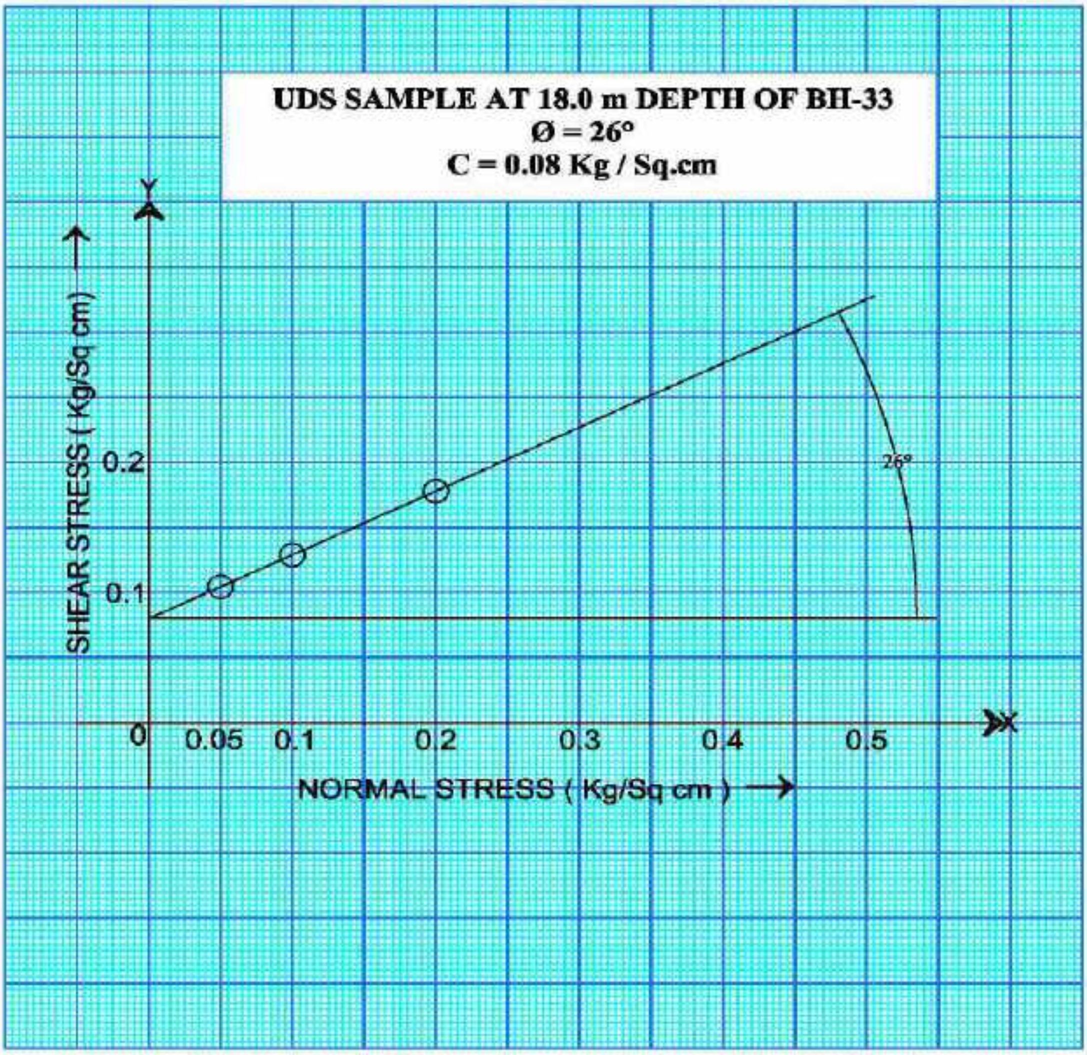


**UDS SAMPLE AT 6.0 m DEPTH OF BH-33**

**Ø = 13°**

**C = 0.14 Kg / Sq.cm**


UDS SAMPLE AT 12.0 m DEPTH OF BH-33
Ø = 27°
C = 0.09 Kg / Sq.cm


UDS SAMPLE AT 18.0 m DEPTH OF BH-33
Ø = 26°
C = 0.08 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°
Y
X

# 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: | $0^{o}$ | 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 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 276.867 | 0.00 | | Clayey Silt(DS), Silty Sand(DS Wash) | | | | | | | | | | | | NX | | | ▨ | | Light Brown | | |
| 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 | Diamond Bit | Nil | >15 | | | | ▨ | | | 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.* |
| 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 | |
| 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 | |
| 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 | |
| 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 | | | | ▨ | | | 12 | |
| 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 | |
| 266.367 | 10.50 | | | 97 | | 3 | | | | | 34 | | Nil | >15 | | | | ▨ | | | 12.5 | |
| 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 | |
| 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 | | Nil | >15 | | | | ▨ | | | 11.53 | |
| 261.867 | 15.00 | | | 100 | | | | | Highly Fractured, Joints of 0°,10°,80° | | 34 | | Nil | >15 | | | | ▨ | | | 12.5 | |
| 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 | |
| 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 | |
| 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 | |
| 255.867 | 21.00 | | | 87 | | 5 | 8 | | Joints of 0°,5°,10° | | 39.33 | | Nil | >15 | | | | | ▨ | | 14.28 | |
| 254.367 | 22.50 | | | 75 | | 9 | 16 | | Joints of 0°,10°,65°, Closed Joint of 80° | | 33.33 | | Nil | >15 | | | | | ▨ | | 15 | |
| 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<br>28.66 | | Nil | >15 | | | | | ▨ | | 12.5 | |
| 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° | | | | 9 | >15 | | | | | ▨ | | 14.28 | |
| 249.867 | 27.00 | | | 74 | | | 14 | 12 | | | 34 | | 18 | >15 | | | | | ▨ | | 13.63 | |
| 248.367 | 28.50 | | | 64 | | | 8 | 28 | | | 34 | | 24 | >15 | | | | | ▨ | | 14.28 | |

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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 (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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | Diamond Bit | 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 | | Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Reddish Brown to Light Brown Staining) | 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 | | 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 | | | 79 | | 3 | 8 | 10 | Highly Fractured, Joints of 0°,10°,15° | | 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 | | | | 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<br>BHUBANESWAR | Job No:- 830 | Report No:- SMC/2050 | Haryana Rail Infrastructure Development Corporation Ltd |

**HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.**
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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 | | Moderately Weathered, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite | 100 | | | | | Highly Fractured | | 30 | Diamond Bit | Nil | >15 | NX | | | | ■ | Light Brown | 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 | | | 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 Weatherd, Highly Fractured, Highly Jointed, Light Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite | 82 | | 11 | 7 | | Highly Fractured | | 45 | | Nil | >15 | | | | | | | 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 | | Highly Weathered, Highly Fractured, Highly Jointed, Gery, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite | 87 | | | 5 | 8 | | | 22 | | 6 | >15 | | | | | | | 16.6 | |
| 258.218 | 36.00 | | | 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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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 | : | $0^o$ | 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 | Size of Core Pieces 10-25mm | Size of Core Pieces 25-75mm | Size of Core Pieces 75-150mm | Size of Core Pieces >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 | Water Loss Partial | Water Loss 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 | Diamond Bit | 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 | ░ | Slightly Weathered, Highly Fractured, Highly Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite | 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 | Joints of 0°,5°,10° | ▨ | 27 | | 18 | >15 | | | | | ■ | | 178 | |
| 243.218 | 51.00 | ░ | | 90 | | 4 | 6 | | | ▨ | 22 | | Nil | >15 | | | | | ■ | | 15.95 | |
| 241.718 | 52.50 | ░ | | 90 | | 3 | 7 | | | ▨ | 22 | | Nil | >15 | | | | | ■ | | 15.78 | |
| 240.218 | 54.00 | ░ | | 70 | | 2 | | 28 | | ▨ | 22 | | Nil | >15 | | | | | ■ | | 18.75 | |
| 238.718 | 55.50 | ░ | | 84 | | 16 | | | | ▨ | 26 | | Nil | >15 | | | | | ■ | | 13.63 | |
| 237.218 | 57.00 | ░ | | 91 | 1 | 8 | | | | ▨ | 26 | | Nil | >15 | | | | | ■ | | 18.07 | |
| 235.718 | 58.50 | ░ | | 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 | | Highly Fractured | ▨ | 25 | | 13 | >15 | | | | | ■ | | 16.3 | |
| 228.218 | 66.00 | ░ | | 91 | | 2 | 7 | | | ▨ | 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 | | Joints of 0°,5°,10°,65° | ▨ | 26 | | 8 | >15 | | | | | ■ | | 16.6 | |
| 222.218 | 72.00 | ░ | | 82 | | | 18 | | | ▨ | 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.
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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 | | | | | Structural condition | Log | % of Core-Recovery | Type of BIT | RQD % | Fracture Freq. / m | Casing | Depth of water level | Water Loss | | | Colour of Returned Water | Rate of Penetration (mm/min) | REMARK / OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | <10mm | 10-25mm | 25-75mm | 75-150mm | >150mm | Description | | 20 40 60 80 100 | | | | | | Nil | Partial | Complete | | | |
| 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.* |
| 292.532 | 3.00 | | | 83 | | 9 | 8 | | | | 28 | | 7 | >15 | | | | | ■ | | 16.6 | |
| 291.032 | 4.50 | | | 75 | | 6 | 19 | | | | 42 | | 7 | >15 | | | | | ■ | | 16.3 | |
| 289.532 | 6.00 | | | 72 | | 15 | 13 | | | | 36 | | 0 | >15 | | | | | ■ | | 15.6 | |
| 288.032 | 7.50 | | | 59 | | 22 | 19 | | | | 46 | | 0 | >15 | | | | | ■ | | 13.04 | |
| 286.532 | 9.00 | | | 78 | | 9 | 13 | | | | 24 | | 7 | >15 | | | | | ■ | | 17.64 | |
| 285.032 | 10.50 | | | 78 | | 8 | 14 | | | | 34 | | 14 | >15 | | | | | ■ | | 16.3 | |
| 283.532 | 12.00 | | | 87 | 1 | 12 | | | | | 20 | | 0 | >15 | | | | | ■ | | 16.66 | |
| 282.032 | 13.50 | | | 90 | | 10 | | | | | 23 | | 0 | >15 | | | | | ■ | | 18.75 | |
| 280.532 | 15.00 | | | 100 | | | | | | | 16 | | 0 | >15 | | | | | ■ | | 15 | |
| 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 | |
| 277.532 | 18.00 | | | 84 | | 5 | 11 | | Joints of 0°, 5, 10°, 15° | | 22 | | 0 | >15 | | | | | ■ | | 12.5 | |
| 276.032 | 19.50 | | | 68 | 2 | 8 | 22 | | | | 41 | | 17 | >15 | | | | | ■ | | 14.28 | |
| 274.532 | 21.00 | | | 82 | | 12 | 6 | | | | 28 | | 0 | >15 | | | | | ■ | | 14.28 | |
| 273.032 | 22.50 | | | 95 | | 5 | | | | | 26 | | 0 | >15 | | | | | ■ | | 16.66 | |
| 271.532 | 24.00 | | | 80 | | | 7 | 13 | Joints of 0°, 5, 10°, 35° | | 36 | | 18 | >15 | | | | | ■ | | 13.63 | |
| 270.032 | 25.50 | | | 97 | | 3 | | | | | 27 | | 0 | >15 | | | | | ■ | | 12.5 | |
| 268.532 | 27.00 | | | 85 | | 9 | 6 | | | | 36 | | 0 | >15 | | | | | ■ | | 16.66 | |
| 267.032 | 28.50 | | | 82 | | 9 | 9 | | | | 33 | | 8 | >15 | | | | | ■ | | 16.66 | |
| 265.532 | 30.00 | | | 91 | 2 | 7 | | | | | 20 | | 0 | >15 | | | | | ■ | | 15.7 | |
| 264.032 | 31.50 | | | 84 | | 16 | | | | | 23 | | 0 | >15 | | | | | ■ | | 16.66 | |
| 262.532 | 33.00 | | | 81 | 2 | 4 | 13 | | | | 21 | | 0 | >15 | | | | | ■ | | 16.66 | |
| 261.032 | 34.50 | | | 78 | | 2 | 20 | | | | 30 | | 7 | >15 | | | | | ■ | | 14.7 | |
| 259.532 | 36.00 | | | 82 | | | 18 | | Joints of 0°, 5, 10°, 45° | | 32 | | 0 | >15 | | | | | ■ | | 17.04 | |
| 258.032 | 37.50 | | | 84 | | 9 | 7 | | | | 31 | | 0 | >15 | | | | | ■ | | 15.6 | |

# Geotechnical Investigation Report

| Consultant: | | Client : |
|---|---|---|
| S.M. CONSULTANTS<br>BHUBANESWAR | Job No:- 830 \| Report No:- SMC/2050 | Haryana Rail Infrastructure Development Corporation Ltd |

**HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.**
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**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: | $0^o$ | 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 (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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 Higly Jointed, Quartzite is the Prominnent 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 | |

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A NTRO HBL COMPANY
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 | | | | | Structural condition | Log | % of Core-Recovery | Type of BIT | RQD % | Fracture Freq. / m | Casing | Depth of water level | Water Loss | | | Colour of Returned Water | Rate of Penetration (mm/min) | REMARK / OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | <10mm | 10-25mm | 25-75mm | 75-150mm | >150mm | Description | | 20 40 60 80 100 | | | | | | Nil | Partial | Complete | | | |
| 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° | | | Diamond Bit | 0 | >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.* |
| 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 | | | Joints of 0°, 5°,10°,15°, 30° | | 35 | | 0 | >15 | | | | | | | 13 | |
| 268.942 | 7.50 | | Slightly Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard, Quartzite (Very Fine Grained Pyrite Crystals) | 72 | | | 28 | | | | | | 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 | | Joints of 0°, 5°,15°, 45° | | 35 | | 22 | >15 | | | | | | | 14 | |
| 262.942 | 13.50 | | | 82 | 1 | 3 | 14 | | | | 32 | | 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 | | Joints of 0°, 5°,10°, 15° | | 41 | | 7 | >15 | | | | | | | 16 | |
| 256.942 | 19.50 | | | 81 | 2 | | 17 | | | | 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 | | | | | | Light Brown | 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 | | | | | | | 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 | |

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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: | $0^0$ | 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 | |

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 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: | | $0^o$ | 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 | | | | | Structural condition | Log | % of Core-Recovery (20 40 60 80 100) | Type of BIT | RQD % | Fracture Freq. / m | Casing | Depth of water level | Water Loss | | | Colour of Returned Water | Rate of Penetration (mm/min) | REMARK / OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | <10mm | 10-25mm | 25-75mm | 75-150mm | >150mm | Description | | | | | | | | Nil | Partial | Complete | | | |
| 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 | 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.* |
| 284.324 | 3.00 | | Moderately Weathered, Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite | 93 | | | 7 | | | | 25 | | 0 | >15 | | | | | ■ | | 14.8 | |
| 282.824 | 4.50 | | | 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 | | Joints of 0°,10°,15°,20° | | 31 | | 10 | >15 | | | | | ■ | | 14.28 | |
| 276.824 | 10.50 | | | 83 | 1 | 3 | 13 | | | | 30 | | 0 | >15 | | | | | ■ | | 12.5 | |
| 275.324 | 12.00 | | | 78 | | 6 | 16 | | | | 34 | | 0 | >15 | | | | | ■ | | 16.6 | |
| 273.824 | 13.50 | | | 74 | | 4 | 9 | 13 | | | 31 | | 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 | Joints of 0°,10°,15°,20° | | 28 | | 15.3 | >15 | | | | | ■ | | 15 | |
| 267.824 | 19.50 | | | 56 | 1 | | 10 | 33 | | | 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 | | | | ■ | | Light Brown | 12.5 | |
| 263.324 | 24.00 | | | 74 | | | 26 | | Joints of 0°,10°,15°,45° | | 43 | | 11 | >15 | | | | ■ | | | 13.63 | |
| 261.824 | 25.50 | | | 65 | | | 6 | 29 | Joints of 0°,10°,15°,20° | | 42 | | 28 | 15-8 | | | | ■ | | | 13.04 | |
| 260.324 | 27.00 | | | 78 | | | 22 | | | | 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 | Joints of 0°,10°,15° | | 39 | | 34 | 15-8 | | | | | ■ | | 15 | |
| 254.324 | 33.00 | | | 83 | | | 17 | | | | 30 | | 14 | >15 | | | | | ■ | | 12.5 | |
| 252.824 | 34.50 | | | 71 | | 2 | | 27 | | | 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 | |

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
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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 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 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 248.324 | 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 | Diamond Bit | 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.* |
| 246.824 | 40.50 | ░ |  | 69 |  | 3 | 5 | 23 |  | ▨ | 34 |  | 20 | >15 |  |  |  | ■ |  |  | 10.71 |  |
| 245.324 | 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 |  |
| 243.824 | 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 |  |
| 242.324 | 45.00 | ░ |  | 55 |  |  |  | 45 | Joints of 0°,10°,15° | ▨ | 44 |  | 44 | 15-8 |  |  |  |  | ■ |  | 11.53 |  |
| 240.824 | 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 |  |
| 239.324 | 48.00 | ░ | Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite | 46 |  |  |  | 54 | Joints of 0°,10°,15° | ▨ | 53 |  | 51.3 | 8-5 |  |  |  |  | ■ |  | 12.5 |  |
| 237.824 | 49.50 | ░ |  | 62 | 1 |  | 26 | 11 |  | ▨ | 45 |  | 15.3 | >15 |  |  |  |  | ■ |  | 11.53 |  |
| 236.324 | 51.00 | ░ |  | 68 |  | 4 |  | 28 |  | ▨ | 38 |  | 26.6 | 15-8 |  |  |  | ■ |  | Light Brown | 12.5 |  |
| 234.824 | 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 |  |  |  | ■ |  |  | 10.71 |  |
| 233.324 | 54.00 | ░ |  | 72 |  |  | 16 | 12 |  | ▨ | 43 |  | 16.3 | >15 |  |  |  |  | ■ |  | 10.71 |  |
| 231.824 | 55.50 | ░ | Slightly Weathered, Moderately Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite | 60 |  |  | 17 | 23 | Joints of 0°,10°,15° | ▨ | 43 |  | 21 | >15 |  |  |  |  | ■ |  | 12.5 |  |
| 230.324 | 57.00 | ░ |  | 76 |  |  | 24 |  |  | ▨ | 31 |  | 8 | >15 |  |  |  |  | ■ |  | 13.63 |  |
| 228.824 | 58.50 | ░ |  | 80 |  |  |  | 20 |  | ▨ | 30 |  | 17.6 | >15 |  |  |  |  | ■ |  | 13.63 |  |
| 227.324 | 60.00 | ░ |  | 75 |  |  |  | 25 |  | ▨ | 25 |  | 20 | >15 |  |  |  | ■ |  | Light Brown | 12.5 |  |
| 225.824 | 61.50 | ░ |  | 70 |  |  | 10 | 20 |  | ▨ | 32 |  | 24.3 | >15 |  |  |  |  | ■ |  | 11.53 |  |
| 224.324 | 62.00 | ░ |  | 83 |  |  | 17 |  | Closed Joint of 70° | ▨ | 66 |  | 8.6 | >15 |  |  |  |  | ■ |  | 14.28 |  |

HARYANA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD.
A JOINT VENTURE OF GOVERNMENT OF HARYANA AND MINISTRY OF RAILWAYS

## 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 | | | Diamond Bit | NA | NA | NX | | | ■ | | Brown | 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 | | Brown colour, very fine to fine grained, clayey silt deposit | | | | | | very fine to fine grained, clayey silt deposit | | 0 | 12 | 45 | | NA | NA | | | | ■ | | | 33.3 | |
| 277.961 | 4.50 | | | | | | | | | | 0 | | | | NA | NA | | | | ■ | | | 27.27 | |
| 276.461 | 6.00 | | | | | | | | | | 0 | 16 | 45 | | NA | NA | | | | ■ | | | 27.27 | |
| 274.961 | 9.00 | | | | | | | | | | 30 | | | | NA | NA | | | | ■ | | | 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 | | 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 | It shows highly fractured weathered rock | | 25 | | | | 11.6 | >15 | | | | | ■ | | 10 | |
| 262.961 | 23.00 | | | <10 | | 70 | | | | | 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 | It shows highly angular fractured and jointed, weak strength | | 47 | | | | 17.13 | >15 | | | | | ■ | | 7.4 | |
| 249.461 | 32.50 | | | <10 | | 60 | 80 | | | | 64 | | | | 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 | |

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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 Nil | Partial | Complete | Colour of Returned Water | Rate of Penetration (mm/min) | REMARK / OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 244.961 | | | | | | | | | | | | | | | | | | | | | | | | |
| 243.461 | 38.00 | | Light Brown colour, Coarse grained, Sand. ( SPT Rebounded) | | | | | | Coarse grained, Sand. (SPT Rebounded) | | 0 | >50 | 2 | | NA | NA | | ↓ | | ■ | | Brown | 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 Prominnent Rock here with some tracts and bands of Phyllite and Schist.* |
| 241.961 | 39.50 | | | | | | | | | | 0 | >50 | 2 | | NA | NA | | | | ■ | | | 14.28 | |
| 240.461 | 41.00 | | Moderatey to Slightly Weathered, Moderately to Highly Fractured, Jointed, Grey, Fine Grained, Interlocking Texture, Iron Leaching, Very Hard Quartzite | <10 | | 60 | | 165 | Highly Fractured | | 32 | | | Diamond Bit | 11 | 15 to 8 | | | | | ■ | | 10.71 | |
| 238.961 | 42.50 | | | <10 | | | 110 | 180 | Joints of 0°,10°,15° | | 41.33 | | | | 19.33 | 15 to 8 | | | | | ■ | | 12.5 | |
| 237.461 | 44.00 | | | <10 | | | 150 | 473 | Joints of 0° | | 54 | | | | 41.53 | 15 to 8 | | | | | ■ | | 11.11 | |
| 235.961 | 45.50 | | | <10 | | 107 | 257 | | Highly Fractured, Joints of 0° | | 30 | | | | 16.66 | 15 to 8 | | | | | ■ | | 12 | |
| 234.461 | 47.00 | | | <10 | | | 180 | | Highly Fractured, Joints of 0°,10°,15° | | 37.33 | | | | 0 | 15 to 8 | | | | | ■ | | 11.53 | |
| 232.961 | 48.50 | | | <10 | | 56 | 316 | | | | 41.33 | | | | 21.06 | 15 to 8 | | | | | ■ | | 10.86 | |
| 231.461 | 50.00 | | | <10 | | 279 | | | | | 30 | | | | 0 | 15 to 8 | | | | | ■ | | 10.34 | |
| 229.961 | 51.50 | | | <10 | 25 | 383 | | | | | 36.66 | | | | 0 | 15 to 8 | | | | | ■ | | 12 | |
| 228.461 | 53.00 | | | <10 | | 71 | 323 | 180 | | | 34.66 | | | | 12 | 15 to 8 | | | | | ■ | | 11.53 | |
| 226.961 | 54.50 | | | <10 | | 135 | 192 | | Highly Fractured, Joints of 0° | | 33.33 | | | | 6.8 | 15 to 8 | | | | | ■ | | 11.11 | |
| 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 | | | 181 | | very fine to Fine Grained, weak silt stone with clay material | | 28 | | | | 6.73 | 15 to 8 | | | | | ■ | | 15 | |
| 223.961 | 58.00 | | | <10 | | 50 | | 160 | | | 38 | | | | 8 | 15 to 8 | | | | | ■ | | 12.96 | |
| 222.461 | 59.50 | | | <10 | | 70 | | | | | 38.33 | | | | 0 | 15 to 8 | | | | | ■ | | 13 | |
| 220.961 | 61.00 | | 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 | |
| 220.461 | 62.00 | | | <10 | | 48 | 345 | 190 | | | 70 | | | | 12.66 | 15 to 8 | | | | | ■ | | 9.5 | |

# Geotechnical Investigation Report

| Consultant: | | Client : |
|---|---|---|
| **S.M. CONSULTANTS**<br>**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
BHUBANESWAR

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 | | | | | | | | | | | | | Nx | --- | --- | | | Partial | | BROWN | **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 | | --- | --- | | | | | | |
| 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 | | --- | --- | | | | | | |

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
BHUBANESWAR

BORE HOLE NO : BH-19
CHAINAGE (m.) : 26210
COLLAR ELEVATION : ---
RAIL LEVEL : ---
START DATE : 25-07-2021
ENDING DATE : 26-07-2021

CO-ORDINATES X : 699776.449
Y : 3122635.179
GROUND ELEVATION : 278.116
AZIMUTH : ---
ANGLE WITH HORIZONTAL : ---

LOCATION : Patuka
TOTAL DEPTH : 50m
TYPE OF CORE BARREL : Double Tube
DEPTH OF WATER TABLE (m) : Not found
DRILLING AGENCY : S.M. Consultants
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 | | --- | --- | | | | | | |

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 | | 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 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 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 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 | | Brown Colour, Fine Grained, Very Dense Compacted, Clayey Silt with None to Low Plasticity | | | | | | | | | | | 60 | 45 | | --- | --- | | | | | | |
| 258.795 | 18.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 255.795 | 21.00 | | | | | | | | | | | | | 67 | 45 | | --- | --- | | | | | | |
| 252.795 | 24.00 | | | | | | | | | | | | | 76 | 45 | | --- | --- | | | | | | |
| 249.795 | 27.00 | | Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility | | | | | | | | | | | | | | --- | --- | | | | | | |
| 246.795 | 30.00 | | | | | | | | | | | | | 58 | 45 | | --- | --- | | | | | | |
| 243.795 | 33.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 240.795 | 36.00 | | | | | | | | | | | | | 67 | 45 | | --- | --- | | | | | | |
| 237.795 | 39.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 234.795 | 42.00 | | | | | | | | | | | | | 75 | 45 | | --- | --- | | | | | | |
| 231.795 | 45.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 228.795 | 48.00 | | | | | | | | | | | | | 79 | 45 | | --- | --- | | | | | | |

# Geotechnical Investigation Report

| Consultant: | | Client : |
|---|---|---|
| S.M. CONSULTANTS<br>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 | | | | | | | | | | | | | | --- | --- | | Absent | Partial | | BROWN | **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.<br>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 | --- | | | | | | |
| 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 | | | | | | | | | | | | | | | | --- | --- | | | | | | |

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
BHUBANESWAR

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 | | | | | | | | | | | | | | --- | --- | | Absent | Partial | | BROWN | **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.<br>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 | --- | | | | | | |
| 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 | | | | | | | | | |

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
BHUBANESWAR

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 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<br>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<br>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
BHUBANESWAR

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 | | | | | | | | | | | | | | | | --- | --- | | | | | | |

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 | | | | | | | | | | | | | | | | --- | --- | | | | | | |

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
BHUBANESWAR

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 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 | | --- | --- | | | | | | |

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 | | | | | | | | | | | | | | | | --- | --- | | | | | | |

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
BHUBANESWAR

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 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 | | 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 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 | | | | | | | | | | | | | 17 | 45 | | --- | --- | | | | | | |
| 267.808 | 3.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 266.308 | 4.50 | | | | | | | | | | | | | 22 | 45 | | --- | --- | | | | | | |
| 264.808 | 6.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 261.808 | 9.00 | | Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility | | | | | | | | | | | 30 | 45 | | --- | --- | | | | | | |
| 258.808 | 12.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 255.808 | 15.00 | | | | | | | | | | | | | 38 | 45 | | --- | --- | | | | | | |
| 252.808 | 18.00 | | | | | | | | | | | | | | | | | --- | | | | | | |
| 249.808 | 21.00 | | | | | | | | | | | | | 44 | 45 | | --- | --- | | | | | | |
| 246.808 | 24.00 | | Brown Colour, Very Fine Grained, Hard Consistency, Silt and Sand with low Compressibility. | | | | | | | | | | | | | | --- | --- | | | | | | |
| 243.808 | 27.00 | | | | | | | | | | | | | 56 | 45 | | --- | --- | | | | | | |
| 240.808 | 30.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 237.808 | 33.00 | | Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility | | | | | | | | | | | 64 | 45 | | --- | --- | | | | | | |
| 234.808 | 36.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 231.808 | 39.00 | | | | | | | | | | | | | 73 | 45 | | --- | --- | | | | | | |
| 228.808 | 42.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 225.808 | 45.00 | | | | | | | | | | | | | 84 | 45 | | --- | --- | | | | | | |

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
BHUBANESWAR

BORE HOLE NO : BH-31
CHAINAGE (m.) : 29050
COLLAR ELEVATION : ---
RAIL LEVEL : ---
START DATE : 19-04-2021
ENDING DATE : 19-04-2021

CO-ORDINATES X : 697028.617
Y : 3123078.475
GROUND ELEVATION : 267.159 m
AZIMUTH : ---
ANGLE WITH HORIZONTAL : 90°

LOCATION : Patuka
TOTAL DEPTH : 20.00 m
TYPE OF CORE BARREL : ---
DEPTH OF WATER TABLE (m) : Absent
DRILLING AGENCY : S.M. Consultants
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 | | | | | | | | | | | | | | | | --- | --- | | | | | | |

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
BHUBANESWAR

| | | | | | |
|---|---|---|---|---|---|
| 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. | | | | | | | | | | | | | | --- | --- | | Absent | Partial | | BROWN | **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 | | Brown Colour, Very Fine Grained, Hard Consistency, Silt and Clay with low Compressibility | | | | | | | | | | | 39 | 45 | | --- | --- | | | | | | |
| 253.581 | 12.00 | | | | | | | | | | | | | | | | --- | --- | | | | | | |
| 250.581 | 15.00 | | | | | | | | | | | | | 50 | 45 | | --- | --- | | | | | | |
| 247.581 | 18.00 | | | | | | | | | | | | | | | | | --- | | | | | | |
| 245.581 | 20.00 | | | | | | | | | | | | | 63 | 45 | | --- | --- | | | | | | |

# ANNEXURE L

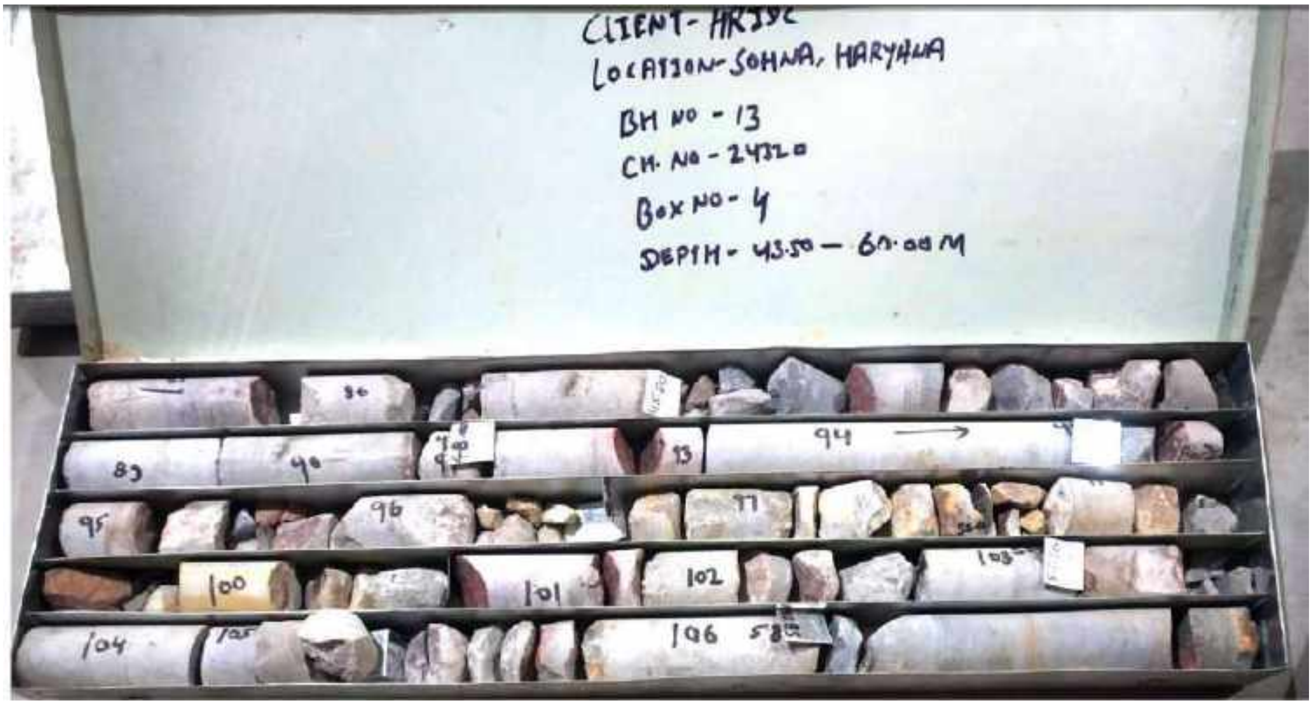
# CORE SAMPLES

## 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)

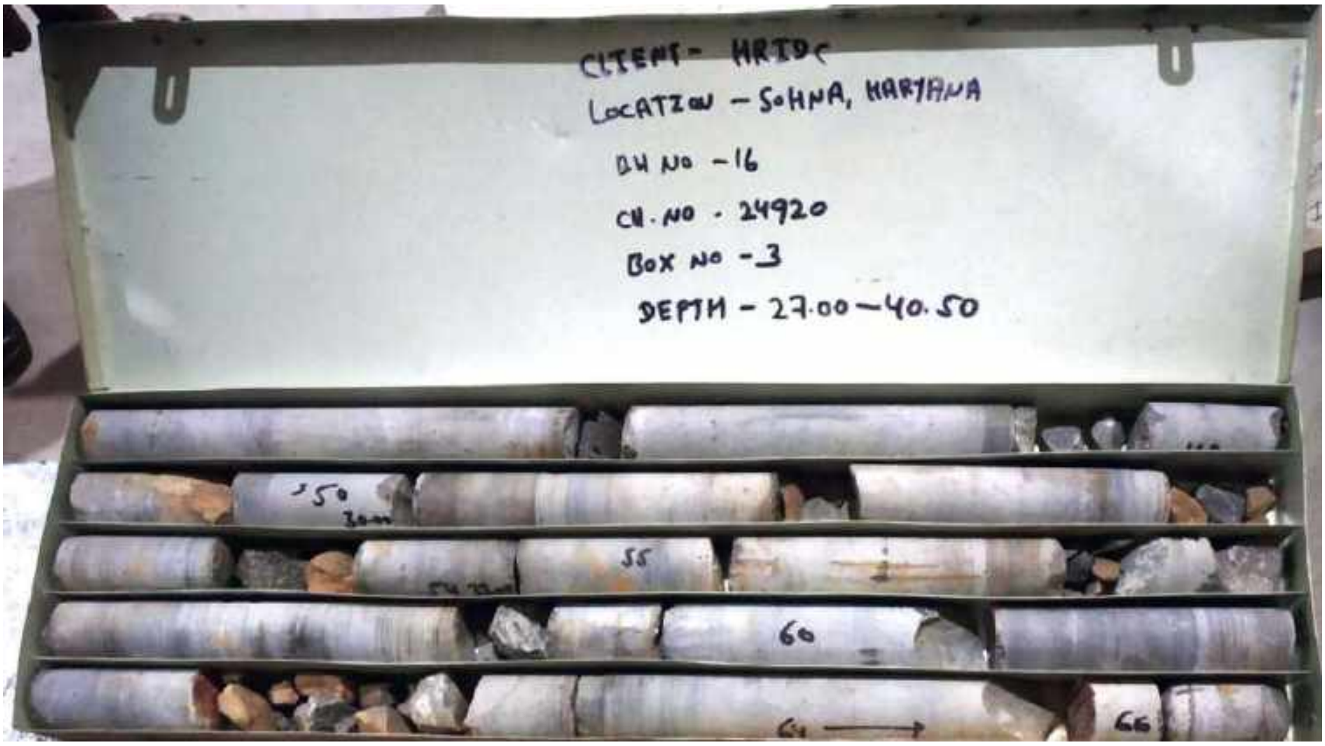
Bh 15(A) Box 3. (Depth 27.0m-40.5m)

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)

# 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** | Shreesta |
| **GEOLOGIST** | Dr Dipanjan Bhattacharjee<br>Assistant Professor<br>Department of Geology<br>Indira Gandhi National Tribal University<br>(A central university established by an act of Parliament)<br>Amarkantak, Madhya Pradesh-484887 |
| **SENIOR CONSULTANT** | Senior Consultant<br>Virendra Swami |

For S.M. Consultants

| | |
|---|---|
| **General Consultant** | |
| **PD/GC** | |
| **DPD/GC/CIVIL** | |
| | |

| | | |
|---|---|---|
| **Client** | | |
| **CPM/HRIDCL** | | |
| **DGM/CIVIL/S/ HRIDCL** | | |
| **EXE/CIVIL/ HRIDCL** | | |
| | | |

**Client:**

HRIDC

HARYANA RAIL INFRASTRUCTURE
DEVELOPMENT CORPORATION
LIMITED.

**Consultant:**

S. M. C.

S.M. CONSULTANTS,
S.M.TOWER, PLOT NO.-130,
MANCHESWAR INDUSTRIAL ESTATE,
RASULGARH, BHUBANESWAR-751010

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# 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.

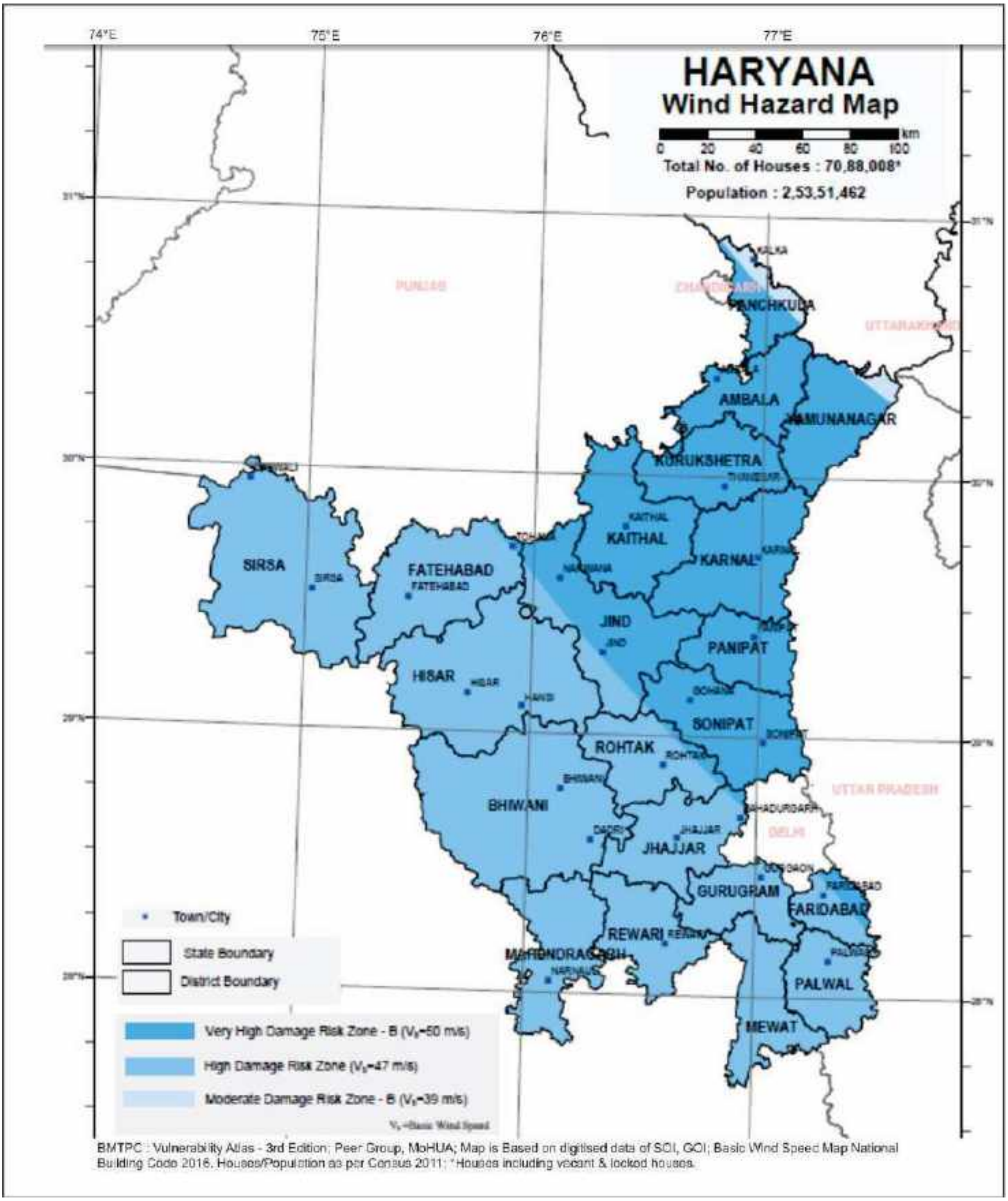
**Figure 2.1: District Map of Haryana.**

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.



BMTPC : Vulnerability Atlas - 3rd Edition; Peer Group, MoHUA; Map is Based on digitised data of SOI, GOI; Basic Wind Speed Map National Building Code 2016. Houses/Population as per Census 2011; *Houses including vacant & locked houses.

**Figure 2.3: Wind Hazard map of Haryana (adopted from BMTPC.**

## 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).

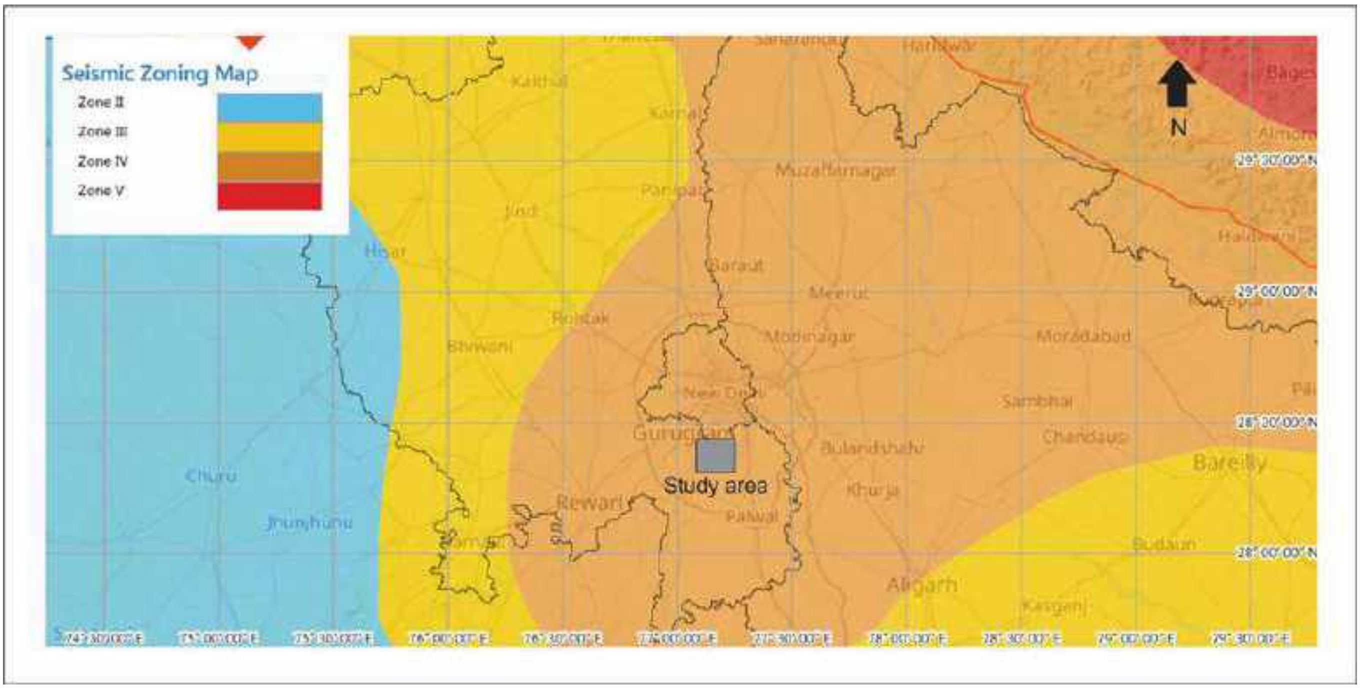


Figure 2.4: Seismic map of state Haryana (adopted from National Centre for seismology).

## 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.

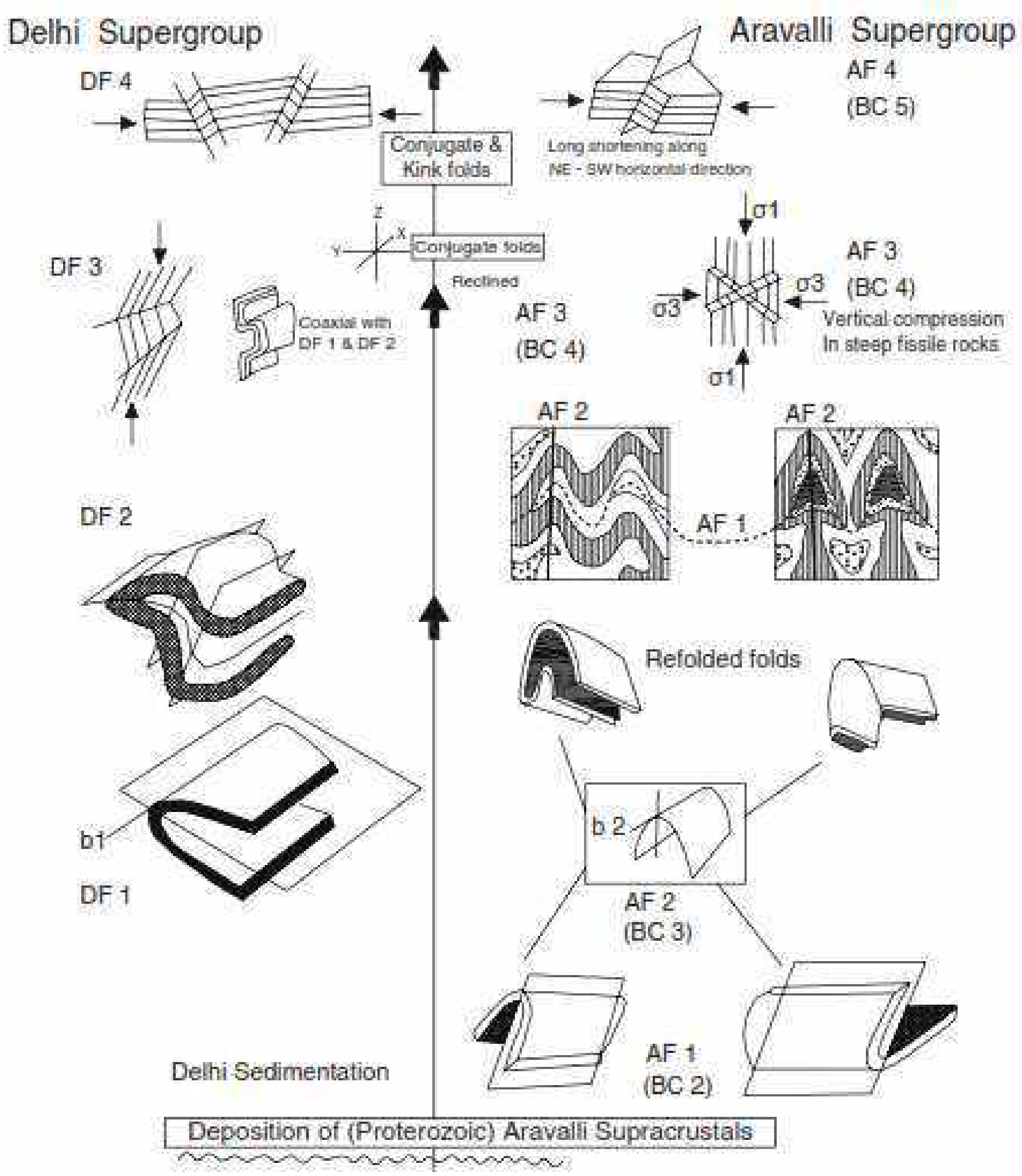


**Figure 2.5: Regional structure of Delhi fold belt (Naha and Mohanty 1988).**

# 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.

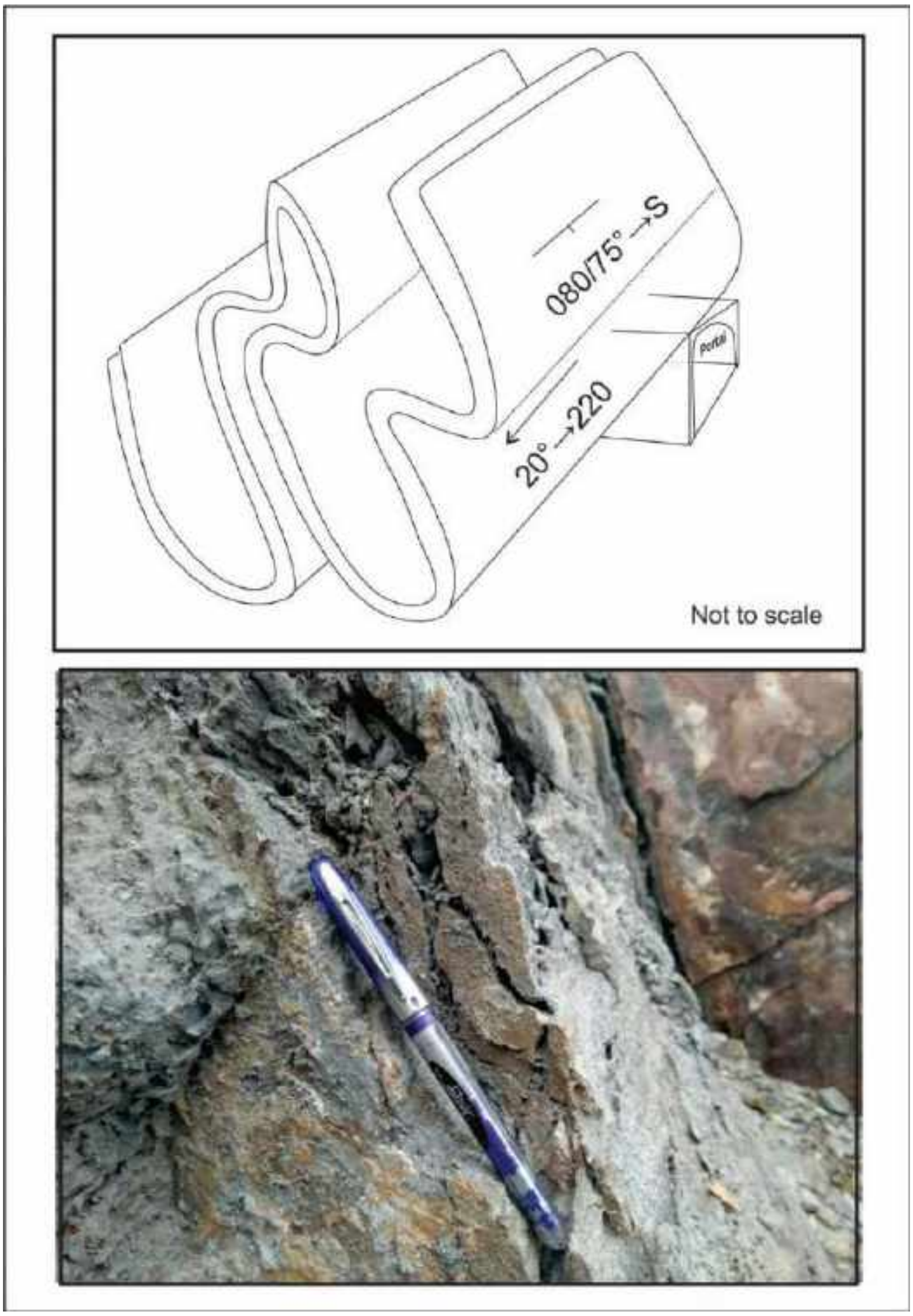


**Figure 3.1: Superposed fold observed at 28 12' 33.57'', 77 02'57.08''**

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).

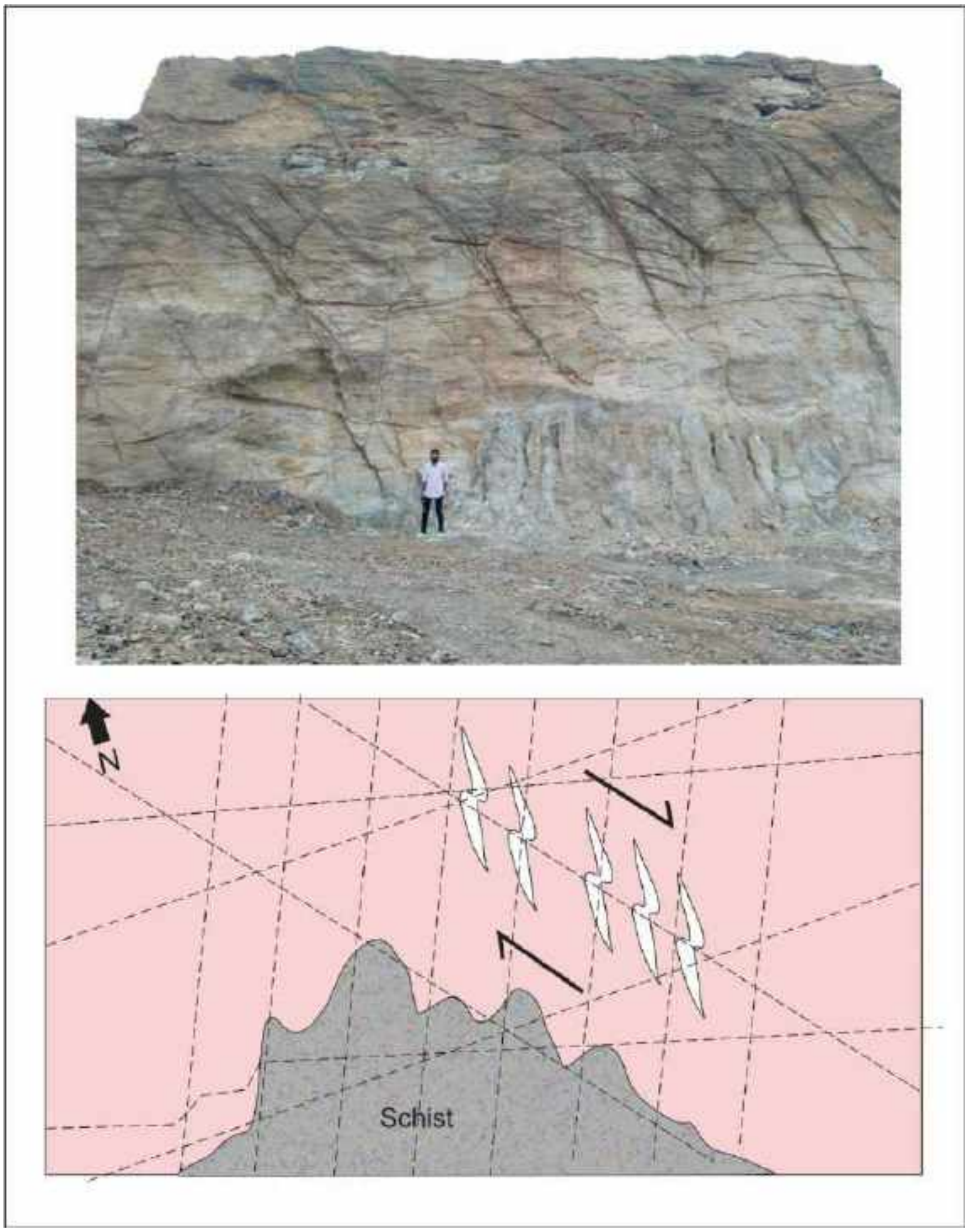


**Figure 3.2: Shear zone observed at location 28 12' 20.93'', 77 02' 40.**

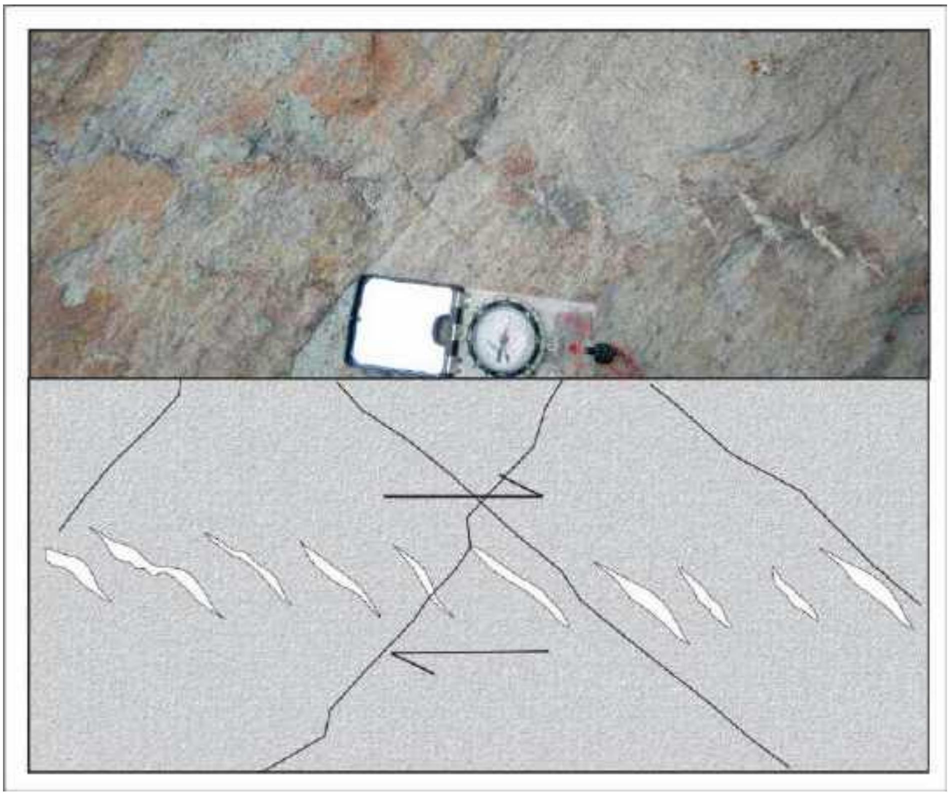


Figure 3.3: Gash veins showing a dextral slip.

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 |

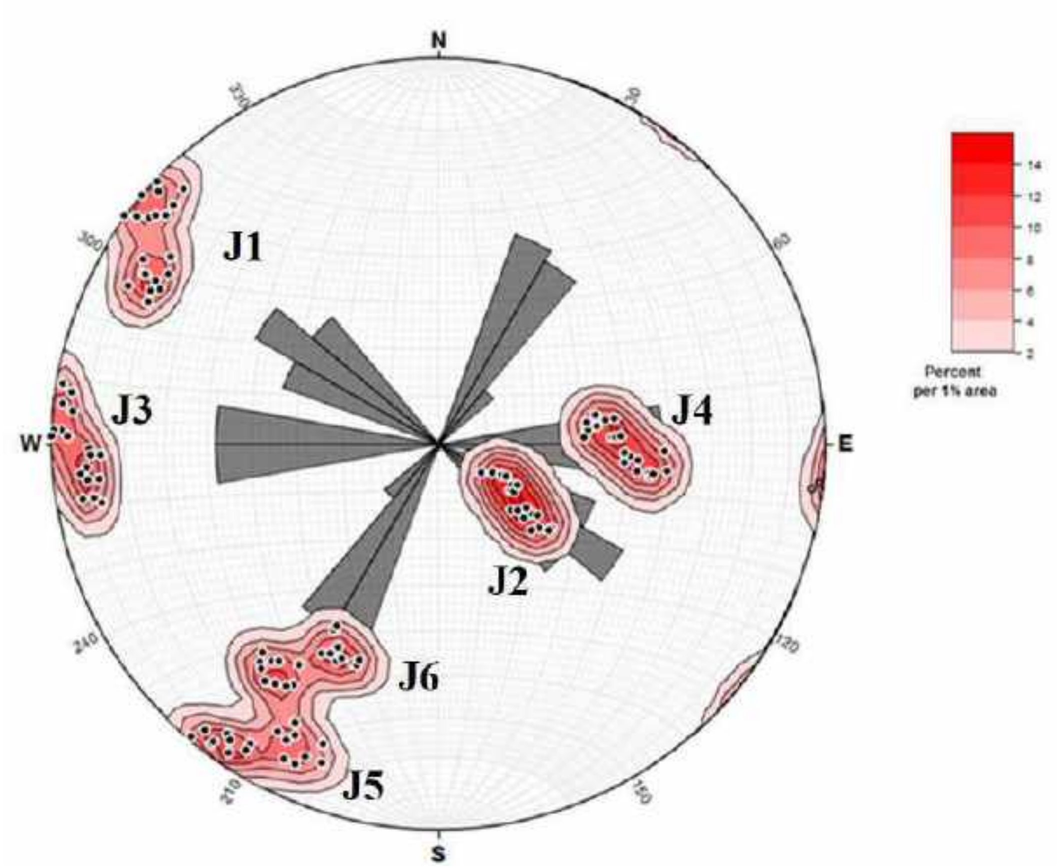
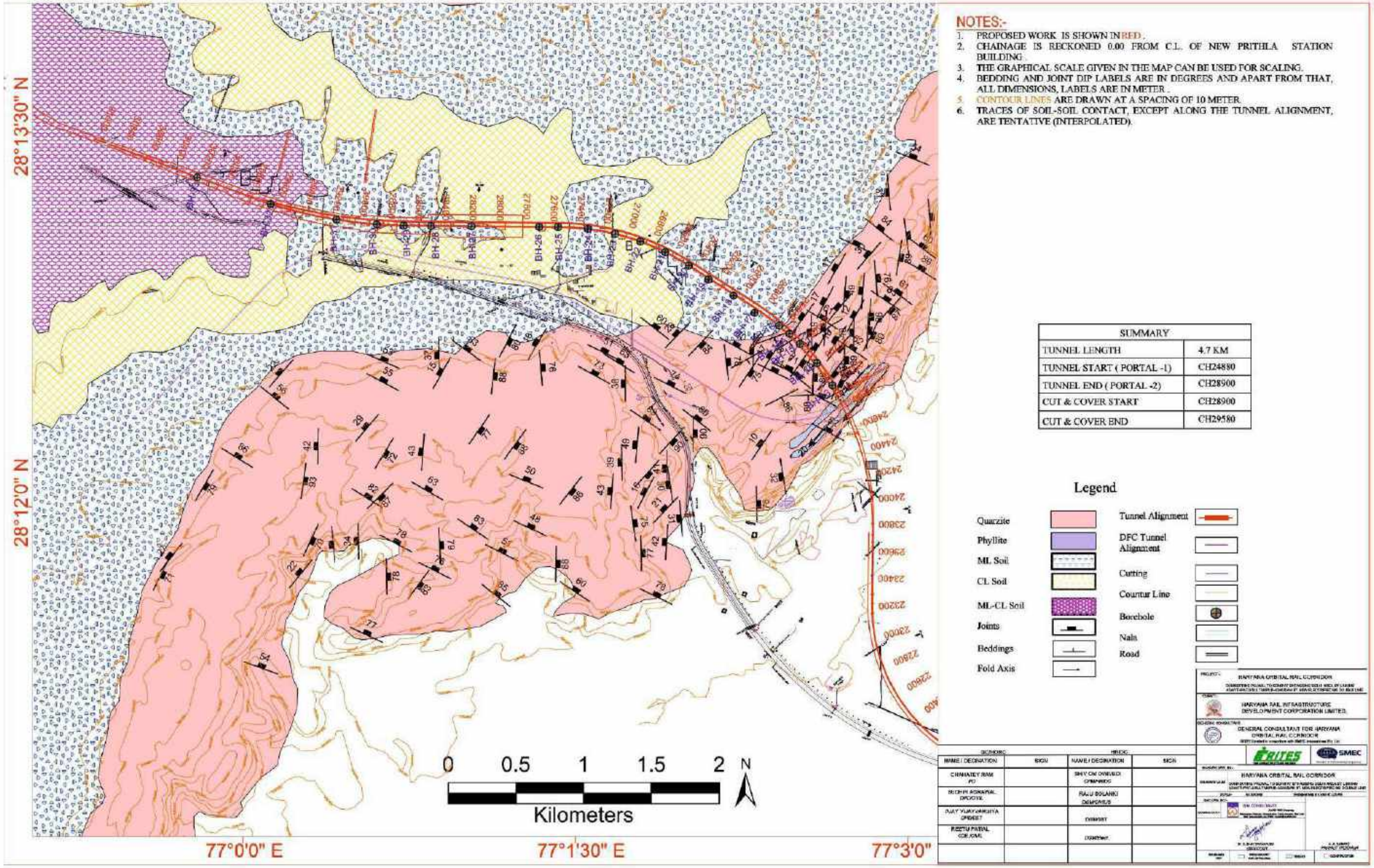


Figure 3.6: Rose and contour diagram of the orientation of the 6 sets of joints (no. of samples N=125)

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;

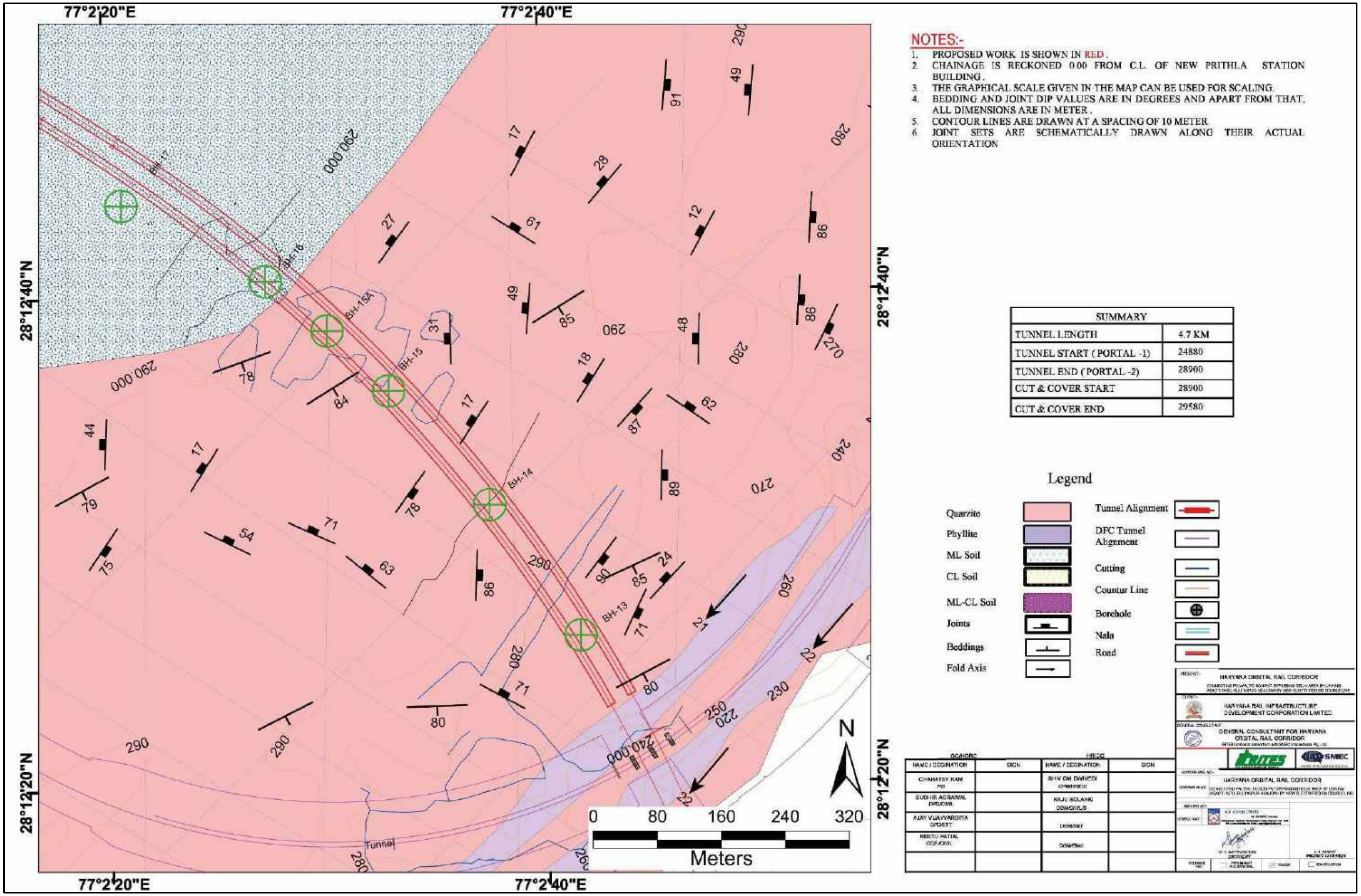


NOTES:-

1. PROPOSED WORK IS SHOWN IN RED.
2. CHAINAGE IS RECKONED 0.00 FROM C.L. OF NEW PRITHLA STATION BUILDING.
3. THE GRAPHICAL SCALE GIVEN IN THE MAP CAN BE USED FOR SCALING.
4. BEDDING AND JOINT DIP LABELS ARE IN DEGREES AND APART FROM THAT, ALL DIMENSIONS, LABELS ARE IN METER.
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. TRACES OF SOIL-SOIL CONTACT, EXCEPT ALONG THE TUNNEL ALIGNMENT, ARE TENTATIVE (INTERPOLATED).

| SUMMARY | |
|---|---|
| TUNNEL LENGTH | 4.7 KM |
| TUNNEL START ( PORTAL -1) | CH24880 |
| TUNNEL END ( PORTAL -2) | CH28900 |
| CUT & COVER START | CH28900 |
| CUT & COVER END | CH29580 |

**Figure 3.7: Geological map of the area at 1:25000 scale.**



NOTES:-

1. PROPOSED WORK IS SHOWN IN RED.
2. CHAINAGE IS RECKONED 0.00 FROM C.L. OF NEW PRITHLA STATION BUILDING.
3. THE GRAPHICAL SCALE GIVEN IN THE MAP CAN BE USED FOR SCALING.
4. BEDDING AND JOINT DIP VALUES ARE IN DEGREES AND APART FROM THAT, ALL DIMENSIONS ARE IN METER.
5. CONTOUR LINES ARE DRAWN AT A SPACING OF 10 METER.
6. JOINT SETS ARE SCHEMATICALLY DRAWN ALONG THEIR ACTUAL ORIENTATION

| SUMMARY | |
|---|---|
| TUNNEL LENGTH | 4.7 KM |
| TUNNEL START ( PORTAL -1) | 24880 |
| TUNNEL END ( PORTAL -2) | 28900 |
| CUT & COVER START | 28900 |
| CUT & COVER END | 29580 |

**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.**

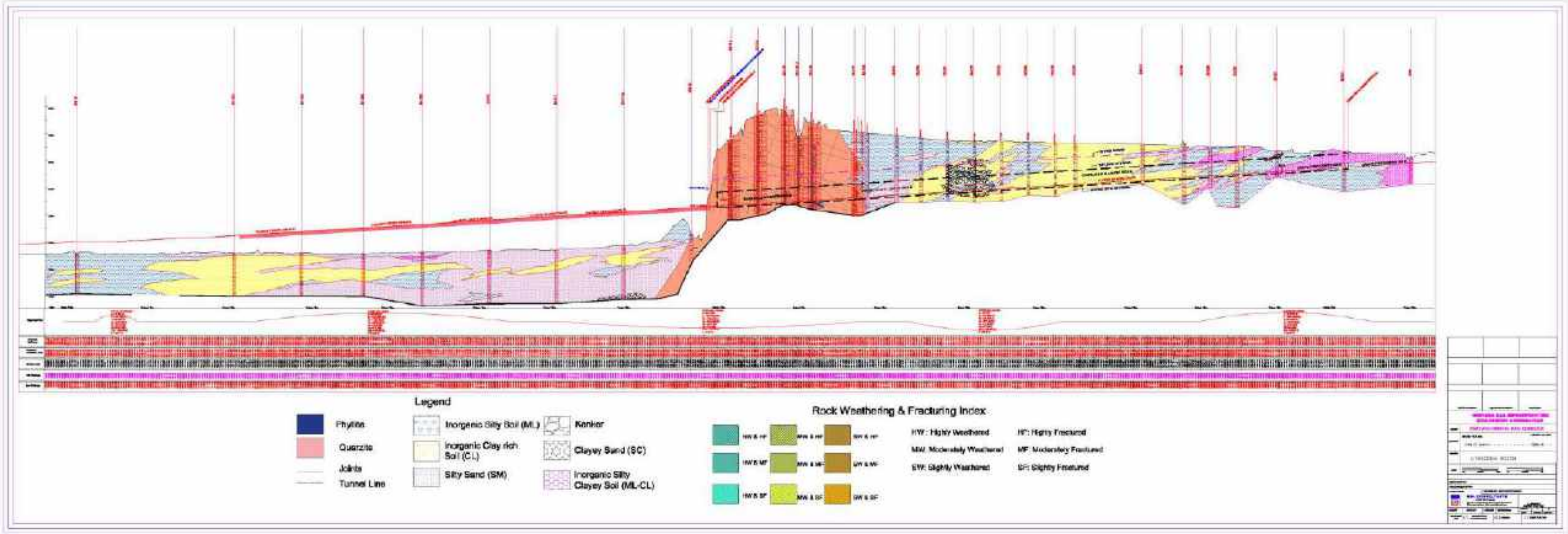


Figure 3.9: L-Section along the tunnel alignment (1:25000 H and 1:2500 V). Joint sets are schematically drawn with their actual orientation.

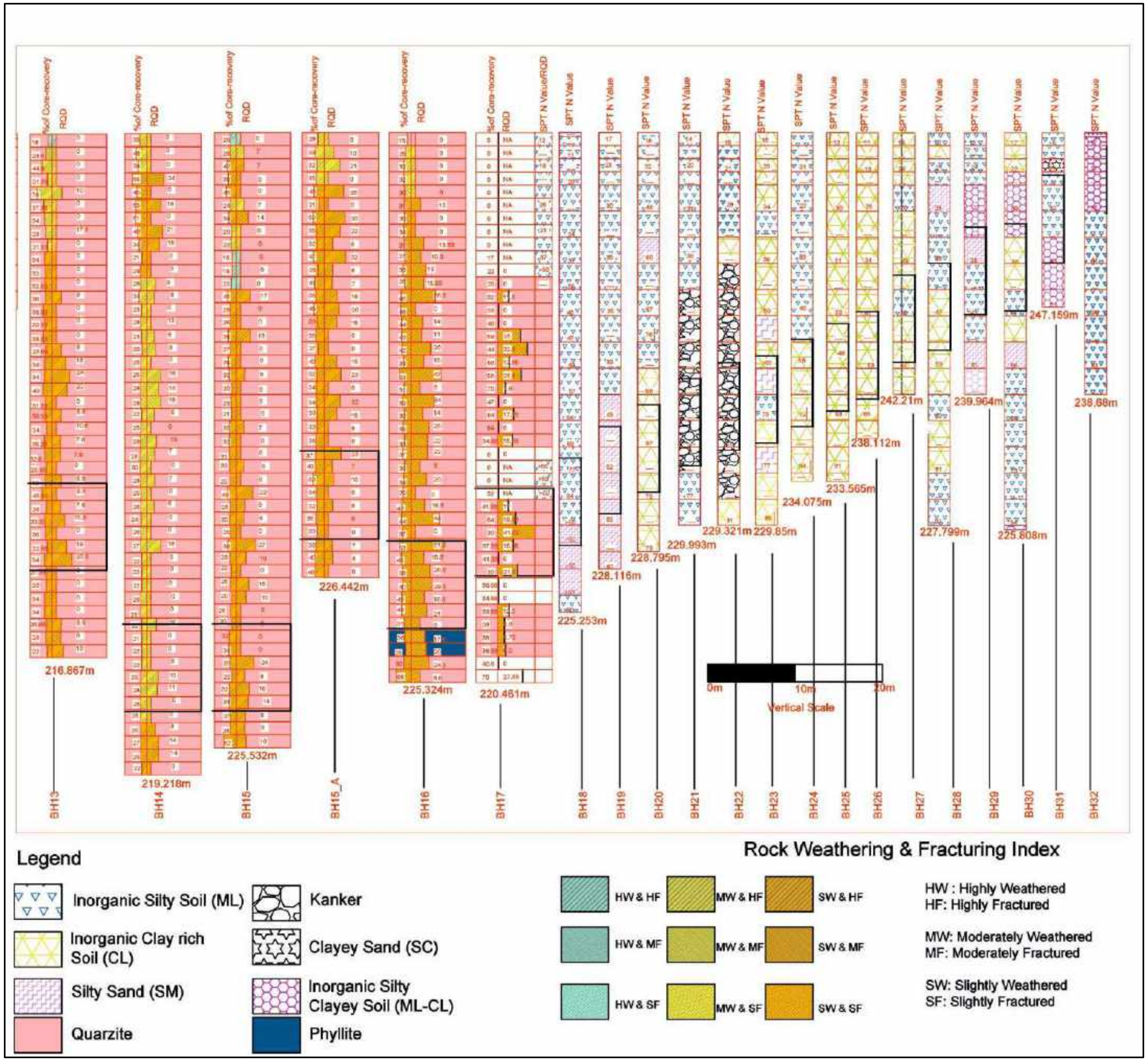


**Figure 3.10: Graphical representation of the distribution of RQD, Core Recovery, SPTN Values and Soil types along each boreholes intersecting the tunnel (BH13-BH32). Thick black lines indicate the position of the tunnel.**

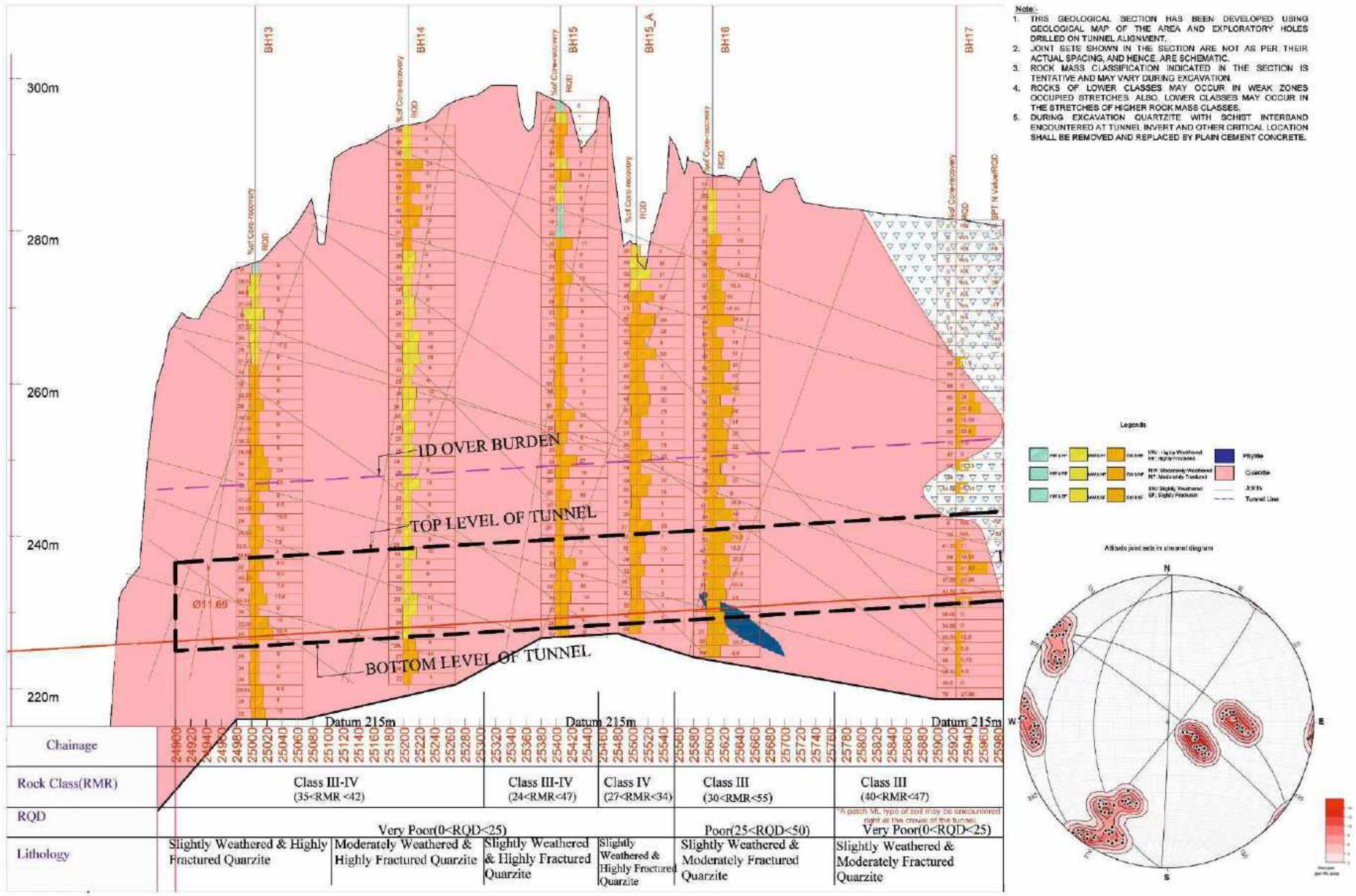
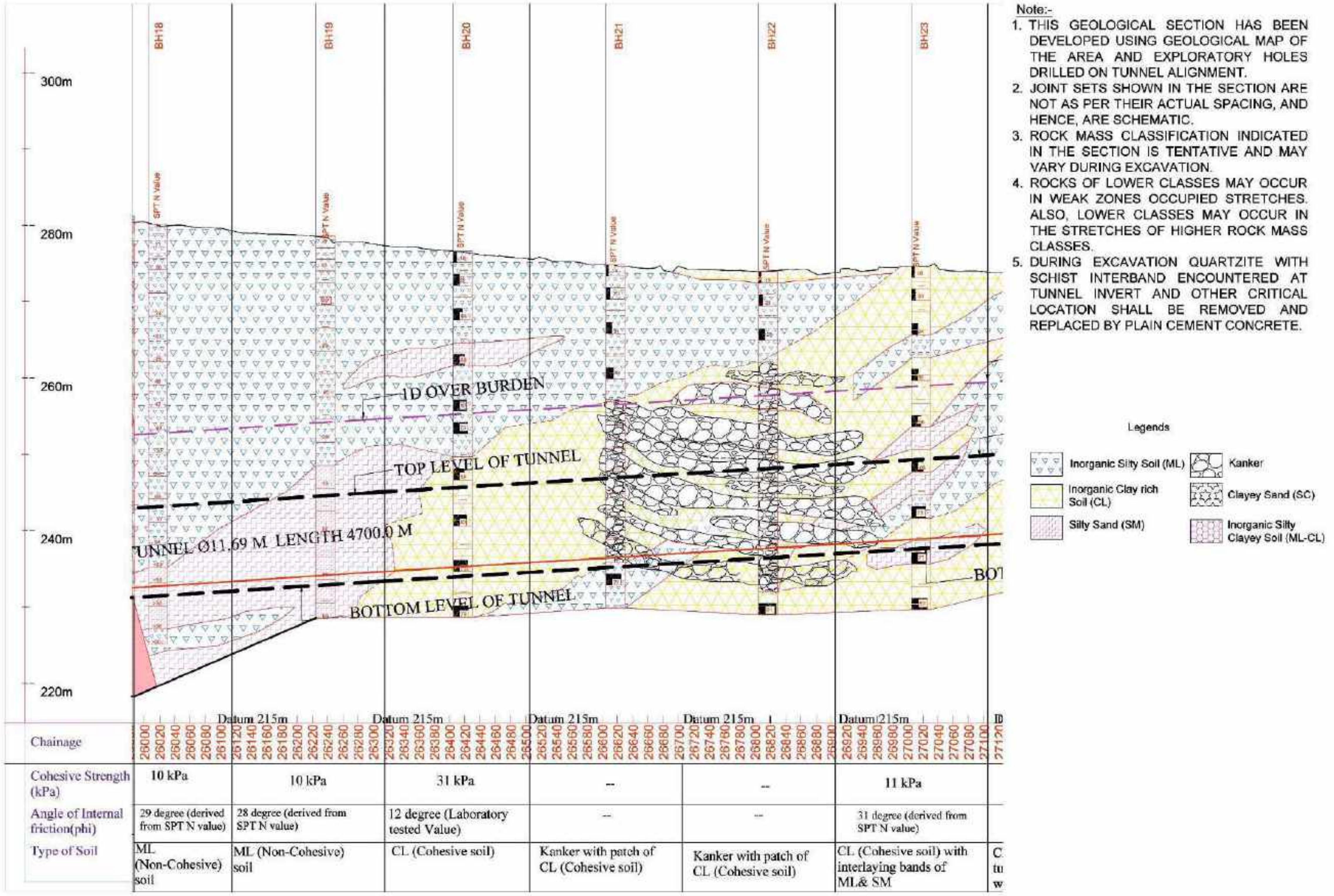


**Figure 3.11: Chainage-wise variation in RQD and RMR (Samples from 2D depth considered only).**

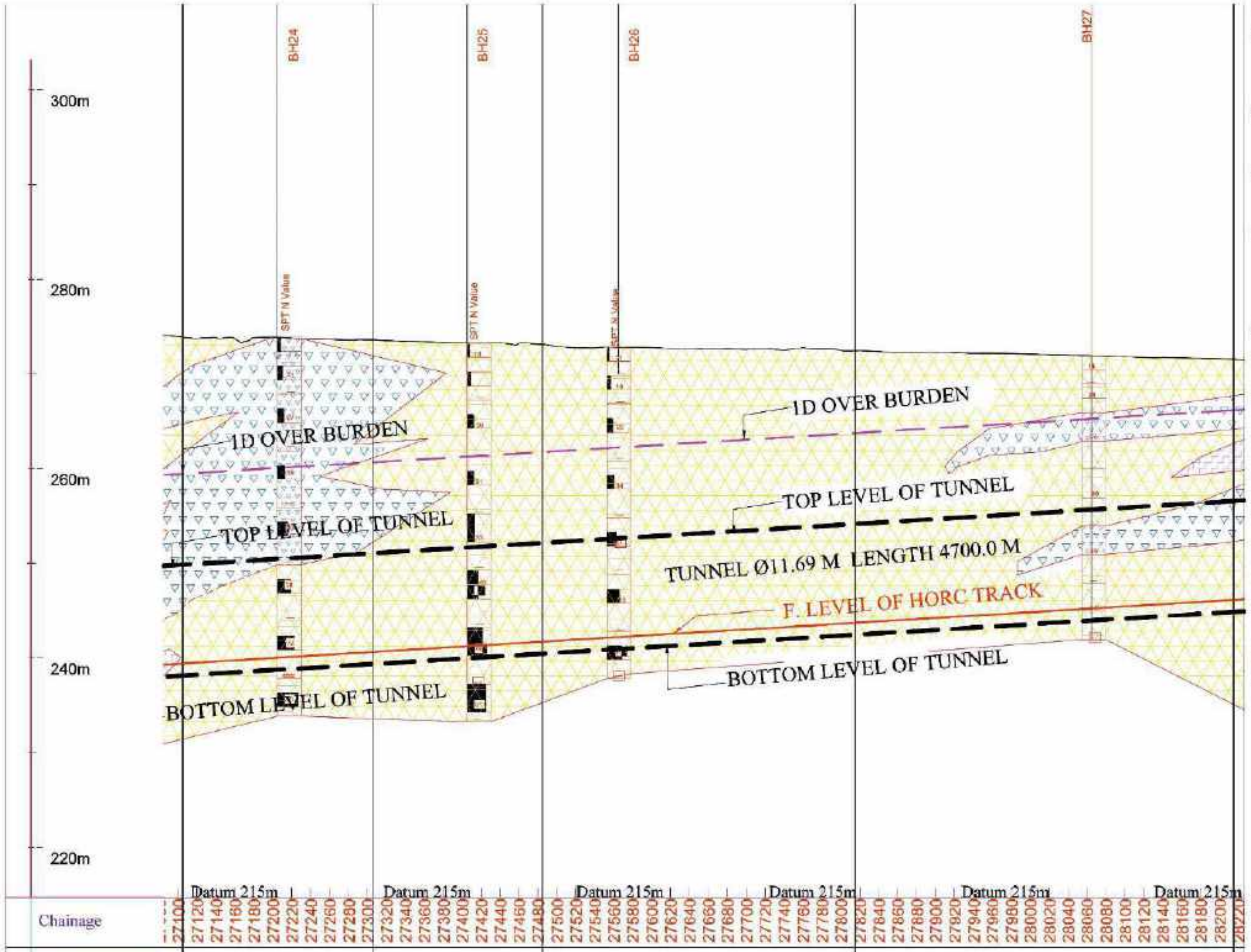


Note:-

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.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cohesive Strength (kPa) | 10 kPa | 10 kPa | 31 kPa | -- | -- | 11 kPa | |
| Angle of Internal friction(phi) | 29 degree (derived from SPT N value) | 28 degree (derived from SPT N value) | 12 degree (Laboratory tested Value) | -- | -- | 31 degree (derived from SPT N value) | |
| Type of Soil | ML (Non-Cohesive) soil | ML (Non-Cohesive) soil | CL (Cohesive soil) | Kanker with patch of CL (Cohesive soil) | Kanker with patch of CL (Cohesive soil) | CL (Cohesive soil) with interlaying bands of ML& SM | C<br>tu<br>w |

**Figure 3.12: Chainage-wise variation in C and $\phi$. (Samples from 2D depth considered only).**



|  |  |  |  |  |
|---|---|---|---|---|
| Cohesive Strength (kPa) | 25 kPa | 28 kPa | 29 kPa | 31 kPa |
| Angle of Internal friction(phi) | 13 degree (Laboratory tested Value) | 11 degree (Laboratory tested Value) | 13 degree (Laboratory tested Value) | 10 degree (Laboratory tested Value) |
| Type of Soil | CL (Cohesive soil) within tunnel alignment and ML within 1D depth. | CL (Cohesive soil) | CL (Cohesive soil) | CL (Cohesive soil) with interlaying bands of ML(Non-cohesive Soil) |

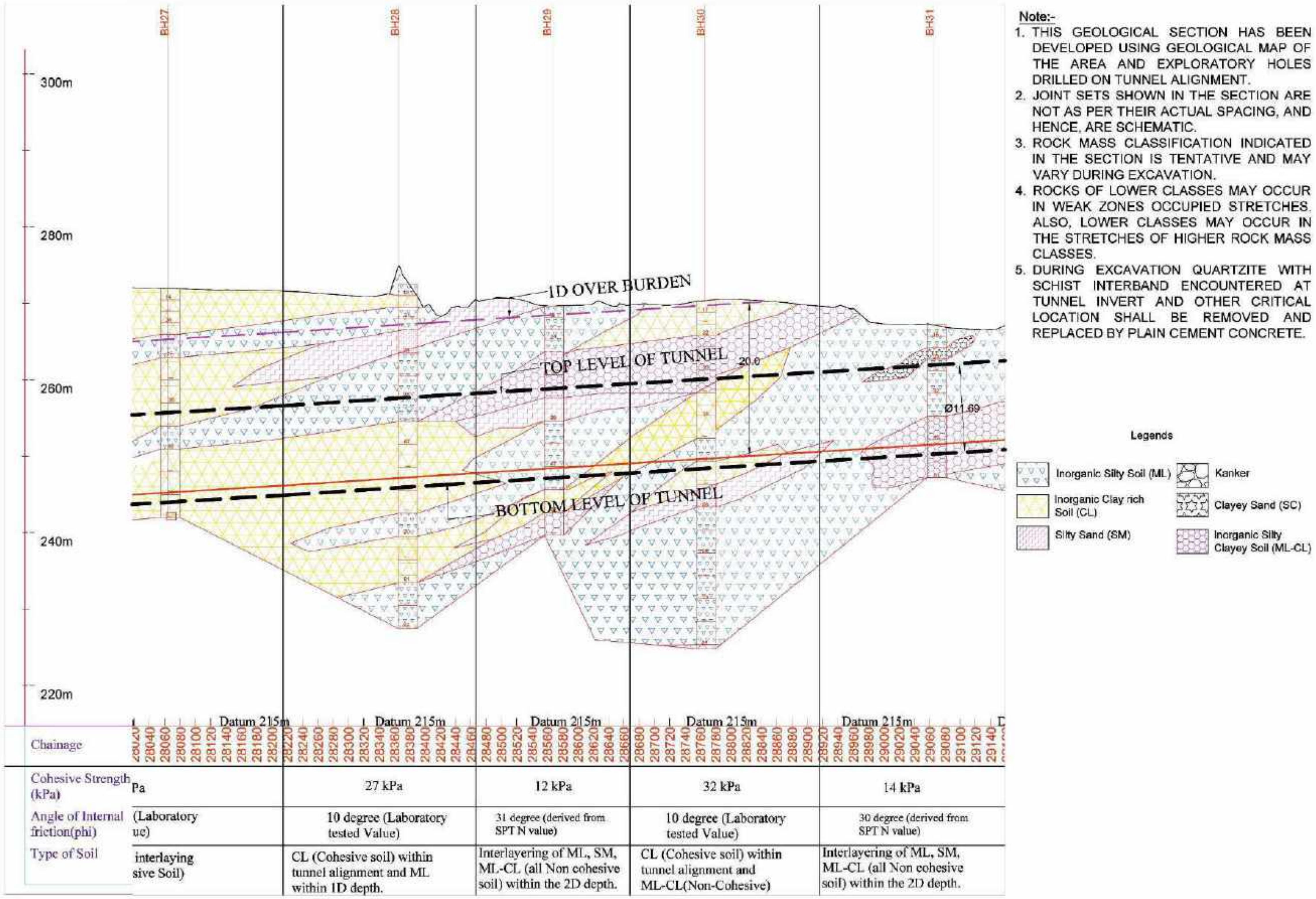
Note:-

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).

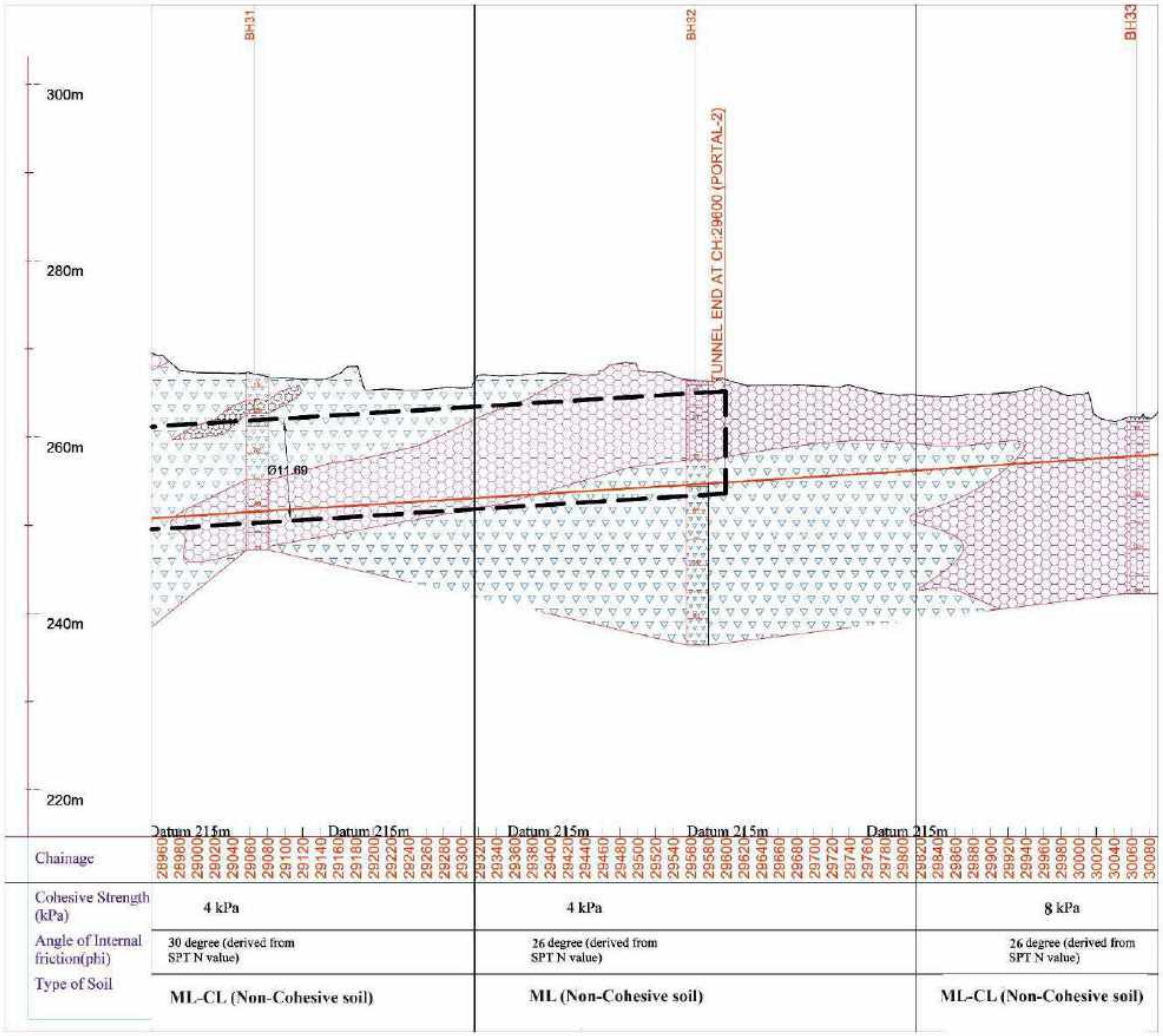


**Note:-**

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.

| | | | | | |
|---|---|---|---|---|---|
| Cohesive Strength (kPa) | Pa | 27 kPa | 12 kPa | 32 kPa | 14 kPa |
| Angle of Internal friction(phi) | (Laboratory ue) | 10 degree (Laboratory tested Value) | 31 degree (derived from SPT N value) | 10 degree (Laboratory tested Value) | 30 degree (derived from SPT N value) |
| Type of Soil | interlaying sive Soil) | CL (Cohesive soil) within tunnel alignment and ML within 1D depth. | Interlayering of ML, SM, ML-CL (all Non cohesive soil) within the 2D depth. | CL (Cohesive soil) within tunnel alignment and ML-CL(Non-Cohesive) | Interlayering of ML, SM, ML-CL (all Non cohesive soil) within the 2D depth. |

**Figure 3.14: Chainage-wise variation in C and $\phi$. (Samples from 2D depth considered only).**



| | | | |
|---|---|---|---|
| Cohesive Strength (kPa) | 4 kPa | 4 kPa | 8 kPa |
| Angle of Internal friction(phi) | 30 degree (derived from SPT N value) | 26 degree (derived from SPT N value) | 26 degree (derived from SPT N value) |
| Type of Soil | ML-CL (Non-Cohesive soil) | ML (Non-Cohesive soil) | ML-CL (Non-Cohesive soil) |

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 3.15: Chainage-wise variation in C and ϕ values, along the cut & cover region, for the strata below formation level.**

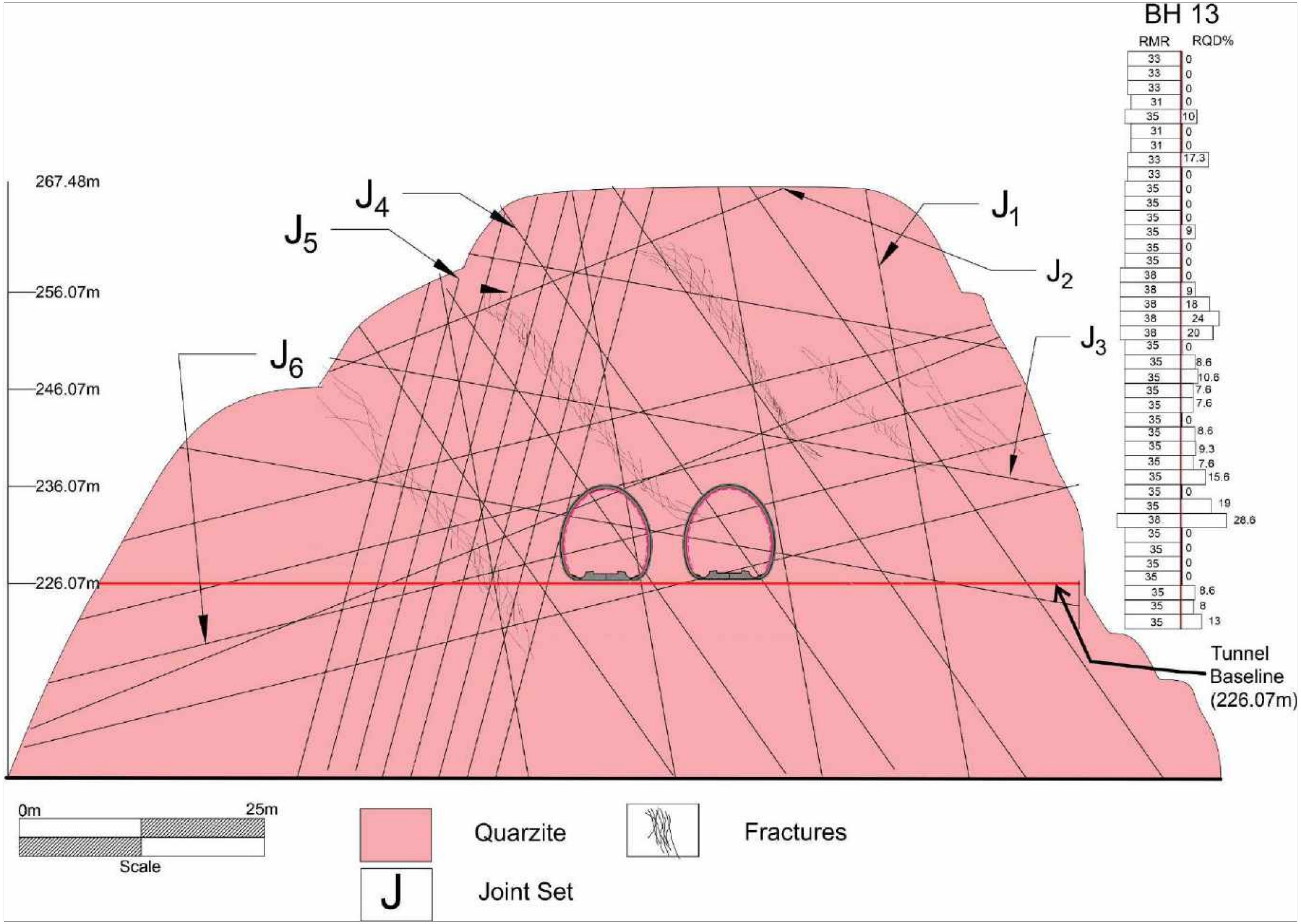


**Figure 3.16: Detailed cross section of the Portal-I, on the mountain front. Joint sets are schematically drawn maintaining their actual orientation. Average spacing between the joints are as follows $J_1$: 300 cm, $J_2$:252.78cm, $J_3$:160cm, $J_4$:80cm, $J_5$:32cm, $J_6$:100cm.**

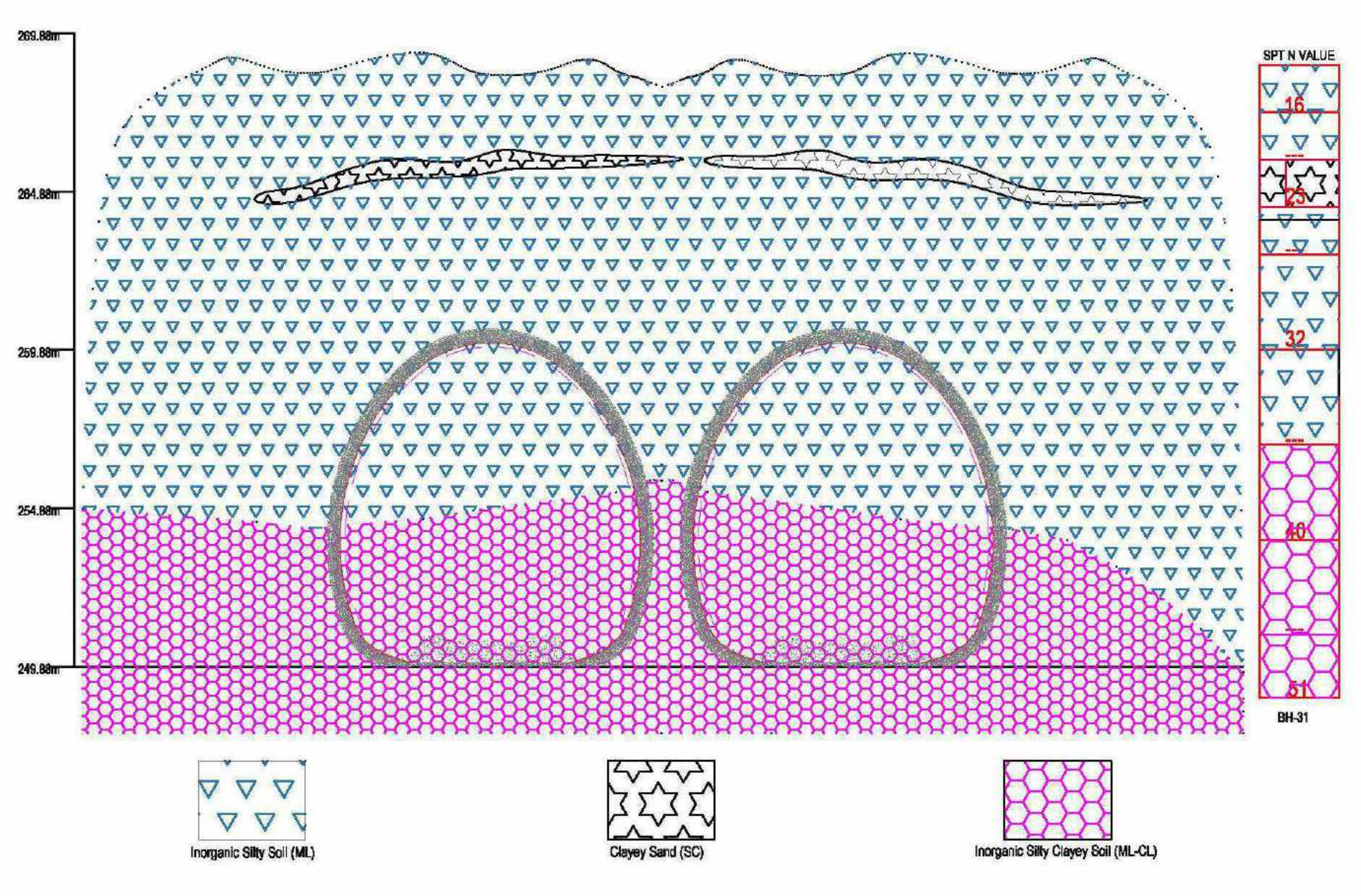


**Figure 3.17: Detailed lithological cross section at the end of NATM Structure in soil (CH 28900).**

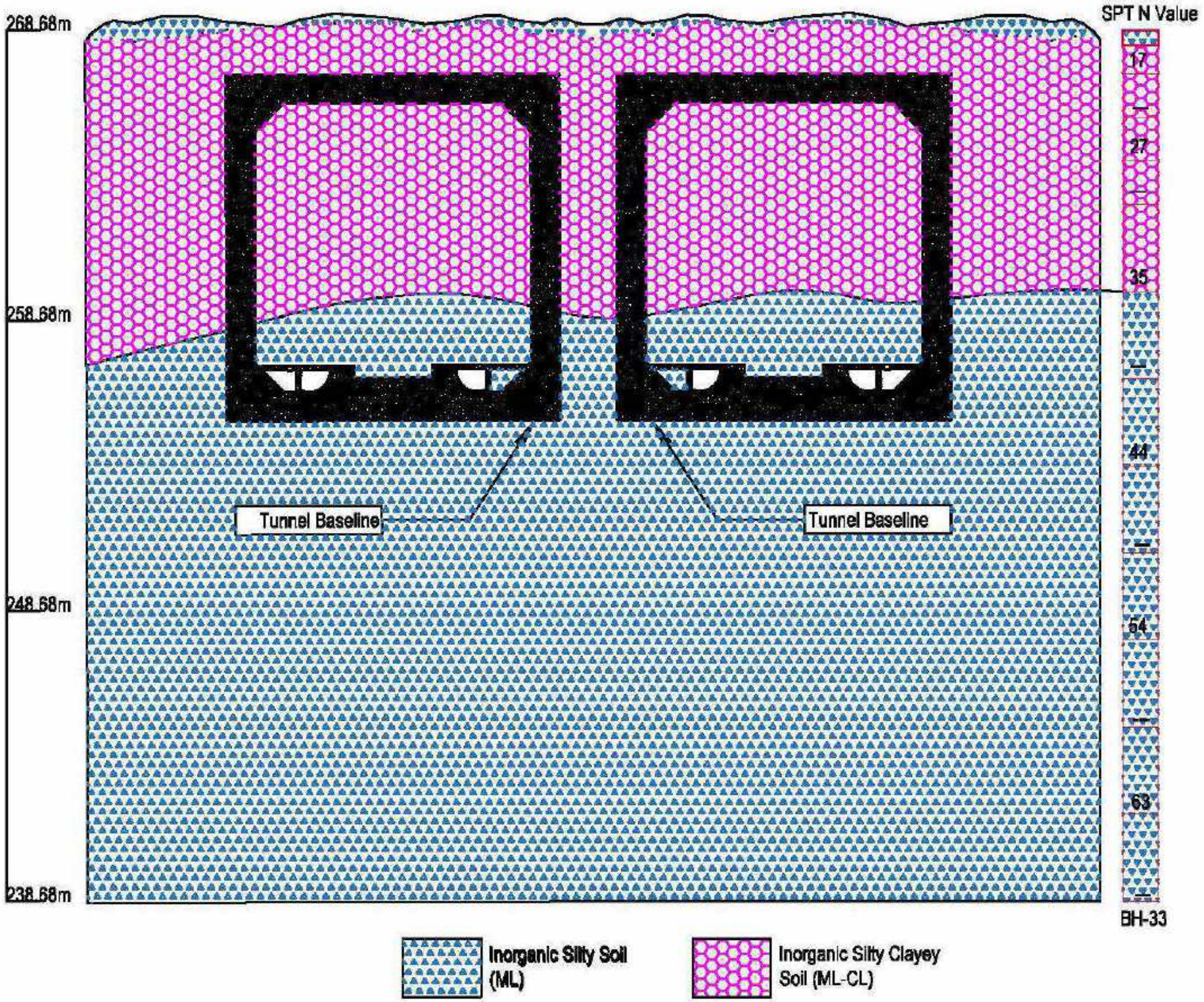


**Figure 3.18: Cut and Cover structure at the end of tunnel – Portal II (CH29600).**

**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$^2$ | Recom mended 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

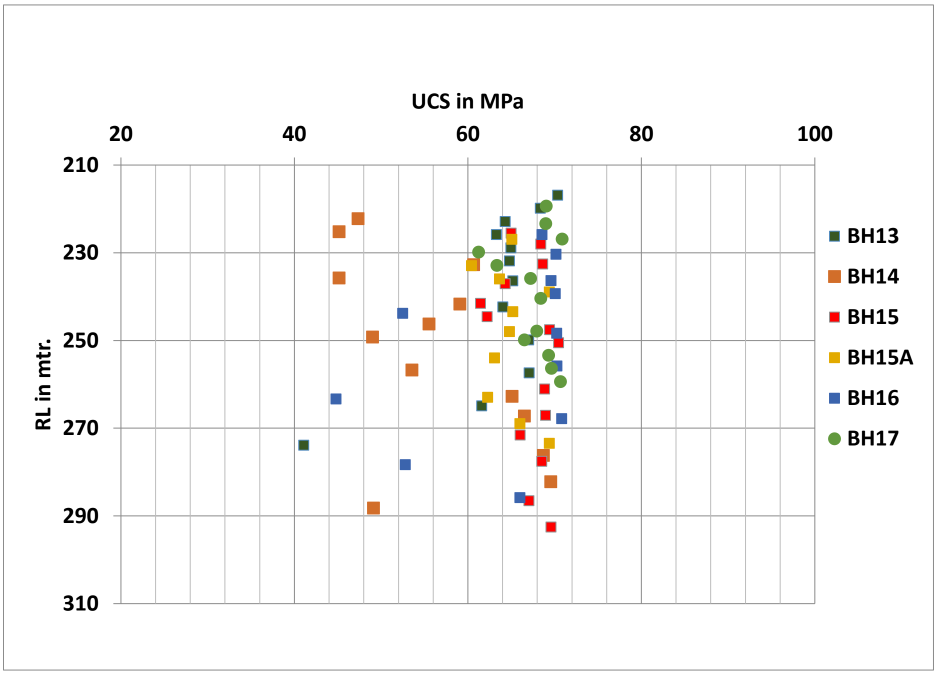


**Figure 4.1: Unconfined Compressive Strength (UCS) of rock mass from entire borehole length vs RL (Refer to Annexure C in Geotechnical Report for detail).**

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.

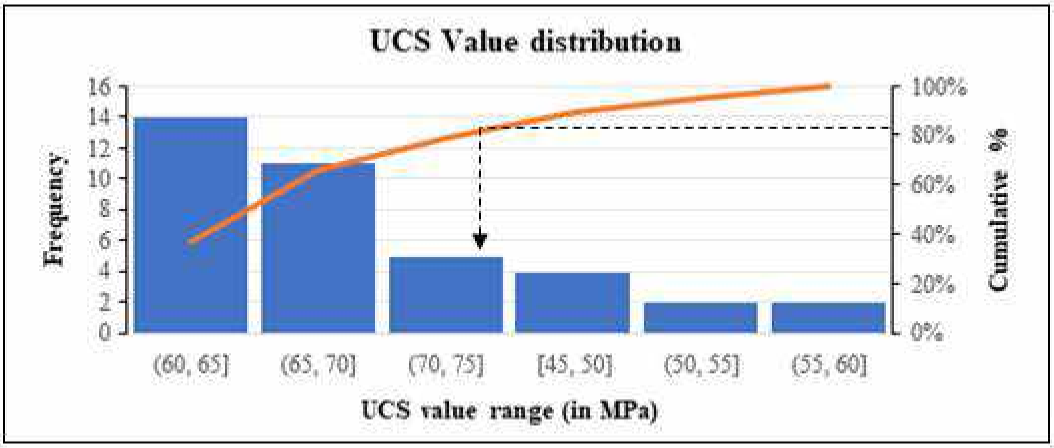


**Figure 4.2: Pareto Chart showing recommended UCS value for the rock mass from 2D depth.**

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.

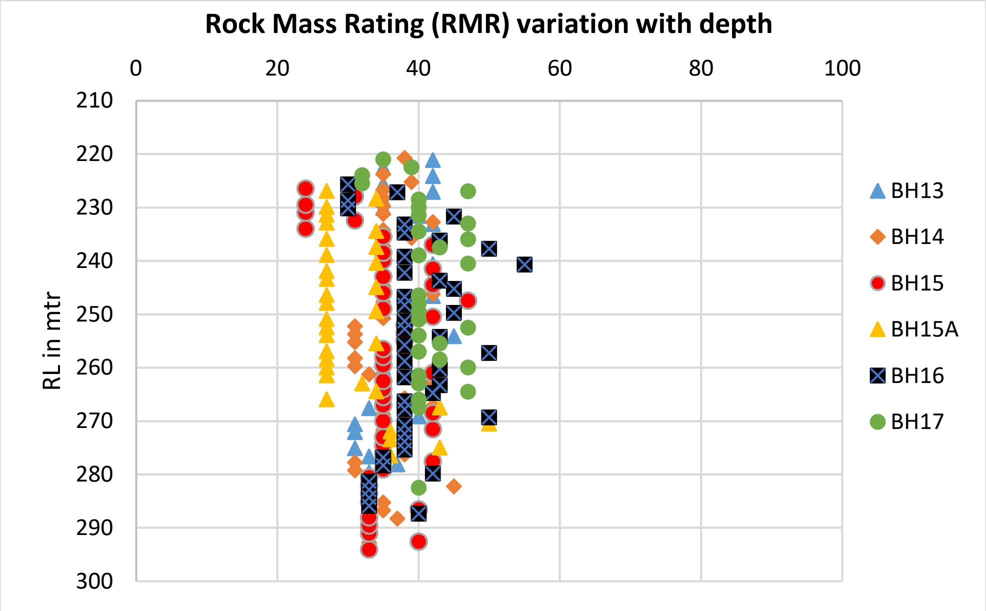


**Figure 4.3:** **Graphical representation of RMR of rock mass from entire borehole length with depth. (Refer to Annexure A in Geotechnical Report for detail).**

RMR value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

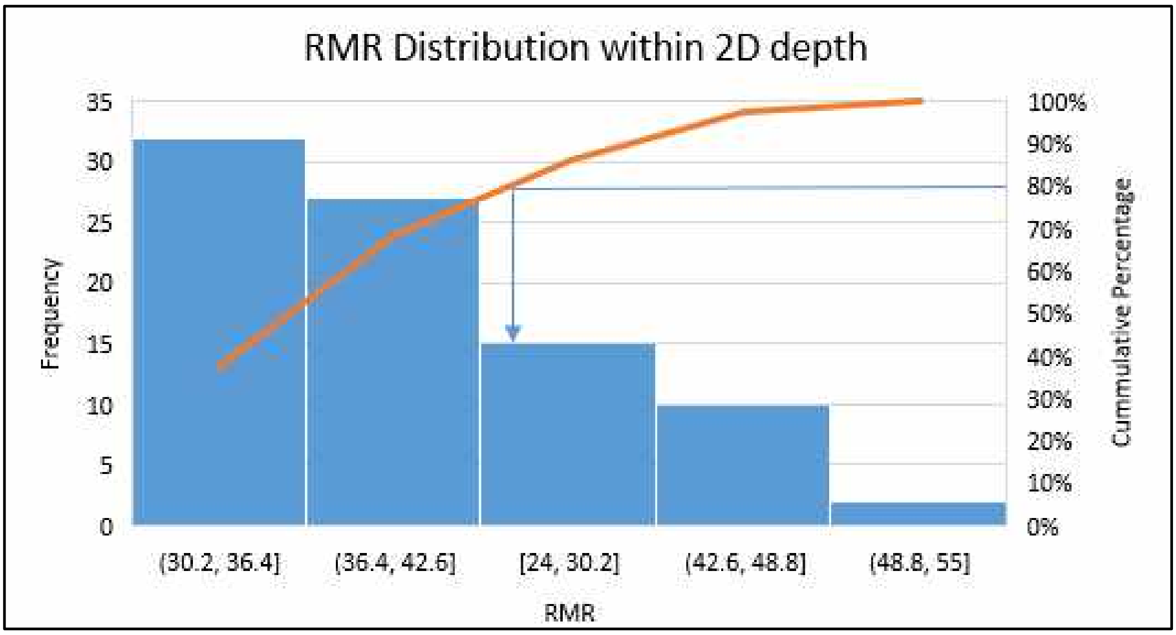


**Figure 4.4: Pareto Chart showing recommended RMR value for the rock mass within 2D depth.**

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:

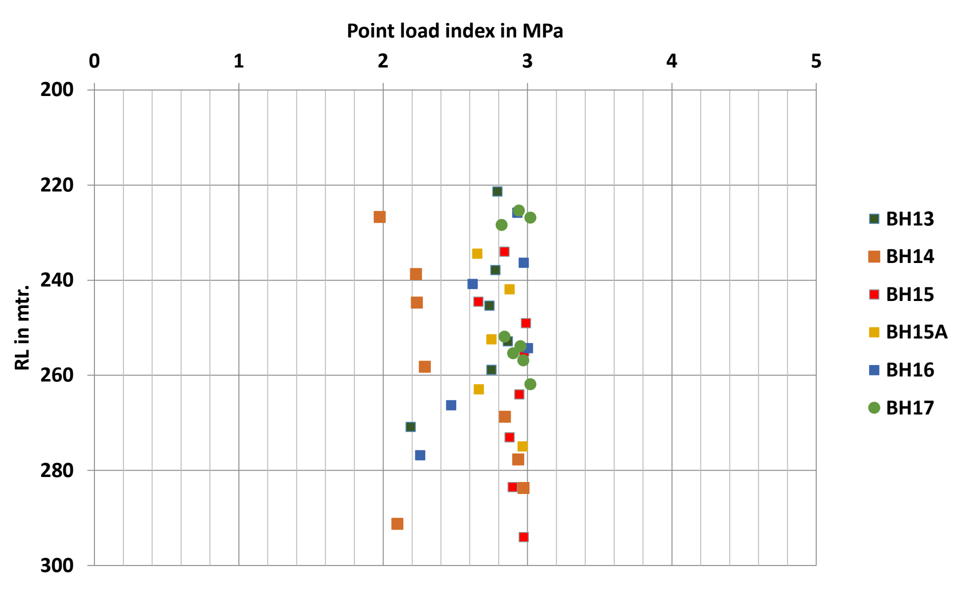


**Figure 4.5:Point Load Index (PLI) of rock mass from entire borehole length vs RL. (Refer to Annexure E in Geotechnical Report for detail).**

PLI value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

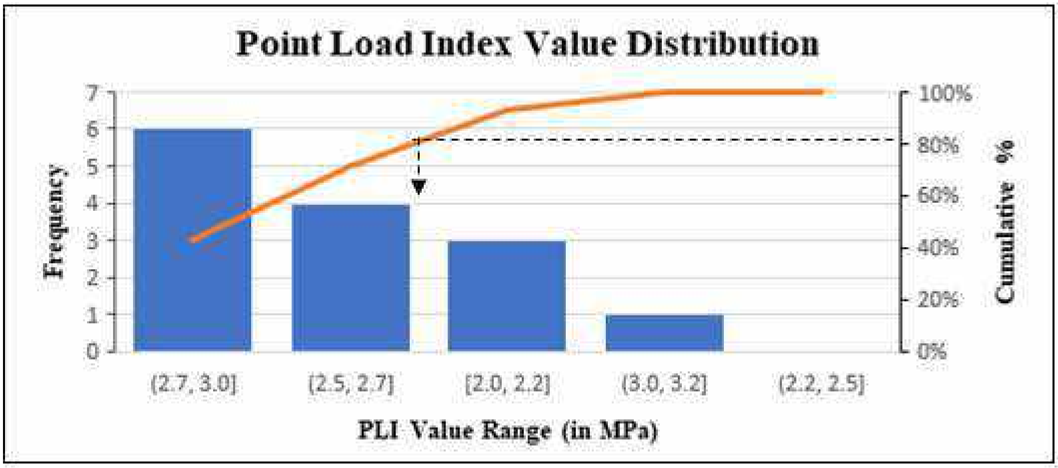


**Figure 4.6: Pareto Chart showing recommended PLI value for the rock mass within 2D depth.**

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:

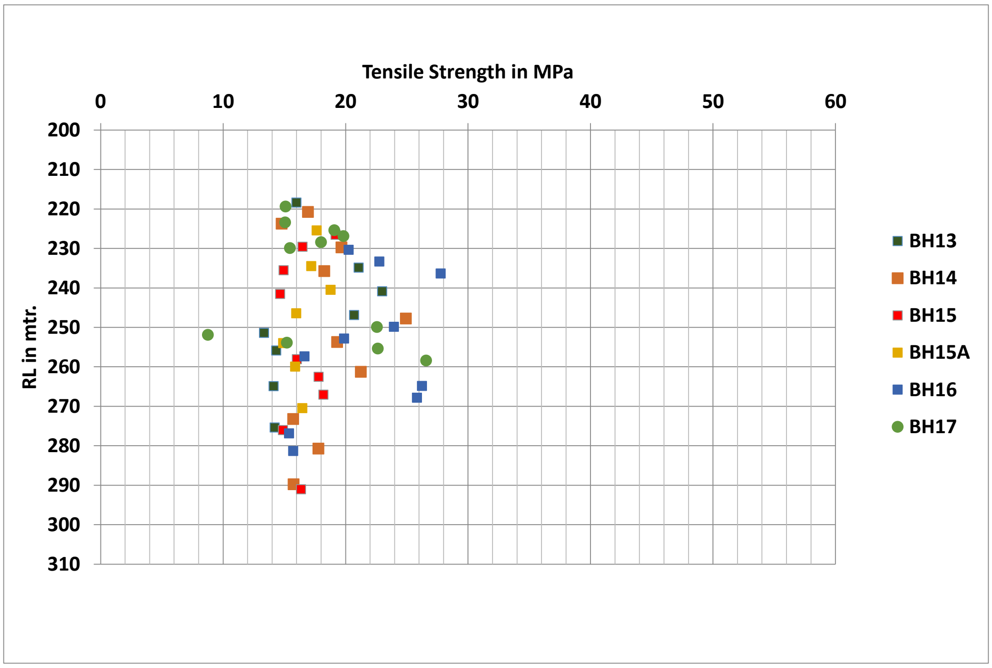


**Figure 4.7:Tensile Strength of rock mass from entire borehole length vs RL. (Refer to Annexure B in Geotechnical Report for detail).**

Tensile strength value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

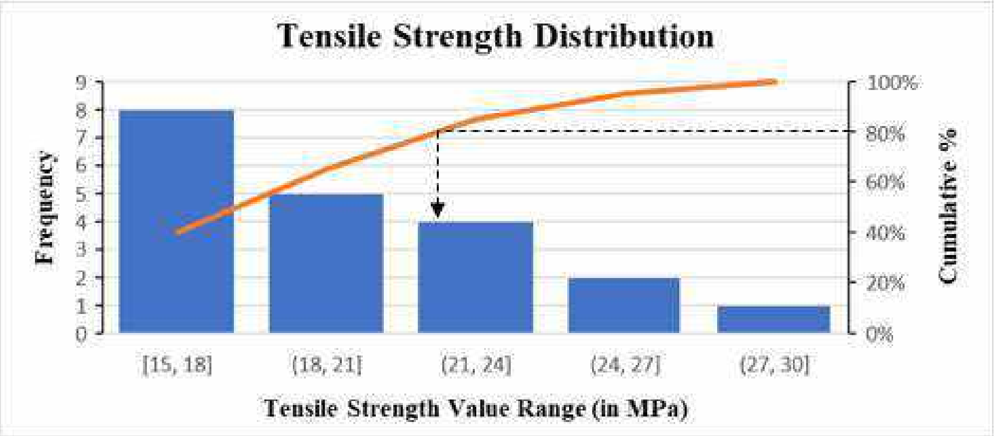


**Figure 4.8: Pareto Chart showing recommended tensile strength value for the rock mass within 2D depth.**

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:

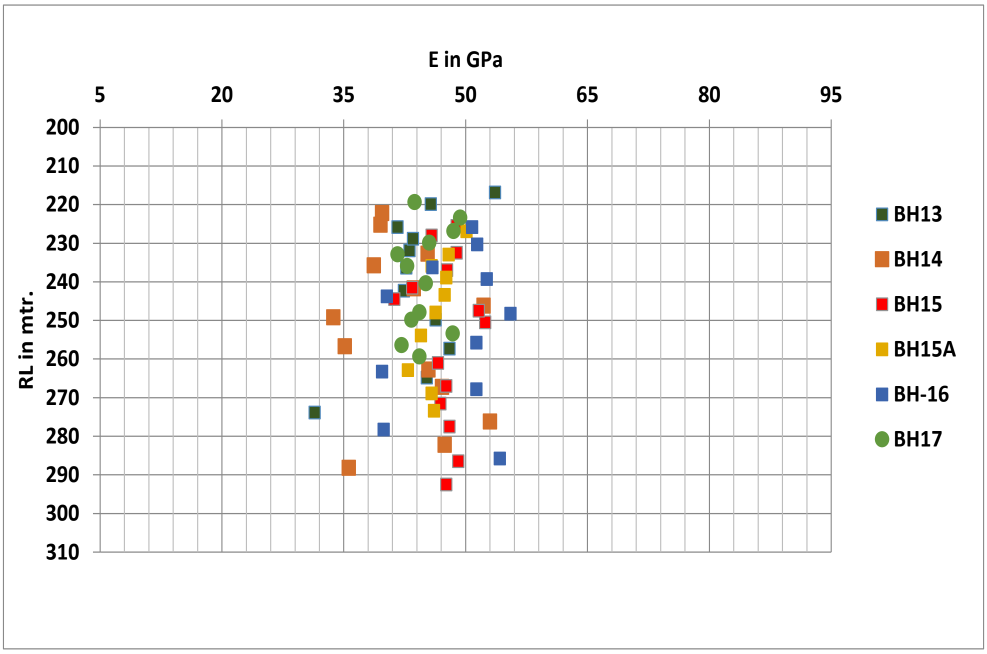


**Figure 4.9: Modulus of Elasticity (E) of rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).**

**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.

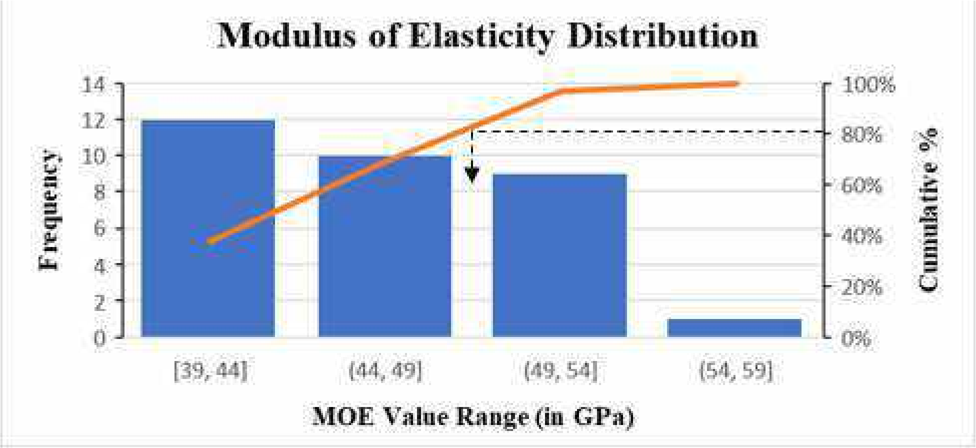


**Figure 4.10: Pareto Chart showing recommended Modulus of Elasticity (E) value for the rock mass within 2D depth.**

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:

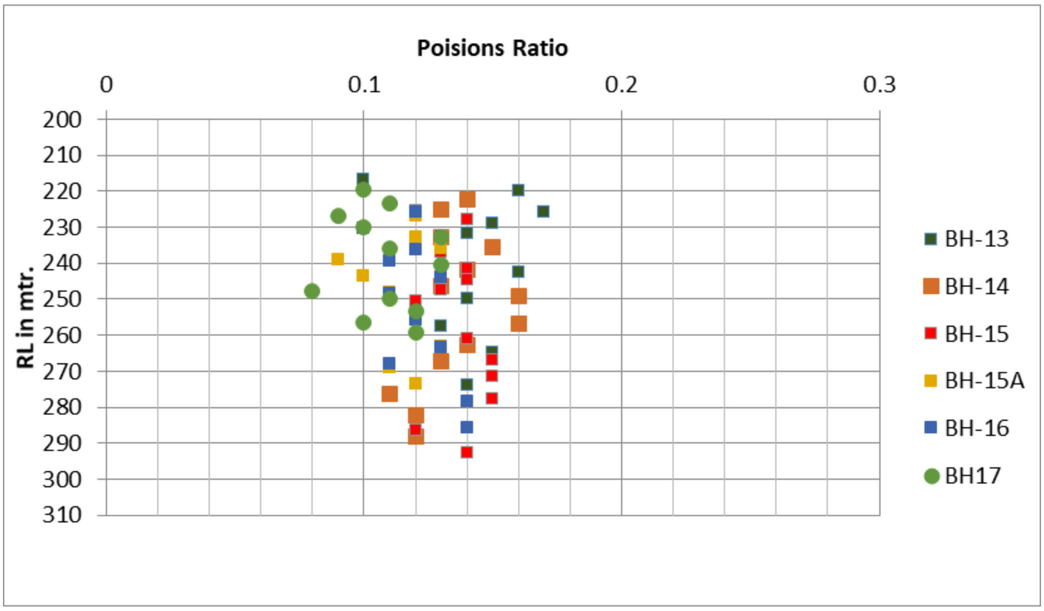


**Figure 4.11: Poisson's Ratio distribution for the entire rock mass from entire borehole length vs RL. (Refer to Annexure F in Geotechnical Report for detail).**

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.

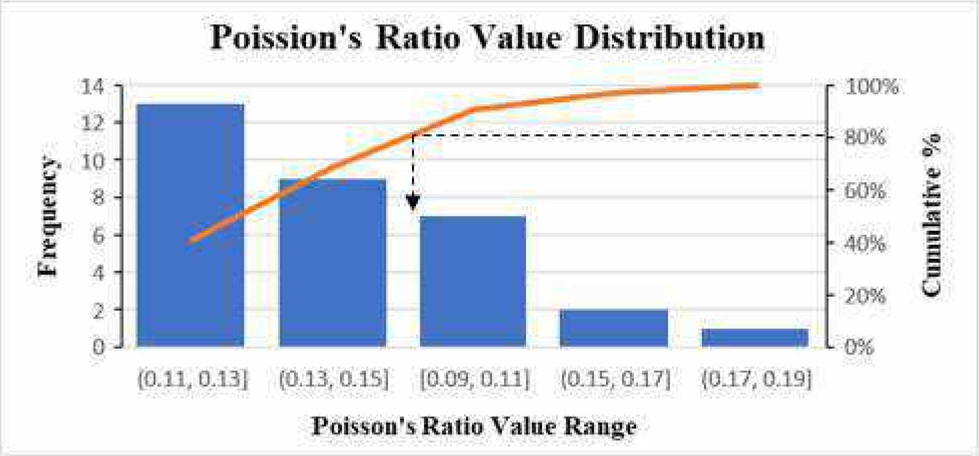


**Figure 4.12: Pareto Chart showing recommended Poisson’s Ratio value for the rock mass within 2D depth.**

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:

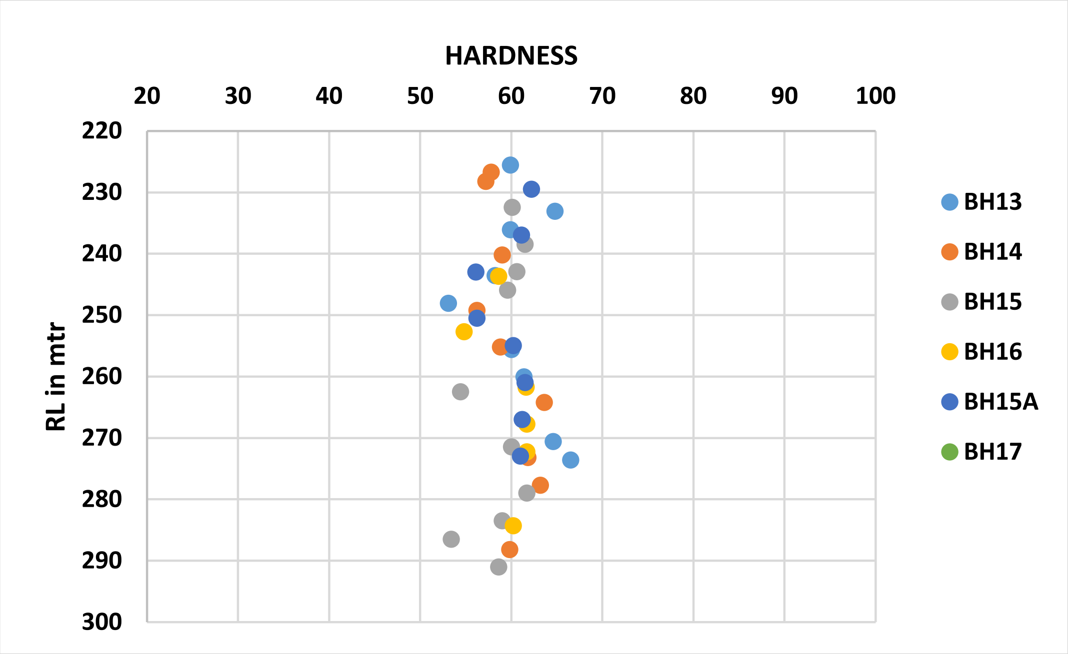


**Figure 4.13: Hardness of rock mass from entire borehole length vs RL. (Refer to Annexure H in Geotechnical Report for detail).**

Hardness value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

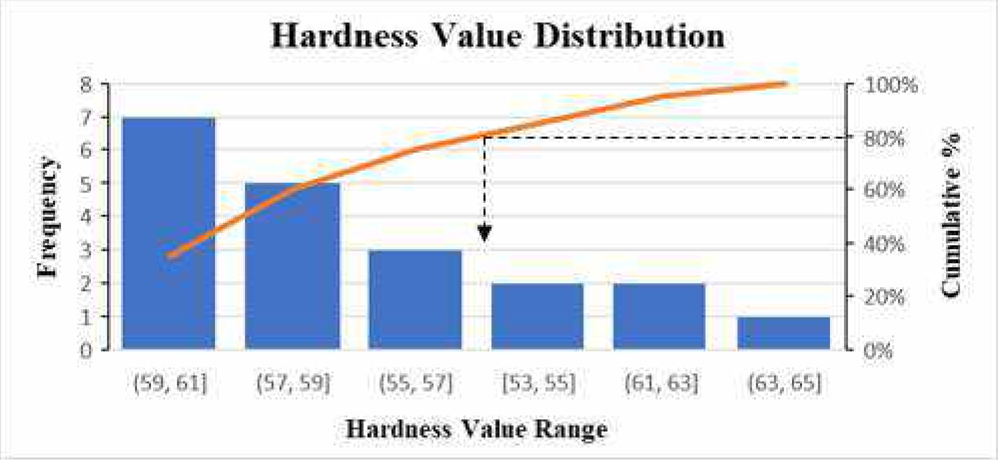


**Figure 4.14: Pareto Chart showing recommended Hardness value for the rock mass within 2D depth.**

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:

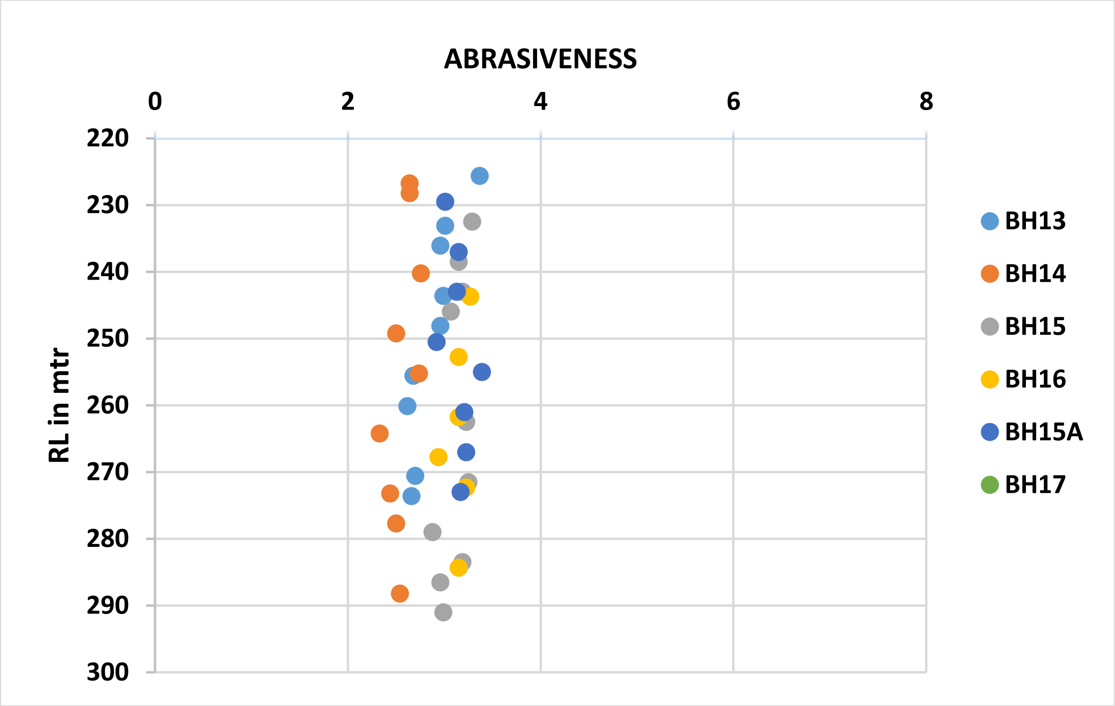


**Figure 4.15:Abrasiveness of rock mass from entire borehole length vs RL. (Refer to Annexure I in Geotechnical Report for detail).**

Abrasive Index value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

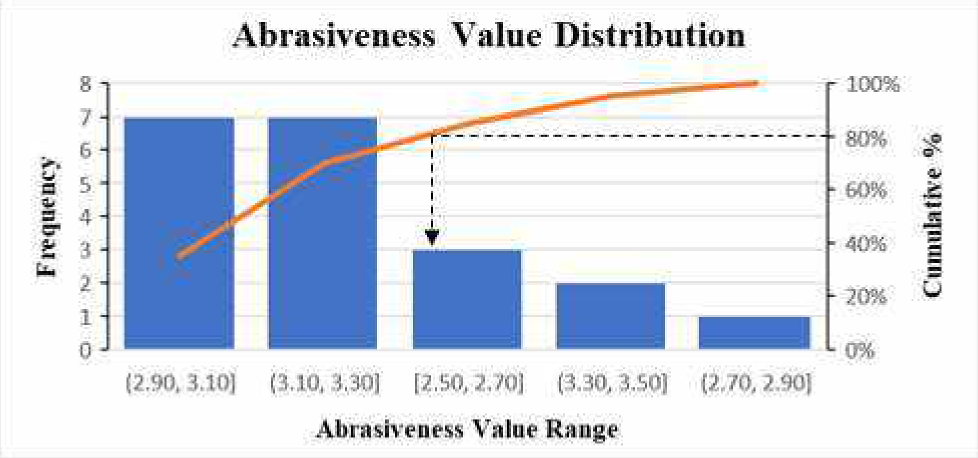


**Figure 4.16: Pareto Chart showing recommended Abrasiveness index value for the rock mass within 2D depth.**

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 ($\phi$):

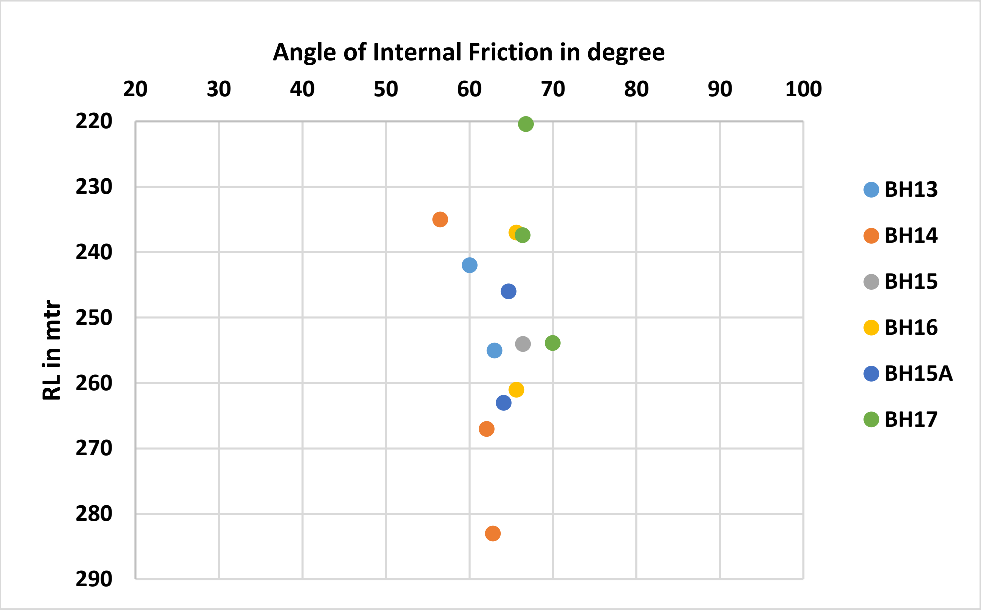


**Figure 4.17: Angle of internal friction of rock mass from entire borehole length vs RL (Refer to Annexure G in Geotechnical Report for detail).**

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.

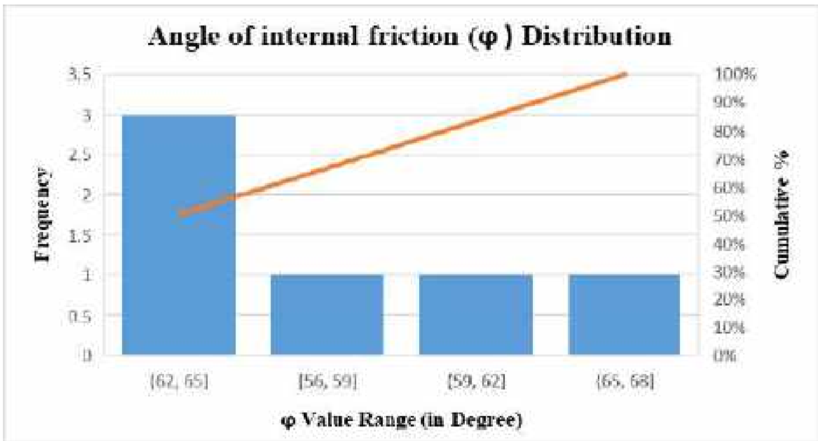


**Figure 4.18: Pareto Chart showing recommended angle of internal friction value for the rock mass within 2D depth. (The straight cumulative frequency curve, in orange, indicates that all of the classes contribute significantly. Therefore, entire range of the population needs to be considered.)**

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:

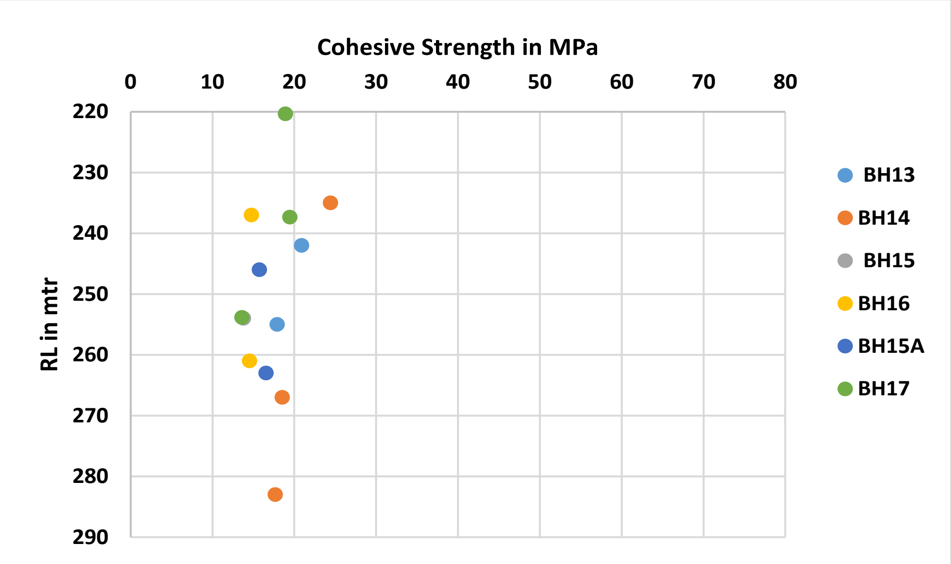


**Figure 4.19: Cohesive strength of rock mass from entire borehole length vs RL (Refer to Annexure F in Geotechnical Report for detail).**

Cohesion value has been recommended using the statistical tool namely Pareto chart, selecting samples from 2D depth only. The result is shown below.

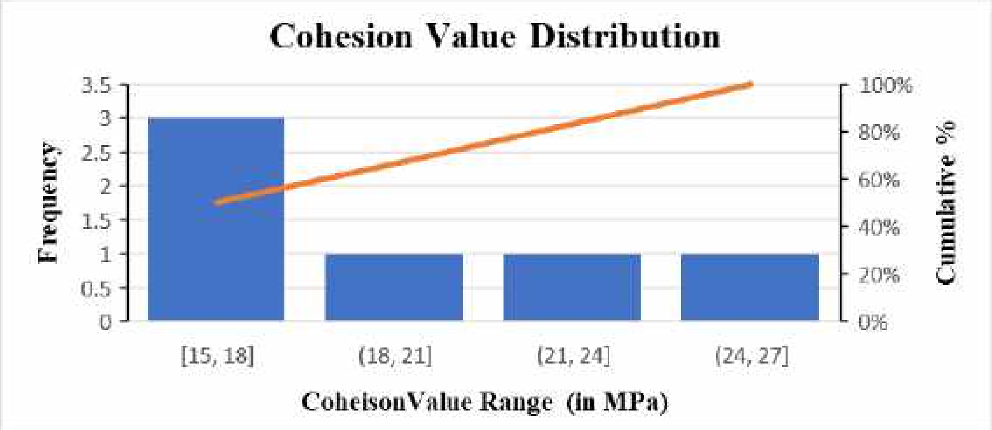


**Figure 4.20: Pareto Chart showing recommended Cohesion value for the rock mass within 2D depth. (The straight cumulative frequency curve, in orange, indicates that all of the classes contribute significantly. Therefore, entire range of the population needs to be considered.)**

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.

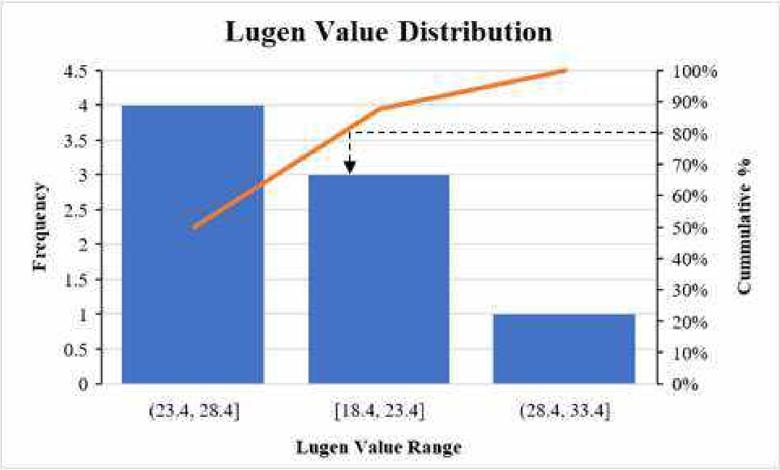


**Figure 4.21: Pareto Chart showing recommended Lugeon value for the rock mass within 2D depth**

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:

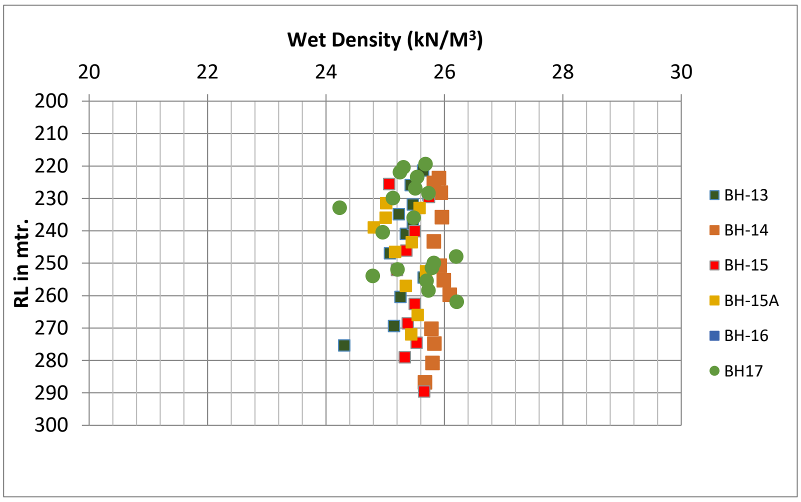


**Figure 4.22: Wet Density for rock mass from entire bore hole length vs RL. (Refer to Annexure D in Geotechnical Report for detail).**

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% ± 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.

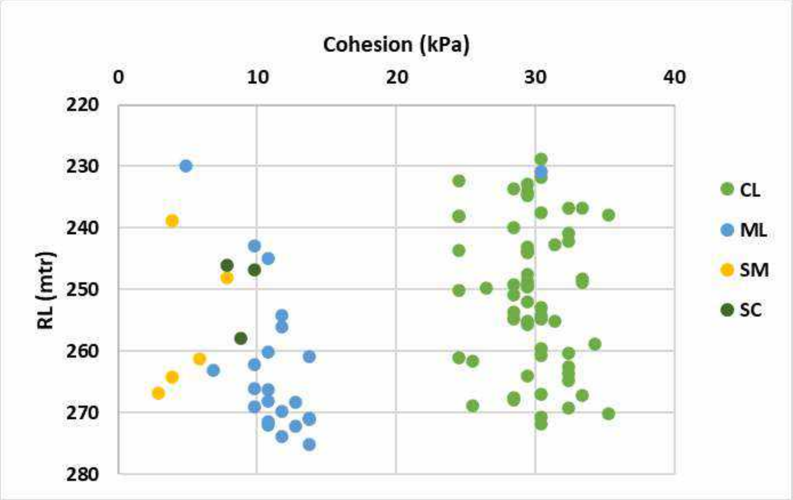


**Figure 5.1 Graph showing laboratory tested cohesion for soil from entire borehole length vs RL. (Refer to Annexure J in Geotechnical Report for detail).**

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.

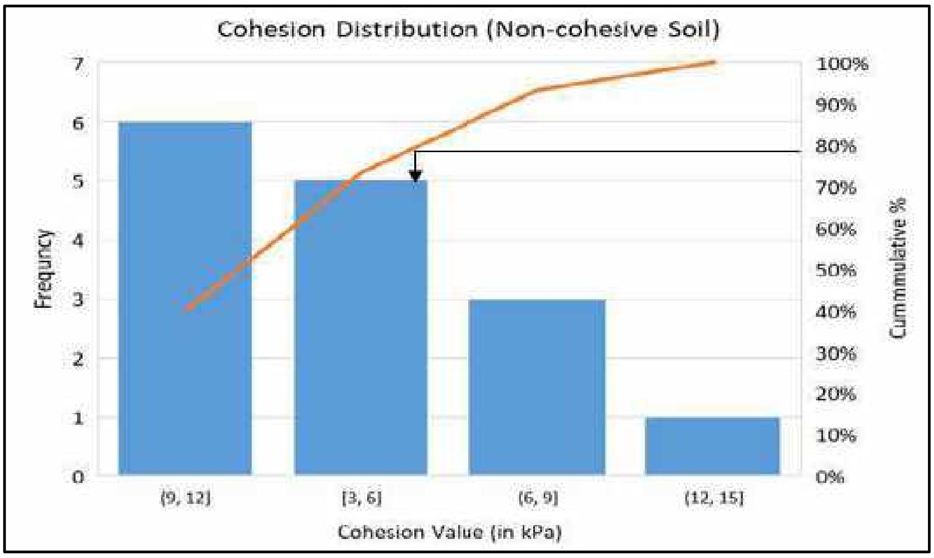


**Figure 5.2: Pareto Chart showing recommended cohesion value for the non-cohesive soil within 2D depth.**

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.

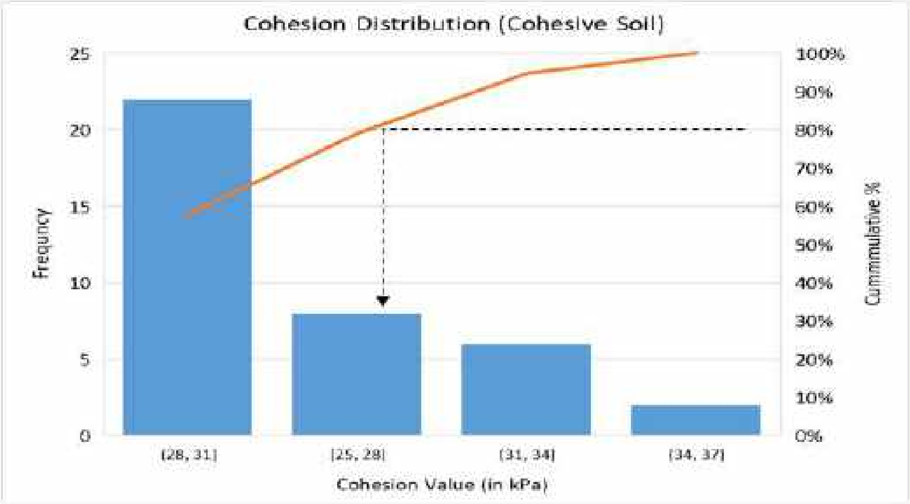


**Figure 5.3: Pareto Chart showing recommended cohesion value for the cohesive soil within 2D depth.**

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.

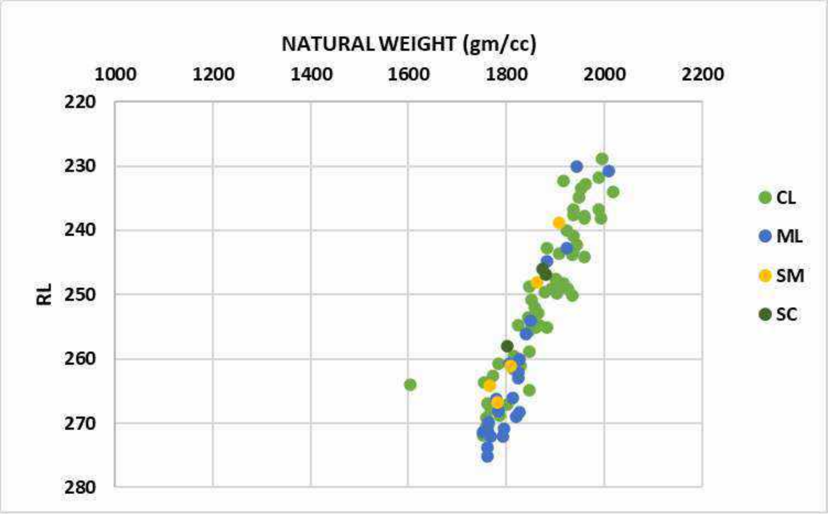


**Figure 5.4: graph for Natural weight of soil from entire borehole length vs RL (Refer to Annexure J in Geotechnical Report for detail).**

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.

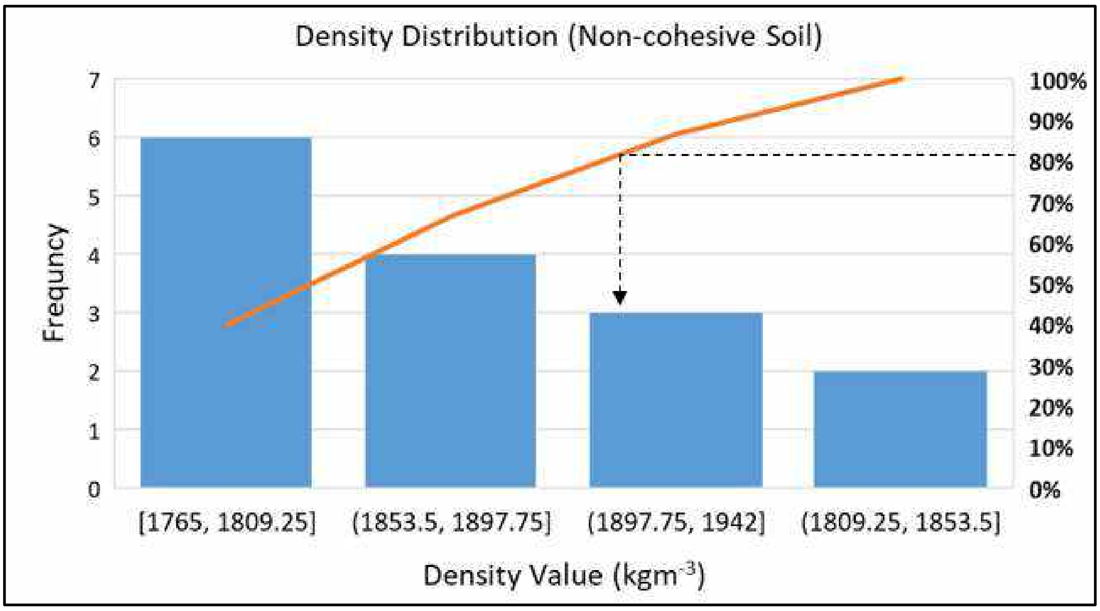


**Figure 5.5: Pareto Chart showing recommended density value for the non-cohesive soil within 2D depth.**

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.

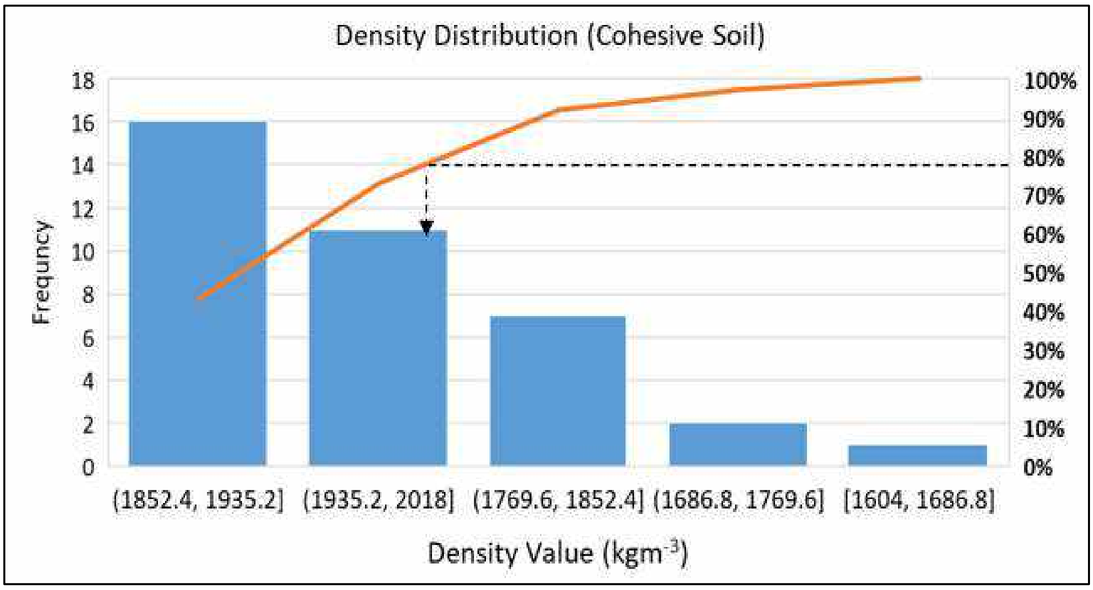


**Figure 5.6: Pareto Chart for recommended density value for the cohesive soil within 2D depth.**

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.

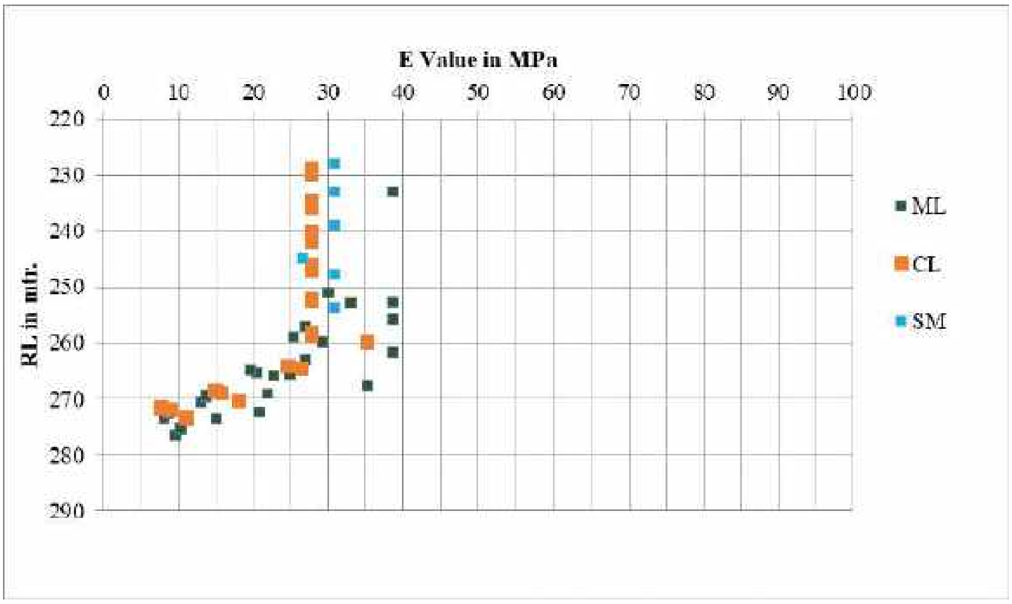


**Figure 5.7: graph for Modulus of elasticity for soil from entire borehole length vs RL. (Refer to Annexure J in Geotechnical Report for detail).**

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.

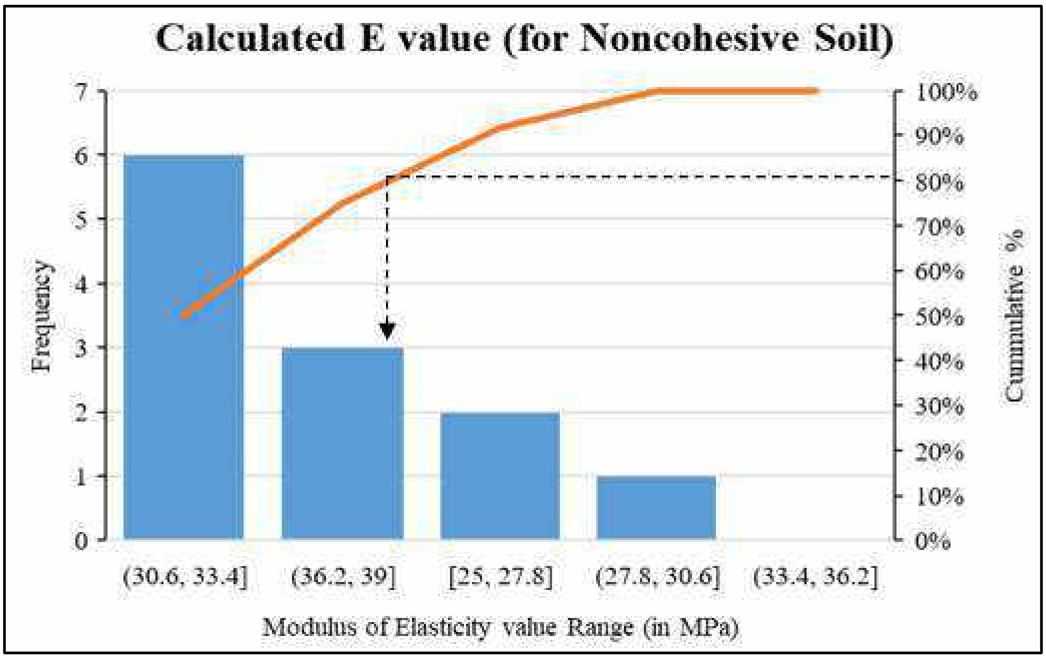


**Figure 5.8: Pareto Chart for recommended E value for the non-cohesive soil within 2D depth.**

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 ($\phi$) for non-cohesive soil

Angle of internal friction ($\phi$) 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.

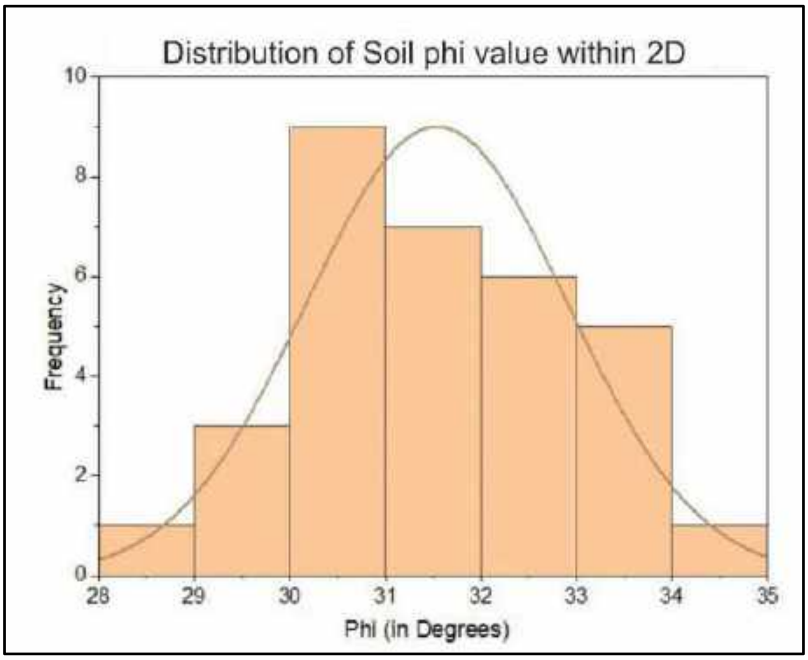


**Figure 5.9: Distribution of non-cohesive soil Phi value within 2D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).**

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.

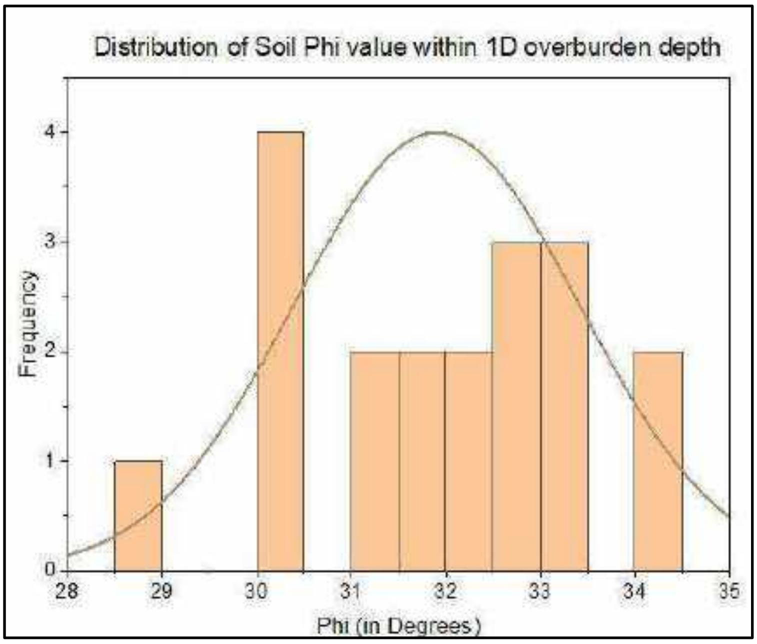


**Figure 5.10: Distribution of non-cohesive soil Phi value within 1D overburden depth**

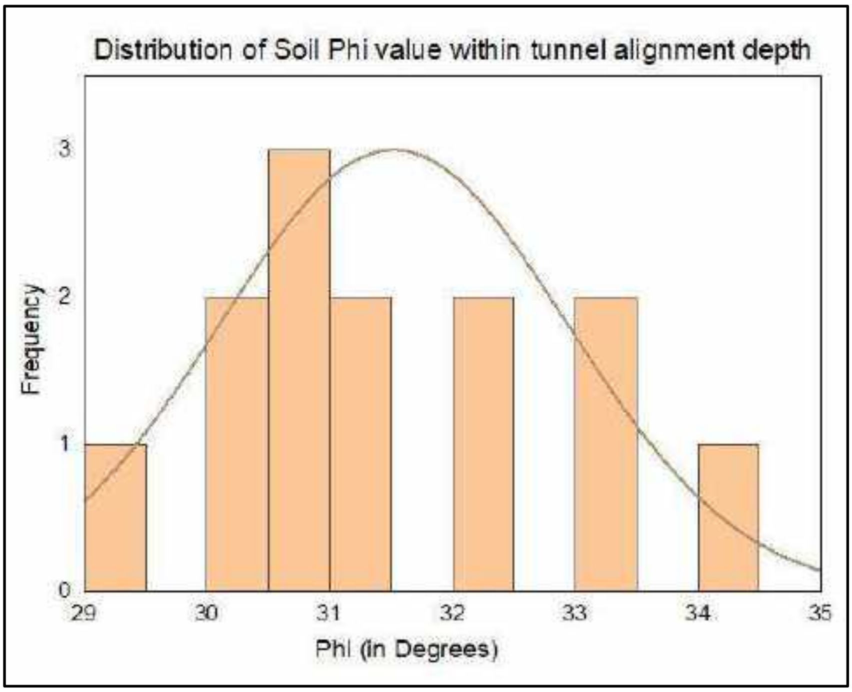


**Figure 5.11: Distribution of non-cohesive soil Phi value within tunnel alignment.**

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 ($\phi$) 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°.**

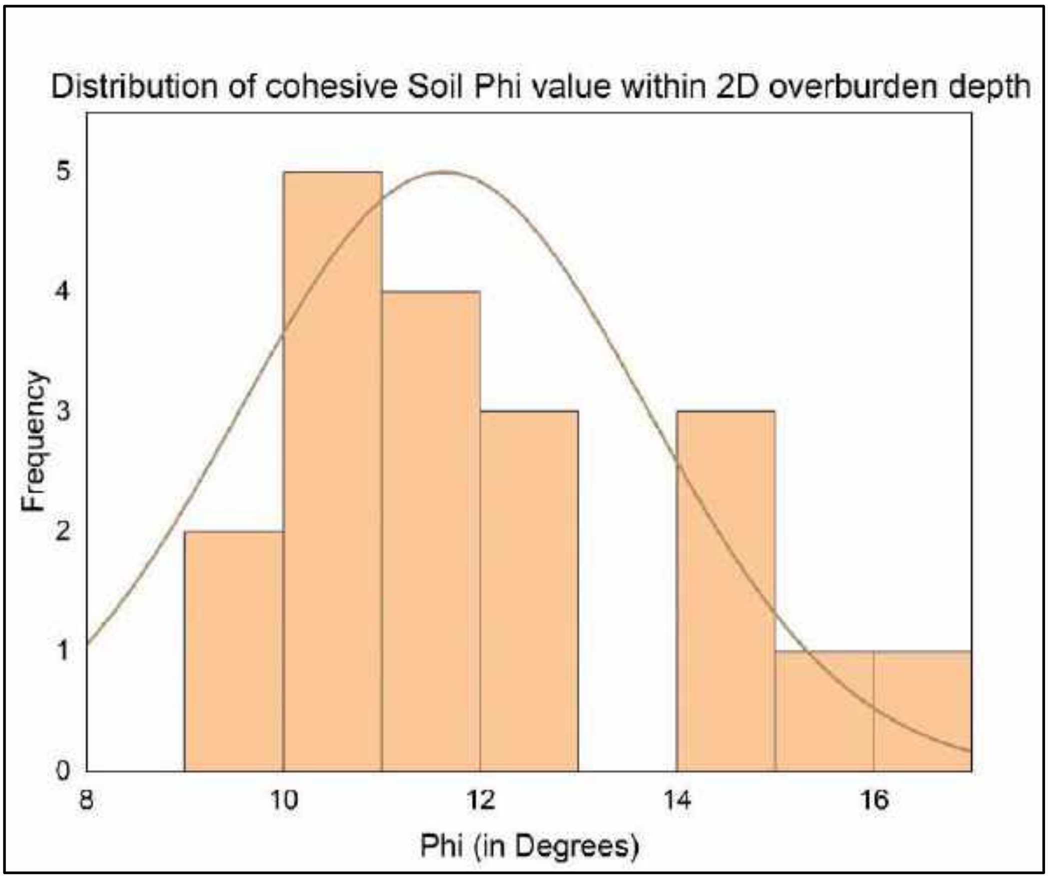


**Figure 5.12: Distribution of cohesive soil Phi value within 2D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).**

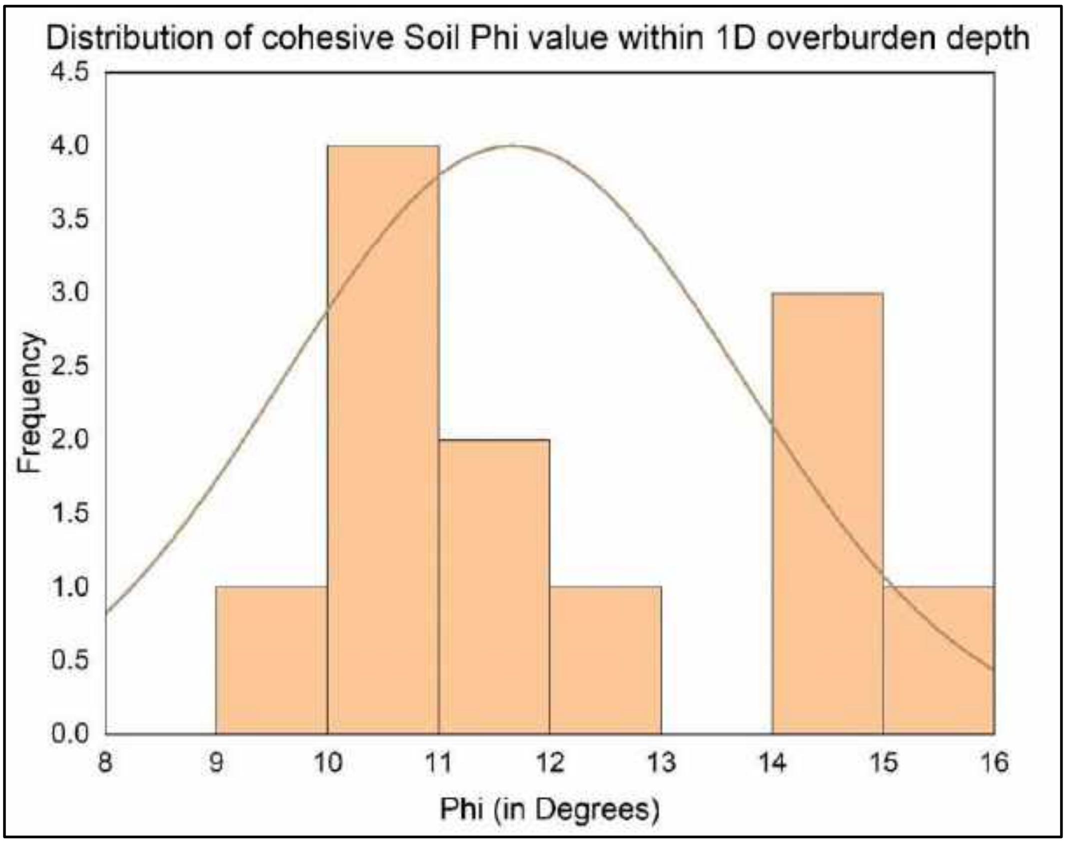


**Figure 5.13: Distribution of cohesive soil Phi value within 1D overburden depth (Detail distribution of phi values along chainage are graphically shown in the Figure 4.12 to 4.14).**

** **for chainage wise variation in C and $\phi$ 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.

# 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
Tel. : 91-141-4046599, Fax : 91-141-2751806
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.

**On soil Samples**

- 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

**On Rock Samples**

  - 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:

$$N' = 15 + \frac{1}{2}(N-15)$$

**(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<br>• Liquid Limit<br>• Plastic Limit | <br>IS: 2720 (Part - 5)<br>IS: 2720 (Part - 5) | <br>√<br>√ | <br>√<br>√ |
| 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 ($\gamma_b$) = W/V

Dry density ($\gamma_d$) = $\gamma_b$/ (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;

$\mu$ = 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 1.42$kg/cm^2$ to 2.24$kg/cm^2$.

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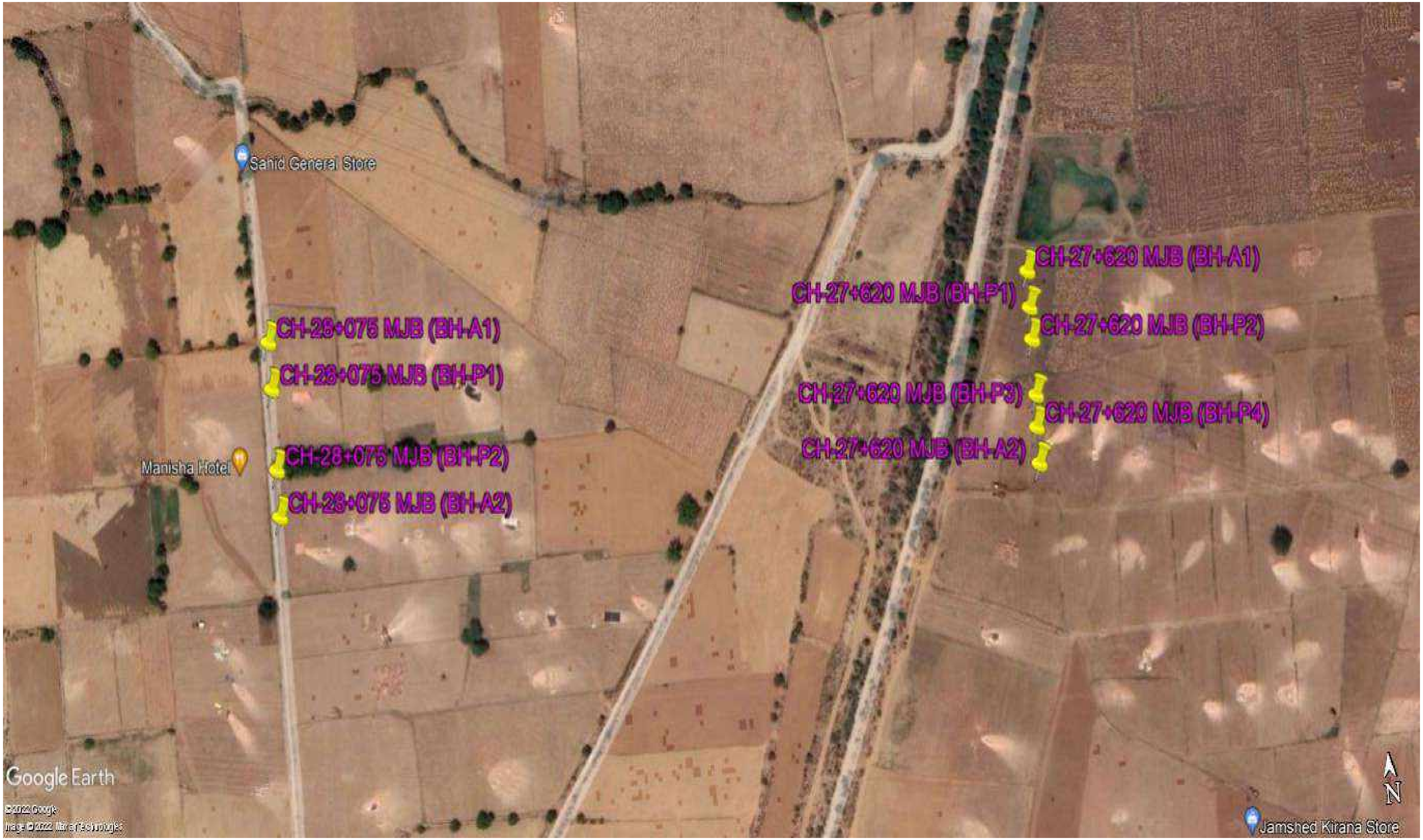
## Abbreviations

| | |
|---|---|
| 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 |

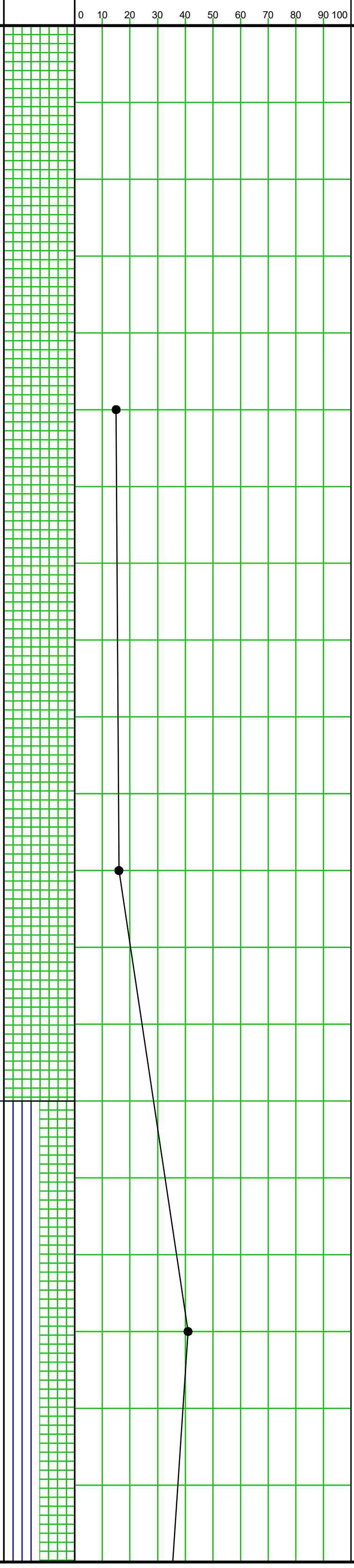

Sahid General Store
CH-28+075 MJB (BH-A1)
CH-28+075 MJB (BH-P1)
Manisha Hotel
CH-28+075 MJB (BH-P2)
CH-28+075 MJB (BH-A2)
CH-27+620 MJB (BH-A1)
CH-27+620 MJB (BH-P1)
CH-27+620 MJB (BH-P2)
CH-27+620 MJB (BH-P3)
CH-27+620 MJB (BH-P4)
CH-27+620 MJB (BH-A2)
N
Jamshed Kirana Store
Google Earth
©2022 Google
Image ©2022 Maxar Technologies


Majid Khan Shop
CH-28+900 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)
N
Google Earth
© 2022 Google
Image © 2022 Maxar Technologies

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 0.0 | | DS | | | | | Brown, Very stiff, Silty clay of low plasticity | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | Brown, Dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 7.5 | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 12 | 17 | 24 | 41 | | | | | |
| 9.0 | | | | | | | | | | | |
| 9.5 | | | | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | | | | |



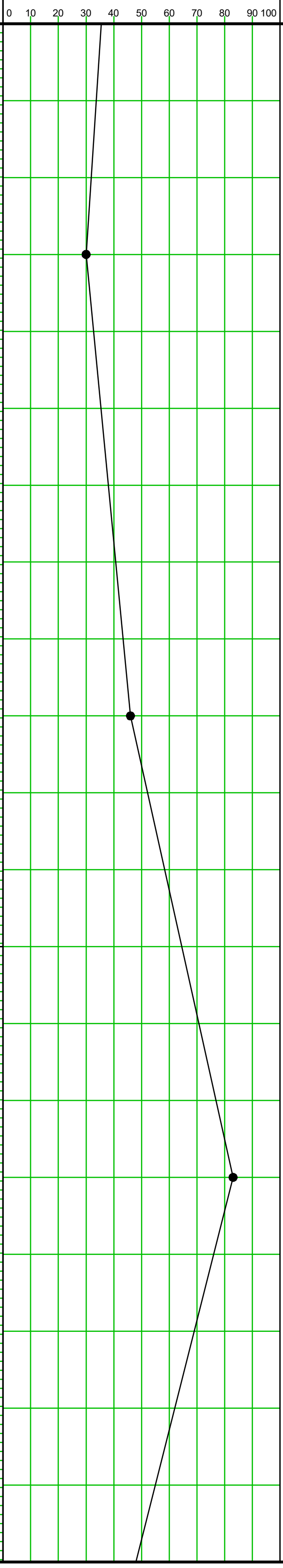
UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | |
| 10.0 | | | | | | | Brown, Dense, Sandy silt of low plasticity with gravel | ML-CL | | |
| 10.5 | | | | | | | | | | |
| 11.0 | | | | | | | | | | |
| 11.5 | 11.5 | SPT-4 | 9 | 14 | 16 | 30 | | | | |
| 12.0 | | | | | | | | | | |
| 12.5 | | | | | | | | | | |
| 13.0 | 13 | UDS-5 | | | | | | | | |
| 13.5 | | | | | | | | | | |
| 14.0 | | | | | | | | | | |
| 14.5 | 14.5 | SPT-5 | 14 | 21 | 25 | 46 | | | | |
| 15.0 | | | | | | | | | | |
| 15.5 | | | | | | | | | | |
| 16.0 | 16 | UDS-6 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | |
| 16.5 | | | | | | | | | | |
| 17.0 | | | | | | | | | | |
| 17.5 | 17.5 | SPT-6 | 22 | 40 | 43 | 83 | | | | |
| 18.0 | | | | | | | | | | |
| 18.5 | | | | | | | | | | |
| 19.0 | 19 | UDS-7 | | | | | | | | |
| 19.5 | | | | | | | | | | |
| 20.0 | | | | | | | | | | |

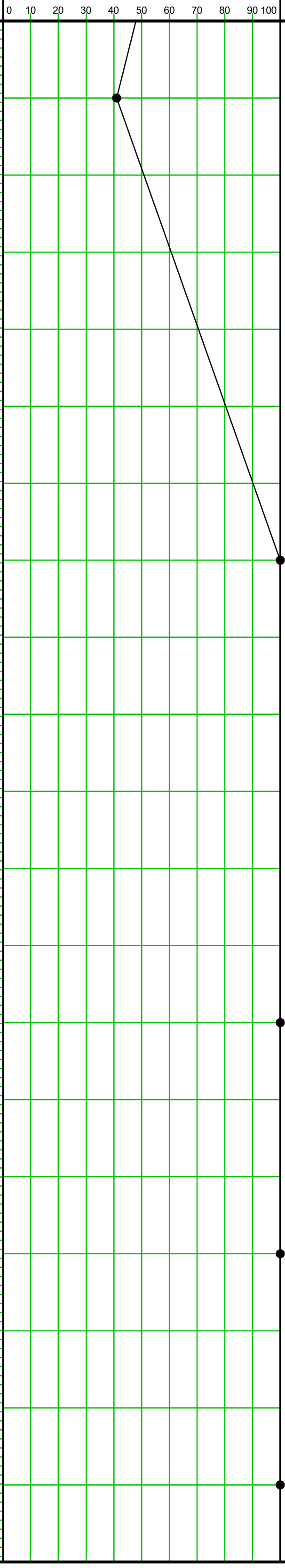
**(Depth v/s SPT N Value)**



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 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |  | |
| 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* | | | | | | | | | |
| 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 | | | | | | | | | | | |

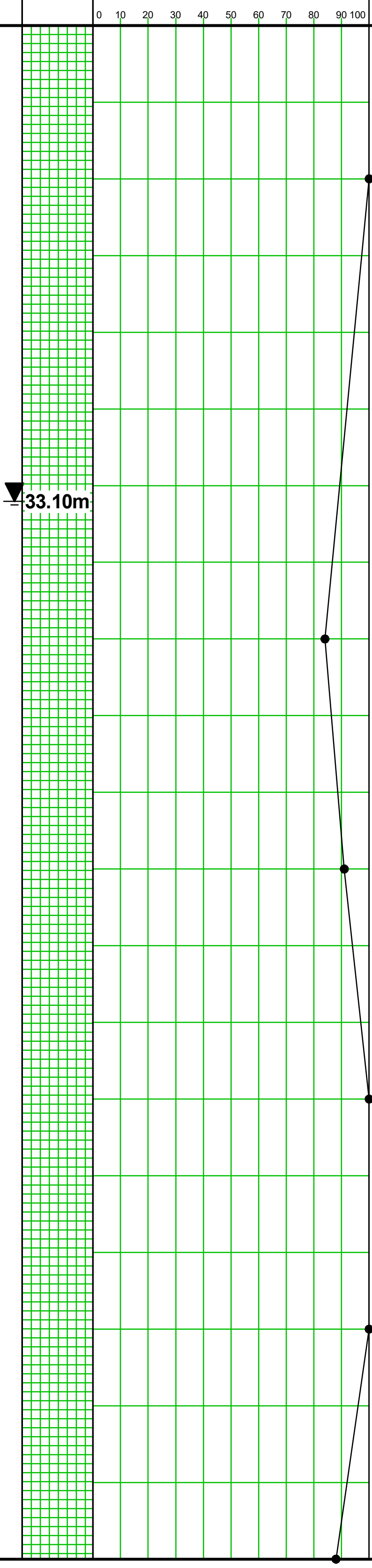
UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 30.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 30.5 | | | | | | | | | |
| 31.0 | 31 | SPT-12 | 40 | 100 (15cm) | - | >100 | | | |
| 31.5 | | | | | | | | | |
| 32.0 | | | | | | | | | |
| 32.5 | 32.5 | UDS* | | | | | | | |
| 33.0 | | | | | | | | | |
| 33.5 | | | | | | | | | |
| 34.0 | 34 | SPT-13 | 32 | 36 | 48 | 84 | | | |
| 34.5 | | | | | | | | | |
| 35.0 | | | | | | | | | |
| 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 | | | |

Graphic Log | (Depth v/s SPT N Value)



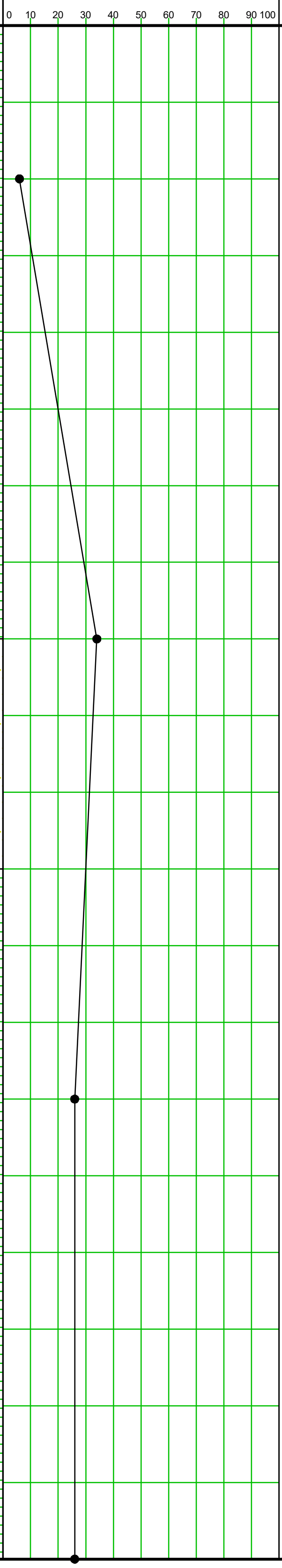
UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Medium stiff, Silty clay of low plasticity | CL | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 2 | 3 | 3 | 6 | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | SPT-2 | 9 | 16 | 18 | 34 | Brown, Dense, Silty sand | SM | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | UDS-2 | | | | | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | CL | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | SPT-3 | 7 | 12 | 14 | 26 | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 9 | 11 | 15 | 26 | | | |

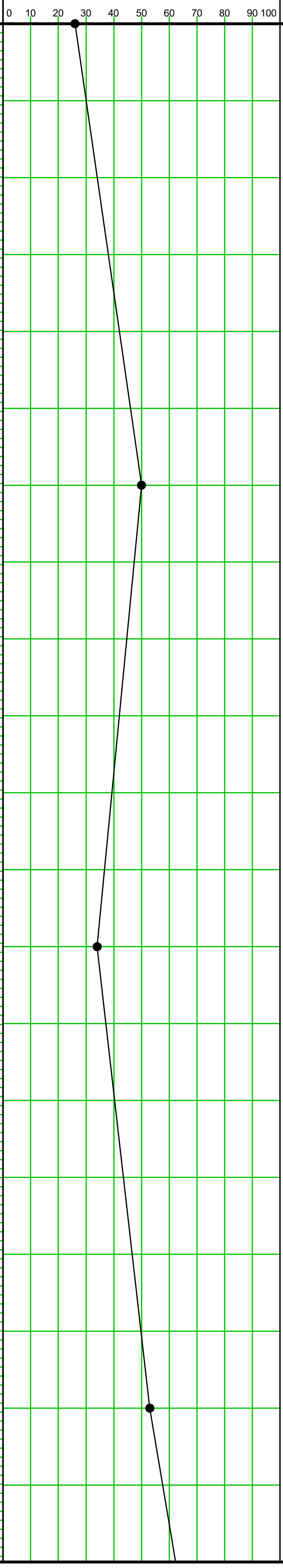
(Depth v/s SPT N Value)



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 | |

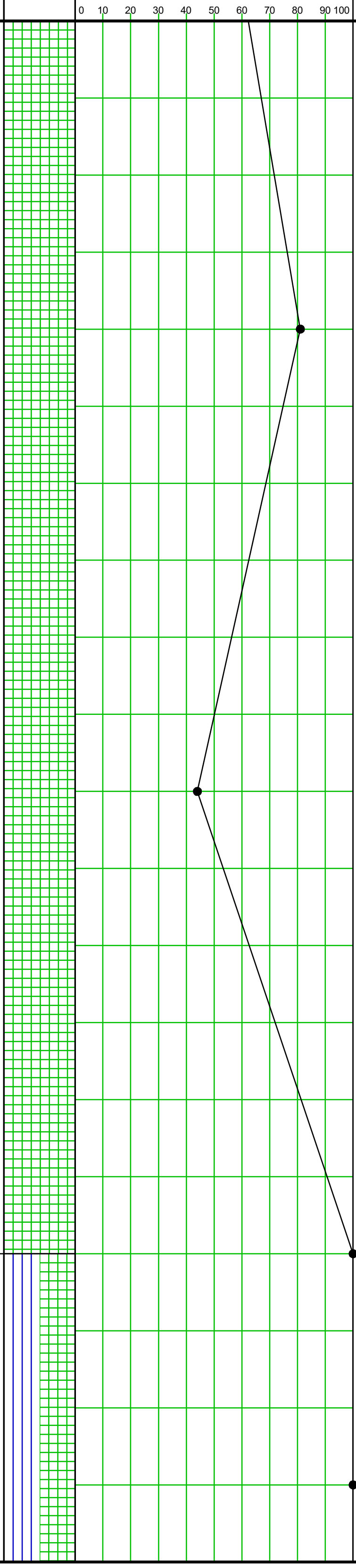
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 10.0 | | | | | | | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | CL | ▦ |  | |
| 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 | | | | | | | | | | | |
| 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 | | | | | | | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 29.0 | | | | | | | | | | | |
| 29.5 | 29.5 | SPT-11 | 40 | 65 | 35 (8cm) | >100 | | | | | |
| 30.0 | | | | | | | | | | | |

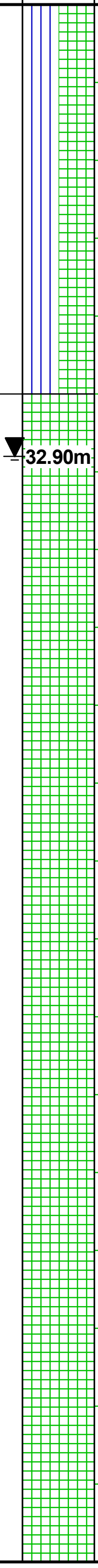


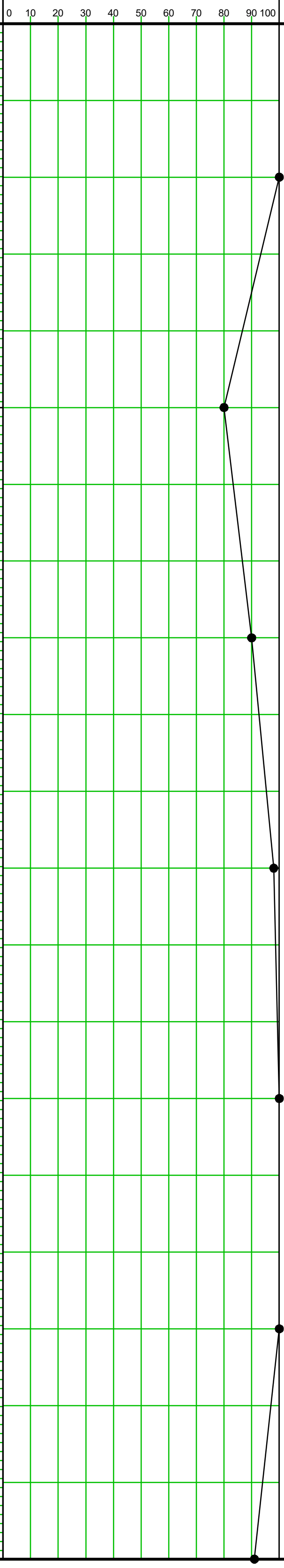
UDS*-UDS not recovered

# 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 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 30.5 | | | | | | | | | | | |
| 31.0 | 31 | SPT-12 | 53 | 75 | 25 (2cm) | >100 | | | | | |
| 31.5 | | | | | | | | | | | |
| 32.0 | | | | | | | | | | | |
| 32.5 | 32.5 | SPT-13 | 21 | 34 | 46 | 80 | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 33.0 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |



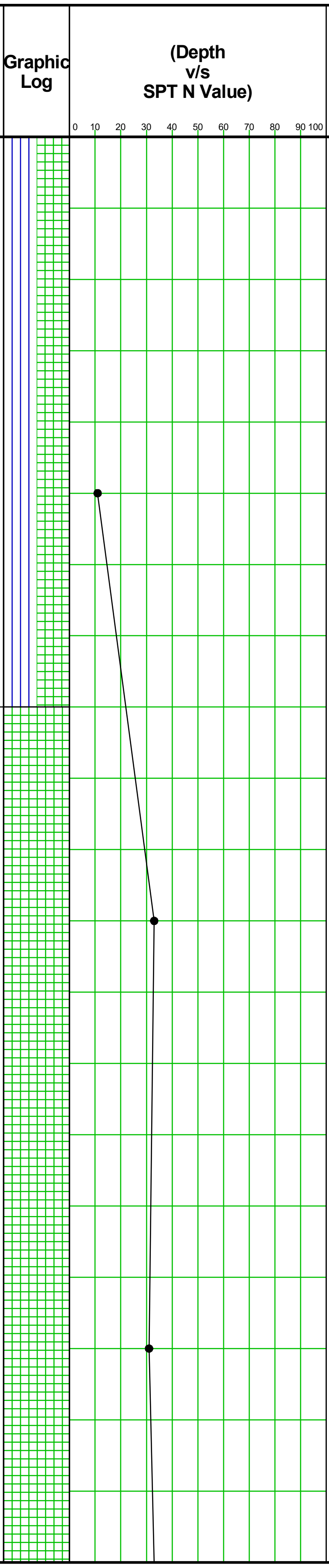


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Medium dense, Sandy silt of low plasticity | ML-CL | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 3 | 5 | 6 | 11 | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 10 | 15 | 18 | 33 | | | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | UDS-3 | | | | | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 12 | 13 | 18 | 31 | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | | |



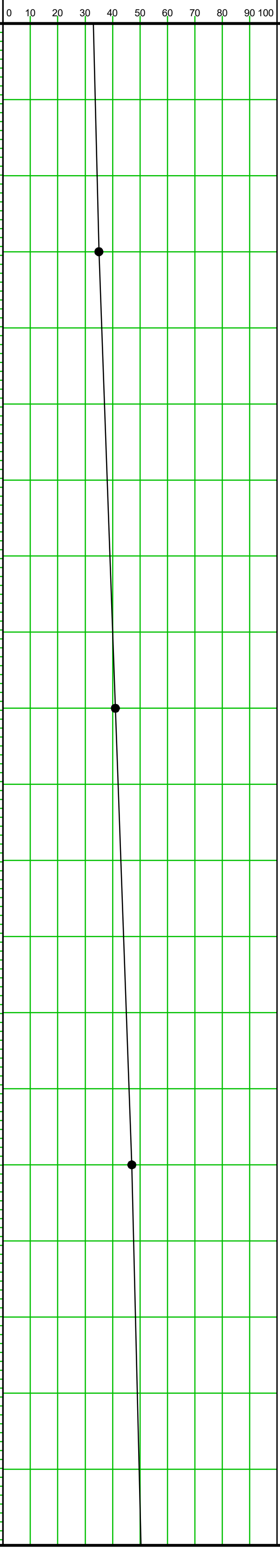
UDS*-UDS not recovered

# 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 :*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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | |
| 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 | | | | | | | | | | |
| 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 | | | | | | | | | | |

(Depth v/s SPT N Value)

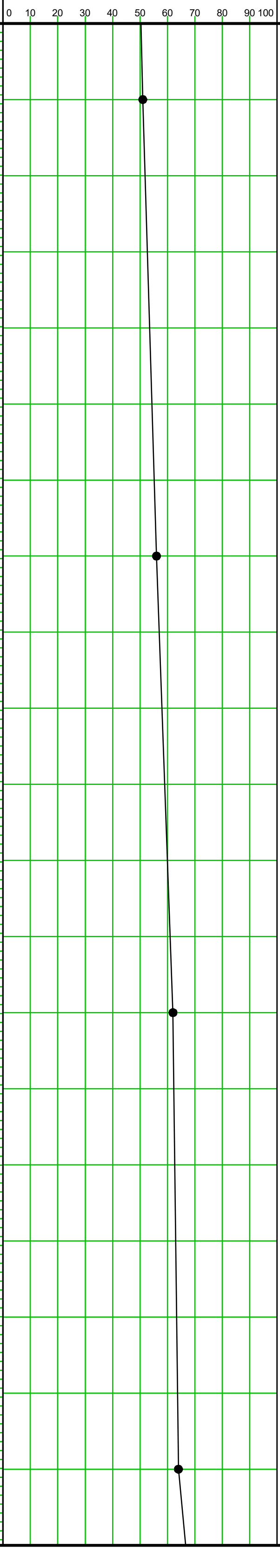


UDS*-UDS not recovered

# 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 | | | | | | | | | | | |

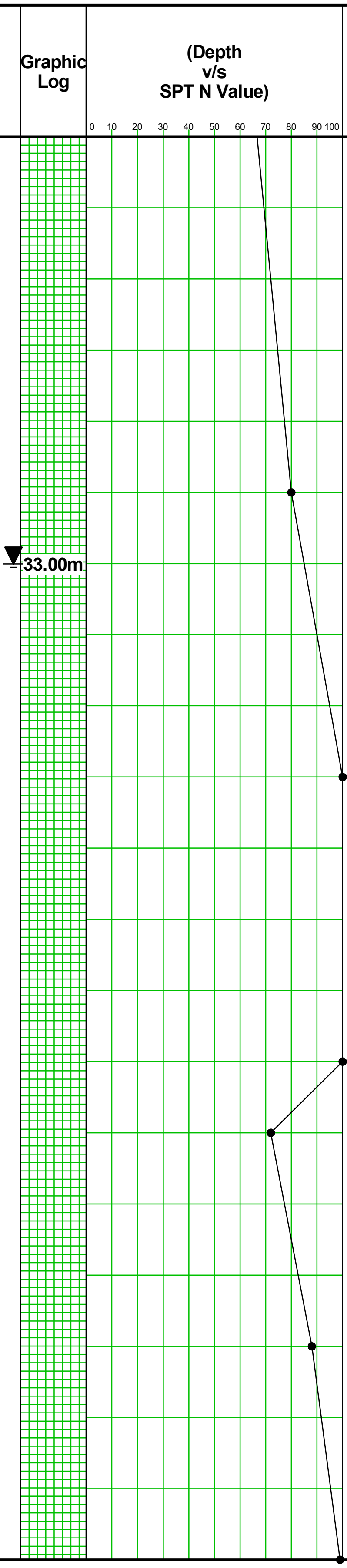


UDS*-UDS not recovered

# 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 | 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 | | | | | | | | | |
| 33.5 | | | | | | | | | |
| 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 | | | |



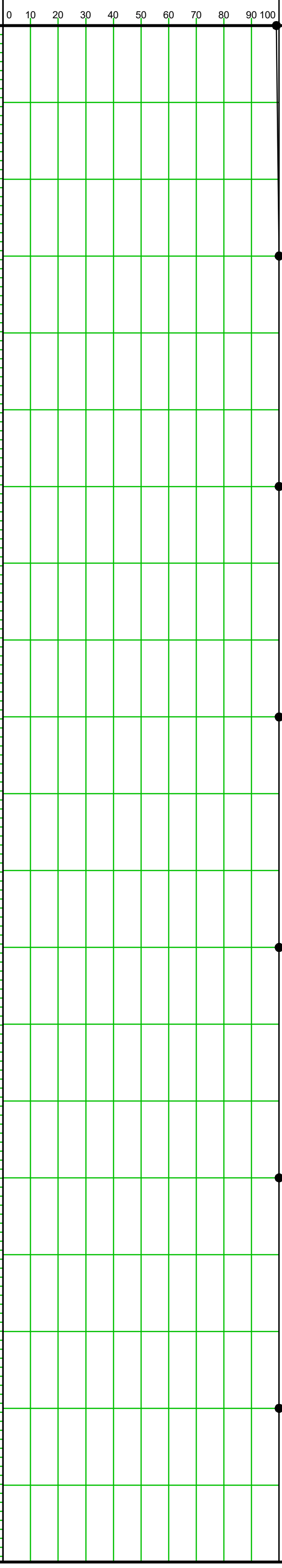
UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 40.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | |
| 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 | | | | | | | | | | |
| 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 | | | | | | | | | | |

(Depth v/s SPT N Value)

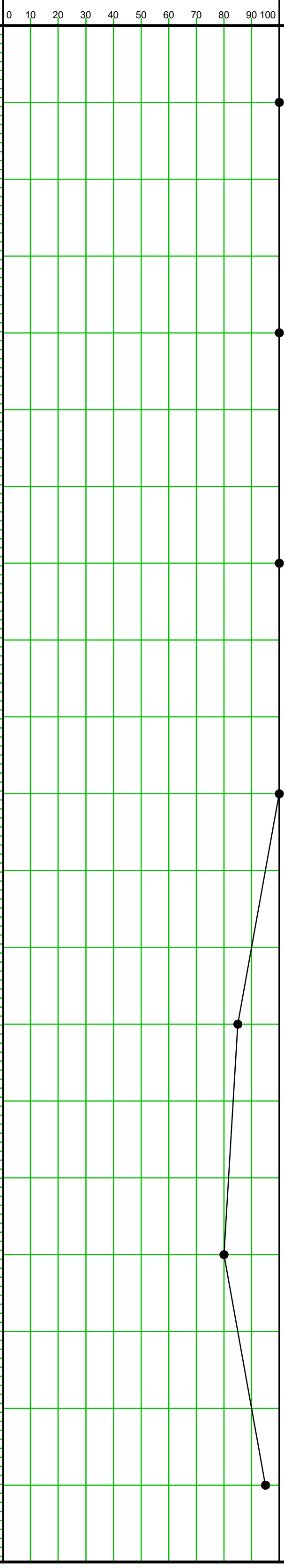


UDS*-UDS not recovered

# 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 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | |
| 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 | - | | | | | | | | | |

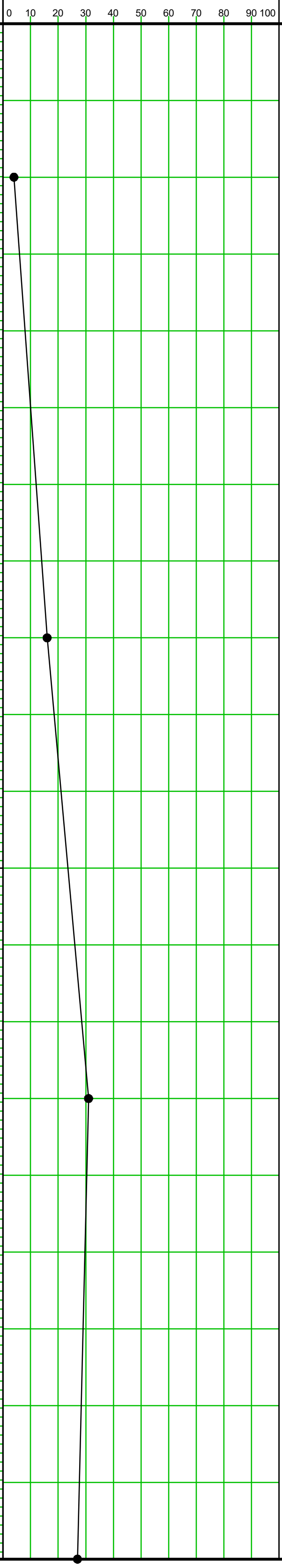


UDS*-UDS not recovered

# 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 | | | | | Brown, Medium stiff to very stiff, Silty clay of low plasticity | CL | | | |
| 0.5 | | | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 1 | 2 | 2 | 4 | | | | | |
| 1.5 | | | | | | | | | | | |
| 2.0 | | | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | | | | | |
| 3.0 | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | |
| 4.0 | 4 | SPT-2 | 5 | 7 | 9 | 16 | | | | | |
| 4.5 | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | |
| 5.5 | 5.5 | UDS-2 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 6.0 | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | |
| 7.0 | 7 | SPT-3 | 10 | 13 | 18 | 31 | | | | | |
| 7.5 | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | | | |
| 9.0 | | | | | | | | | | | |
| 9.5 | | | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 9 | 12 | 15 | 27 | | | | | |



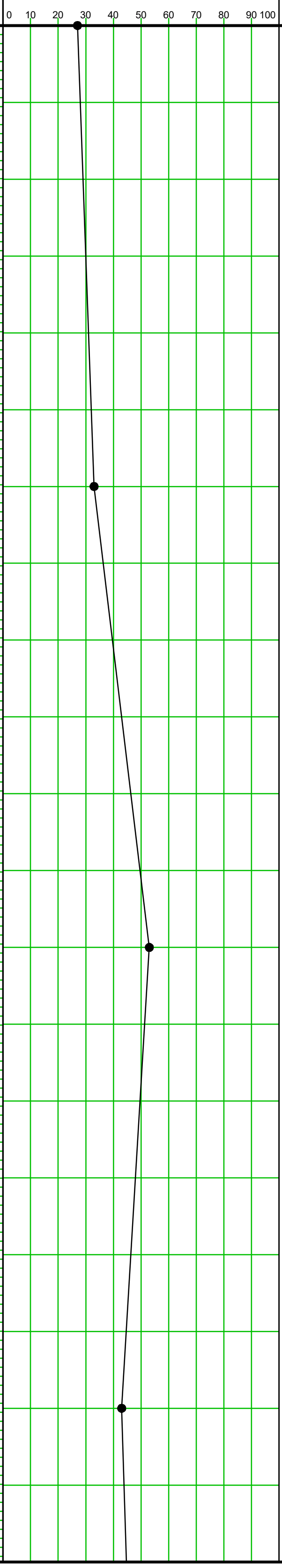
UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | |
| 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 | | | | | | | | | | |
| 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 | | | | | | | | | | |

(Depth v/s SPT N Value)

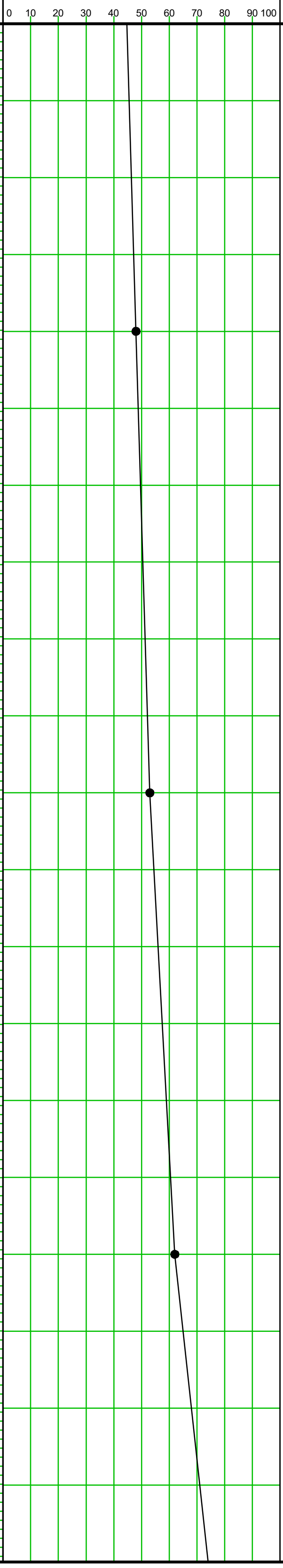


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 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 | 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 | | | | | |
| 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 | | | | | | | | | | | |

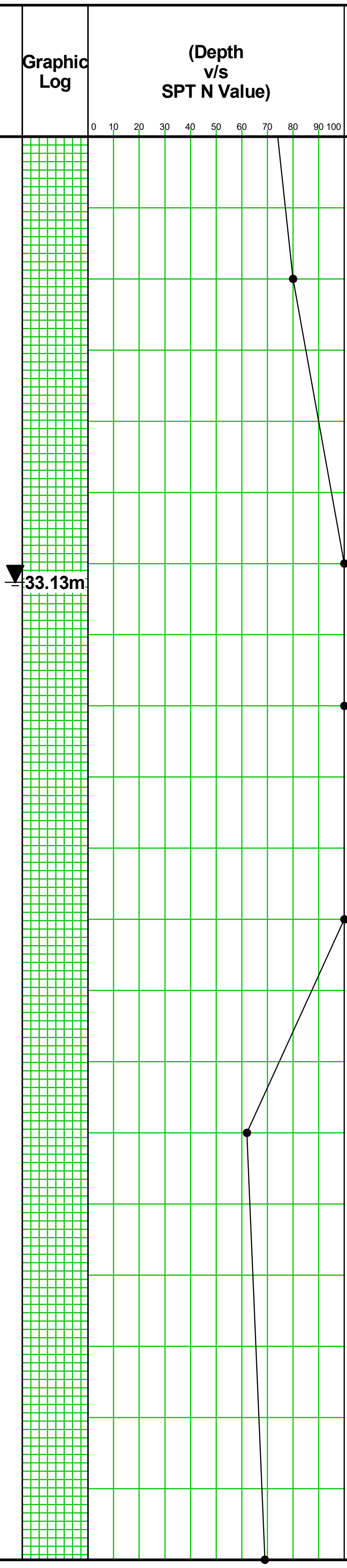


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 30.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 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 | | | |
| 33.5 | | | | | | | | | |
| 34.0 | 34 | SPT-13 | 48 | 69 | 31 (5cm) | >100 | | | |
| 34.5 | | | | | | | | | |
| 35.0 | | | | | | | | | |
| 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 | | | |

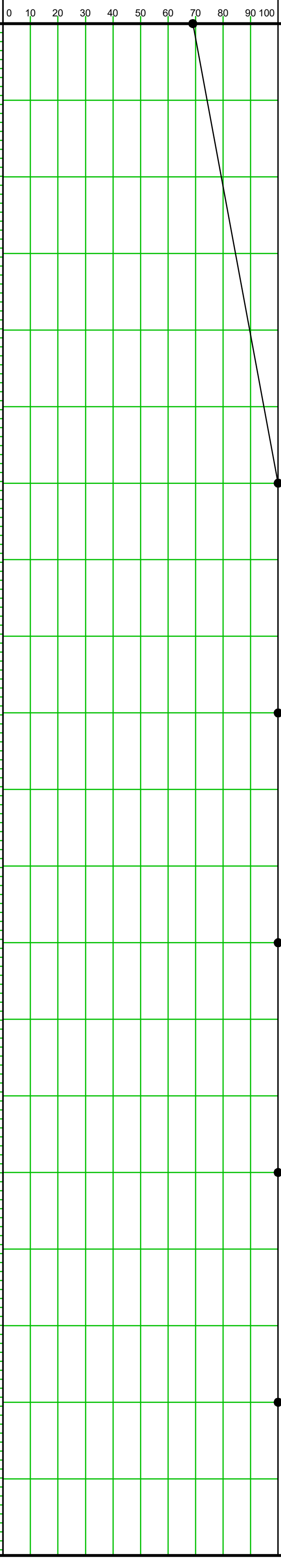


UDS*-UDS not recovered

# 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 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |

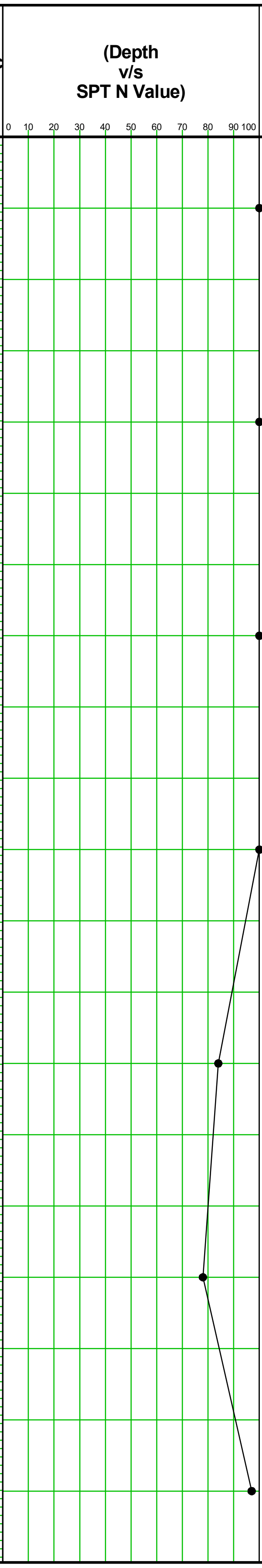


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 50.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | |
| 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 | | | | |
| 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

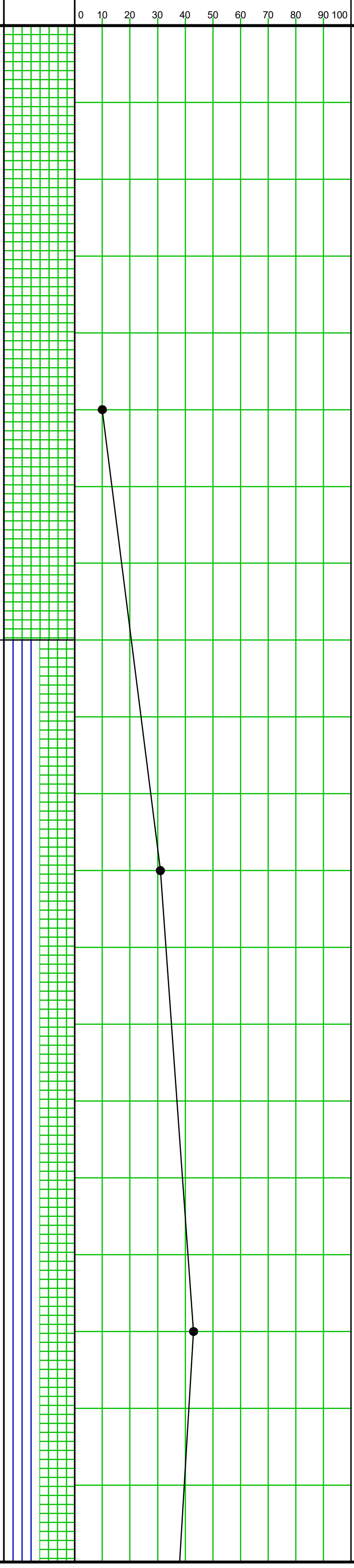
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Stiff, Silty clay of low plasticity | CL | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 3 | 4 | 6 | 10 | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Medium dense to dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 10 | 14 | 17 | 31 | | | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | UDS-3 | | | | | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 11 | 19 | 24 | 43 | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | | |

Graphic Log

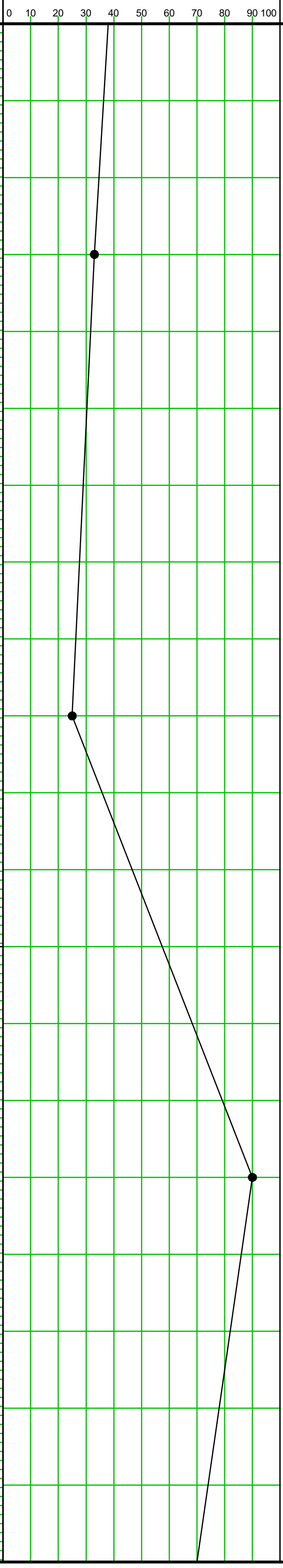
(Depth v/s SPT N Value)



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 | |

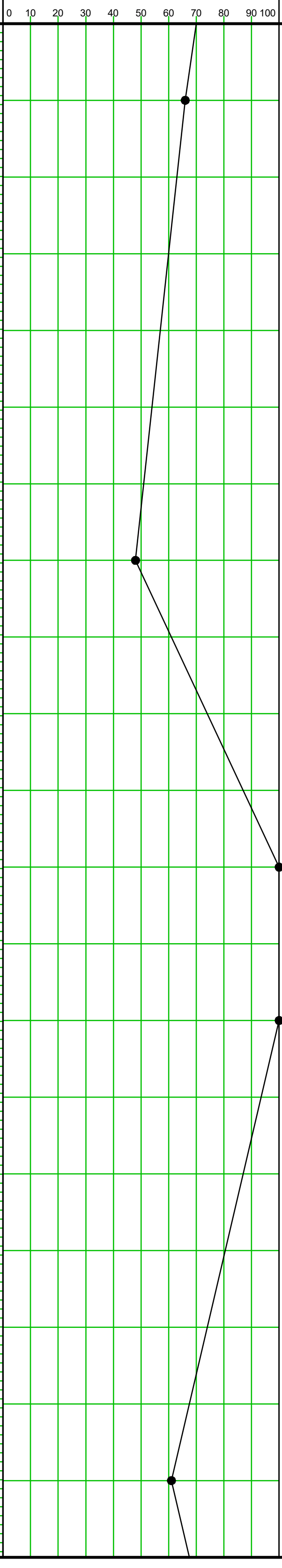
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm N1 | N2 | N3 | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Medium dense to dense, Sandy silt of low plasticity with gravel | ML-CL | |  | |
| 10.5 | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | |
| 11.5 | 11.5 | SPT-4 | 8 | 14 | 19 | 33 | | | | | |
| 12.0 | | | | | | | | | | | |
| 12.5 | | | | | | | | | | | |
| 13.0 | 13 | UDS-5 | | | | | | | | | |
| 13.5 | | | | | | | | | | | |
| 14.0 | | | | | | | | | | | |
| 14.5 | 14.5 | SPT-5 | 7 | 11 | 14 | 25 | | | | | |
| 15.0 | | | | | | | | | | | |
| 15.5 | | | | | | | | | | | |
| 16.0 | 16 | UDS-6 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 16.5 | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | |
| 17.5 | 17.5 | SPT-6 | 23 | 39 | 51 | 90 | | | | | |
| 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 :*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 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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* | | | | | | | | | |
| 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 | | | | | | | | | | | |



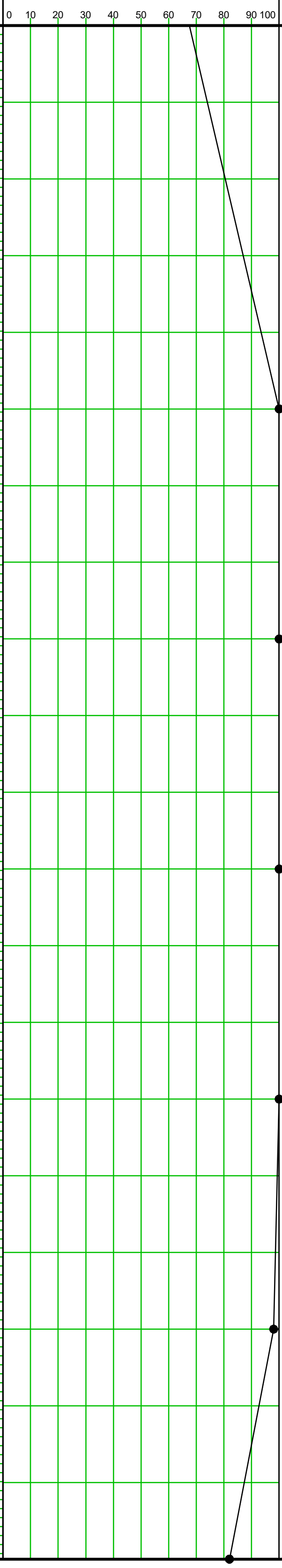
UDS*-UDS not recovered

# 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 | 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 | | | | |

(Depth v/s SPT N Value)

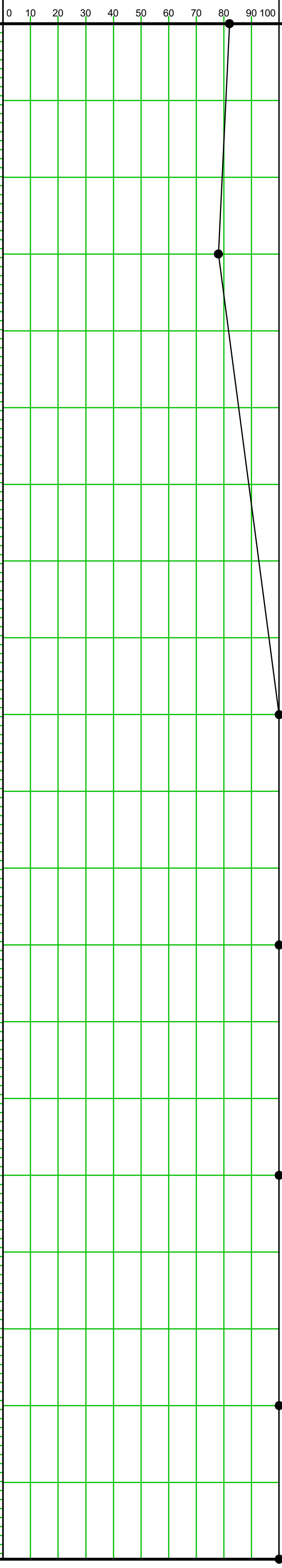


UDS*-UDS not recovered

# 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 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

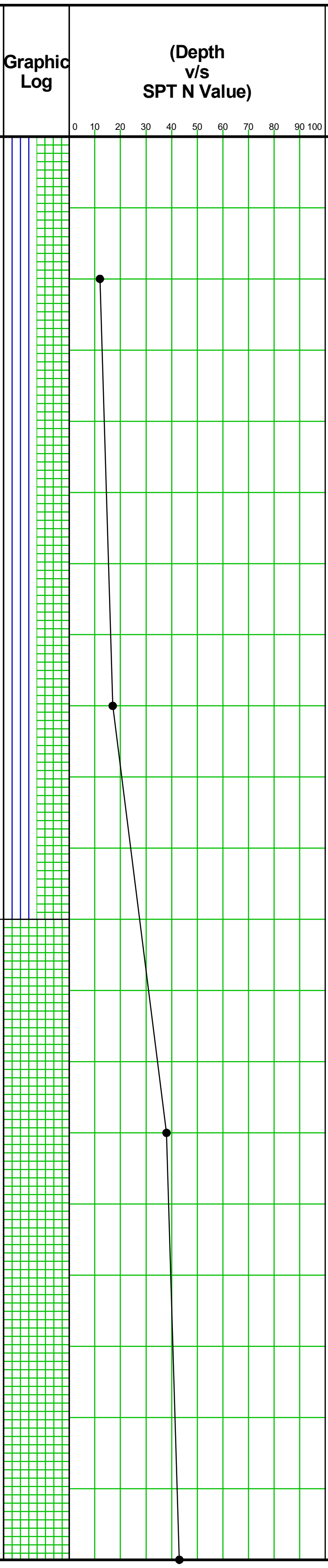


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Medium dense, Sandy silt of low plasticity | ML-CL | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 4 | 5 | 7 | 12 | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | SPT-2 | 6 | 7 | 10 | 17 | | | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | UDS-2 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | SPT-3 | 10 | 16 | 22 | 38 | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 12 | 18 | 25 | 43 | | | |

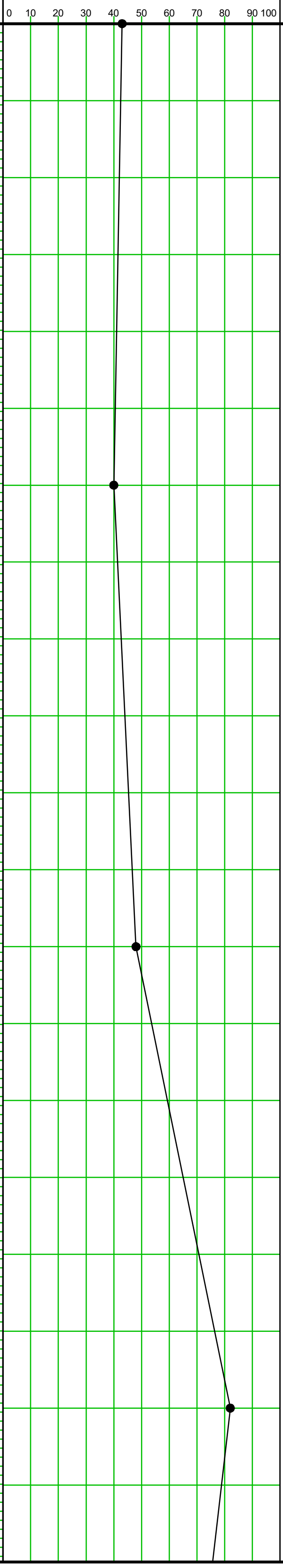


UDS*-UDS not recovered

# 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 | |

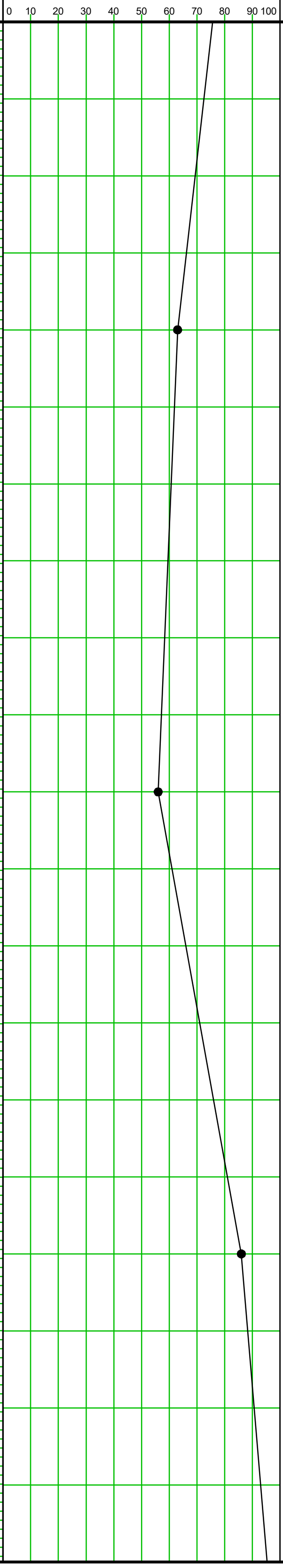
| **Depth (m)** | **In-Situ Sample Depth (m)** | **Sample Type** | **Blow counts per 15cm** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 10.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | ▦ | | |
| 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 | | | | | | | | | | | |
| 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 | |

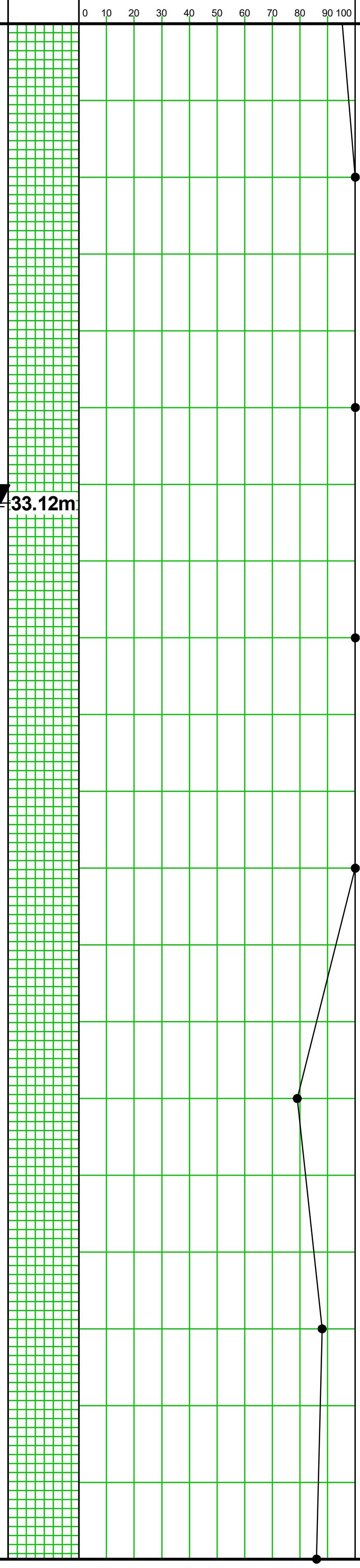
| **Depth (m)** | **In-Situ Sample Depth (m)** | **Sample Type** | **Blow counts per 15cm** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 20.0 | | | | | | | | | |  | |
| 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 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

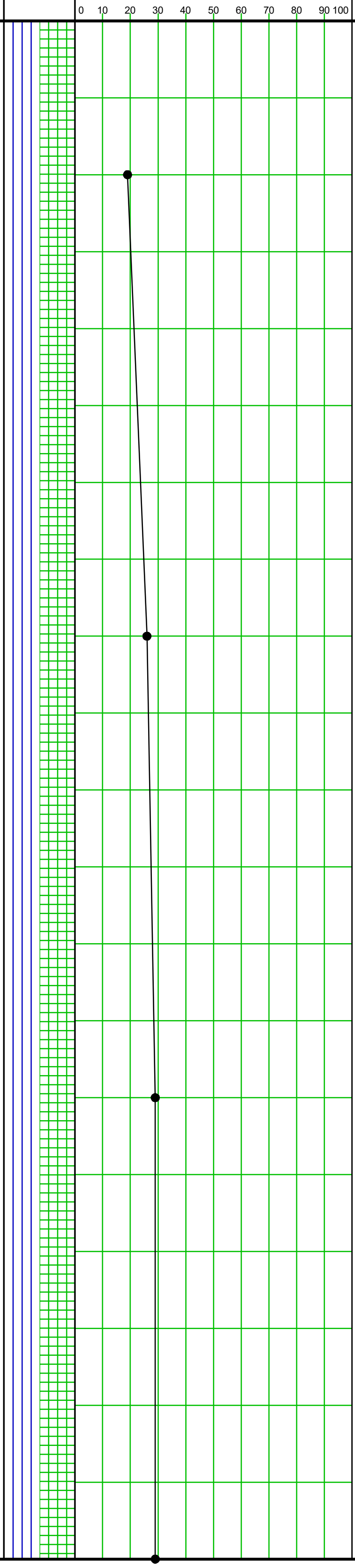


UDS*-UDS not recovered

# 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 | | | | | Brown, Medium dense to dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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

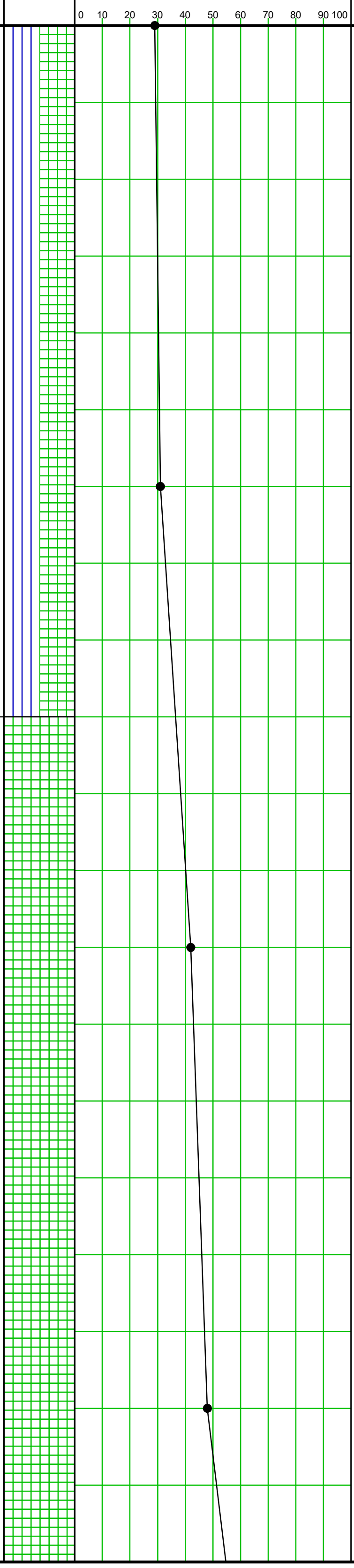
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Medium dense to dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 10.5 | | | | | | | | | |
| 11.0 | | | | | | | | | |
| 11.5 | 11.5 | UDS-4 | | | | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | 13 | SPT-5 | 10 | 13 | 18 | 31 | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | | | | | |
| 14.5 | 14.5 | UDS-5 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 15.0 | | | | | | | | | |
| 15.5 | | | | | | | | | |
| 16.0 | 16 | SPT-6 | 13 | 18 | 24 | 42 | | | |
| 16.5 | | | | | | | | | |
| 17.0 | | | | | | | | | |
| 17.5 | 17.5 | UDS-6 | | | | | | | |
| 18.0 | | | | | | | | | |
| 18.5 | | | | | | | | | |
| 19.0 | 19 | SPT-7 | 15 | 20 | 28 | 48 | | | |
| 19.5 | | | | | | | | | |
| 20.0 | | | | | | | | | |

Graphic Log

(Depth v/s SPT N Value)

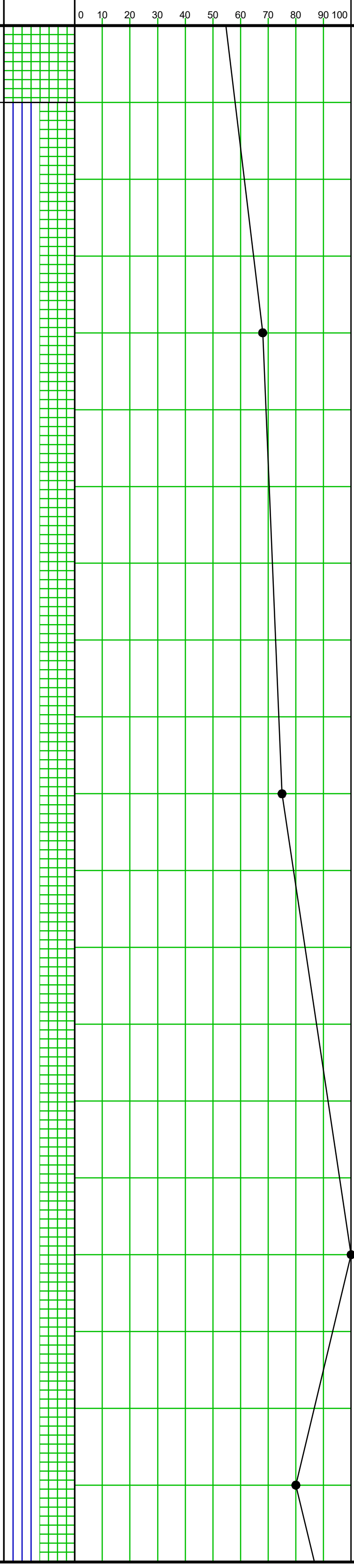


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 20.5 | 20.5 | UDS-7 | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | |
| 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

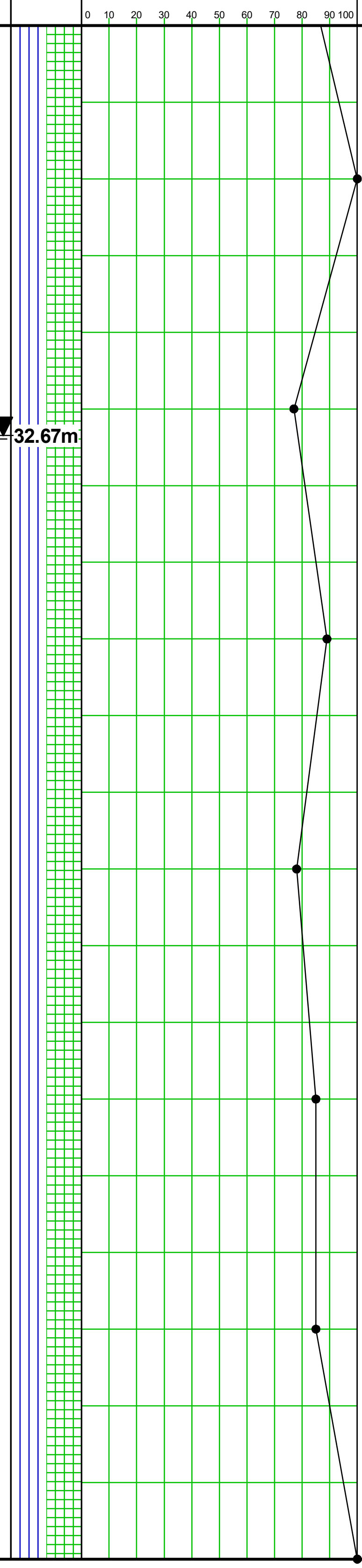
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 30.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | | | | | | | |
| 33.5 | | | | | | | | | |
| 34.0 | 34 | SPT-14 | 20 | 41 | 48 | 89 | | | |
| 34.5 | | | | | | | | | |
| 35.0 | | | | | | | | | |
| 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 | | | |

Graphic Log

(Depth v/s SPT N Value)



UDS*-UDS not recovered

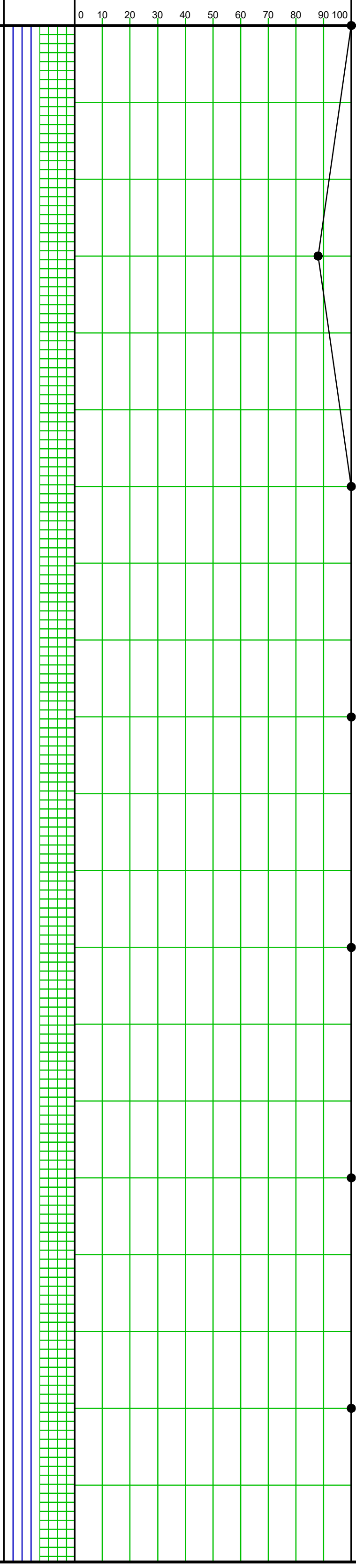
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 40.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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<br>(12cm) | >100 | | | |
| 43.5 | | | | | | | | | |
| 44.0 | | | | | | | | | |
| 44.5 | 44.5 | SPT-21 | 25 | 59 | 38<br>(10cm) | >100 | | | |
| 45.0 | | | | | | | | | |
| 45.5 | | | | | | | | | |
| 46.0 | 46 | SPT-22 | 27 | 51 | 49<br>(13cm) | >100 | | | |
| 46.5 | | | | | | | | | |
| 47.0 | | | | | | | | | |
| 47.5 | 47.5 | SPT-23 | 37 | 53 | 47<br>(8cm) | >100 | | | |
| 48.0 | | | | | | | | | |
| 48.5 | | | | | | | | | |
| 49.0 | 49 | SPT-24 | 36 | 100<br>(14cm) | - | >100 | | | |
| 49.5 | | | | | | | | | |
| 50.0 | | | | | | | | | |

Graphic Log

(Depth v/s SPT N Value)

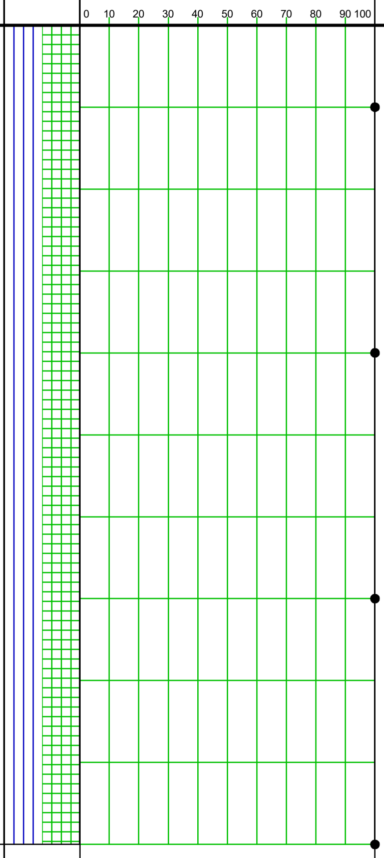


UDS*-UDS not recovered

# 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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 50.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |



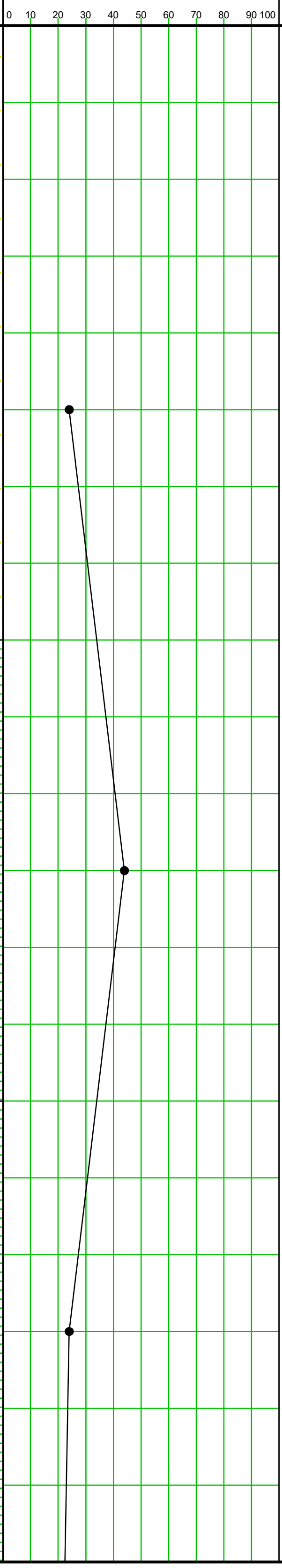
UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | |
| 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)

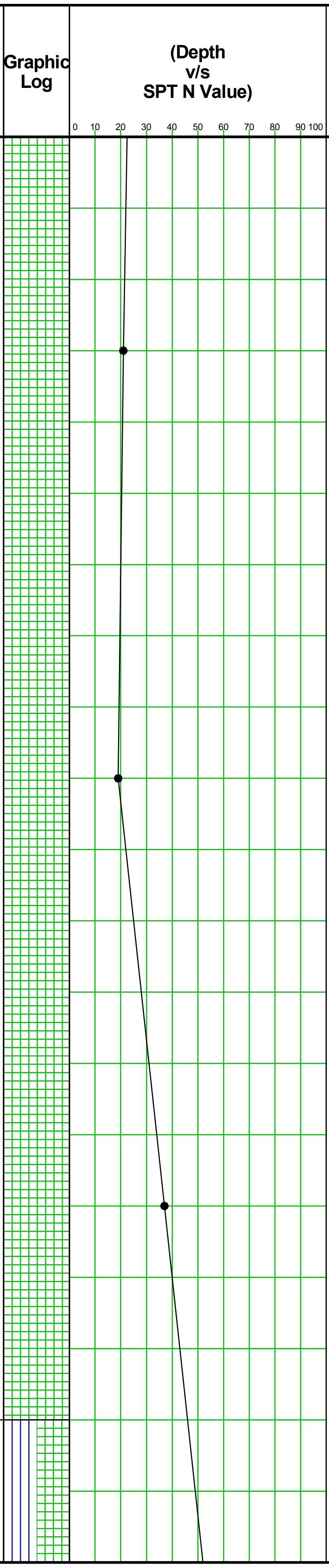


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Very stiff to hard, Silty clay of low plasticity | CL | |
| 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 | | | |
| 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 | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 19.5 | | | | | | | | | |
| 20.0 | | | | | | | | | |

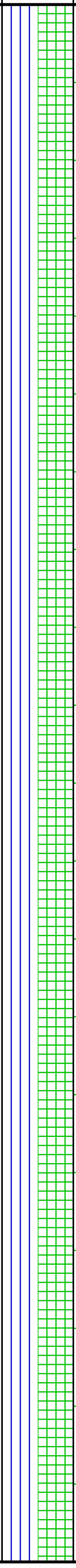


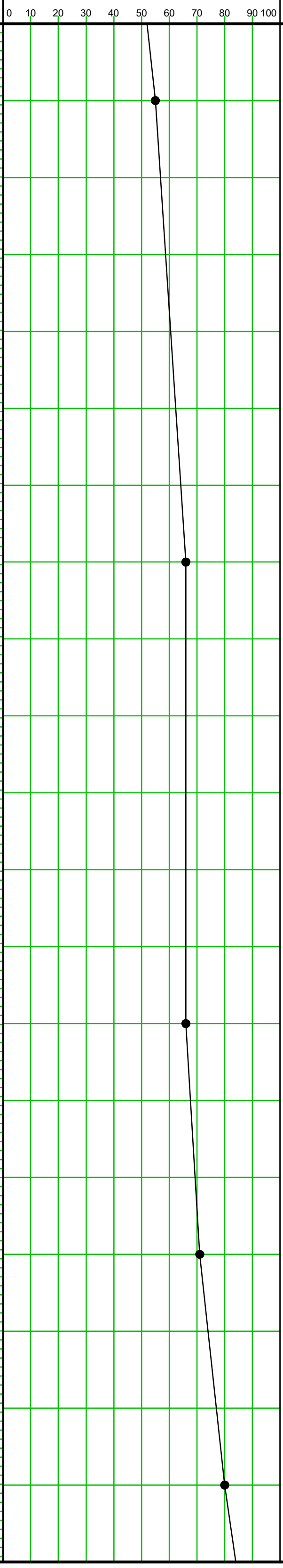
UDS*-UDS not recovered

# 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 :*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 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | |
| 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

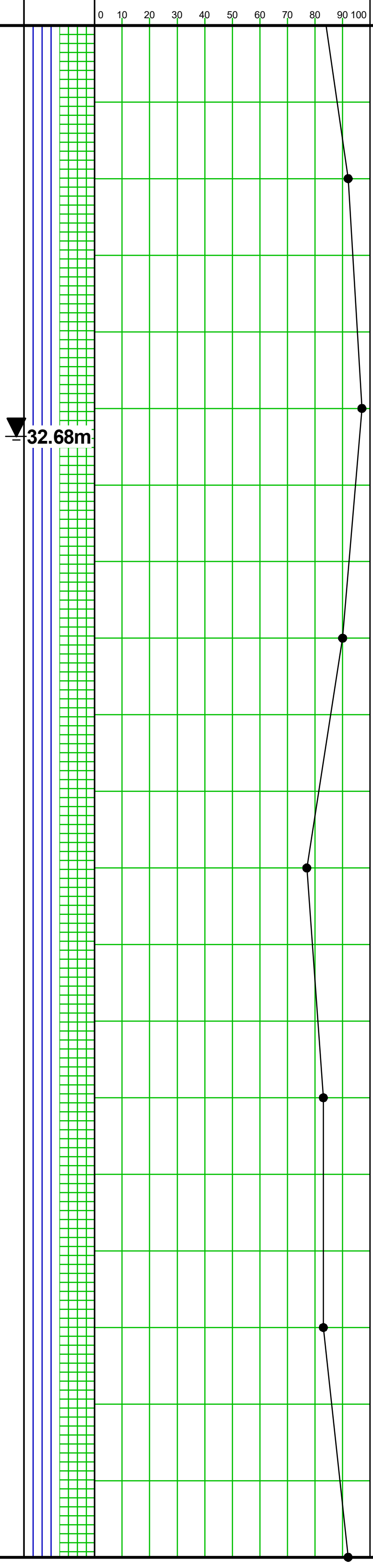
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 30.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | | | | | | | |
| 33.5 | | | | | | | | | |
| 34.0 | 34 | SPT-14 | 18 | 40 | 50 | 90 | | | |
| 34.5 | | | | | | | | | |
| 35.0 | | | | | | | | | |
| 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 | | | |

Graphic Log

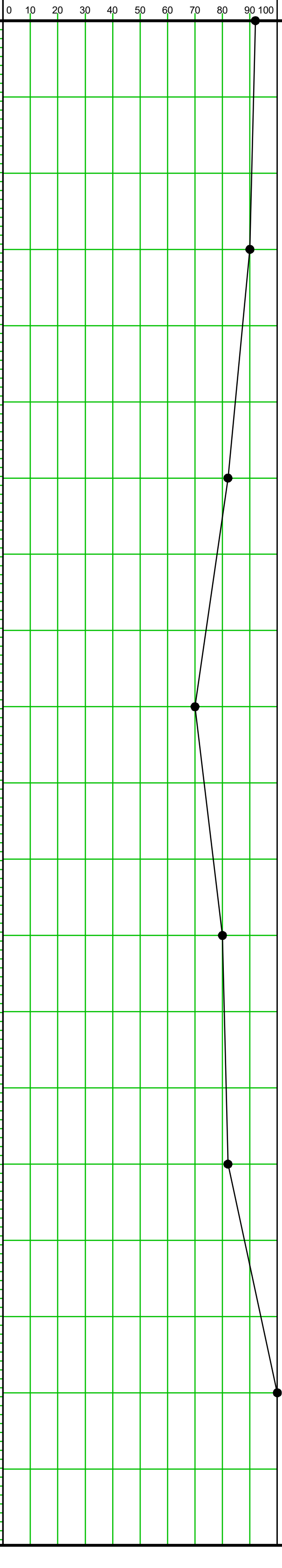
(Depth v/s SPT N Value)



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 | |

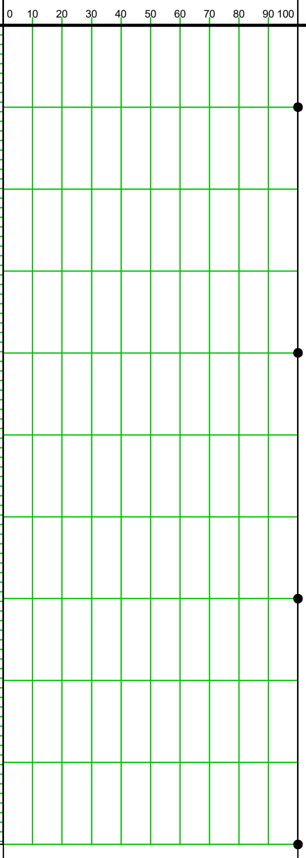
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm N1 | N2 | N3 | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 40.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |  | |
| 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 | | | | | | | | | | | |
| 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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 50.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

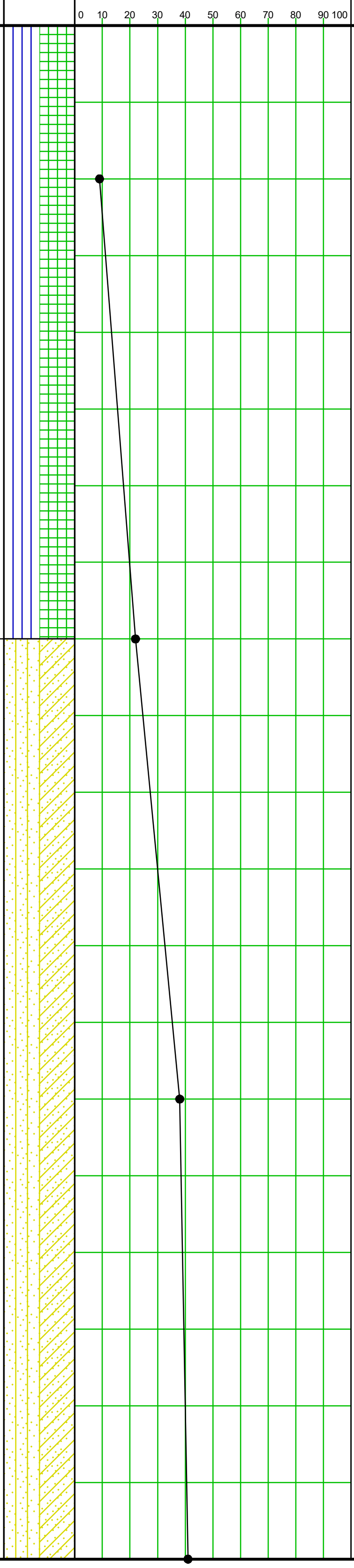


UDS*-UDS not recovered

# 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 | | | | | Brown, Loose, Sandy silt of low plasticity | ML-CL | | | |
| 0.5 | | | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 3 | 4 | 5 | 9 | | | | | |
| 1.5 | | | | | | | | | | | |
| 2.0 | | | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | | | | | |
| 3.0 | | | | | | | | | | | |
| 3.5 | | | | | | | | | | | |
| 4.0 | 4 | SPT-2 | 9 | 10 | 12 | 22 | Brown, Medium dense to dense, Silty sand with clay & gravel | SM-SC | | | |
| 4.5 | | | | | | | | | | | |
| 5.0 | | | | | | | | | | | |
| 5.5 | 5.5 | UDS-2 | | | | | | | | | |
| 6.0 | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | |
| 7.0 | 7 | SPT-3 | 12 | 17 | 21 | 38 | | | | | |
| 7.5 | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | | | |
| 9.0 | | | | | | | | | | | |
| 9.5 | | | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 10 | 16 | 25 | 41 | | | | | |

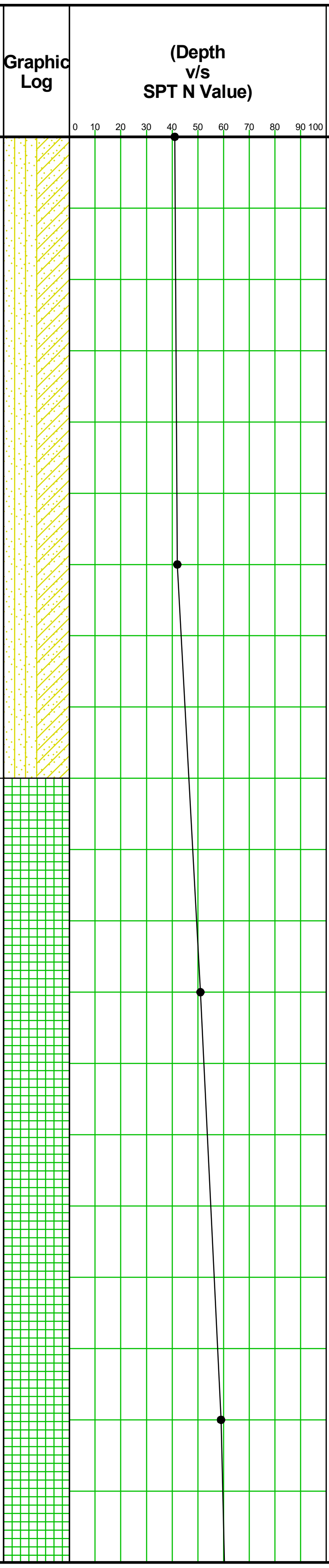


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | |
| 10.0 | | | | | | | Brown, Medium dense to dense, Silty sand with clay & gravel | SM-SC | |
| 10.5 | | | | | | | | | |
| 11.0 | | | | | | | | | |
| 11.5 | 11.5 | UDS-4 | | | | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | 13 | SPT-5 | 10 | 20 | 22 | 42 | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | | | | | |
| 14.5 | 14.5 | UDS-5 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 15.0 | | | | | | | | | |
| 15.5 | | | | | | | | | |
| 16.0 | 16 | SPT-6 | 14 | 21 | 30 | 51 | | | |
| 16.5 | | | | | | | | | |
| 17.0 | | | | | | | | | |
| 17.5 | 17.5 | UDS-6 | | | | | | | |
| 18.0 | | | | | | | | | |
| 18.5 | | | | | | | | | |
| 19.0 | 19 | SPT-7 | 16 | 24 | 35 | 59 | | | |
| 19.5 | | | | | | | | | |
| 20.0 | | | | | | | | | |

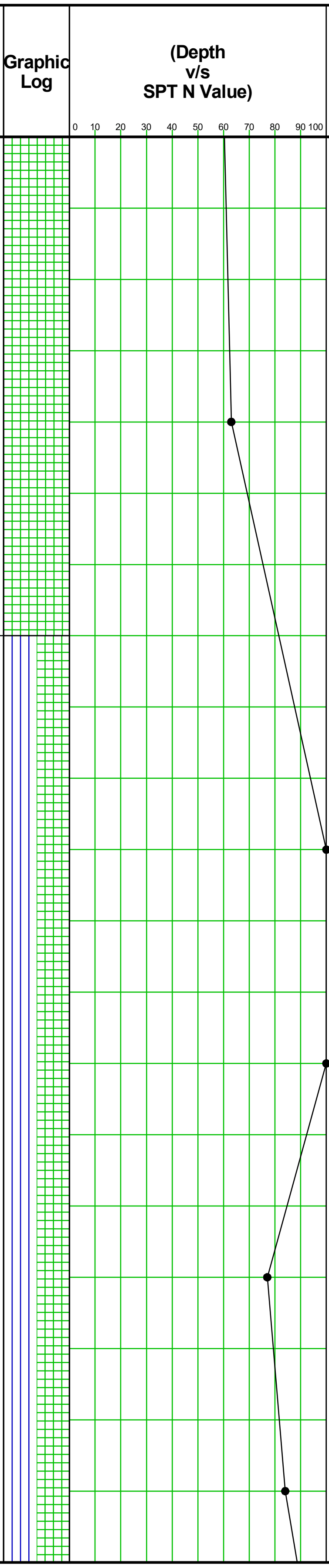


UDS*-UDS not recovered

# 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 | 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 | 18 | 27 | 36 | 63 | | | |
| 22.5 | | | | | | | | | |
| 23.0 | | | | | | | | | |
| 23.5 | 23.5 | UDS-8 | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 24.0 | | | | | | | | | |
| 24.5 | | | | | | | | | |
| 25.0 | 25 | SPT-9 | 31 | 52 | 48<br>(9cm) | >100 | | | |
| 25.5 | | | | | | | | | |
| 26.0 | | | | | | | | | |
| 26.5 | 26.5 | SPT-10 | 29 | 50 | 50<br>(9cm) | >100 | | | |
| 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

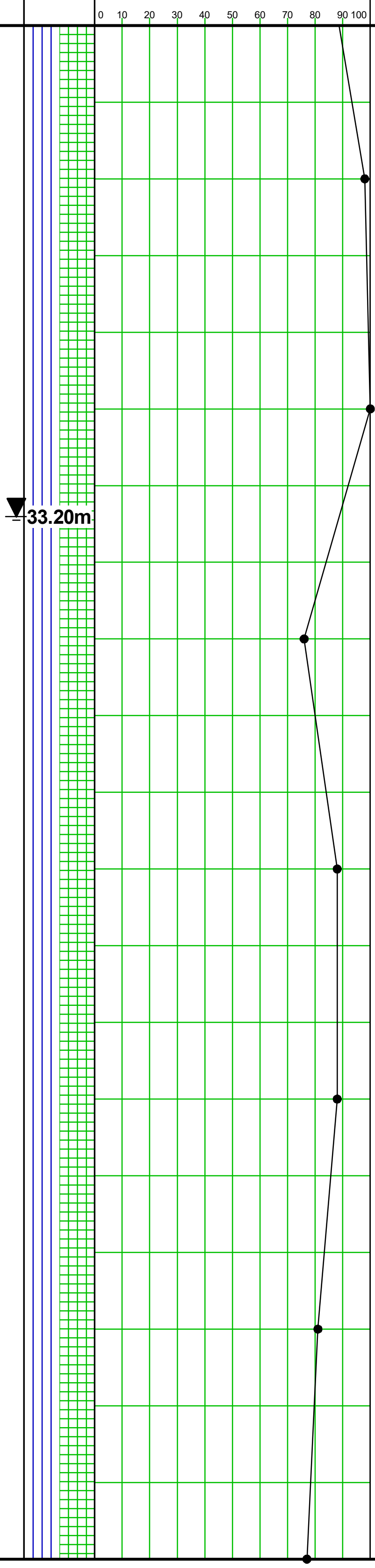
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 30.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | | | | | | | |
| 33.5 | | | | | | | | | |
| 34.0 | 34 | SPT-15 | 16 | 35 | 41 | 76 | | | |
| 34.5 | | | | | | | | | |
| 35.0 | | | | | | | | | |
| 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 | | | |

Graphic Log

(Depth v/s SPT N Value)

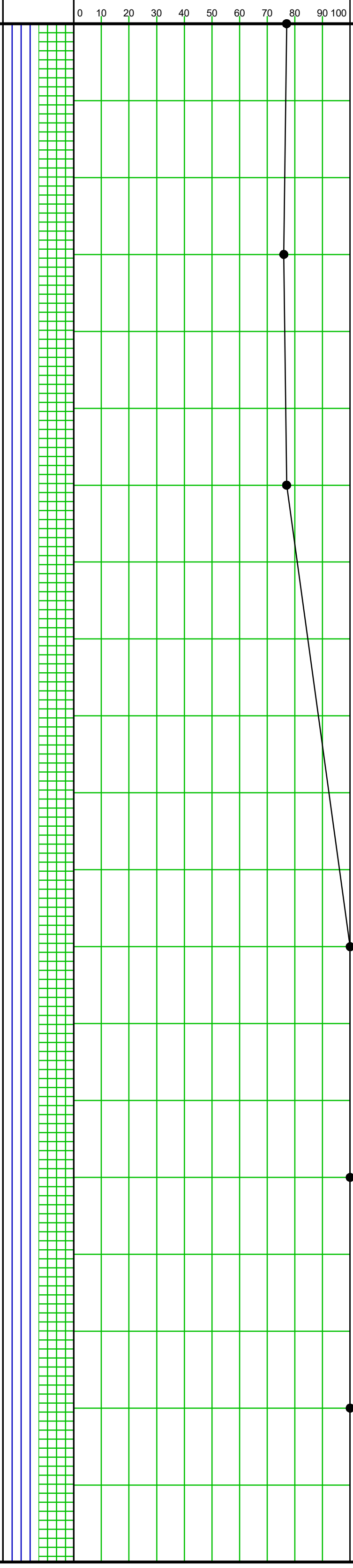


UDS*-UDS not recovered

# 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 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |

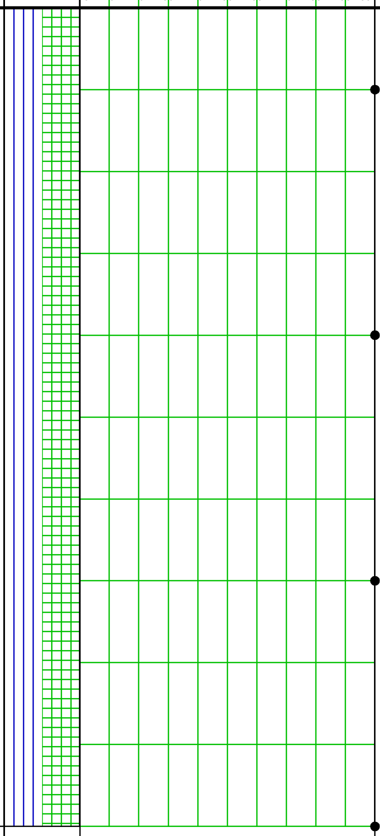


UDS*-UDS not recovered

# 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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | 0 10 20 30 40 50 60 70 80 90 100 | |
| 50.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

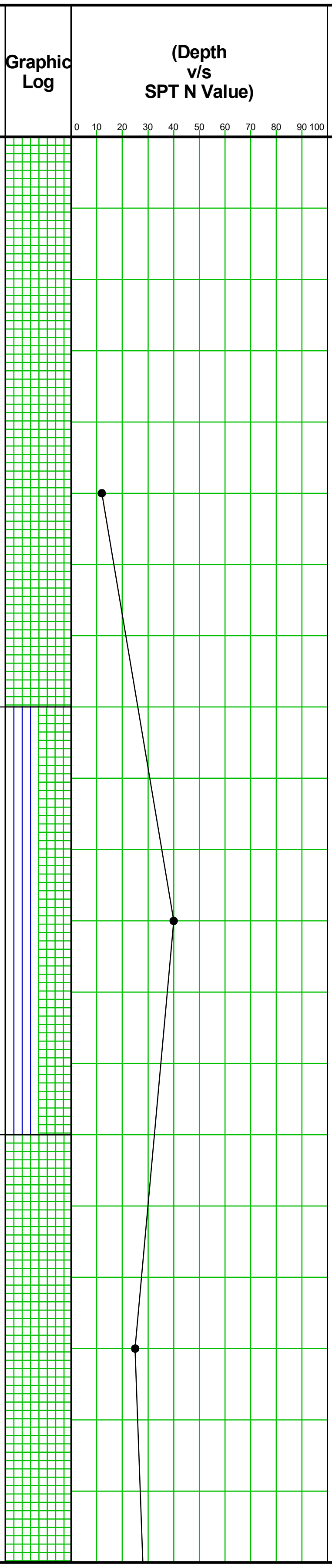


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Stiff, Silty clay of low plasticity | CL | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 5 | 6 | 6 | 12 | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 12 | 18 | 22 | 40 | | | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | UDS-3 | | | | | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | CL | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 7 | 11 | 14 | 25 | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | | |

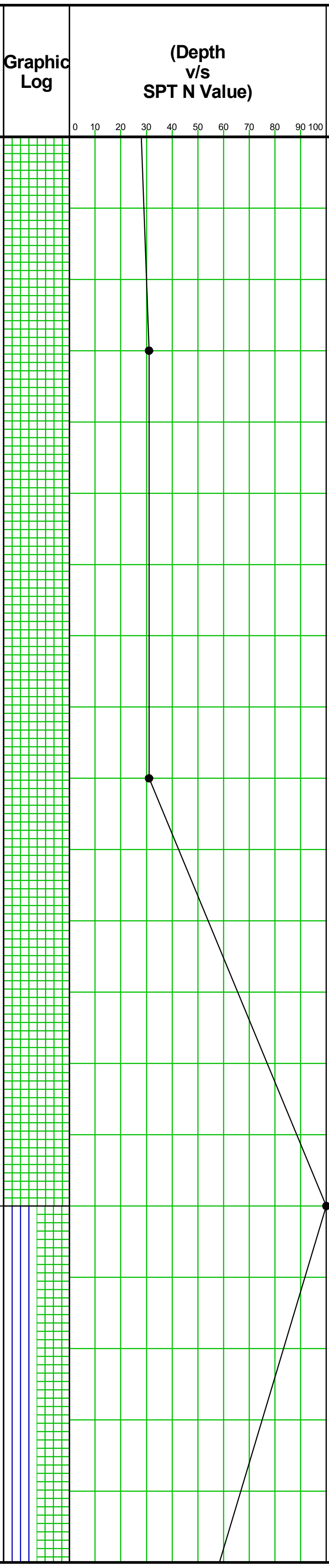


UDS*-UDS not recovered

# 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+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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | CL | |
| 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 | | | | | | | | | |
| 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 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 18.5 | | | | | | | | | |
| 19.0 | 19 | UDS-7 | | | | | | | |
| 19.5 | | | | | | | | | |
| 20.0 | | | | | | | | | |

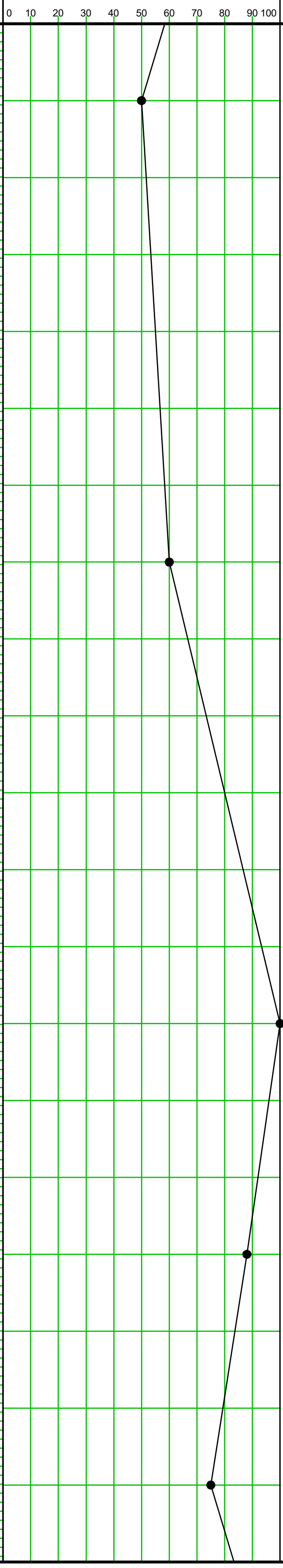


UDS*-UDS not recovered

# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana. | | *Client :*HRIDCL |
| *BH Location/Chainage :*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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 20.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | |
| 25.5 | | | | | | | | | | | |
| 26.0 | | | | | | | | | | | |
| 26.5 | 26.5 | SPT-9 | 30 | 48 | 52<br>(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 | | | | | | | | | | | |

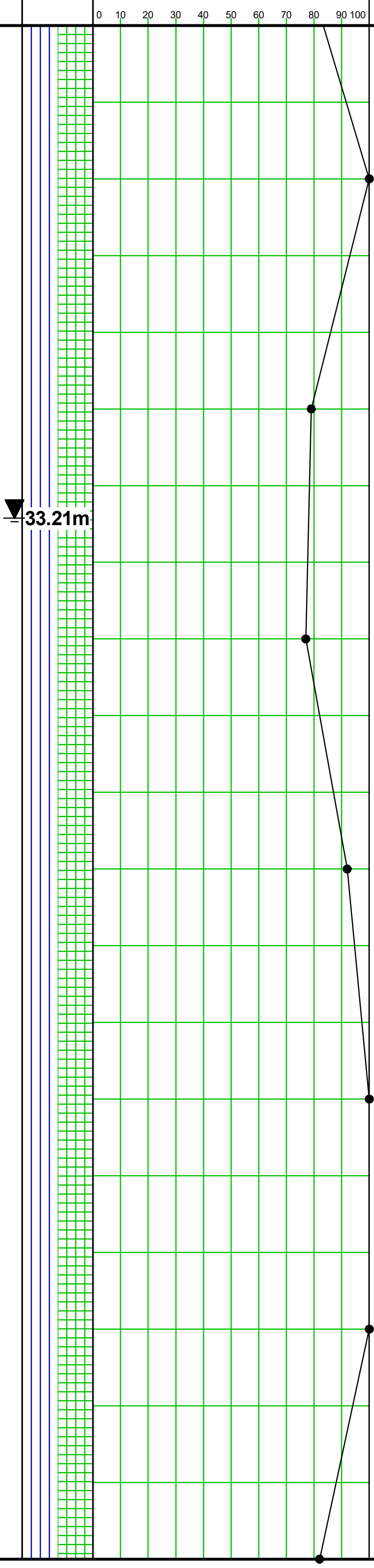


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 30.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 34.0 | 34 | SPT-14 | 20 | 35 | 42 | 77 | | | | | |
| 34.5 | | | | | | | | | | | |
| 35.0 | | | | | | | | | | | |
| 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 | | | | | |



UDS*-UDS not recovered

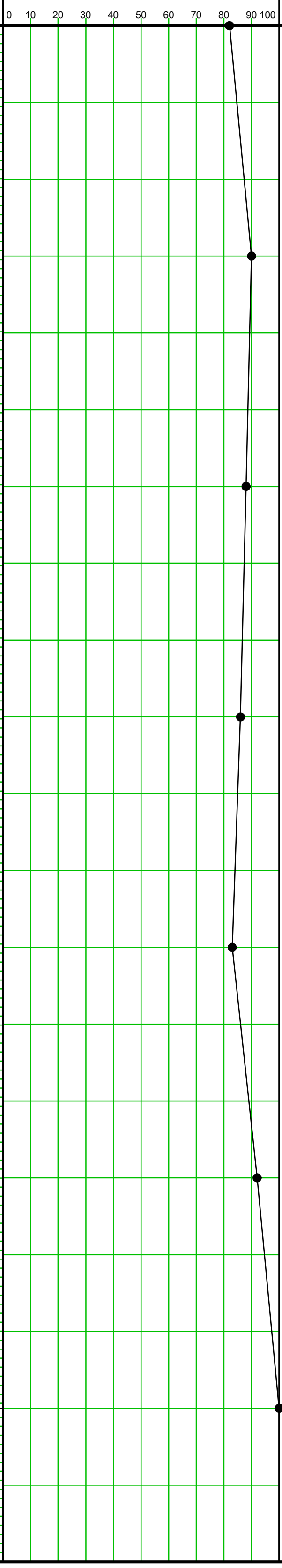
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 40.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 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 | | | |
| 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 | | | | | | | | | |

Graphic Log

(Depth v/s SPT N Value)

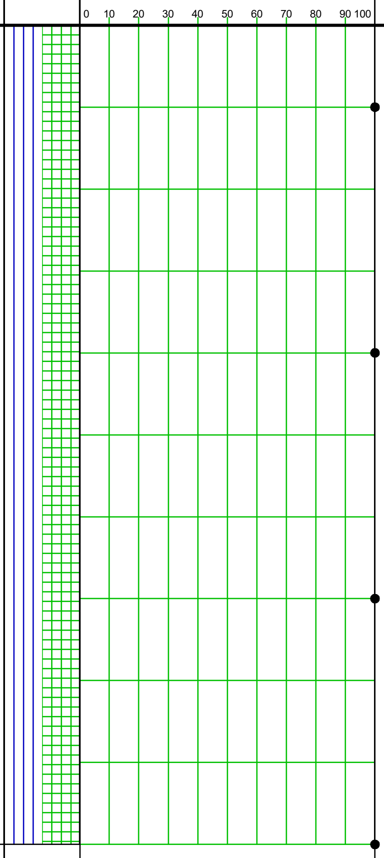


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 50.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

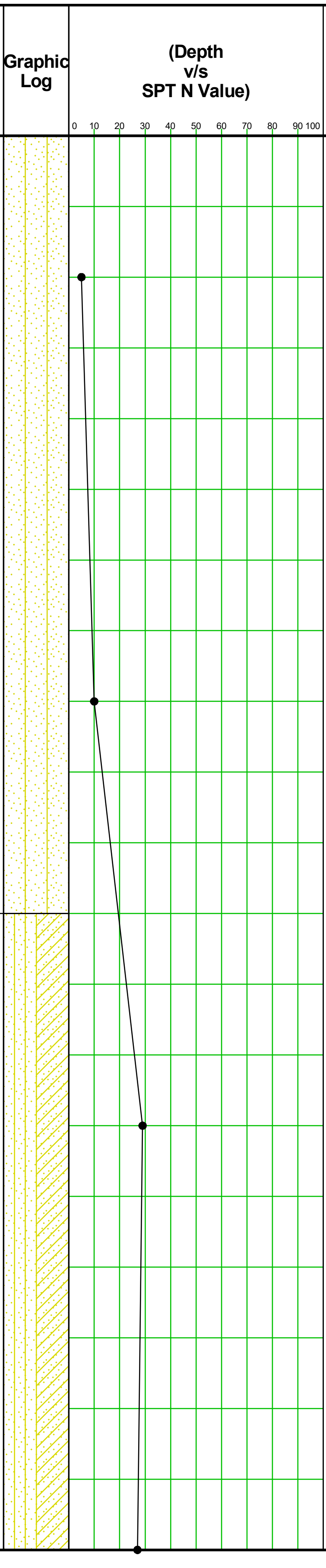


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Loose, Silty sand | SM | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 2 | 2 | 3 | 5 | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | SPT-2 | 3 | 4 | 6 | 10 | | | |
| 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 | 8 | 12 | 17 | 29 | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 7 | 12 | 15 | 27 | | | |

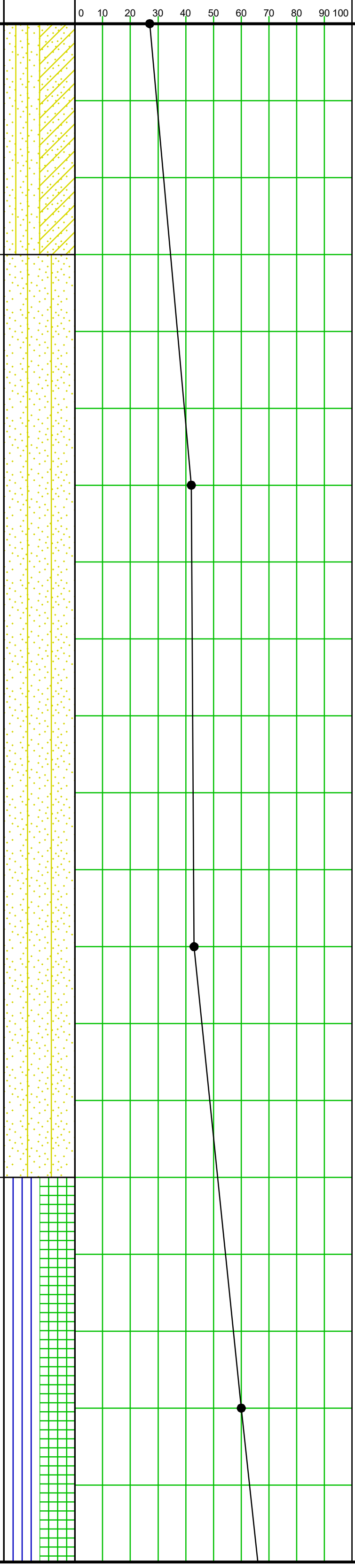


UDS*-UDS not recovered

# 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 | | | | | | | Brown, Medium dense, Silty sand with clay | SM-SC | | | |
| 10.5 | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | |
| 11.5 | 11.5 | UDS-4 | | | | | Brown, Dense, Silty sand with gravel | SM | | | |
| 12.0 | | | | | | | | | | | |
| 12.5 | | | | | | | | | | | |
| 13.0 | 13 | SPT-5 | 12 | 18 | 24 | 42 | | | | | |
| 13.5 | | | | | | | | | | | |
| 14.0 | | | | | | | | | | | |
| 14.5 | 14.5 | UDS-5 | | | | | | | | | |
| 15.0 | | | | | | | | | | | |
| 15.5 | | | | | | | | | | | |
| 16.0 | 16 | SPT-6 | 10 | 16 | 27 | 43 | | | | | |
| 16.5 | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | |
| 17.5 | 17.5 | UDS-6 | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 18.0 | | | | | | | | | | | |
| 18.5 | | | | | | | | | | | |
| 19.0 | 19 | SPT-7 | 20 | 27 | 33 | 60 | | | | | |
| 19.5 | | | | | | | | | | | |
| 20.0 | | | | | | | | | | | |

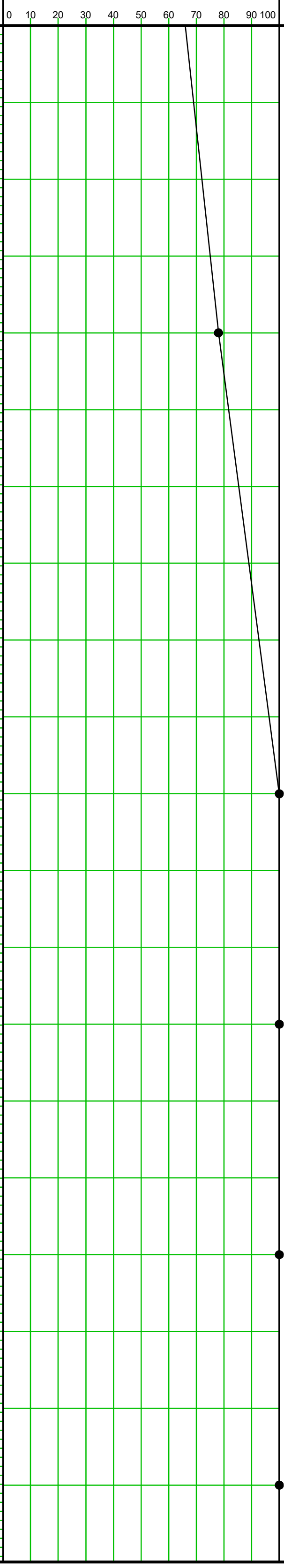


UDS*-UDS not recovered

# 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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 20.0 | | | | | | | | | | | |
| 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<br>(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<br>(9cm) | >100 | | | | | |
| 27.0 | | | | | | | | | | | |
| 27.5 | | | | | | | | | | | |
| 28.0 | 28 | SPT-11 | 28 | 58 | 42<br>(6cm) | >100 | | | | | |
| 28.5 | | | | | | | | | | | |
| 29.0 | | | | | | | | | | | |
| 29.5 | 29.5 | SPT-12 | 16 | 47 | 53<br>(8cm) | >100 | | | | | |
| 30.0 | | | | | | | | | | | |

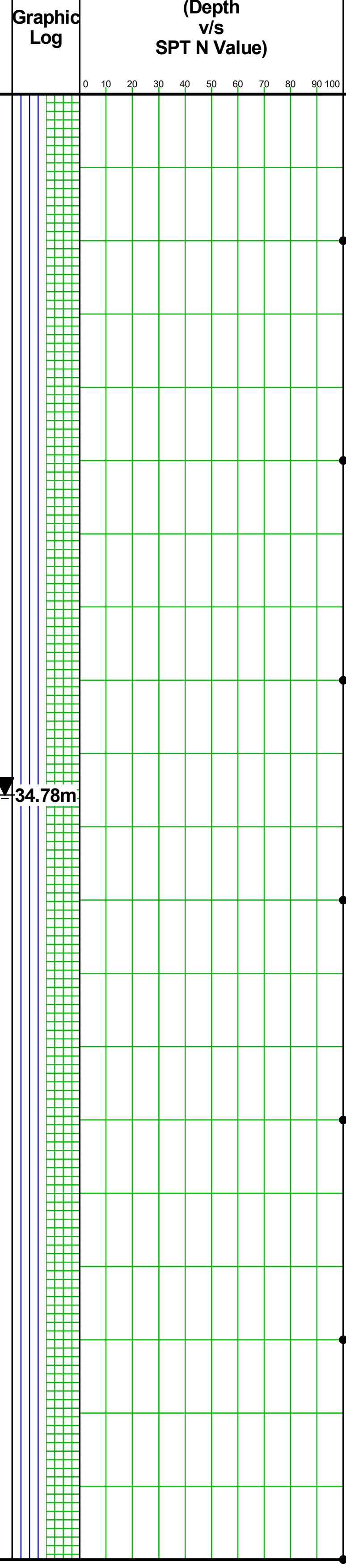


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | |
| 30.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | | | | | | | |
| 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

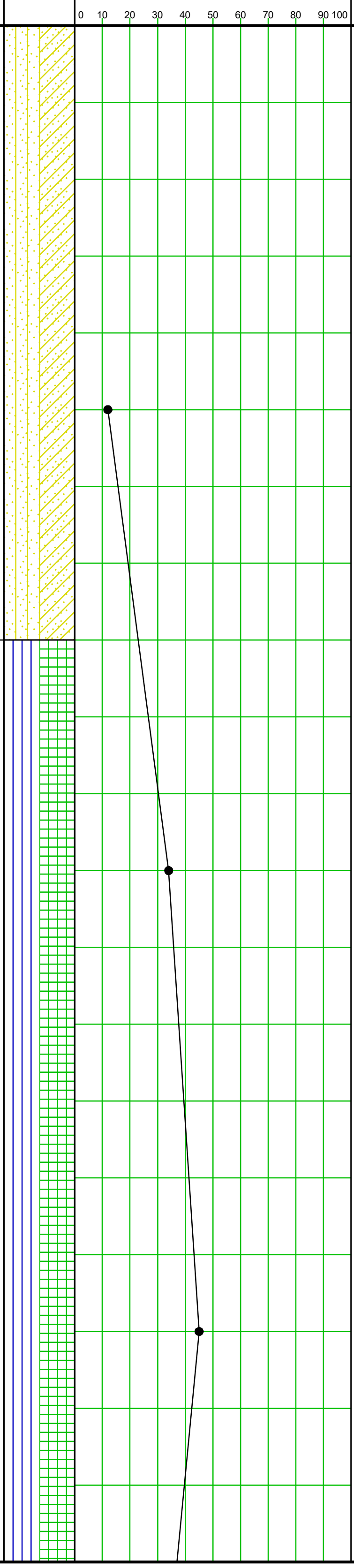
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Medium dense, Silty sand with clay | SM-SC | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 3 | 5 | 7 | 12 | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 13 | 15 | 19 | 34 | | | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | UDS-3 | | | | | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 16 | 20 | 25 | 45 | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | | |

Graphic Log

(Depth v/s SPT N Value)

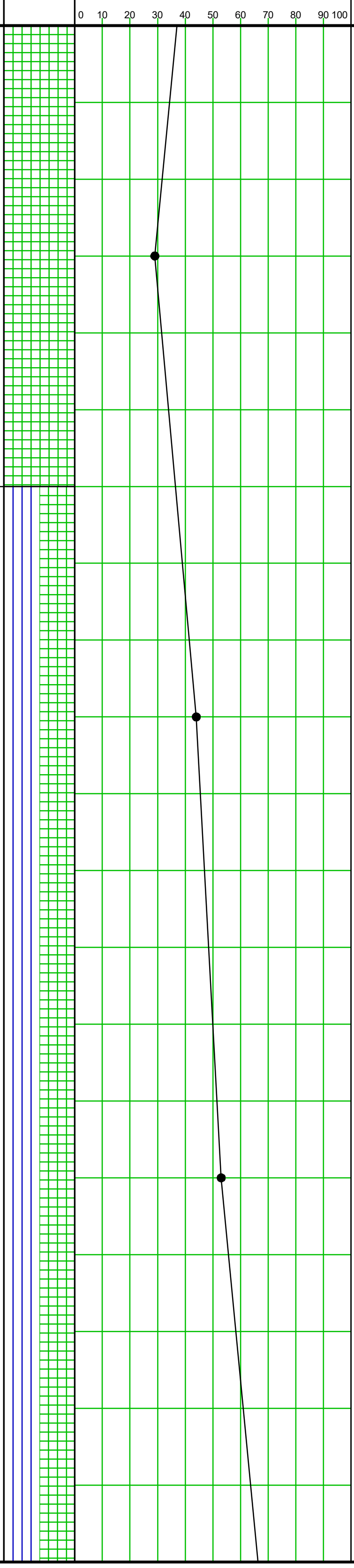


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 10.0 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |

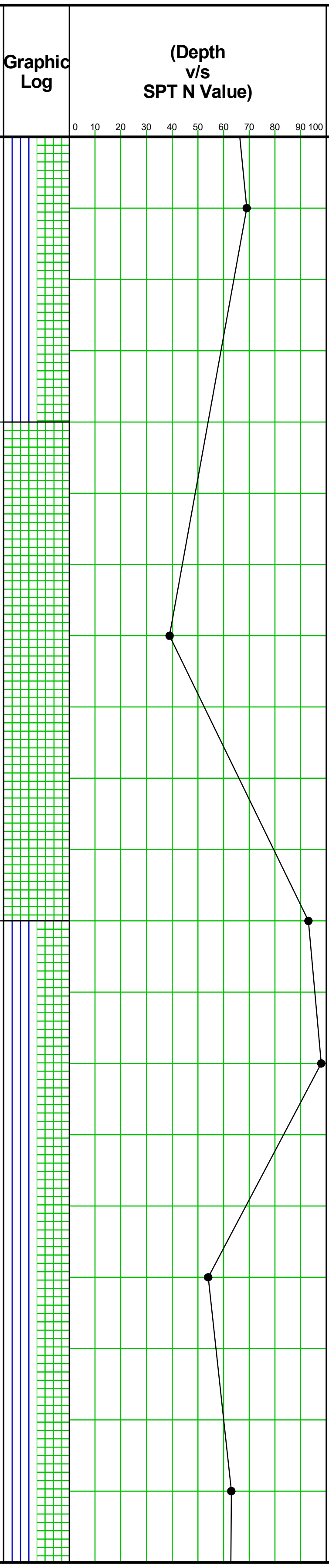


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 20.5 | 20.5 | SPT-7 | 28 | 33 | 36 | 69 | | | |
| 21.0 | | | | | | | | | |
| 21.5 | | | | | | | | | |
| 22.0 | 22 | UDS-8 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 22.5 | | | | | | | | | |
| 23.0 | | | | | | | | | |
| 23.5 | 23.5 | SPT-8 | 16 | 18 | 21 | 39 | | | |
| 24.0 | | | | | | | | | |
| 24.5 | | | | | | | | | |
| 25.0 | 25 | UDS* | | | | | | | |
| 25.5 | 25.5 | SPT-9 | 32 | 43 | 50 | 93 | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | |
| 28.5 | | | | | | | | | |
| 29.0 | | | | | | | | | |
| 29.5 | 29.5 | SPT-12 | 18 | 26 | 37 | 63 | | | |
| 30.0 | | | | | | | | | |



UDS*-UDS not recovered

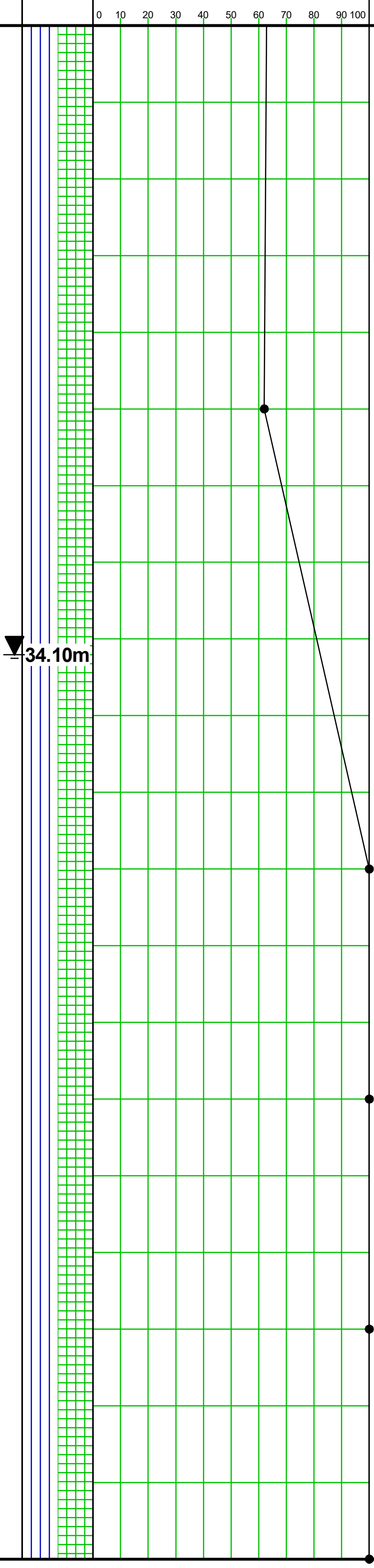
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 30.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | | | | | |
| 34.5 | | | | | | | | | |
| 35.0 | | | | | | | | | |
| 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 | | | |

Graphic Log

(Depth v/s SPT N Value)

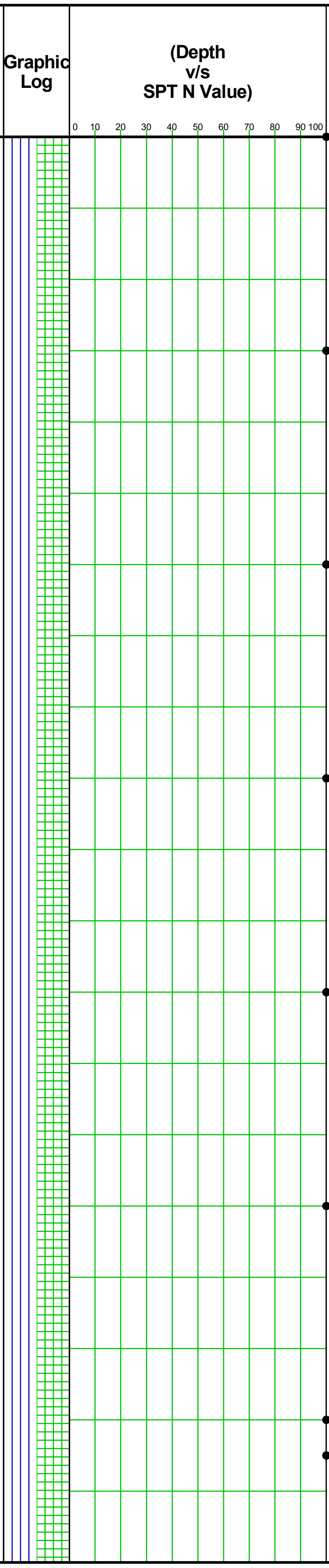


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 40.0 | | | | | | | | | |
| 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 | | | | | | | | | |

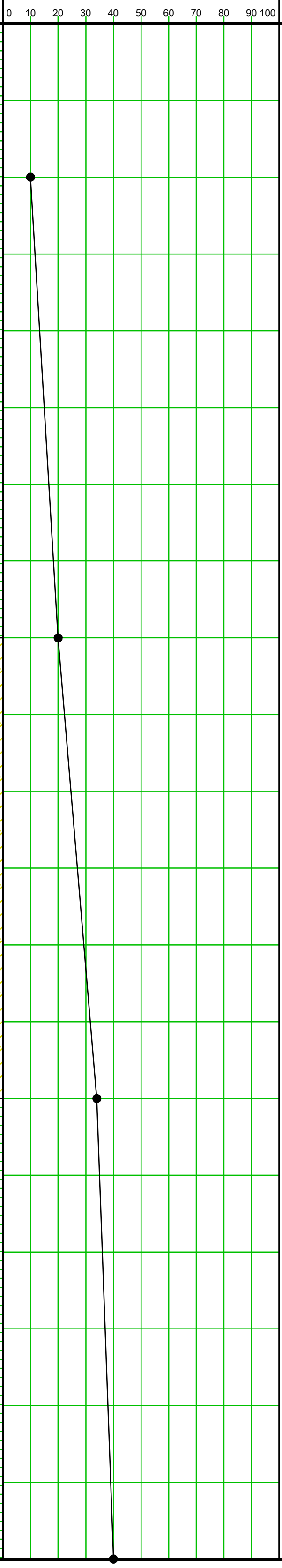


UDS*-UDS not recovered

# 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 | | | | | |

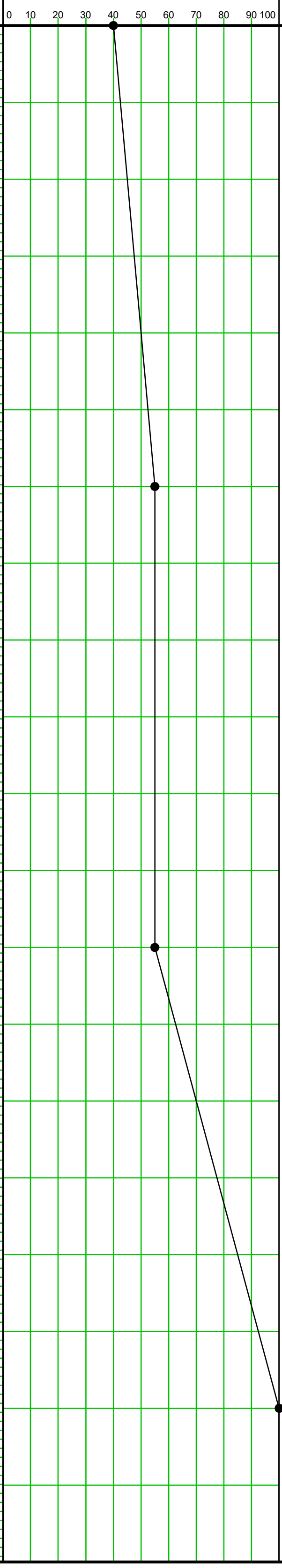


UDS*-UDS not recovered

# 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 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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<br>(5cm) | >100 | | | | | |
| 19.5 | | | | | | | | | | | |
| 20.0 | | | | | | | | | | | |

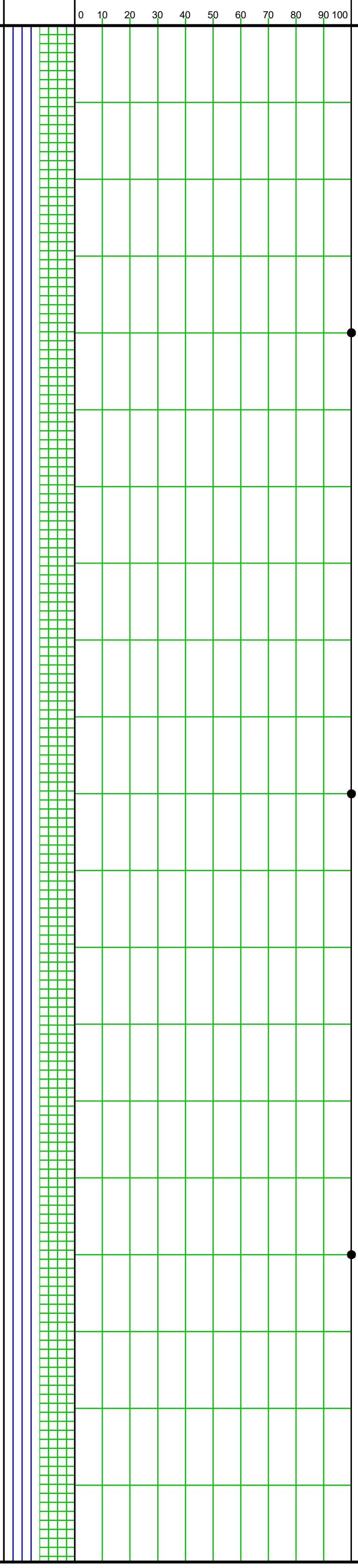


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 20.0 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | |
| 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 | | | | | | | | | | | |

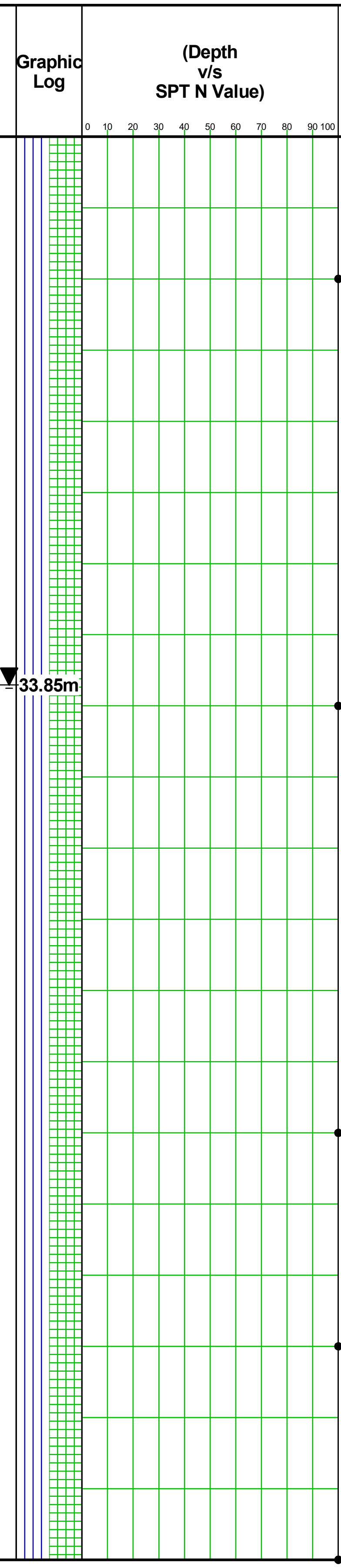


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | |
| 30.0 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | |
| 34.5 | | | | | | | | | |
| 35.0 | | | | | | | | | |
| 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 | | | |



UDS*-UDS not recovered

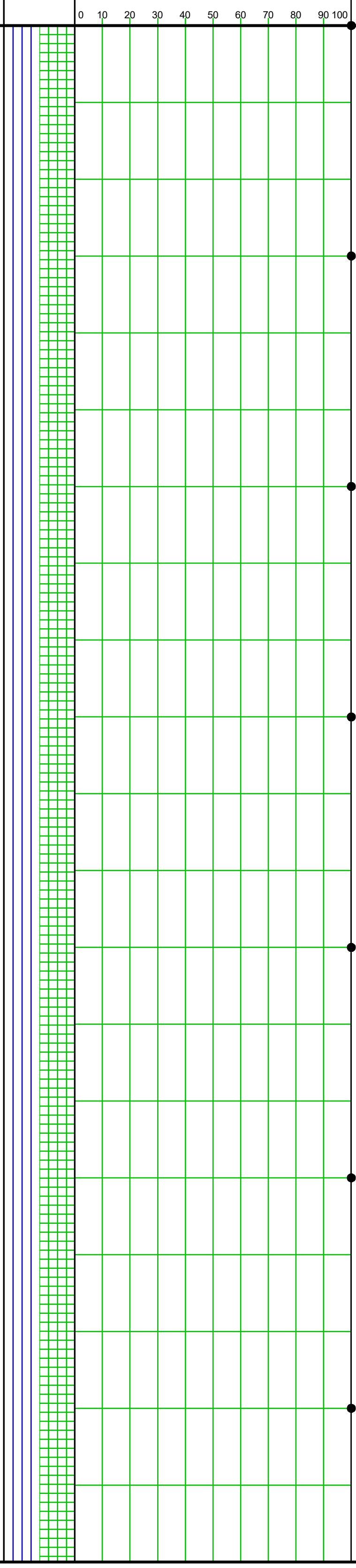
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | |
| 40.0 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 40.5 | | | | | | | | | |
| 41.0 | | | | | | | | | |
| 41.5 | 41.5 | SPT-16 | 42 | 68 | 32<br>(7cm) | >100 | | | |
| 42.0 | | | | | | | | | |
| 42.5 | | | | | | | | | |
| 43.0 | 43 | SPT-17 | 49 | 75 | 25<br>(9cm) | >100 | | | |
| 43.5 | | | | | | | | | |
| 44.0 | | | | | | | | | |
| 44.5 | 44.5 | SPT-18 | 52 | 100<br>(10cm) | - | >100 | | | |
| 45.0 | | | | | | | | | |
| 45.5 | | | | | | | | | |
| 46.0 | 46 | SPT-19 | 40 | 100<br>(15cm) | - | >100 | | | |
| 46.5 | | | | | | | | | |
| 47.0 | | | | | | | | | |
| 47.5 | 47.5 | SPT-20 | 48 | 100<br>(3cm) | - | >100 | | | |
| 48.0 | | | | | | | | | |
| 48.5 | | | | | | | | | |
| 49.0 | 49<br>49.23 | SPT-21 | 45 | 100<br>(8cm) | - | >100 | | | |
| 49.5 | | | | | | | | | |
| 50.0 | | | | | | | | | |

**Graphic Log**

**(Depth v/s SPT N Value)**

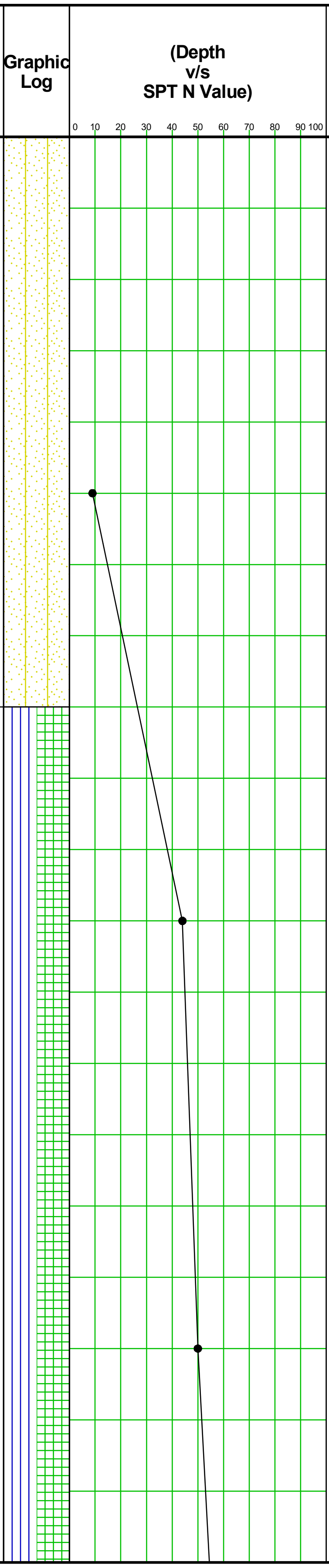


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Loose, Silty sand | SM | |
| 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 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 12 | 19 | 25 | 44 | | | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | UDS-3 | | | | | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 14 | 22 | 28 | 50 | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | | |

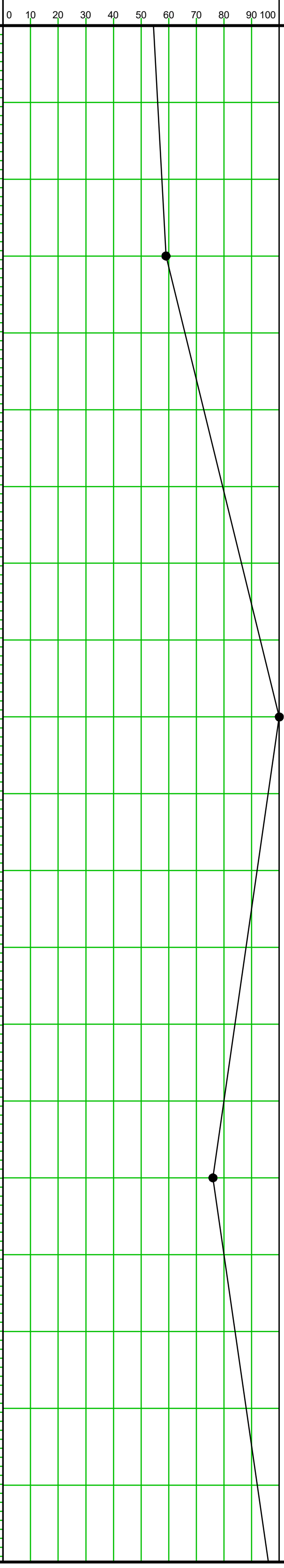


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 10.0 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |

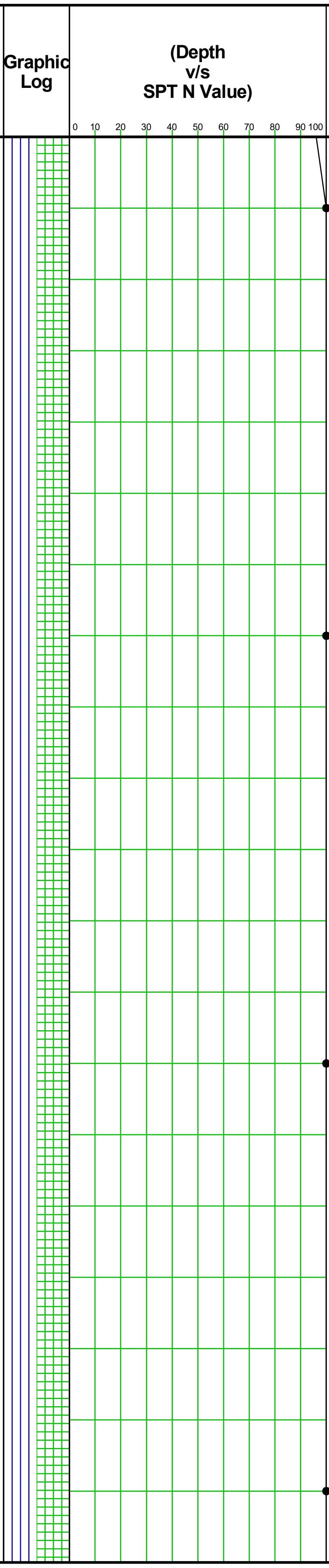


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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* | | | | | | | |
| 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 | | | | | | | | | |

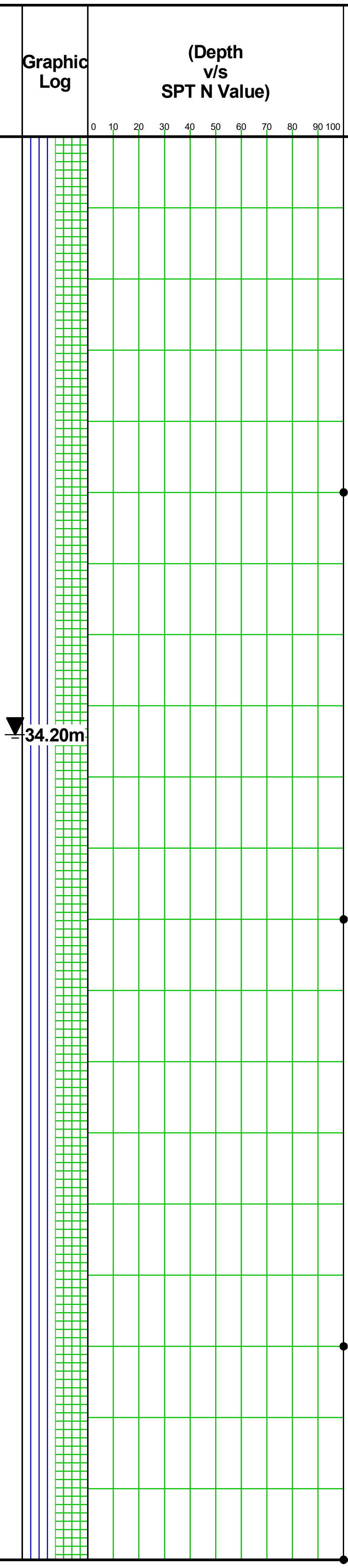


UDS*-UDS not recovered

# 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 | |

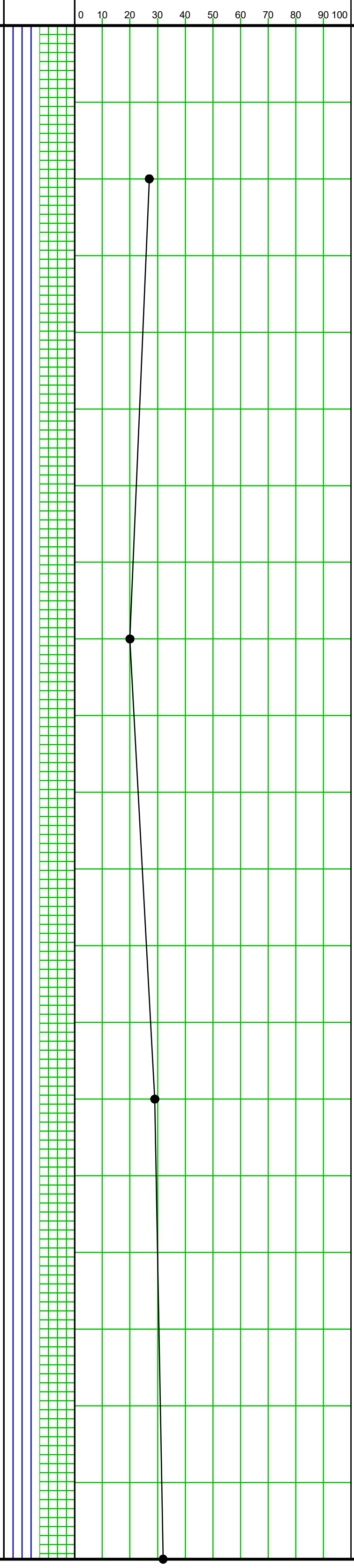
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm N1 | N2 | N3 | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 30.0 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 30.5 | | | | | | | | | |
| 31.0 | 31 | UDS* | | | | | | | |
| 31.5 | | | | | | | | | |
| 32.0 | | | | | | | | | |
| 32.5 | 32.5 | SPT-11 | 48 | 75 | 25<br>(4cm) | >100 | | | |
| 33.0 | | | | | | | | | |
| 33.5 | | | | | | | | | |
| 34.0 | 34 | UDS* | | | | | | | |
| 34.5 | | | | | | | | | |
| 35.0 | | | | | | | | | |
| 35.5 | 35.5 | SPT-12 | 38 | 63 | 37<br>(10cm) | >100 | | | |
| 36.0 | | | | | | | | | |
| 36.5 | | | | | | | | | |
| 37.0 | 37 | UDS* | | | | | | | |
| 37.5 | | | | | | | | | |
| 38.0 | | | | | | | | | |
| 38.5 | 38.5 | SPT-13 | 32 | 49 | 51<br>(13cm) | >100 | | | |
| 39.0 | | | | | | | | | |
| 39.5 | | | | | | | | | |
| 40.0 | 40 | SPT-14 | 54 | 69 | 31<br>(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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 0.0 | | DS | | | | | Brown, Medium dense to dense, Sandy silt of low plasticity with gravel | ML-CL | |  | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

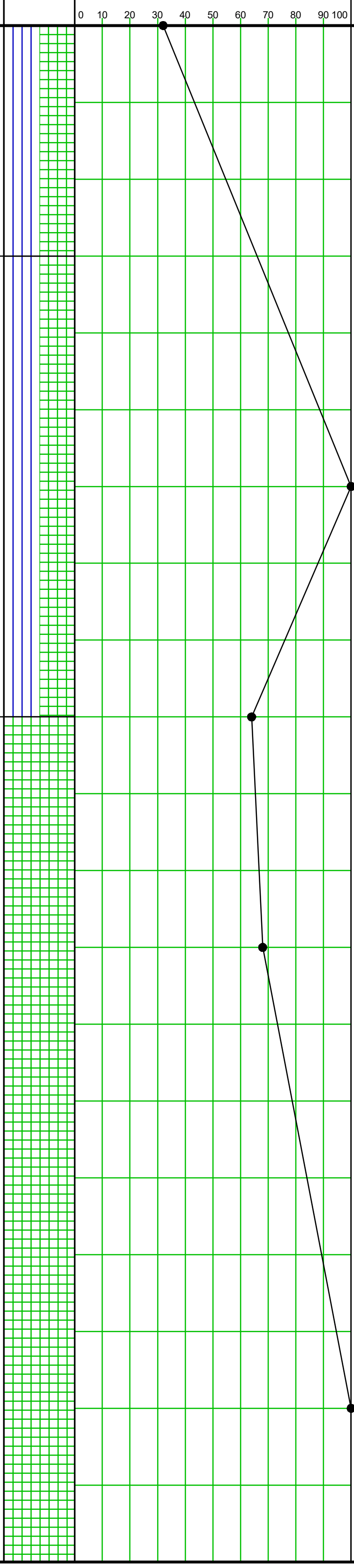
UDS*-UDS not recovered

# 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 | 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 | | | | | | | | | |

Graphic Log

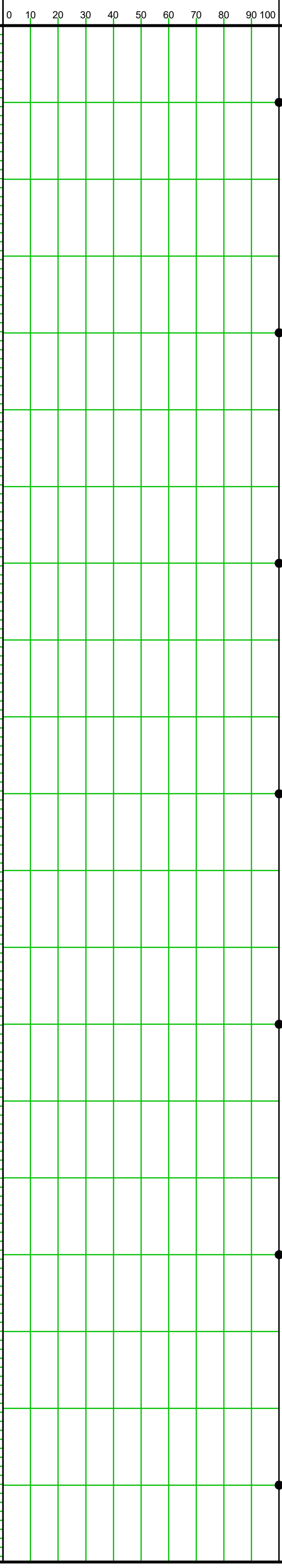


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 20.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | |
| 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 | | | | | | | | | | | |

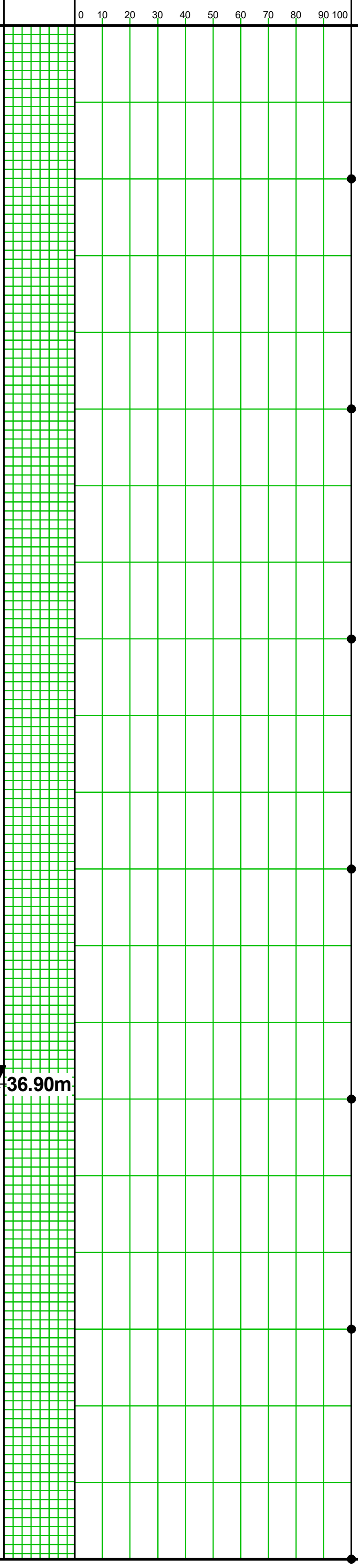


UDS*-UDS not recovered

# *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 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

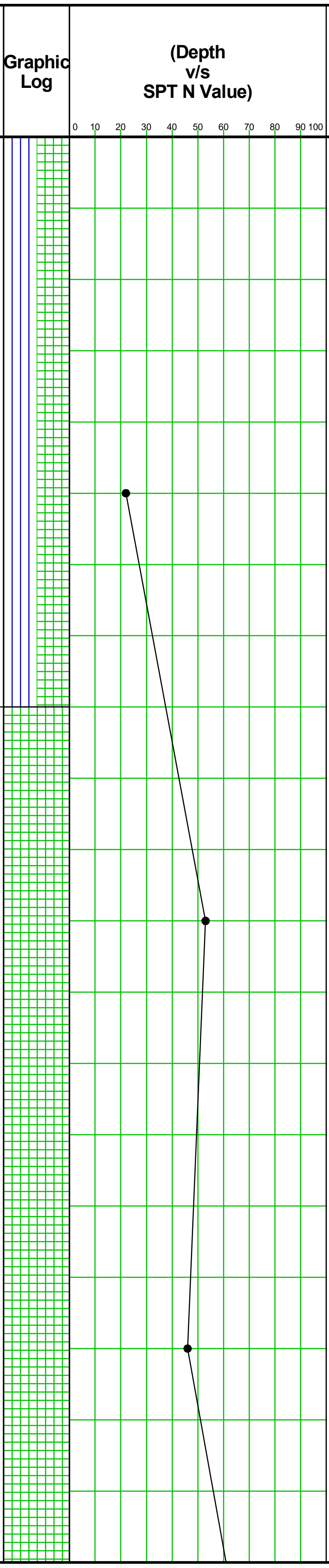


UDS*-UDS not recovered

# 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 |
|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Medium dense, Sandy silt of low plasticity with gravel | ML-CL |
| 0.5 | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | |
| 1.5 | | | | | | | | |
| 2.0 | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 7 | 9 | 13 | 22 | | |
| 3.0 | | | | | | | | |
| 3.5 | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL |
| 4.5 | | | | | | | | |
| 5.0 | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 15 | 24 | 29 | 53 | | |
| 6.0 | | | | | | | | |
| 6.5 | | | | | | | | |
| 7.0 | 7 | UDS-3 | | | | | | |
| 7.5 | | | | | | | | |
| 8.0 | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 12 | 19 | 27 | 46 | | |
| 9.0 | | | | | | | | |
| 9.5 | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | |



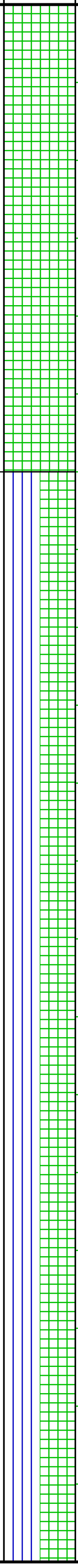
Special Observations

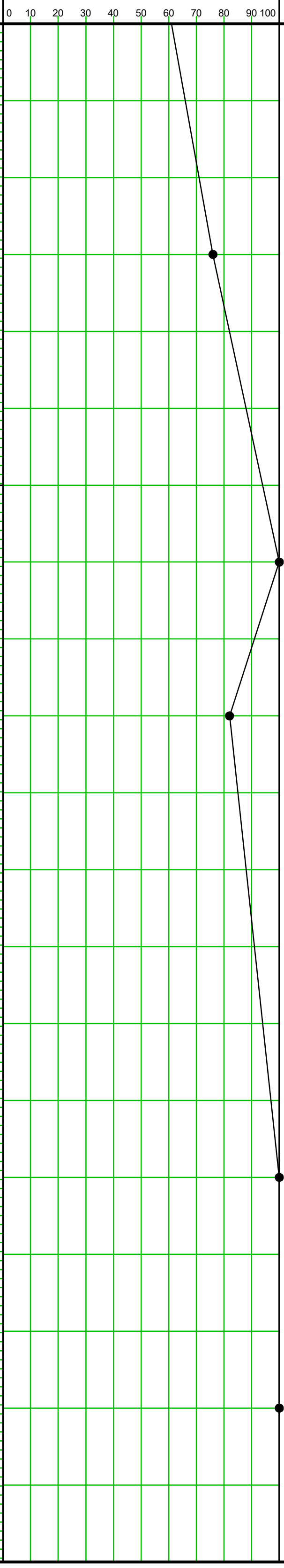
UDS*-UDS not recovered

# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana. | | *Client :*HRIDCL |
| *BH Location/Chainage :*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 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 10.5 | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | |
| 11.5 | 11.5 | SPT-4 | 23 | 34 | 42 | 76 | | | | | |
| 12.0 | | | | | | | | | | | |
| 12.5 | | | | | | | | | | | |
| 13.0 | 13 | UDS-5 | | | | | | | | | |
| 13.5 | 13.5 | SPT-5 | 29 | 45 | 55 (7cm) | >100 | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 14.0 | | | | | | | | | | | |
| 14.5 | 14.5 | SPT-6 | 24 | 38 | 44 | 82 | | | | | |
| 15.0 | | | | | | | | | | | |
| 15.5 | | | | | | | | | | | |
| 16.0 | 16 | UDS-6 | | | | | | | | | |
| 16.5 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |





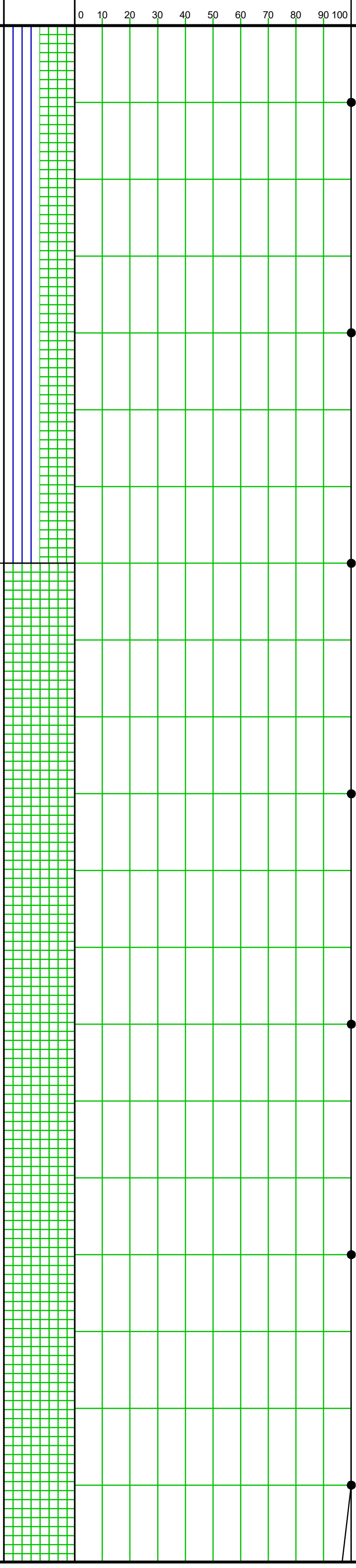
UDS*-UDS not recovered

# 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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | |
| 20.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 20.5 | 20.5 | SPT-9 | 36 | 53 | 47 (7cm) | >100 | | | |
| 21.0 | | | | | | | | | |
| 21.5 | | | | | | | | | |
| 22.0 | 22 | SPT-10 | 35 | 100 (13cm) | - | >100 | | | |
| 22.5 | | | | | | | | | |
| 23.0 | | | | | | | | | |
| 23.5 | 23.5 | SPT-11 | 30 | 46 | 54 (10cm) | >100 | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 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 | | | | | | | | | |
| 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 | | | | | | | | | |

**Graphic Log** **(Depth v/s SPT N Value)**

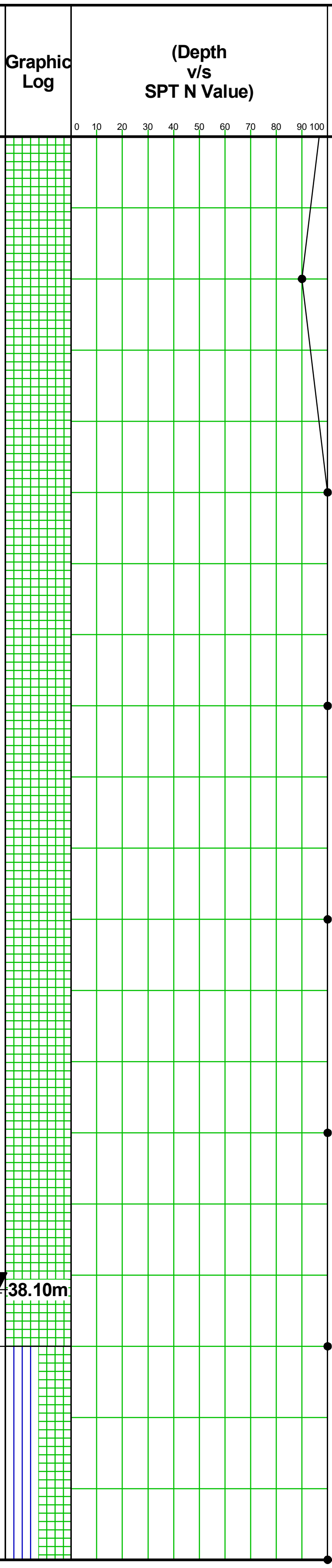


UDS*-UDS not recovered

# *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 30.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 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 | | | |
| 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 | | | | | | | | | |
| 38.5 | 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 | | | |

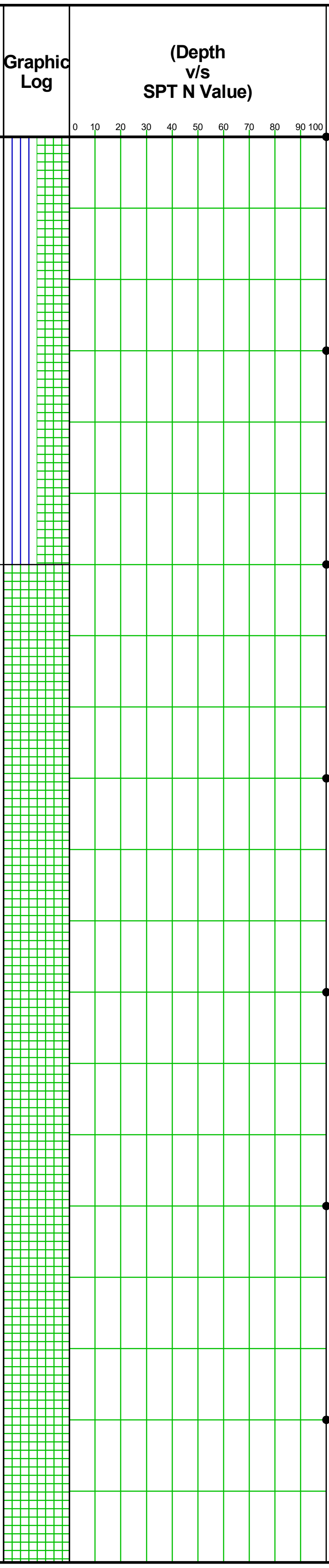


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 40.0 | | | | | | | | | |
| 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

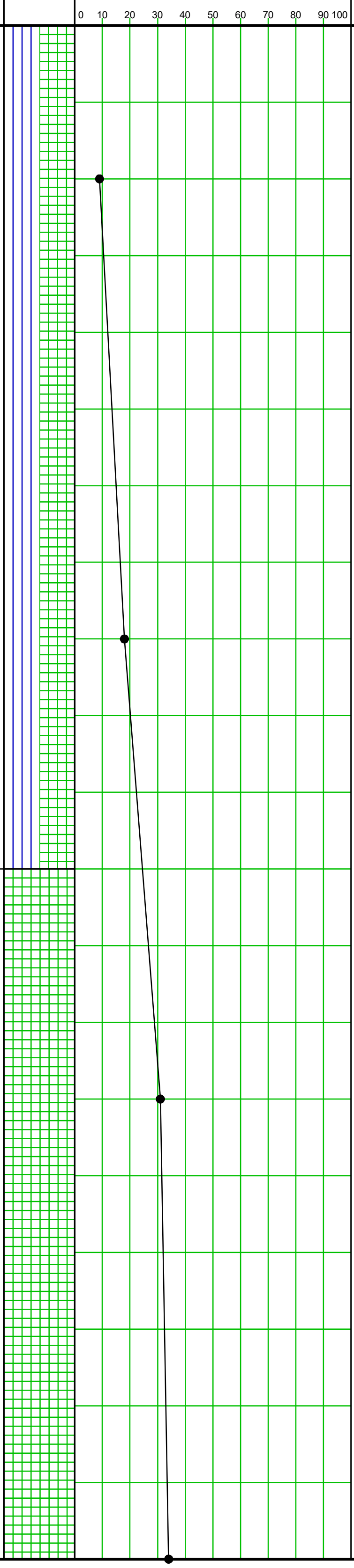
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | | | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | |
| 0.0 | | DS | | | | | Brown, Loose to medium dense, Sandy silt of low plasticity | ML-CL | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 3 | 4 | 5 | 9 | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | SPT-2 | 5 | 7 | 11 | 18 | | | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | UDS-2 | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | CL | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | SPT-3 | 8 | 14 | 17 | 31 | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 12 | 16 | 18 | 34 | | | |

Graphic Log

(Depth v/s SPT N Value)

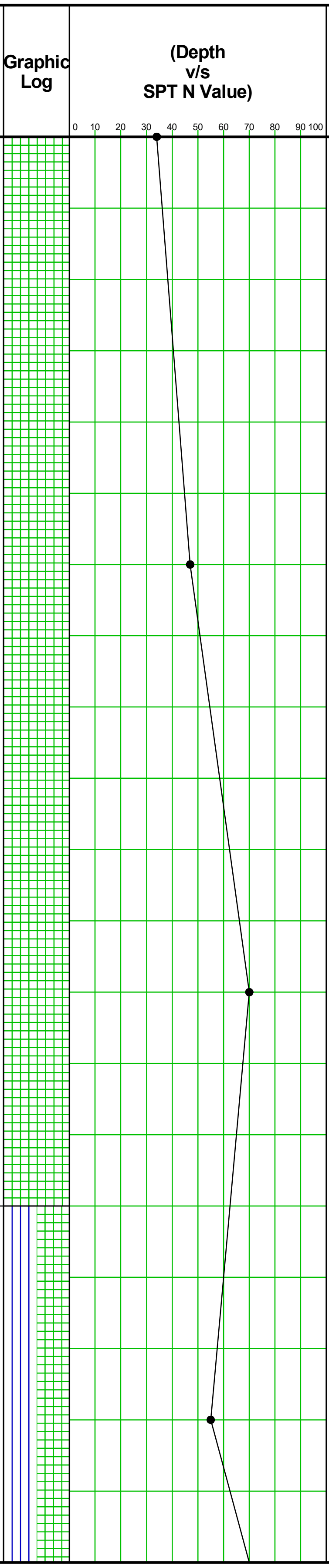


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | CL | |
| 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 | | | | | | | | | |
| 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 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | ML-CL | |
| 18.0 | | | | | | | | | |
| 18.5 | | | | | | | | | |
| 19.0 | 19 | SPT-7 | 20 | 23 | 32 | 55 | | | |
| 19.5 | | | | | | | | | |
| 20.0 | | | | | | | | | |

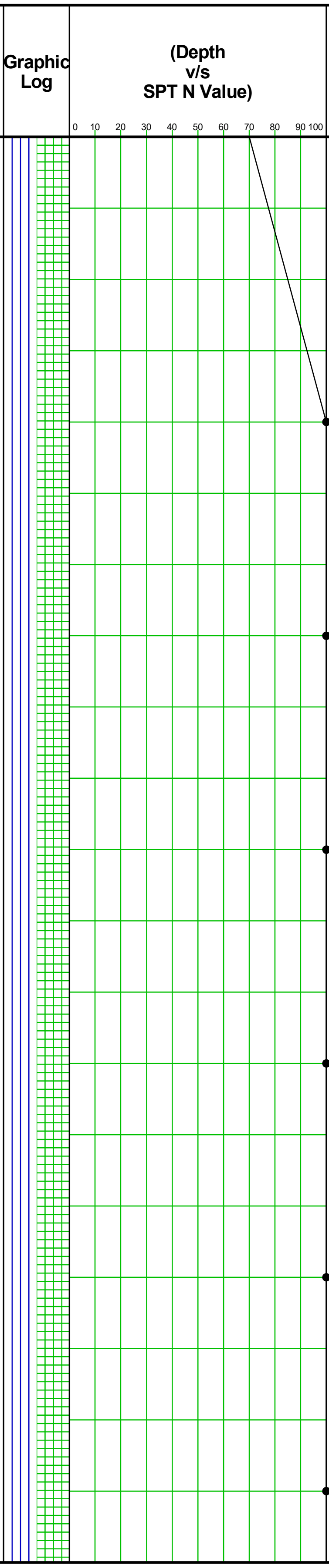


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | ML-CL | |
| 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 | | | |
| 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 | | | | | | | | | |

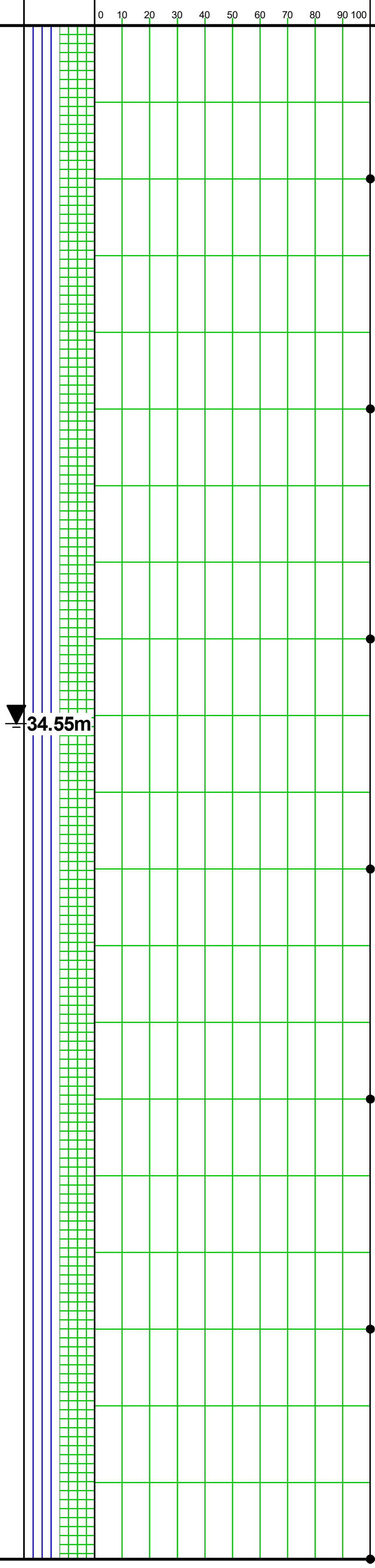


UDS*-UDS not recovered

# 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 | |

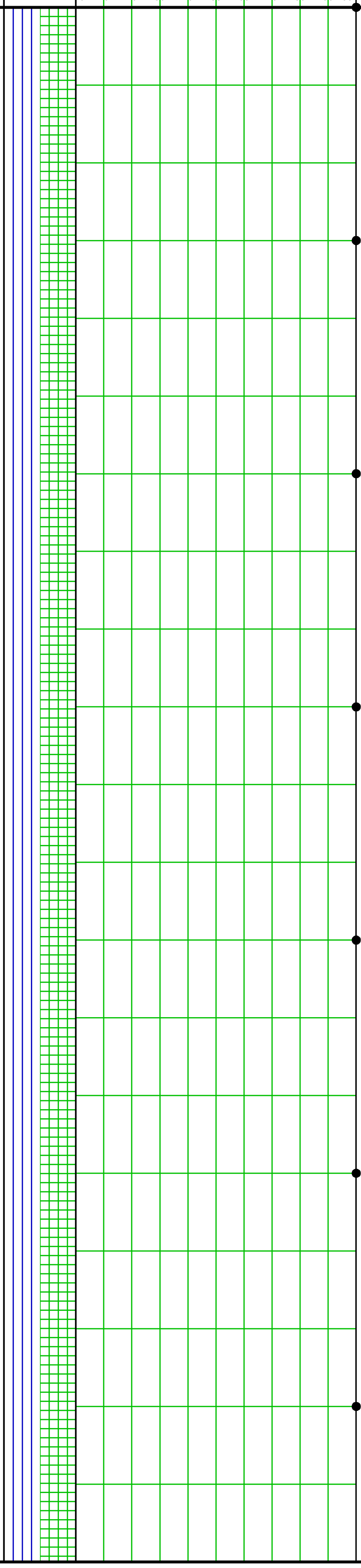
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 30.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 35.0 | | | | | | | | | | | |
| 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 | | | | | |



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 | |

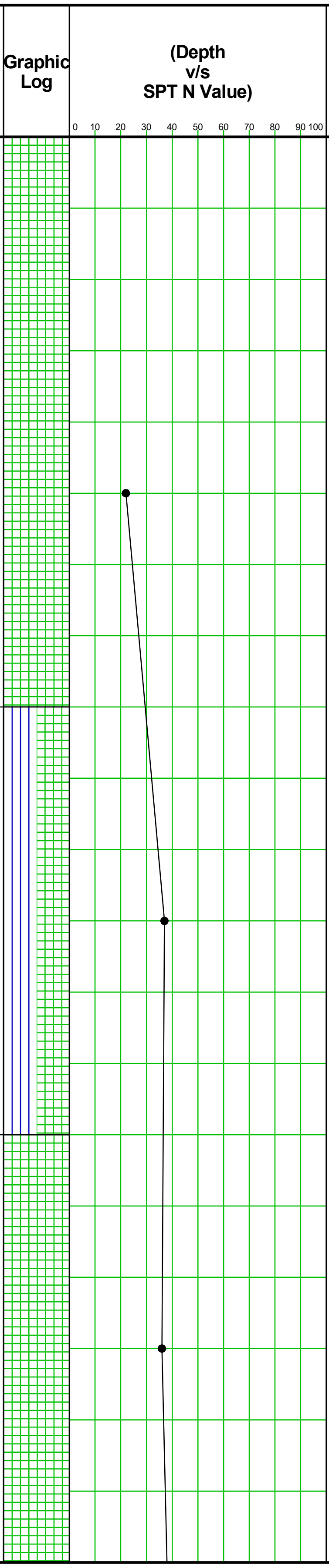
| **Depth (m)** | **In-Situ Sample Depth (m)** | **Sample Type** | **Blow counts per 15cm** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 40.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | ML-CL |  | | |
| 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 | | | | | | | | | | | |
| 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<br>49.08 | SPT-26<br>- | 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Very stiff, Silty clay of low plasticity | CL | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 7 | 9 | 13 | 22 | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 12 | 16 | 21 | 37 | | | |
| 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 | 9 | 12 | 24 | 36 | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | | |

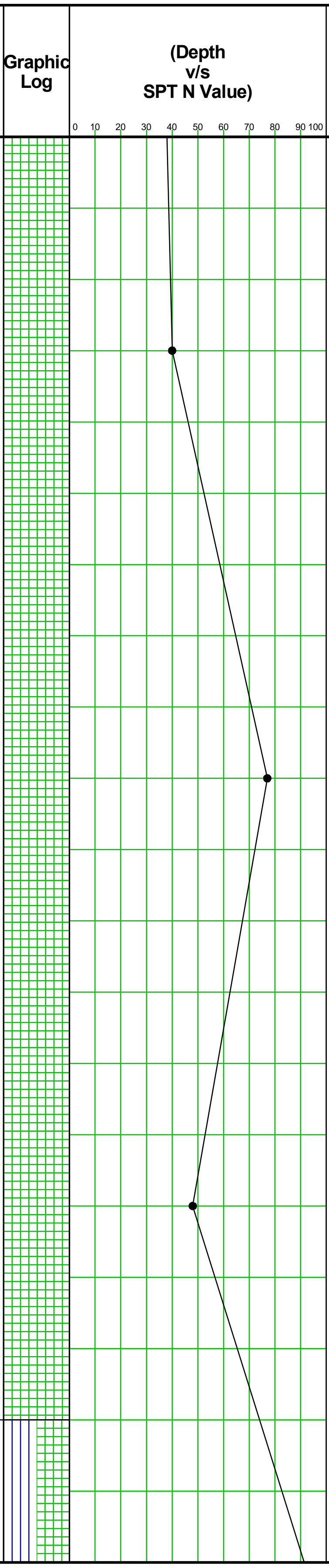


UDS*-UDS not recovered

# 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+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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 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 | | | |
| 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 | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 19.5 | | | | | | | | | |
| 20.0 | | | | | | | | | |

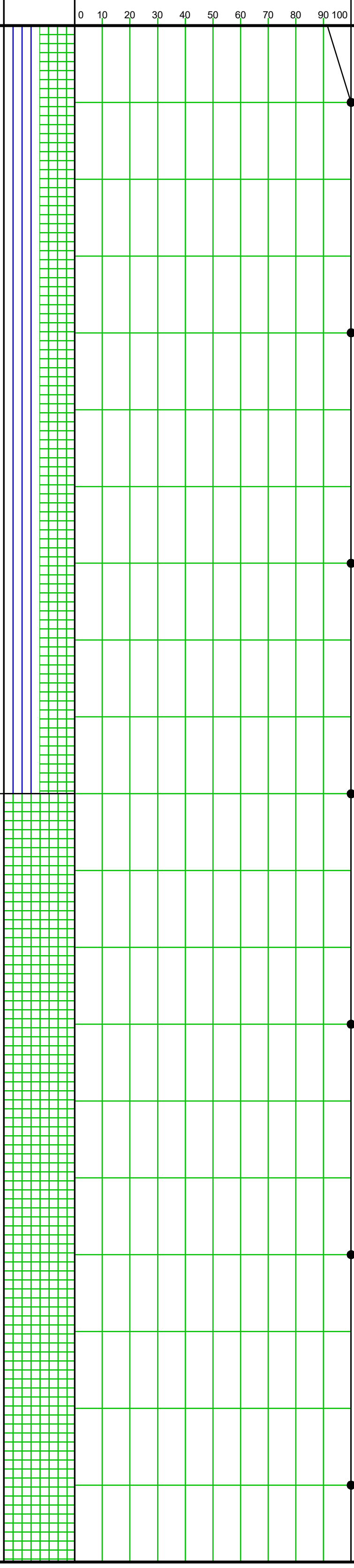


UDS*-UDS not recovered

# 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+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) 0 10 20 30 40 50 60 70 80 90 100 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | | |
| 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 | | | | | | | | | | | |
| 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 | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 25.5 | | | | | | | | | | | |
| 26.0 | | | | | | | | | | | |
| 26.5 | 26.5 | SPT-11 | 45 | 100 (4cm) | - | >100 | | | | | |
| 27.0 | | | | | | | | | | | |
| 27.5 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |

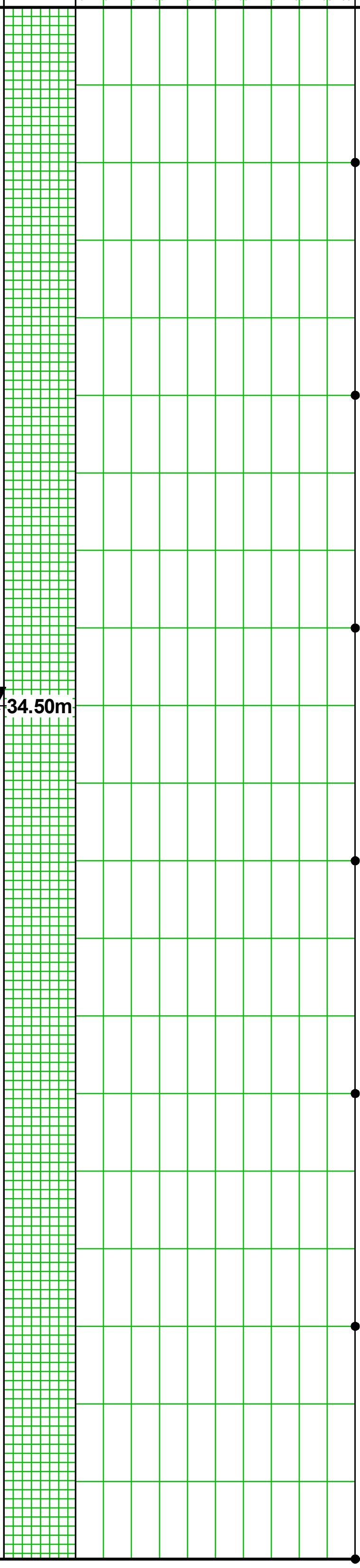


UDS*-UDS not recovered

# FIELD BOREHOLE LOG

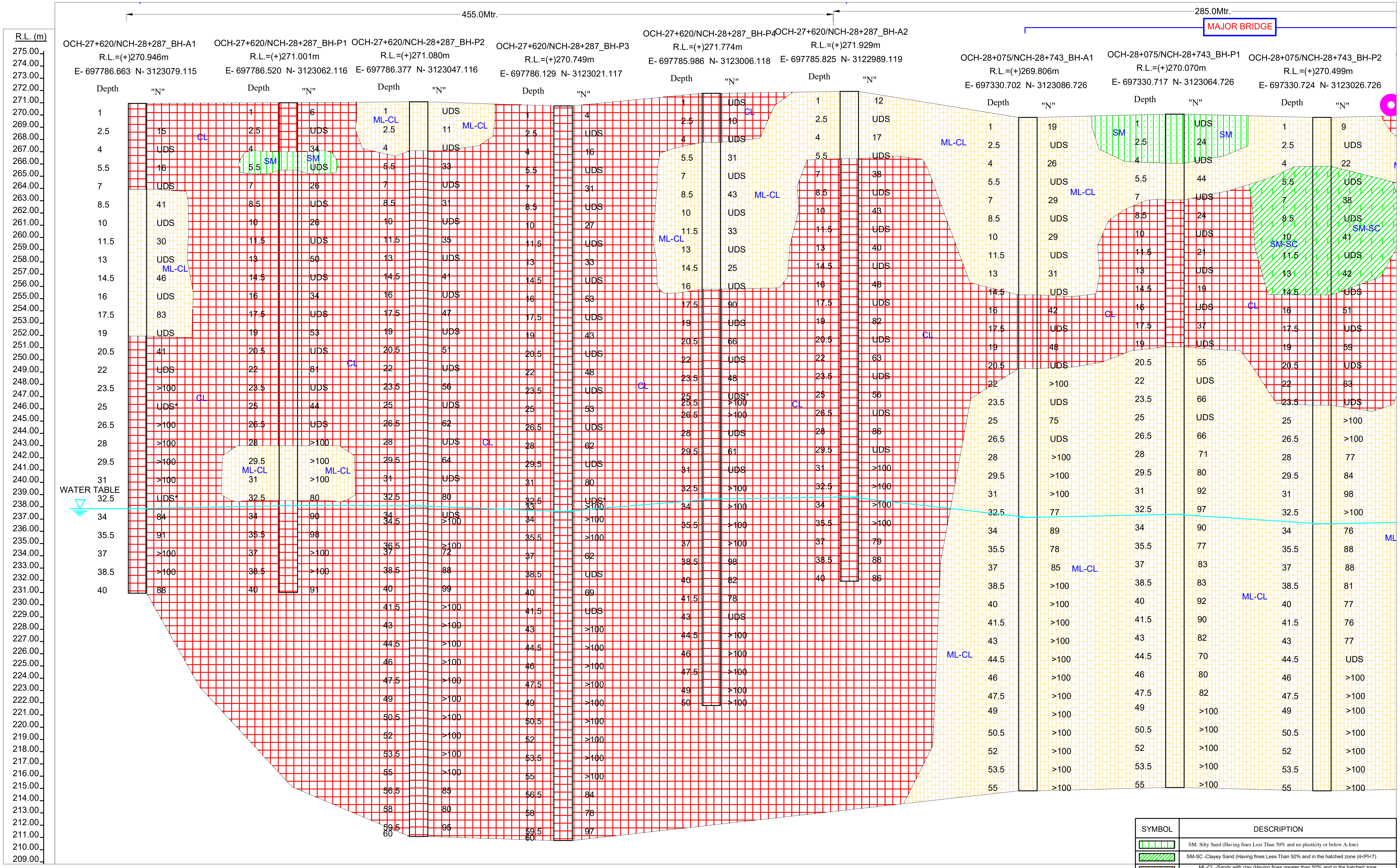
| | | |
|---|---|---|
| *Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana. | | *Client :*HRIDCL |
| *BH Location/Chainage :*28+900 km | *Northing :*3123180.027 m | *Easting :*696517.163 m |
| *Reduced Level (m):*(+)263.847 | *BH. No. :*BH-A2 | *BH Termination 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | 0 10 20 30 40 50 60 70 80 90 100 | |
| 30.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 30.5 | | | | | | | | | | | |
| 31.0 | 31 | SPT-14 | 41 | 53<br>(7cm) | 47 | >100 | | | | | |
| 31.5 | | | | | | | | | | | |
| 32.0 | | | | | | | | | | | |
| 32.5 | 32.5 | SPT-15 | 32 | 47 | 53<br>(4cm) | >100 | | | | | |
| 33.0 | | | | | | | | | | | |
| 33.5 | | | | | | | | | | | |
| 34.0 | 34 | SPT-16 | 45 | 59 | 41<br>(6cm) | >100 | | | | | |
| 34.5 | | | | | | | | | 34.50m | | |
| 35.0 | | | | | | | | | | | |
| 35.5 | 35.5 | SPT-17 | 58 | 100<br>(5cm) | - | >100 | | | | | |
| 36.0 | | | | | | | | | | | |
| 36.5 | | | | | | | | | | | |
| 37.0 | 37 | SPT-18 | 35 | 48 | 52<br>(8cm) | >100 | | | | | |
| 37.5 | | | | | | | | | | | |
| 38.0 | | | | | | | | | | | |
| 38.5 | 38.5 | SPT-19 | 38 | 55 | 45<br>(6cm) | >100 | | | | | |
| 39.0 | | | | | | | | | | | |
| 39.5 | | | | | | | | | | | |
| 40.0 | 40 | SPT-20 | 33 | 100<br>(15cm) | - | >100 | | | | | |



UDS*-UDS not recovered

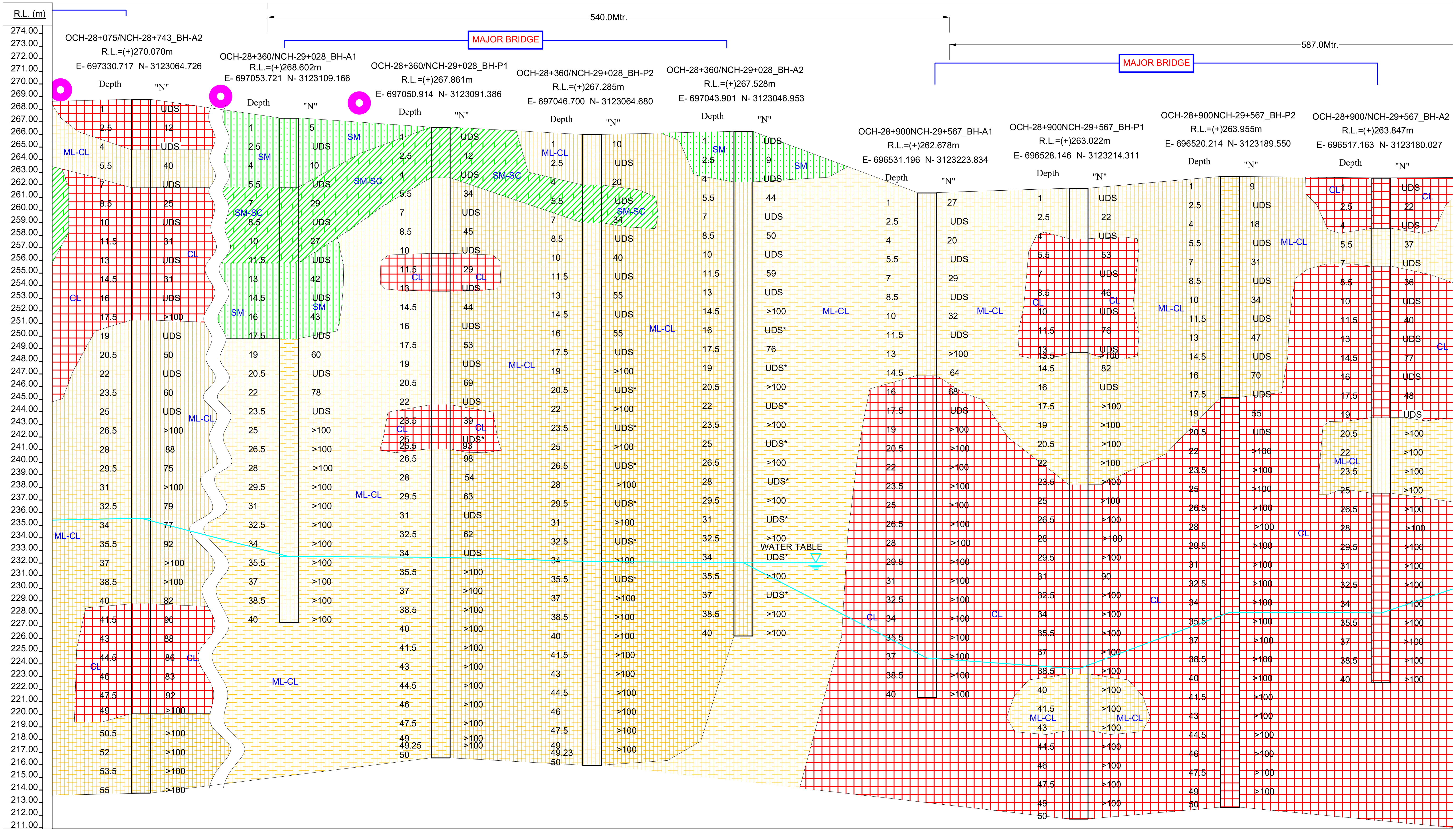
# CONDUCTING GEOTECHNICAL INVESTIGATION, PREPARATION OF GEOTECHNICAL REPORT FOR DESIGNING OF BRIDGES AND FOR EMBANKMENT IN CONNECTION WITH CONSTRUCTION OF HARYANA ORBITAL RAIL CORRIDOR (HORC) PROJECT FROM PALWAL TO HARSANA KALAN INCLUDING CONNECTIVITY TO EXISTING IR NETWORK IN THE STATE OF HARYANA.



| 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.



| 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

# 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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 11-10-2021 | to | 12-10-2021 | 27+620<br>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.

# SOIL CHARACTERISTICS

| Project | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 11-10-2021 | to | 12-10-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | - | - | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 9.44<br>6.30<br>5.16<br>4.57 | 1.79<br>1.39<br>0.92<br>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 | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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<br>Total<br>Effective | <br>0.26<br>0.21 | <br>22<br>26 | - | - | - | - | - | - | - | - |

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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 11-10-2021 | to | 12-10-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| SPT-10 | 28.00 | 100<br>(25cm) | 100<br>(25cm) | Brown, Very dense, Sandy silt of low plasticity with gravel | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-11 | 29.50 | 100<br>(23cm) | - | | ML-CL | | 7 | 49 | 28 | 3 | 5 | 8 | 0 | 26 | 20 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-12 | 31.00 | 100<br>(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<br>(25cm) | 100<br>(25cm) | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-17 | 38.50 | 100<br>(23cm) | 100<br>(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.

# 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<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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:-
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 | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 18-11-2021 | to | 20-11-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| UDS-10 | 29.50 | - | - | Brown, Hard, Silty clay of low plasticity with gravel | 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 | - | - | | 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 | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 18-11-2021 | to | 20-11-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | - | - | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 18-11-2021 | to | 20-11-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>(25cm) | 100<br>(25cm) | | CL | | 10 | 47 | 27 | 4 | 3 | 9 | 0 | 30 | 20 | 10 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-10 | 26.50 | 100<br>(23cm) | 100<br>(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.

# SOIL CHARACTERISTICS

| Project | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 18-11-2021 | to | 20-11-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| UDS-9 | 28.00 | - | - | Brown, Hard, Silty clay of low plasticity with gravel | 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 | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 18-11-2021 | to | 21-11-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | - | - | - | - | - | - | - | - | - | - | - | - |

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<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| SPT-10 | 29.50 | 64 | 64 | Brown, Hard, Silty clay of low plasticity with gravel | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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) | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18-11-2021 | to | 21-11-2021 | 27+620<br>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** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Sand** | | | **Gravel** | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | **Clay** | **Silt** | **Fine** | **Medium** | **Coarse** | **Fine** | **Coarse** | **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 ($C_c$)** |
| SPT-28 | 58.00 | 80 | 80 | Brown, Hard, Silty clay of low plasticity with gravel | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-29 | 59.50 | 95 | 95 | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| - | 60.00 | - | - | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 18-11-2021 | to | 19-11-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 18-11-2021 | to | 19-11-2021 | 27+620<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | Liquid Limit | Plastic Limit | Plasticity Index | Shrinkage Limit | | | | | Type of Test | Cohesion C (kg/cm$^2$) | Angle of Friction ($\varphi^\circ$) | | | | 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 ($C_c$) |
| 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.

# SOIL CHARACTERISTICS

| Project | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 16-10-2021 | to | 18-10-2021 | 28+075<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>(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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 16-10-2021 | to | 18-10-2021 | 28+075<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| SPT-11 | 29.50 | 80 | 37 | Brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | | 8 | 44 | 22 | 10 | 3 | 13 | 0 | 28 | 21 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-12 | 31.00 | 100<br>(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<br>(19cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-19 | 41.50 | 88 | 28 | | ML-CL | | 6 | 49 | 25 | 9 | 1 | 10 | 0 | 26 | 20 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-20 | 43.00 | 100<br>(27cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-21 | 44.50 | 100<br>(25cm) | - | | ML-CL | | 8 | 48 | 29 | 2 | 1 | 12 | 0 | 28 | 21 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-22 | 46.00 | 100<br>(28cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-23 | 47.50 | 100<br>(23cm) | - | | ML-CL | | 7 | 49 | 30 | 3 | 2 | 8 | 1 | 27 | 20 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-24 | 49.00 | >100 | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-25 | 50.50 | 100<br>(28cm) | - | | ML-CL | | 6 | 55 | 27 | 1 | 0 | 11 | 0 | 26 | 20 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-26 | 52.00 | 100<br>(22cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-27 | 53.50 | 100<br>(23cm) | - | | ML-CL | | 7 | 47 | 30 | 3 | 1 | 12 | 0 | 27 | 20 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-28 | 55.00 | 100<br>(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.

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 11-10-2021 | to | 15-10-2021 | 28+075<br>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$^2$) | $C_v$ 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 | 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 7.05<br>6.30<br>5.15<br>4.23 | 2.02<br>1.44<br>0.97<br>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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 11-10-2021 | to | 15-10-2021 | 28+075<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| SPT-10 | 28.00 | 71 | 33 | Brown, Very dense, Sandy silt of low plasticity with gravel | 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 | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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<br>(25cm) | - | | ML-CL | | 6 | 53 | 26 | 6 | 2 | 7 | 0 | 26 | 20 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-25 | 50.50 | 100<br>(22cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-26 | 52.00 | 100<br>(20cm) | - | | ML-CL | | 7 | 46 | 27 | 7 | 3 | 8 | 2 | 27 | 20 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-27 | 53.50 | 100<br>(23cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-28 | 55.00 | 100<br>(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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 11-10-2021 | to | 14-10-2021 | 28+075<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>Total<br>Effective | 0.23<br>0.20 | 24<br>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 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 11-10-2021 | to | 14-10-2021 | 28+075<br>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 ($\varphi^\circ$)** | | | | **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 | Brown, Very dense, Sandy silt of low plasticity with gravel | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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 | | 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<br>(26cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-23 | 47.50 | 100<br>(22cm) | - | | ML-CL | | 6 | 47 | 28 | 7 | 2 | 10 | 0 | 27 | 21 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-24 | 49.00 | 100<br>(18cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-25 | 50.50 | 100<br>(21cm) | - | | ML-CL | | 7 | 44 | 30 | 3 | 5 | 9 | 2 | 27 | 20 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-26 | 52.00 | 100<br>(23cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-27 | 53.50 | 100<br>(19cm) | - | | ML-CL | | 7 | 45 | 20 | 13 | 4 | 11 | 0 | 26 | 19 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-28 | 55.00 | 100<br>(27cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 16-10-2021 | to | 18-10-2021 | 28+075<br>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$^2$) | $C_v$ 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 | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 9.39<br>8.23<br>5.96<br>4.78 | 2.28<br>1.85<br>1.24<br>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<br>(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.

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 16-10-2021 | to | 18-10-2021 | 28+075<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

# SOIL CHARACTERISTICS

| **Project** | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 13-10-2021 | to | 14-10-2021 | 28+360<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 13-10-2021 | to | 14-10-2021 | 28+360<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| SPT-11 | 28.00 | 100<br>(21cm) | - | Brown, Very dense, Sandy silt of low plasticity with gravel | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-12 | 29.50 | 100<br>(23cm) | - | | ML-CL | | 8 | 47 | 26 | 6 | 2 | 11 | 0 | 28 | 21 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-13 | 31.00 | 100<br>(22cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-14 | 32.50 | 100<br>(23cm) | - | | ML-CL | | 7 | 44 | 25 | 13 | 1 | 10 | 0 | 26 | 19 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-15 | 34.00 | 100<br>(21cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-16 | 35.50 | 100<br>(22cm) | - | | ML-CL | | 6 | 52 | 27 | 5 | 2 | 8 | 0 | 27 | 21 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-17 | 37.00 | 100<br>(20cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-18 | 38.50 | 100<br>(23cm) | - | | ML-CL | | 7 | 47 | 26 | 7 | 2 | 11 | 0 | 26 | 20 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-19 | 40.00 | 100<br>(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.

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 13-10-2021 | to | 15-10-2021 | 28+360<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | Liquid Limit | Plastic Limit | Plasticity Index | Shrinkage Limit | | | | | Type of Test | Cohesion C (kg/cm$^2$) | Angle of Friction ($\varphi^\circ$) | | | | 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 ($C_c$) |
| 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<br>Total<br>Effective | 0.21<br>0.18 | 24<br>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<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| SPT-9 | 25.50 | 93 | 45 | Brown, Very dense, Sandy silt of low plasticity with gravel | 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<br>(22cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-15 | 37.00 | 100<br>(20cm) | - | | ML-CL | | 8 | 51 | 23 | 4 | 3 | 10 | 1 | 28 | 21 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-16 | 38.50 | 100<br>(22cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-17 | 40.00 | 100<br>(21cm) | - | | ML-CL | | 7 | 46 | 27 | 7 | 5 | 8 | 0 | 27 | 20 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-18 | 41.50 | 100<br>(20cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-19 | 43.00 | 100<br>(20cm) | - | | ML-CL | | 6 | 50 | 25 | 6 | 2 | 9 | 2 | 27 | 21 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-20 | 44.50 | 100<br>(22cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-21 | 46.00 | 100<br>(22cm) | - | | ML-CL | | 7 | 45 | 30 | 4 | 5 | 7 | 2 | 26 | 19 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-22 | 47.50 | 100<br>(22cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-23 | 49.00 | 100<br>(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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 12-10-2021 | to | 14-10-2021 | 28+360<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>(20cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UDS* | 20.50 | - | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-8 | 22.00 | 100<br>(20cm) | - | | ML-CL | | 7 | 46 | 30 | 6 | 1 | 10 | 0 | 27 | 20 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UDS* | 23.50 | - | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-9 | 25.00 | 100<br>(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.

# SOIL CHARACTERISTICS

| Project | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 12-10-2021 | to | 14-10-2021 | 28+360<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| SPT-10 | 28.00 | 100 | 46 | Brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | | 8 | 47 | 28 | 7 | 2 | 8 | 0 | 27 | 20 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UDS* | 29.50 | - | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-11 | 31.00 | 100<br>(19cm) | - | | ML-CL | | 7 | 50 | 24 | 6 | 3 | 10 | 0 | 27 | 21 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UDS* | 32.50 | - | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-12 | 34.00 | 100<br>(21cm) | - | | ML-CL | | 6 | 52 | 29 | 5 | 1 | 7 | 0 | 26 | 20 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UDS* | 35.50 | - | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-13 | 37.00 | 100<br>(20cm) | - | | ML-CL | | 7 | 50 | 22 | 8 | 4 | 9 | 0 | 27 | 20 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-14 | 38.50 | 100<br>(23cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-15 | 40.00 | 100<br>(20cm) | - | | ML-CL | | 8 | 48 | 24 | 10 | 2 | 8 | 0 | 28 | 21 | 7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-16 | 41.50 | 100<br>(22cm) | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-17 | 43.00 | 100<br>(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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 12-10-2021 | to | 13-10-2021 | 28+360<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | Liquid Limit | Plastic Limit | Plasticity Index | Shrinkage Limit | | | | | Type of Test | Cohesion C ($kg/cm^2$) | Angle of Friction ($\varphi^\circ$) | | | | 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 ($C_c$) |
| 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<br>(21cm) | - | | ML-CL | | 7 | 46 | 26 | 9 | 5 | 5 | 2 | 27 | 21 | 6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UDS* | 25.00 | - | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-9 | 26.50 | 100<br>(20cm) | - | | ML-CL | | 8 | 44 | 16 | 14 | 8 | 10 | 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.

CEG TEST HOUSE

# SOIL CHARACTERISTICS

| **Project** | | **Date of Boring** | | | **Chainage (km.)/Location** | **B.H. No.** | **Depth of Water Table** | **Termination Depth** | **Cordinates (E,N)** | | **R.L.** | **Ref. Code** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 12-10-2021 | to | 13-10-2021 | 28+360<br>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** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Sand** | | | **Gravel** | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | **Clay** | **Silt** | **Fine** | **Medium** | **Coarse** | **Fine** | **Coarse** | **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 ($C_c$)** |
| 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.

# SOIL CHARACTERISTICS

| Project | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 18-10-2021 | to | 21-10-2021 | 28+900<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>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** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Sand** | | | **Gravel** | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | **Clay** | **Silt** | **Fine** | **Medium** | **Coarse** | **Fine** | **Coarse** | **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 ($C_c$)** |
| 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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 19-10-2021 | to | 22-10-2021 | 28+900<br>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 ($\varphi^o$) | | | | 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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 19-10-2021 | to | 22-10-2021 | 28+900<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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:-
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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 15-10-2021 | to | 18-10-2021 | 28+900<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 9.58<br>8.53<br>7.59<br>6.17 | 1.15<br>0.84<br>0.52<br>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 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 15-10-2021 | to | 18-10-2021 | 28+900<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| SPT-12 | 28.00 | 100 (25cm) | 100 (25cm) | Brown, Hard, Silty clay of low plasticity with gravel | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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 | - | | 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 | - | - | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 16-10-2021 | to | 18-10-2021 | 28+900<br>Major Bridge | BH-A2 | 34.50 m | 40.00 m | 696517.163 m | 3123180.027 m | (+)263.847 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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 10.07<br>8.47<br>6.84<br>5.82 | 1.48<br>1.06<br>0.63<br>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<br>Total<br>Effective | 0.30<br>0.23 | 24<br>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 | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 16-10-2021 | to | 18-10-2021 | 28+900<br>Major Bridge | BH-A2 | 34.50 m | 40.00 m | 696517.163 m | 3123180.027 m | (+)263.847 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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | - | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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.

## RESULT OF CHEMICAL ANALYSIS OF SOIL SAMPLES

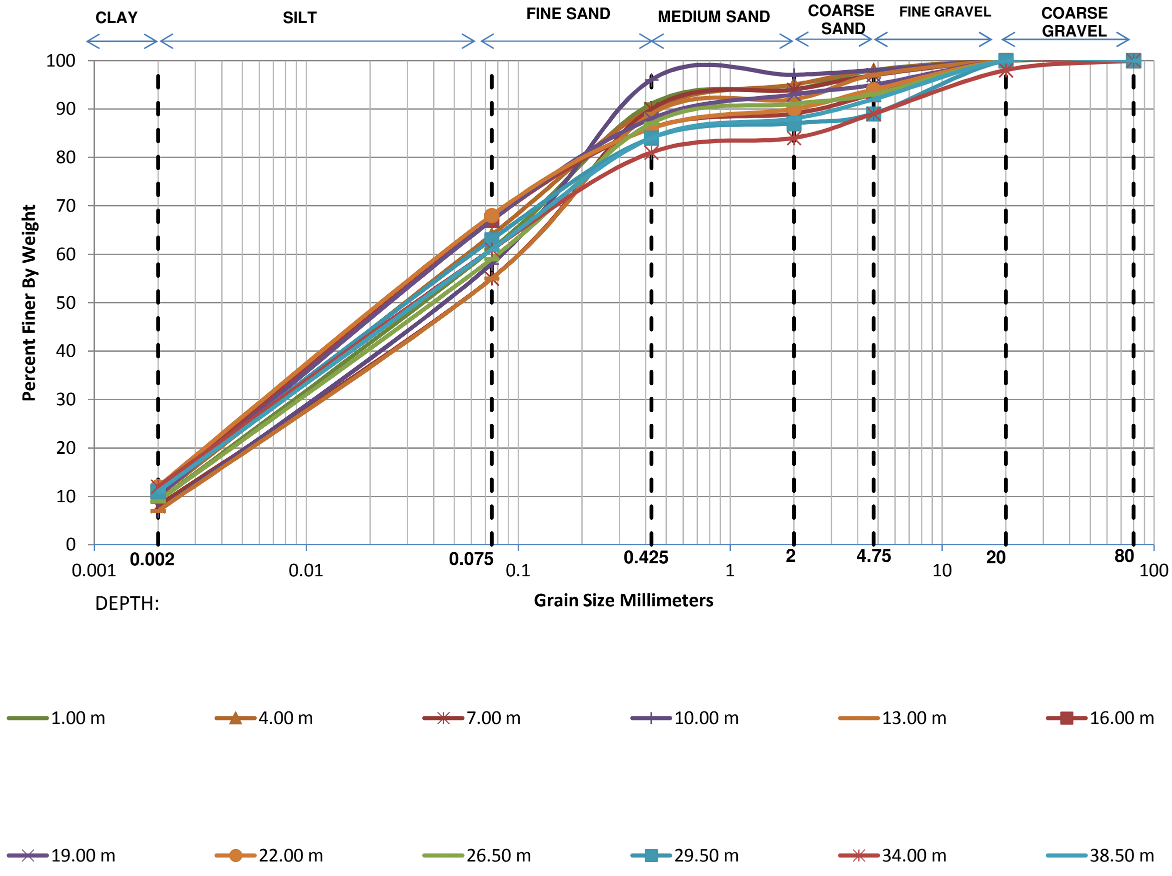
| Sr. No | Chainage Old (km) | Chainage New (km) | BH No. | Depth of collected sample (m) | pH | Chlorides ($Cl^-$) | | Sulphate ($SO_3^{2-}$) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (mg/kg) | (%) | (mg/kg) | (%) |
| 1. | 27+620 | 28+287 | BH-A1 | 19.00 | 7.93 | 78.34 | 0.0078 | 30.71 | 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 ($Cl^-$) | Sulphate ($SO_3^{2-}$) |
|---|---|---|---|---|---|---|
| | | | | | (mg/l) | (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

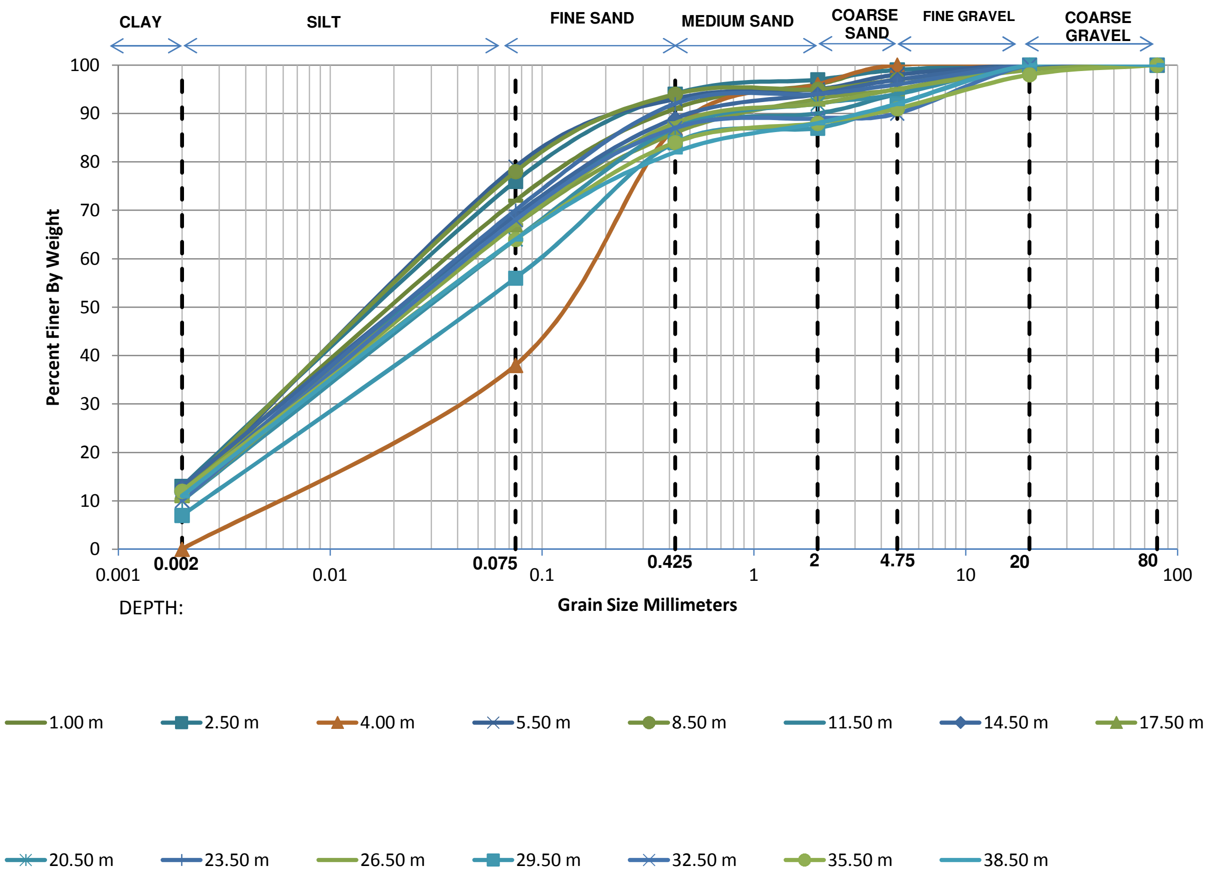
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

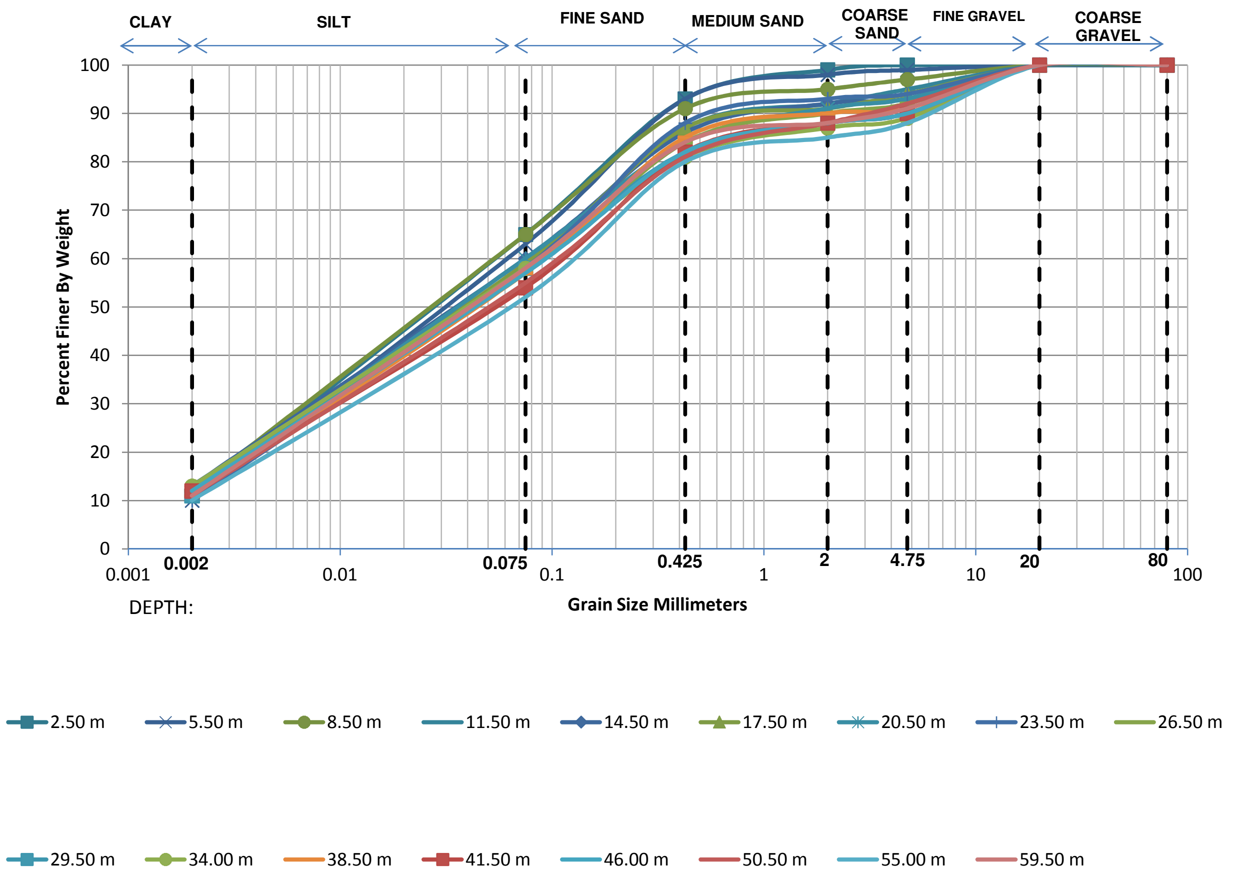
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

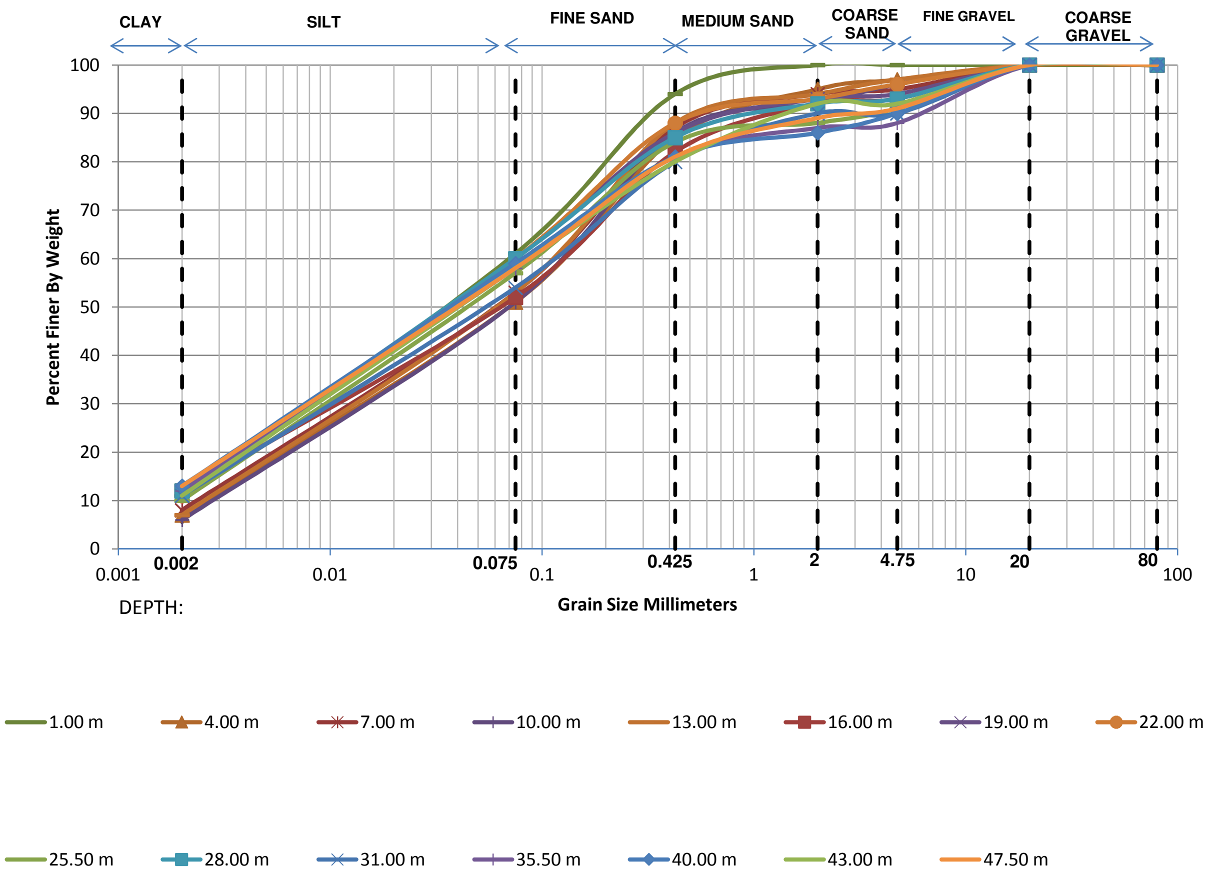
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

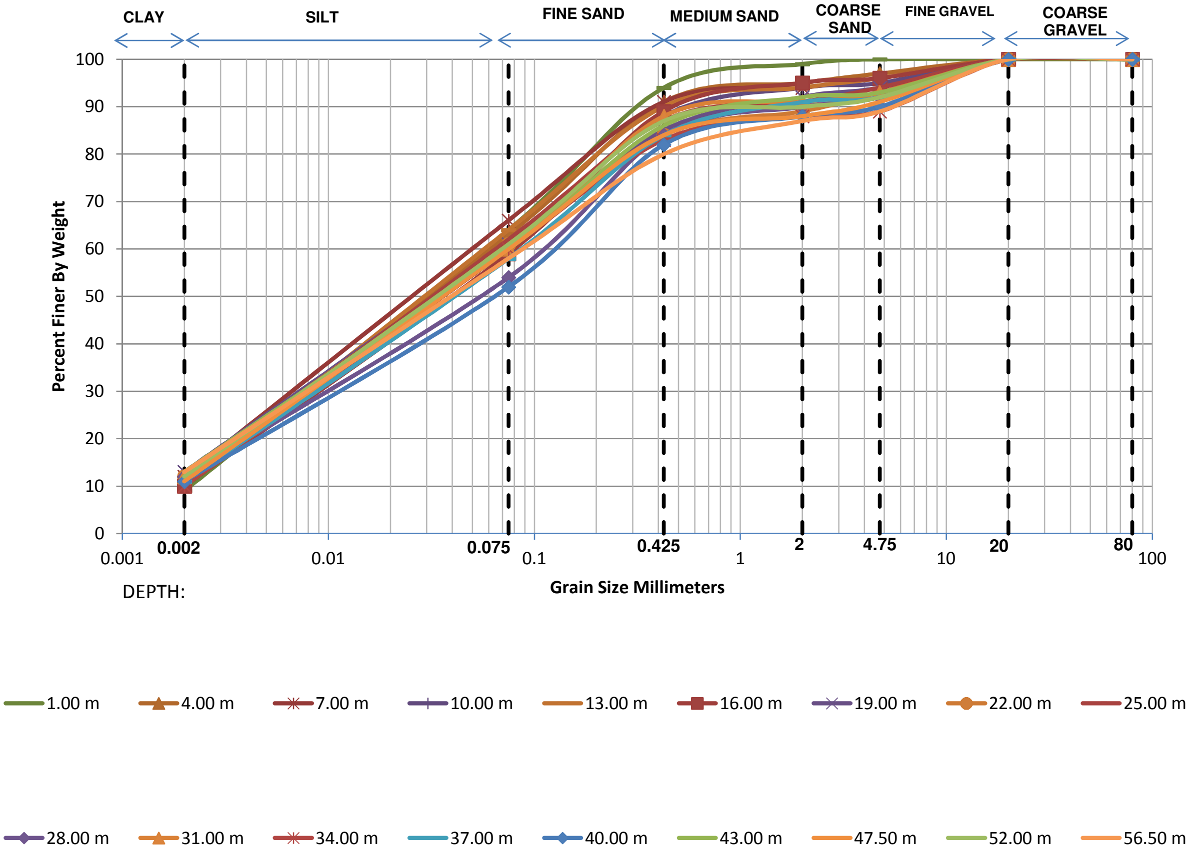
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

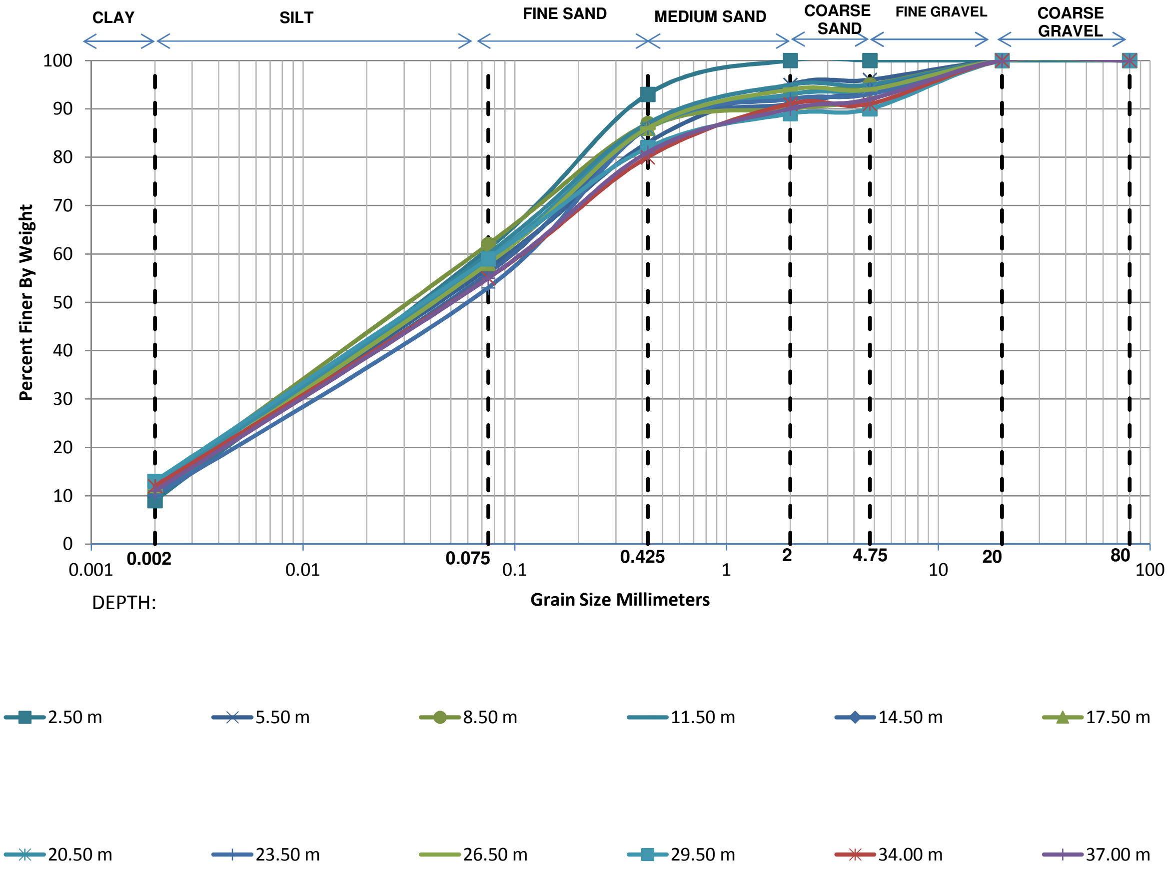
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

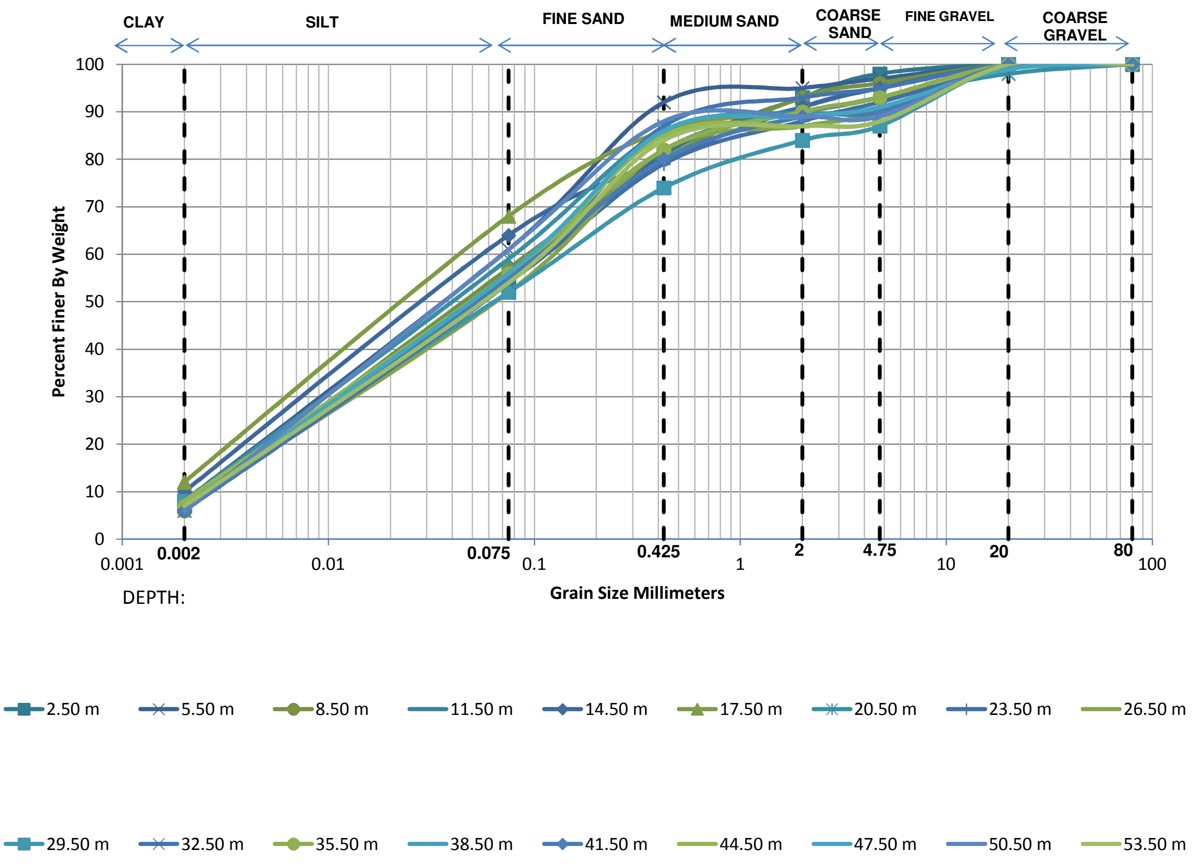
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

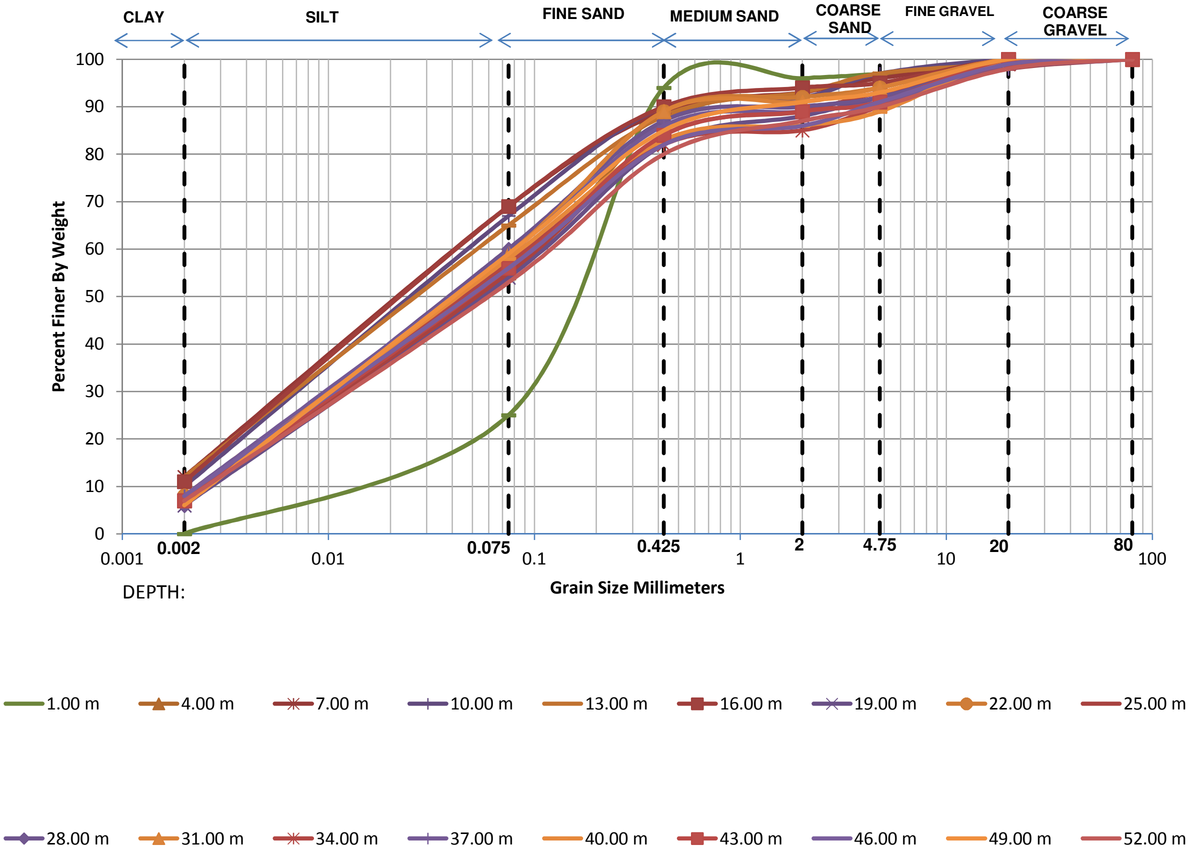
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

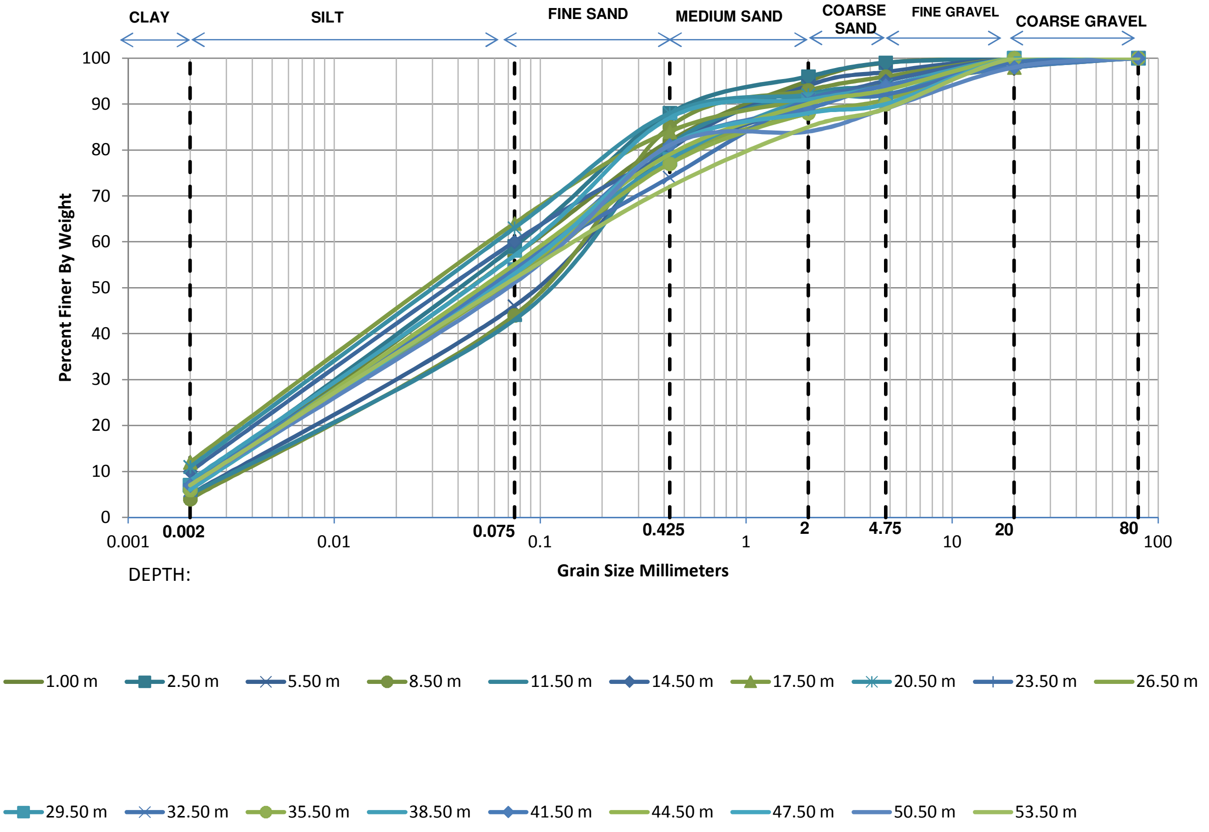
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

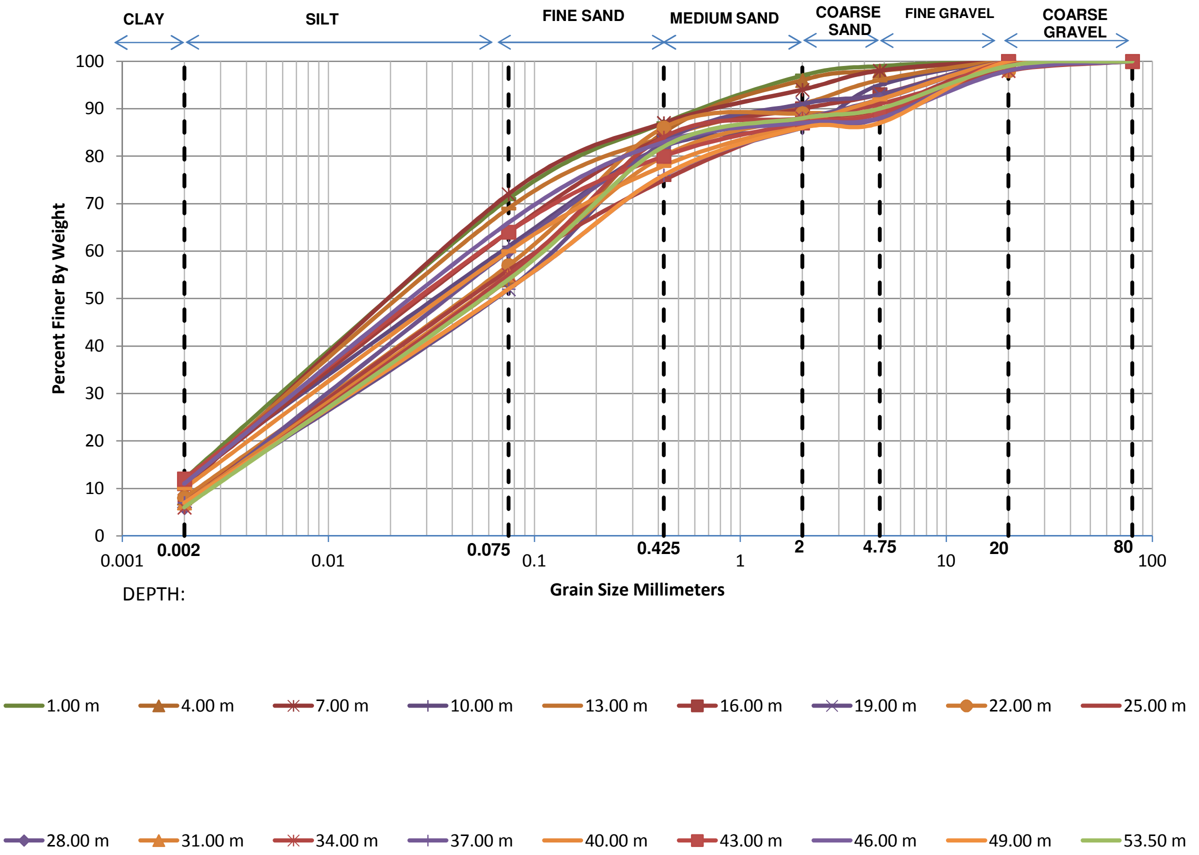
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

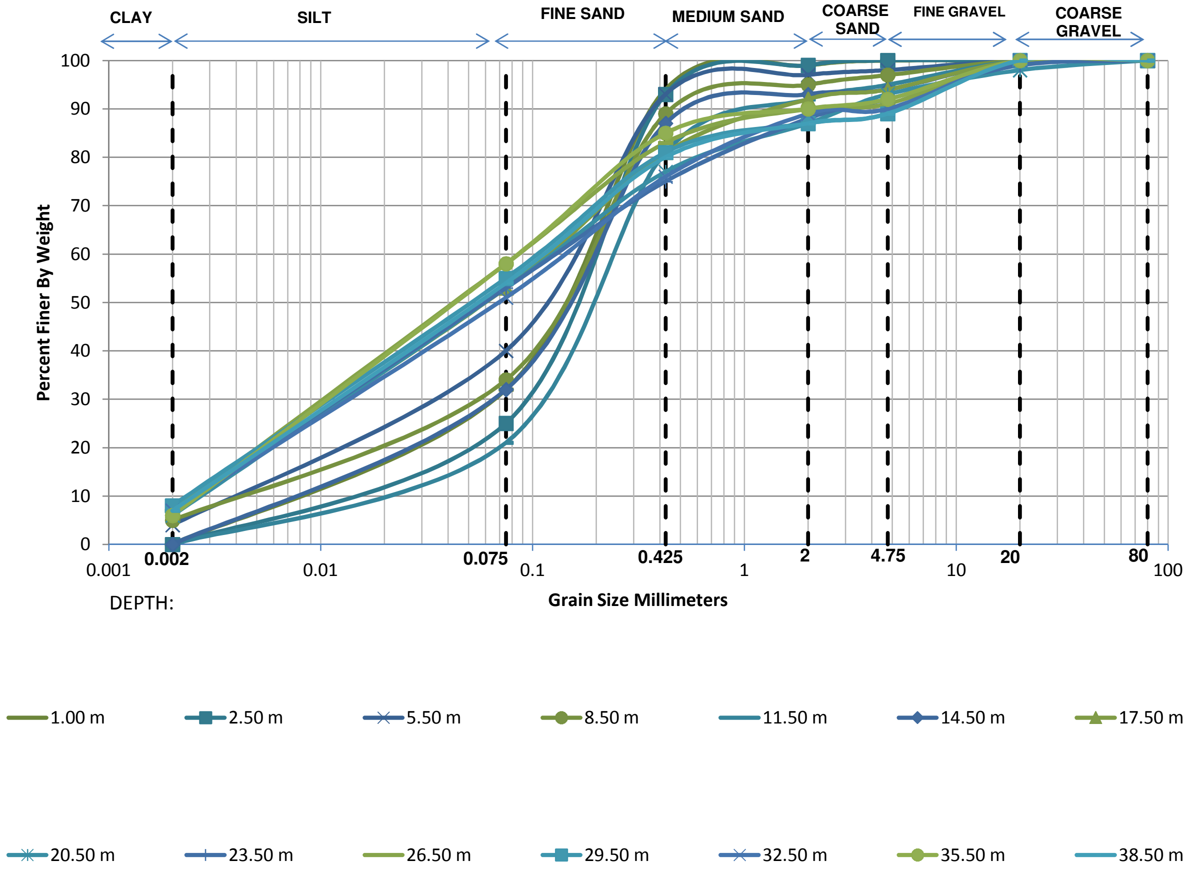
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

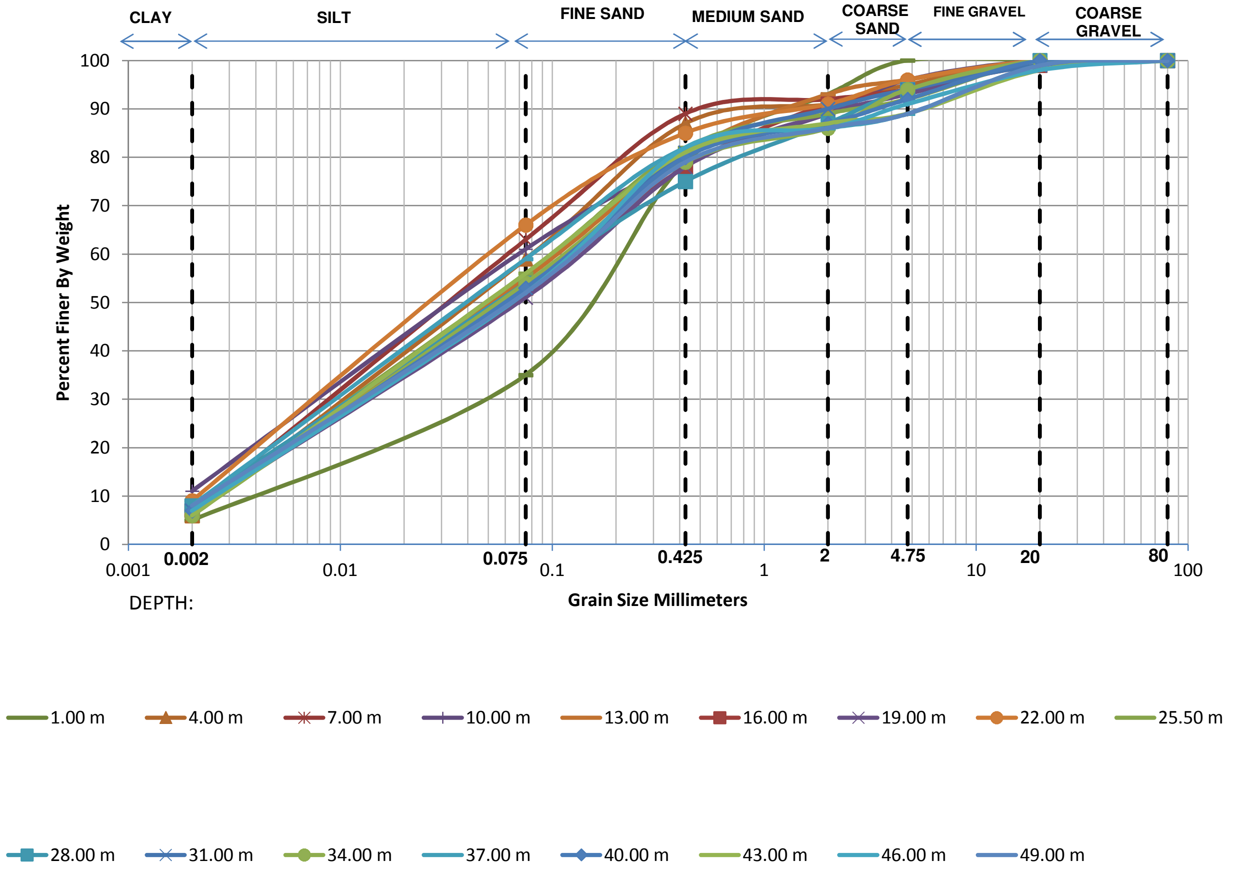
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

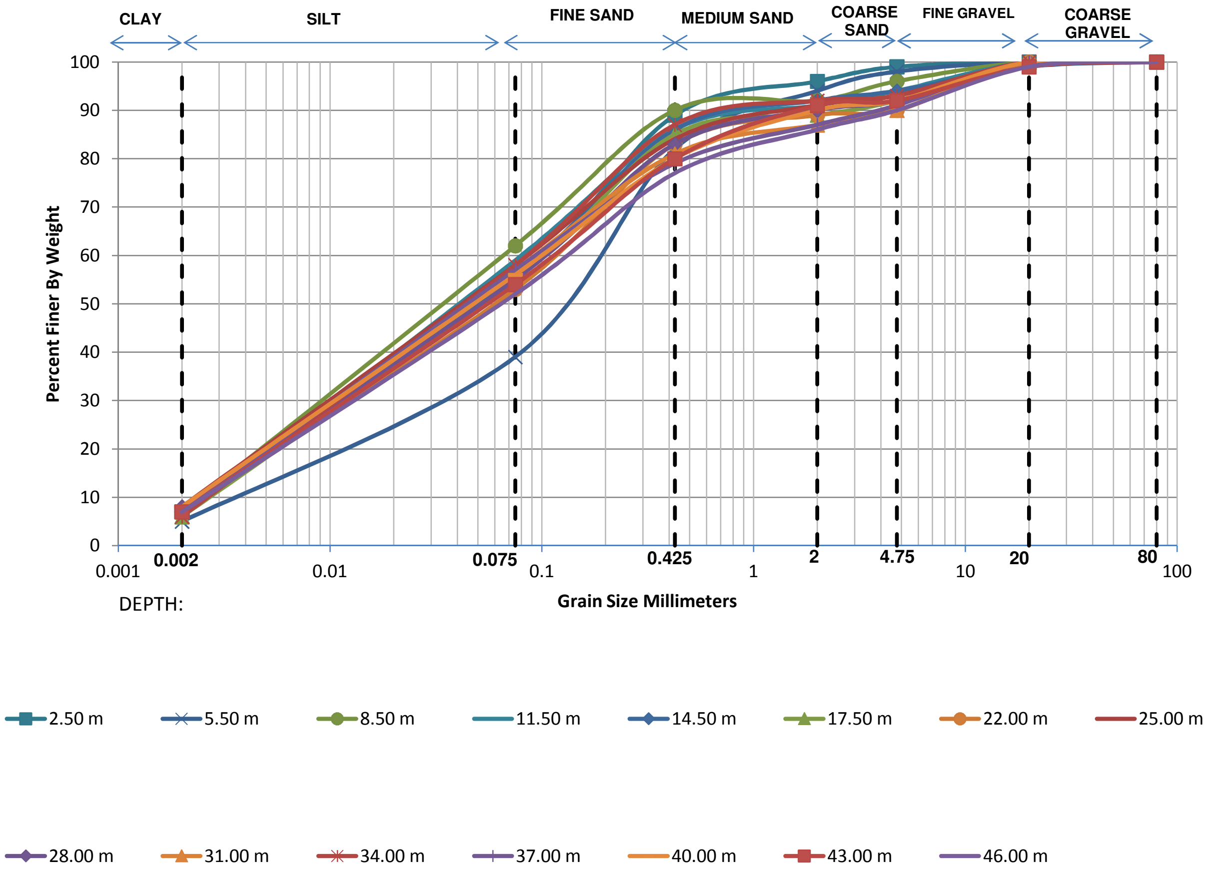
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

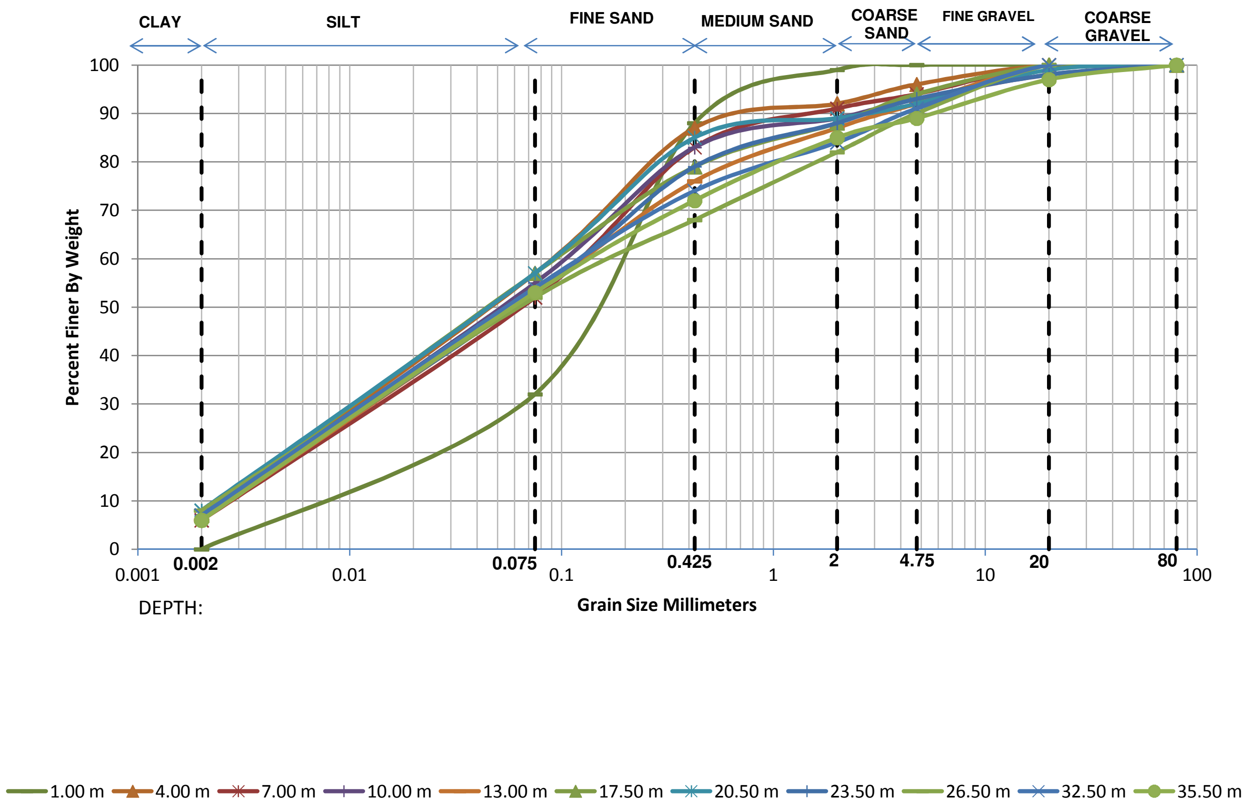
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

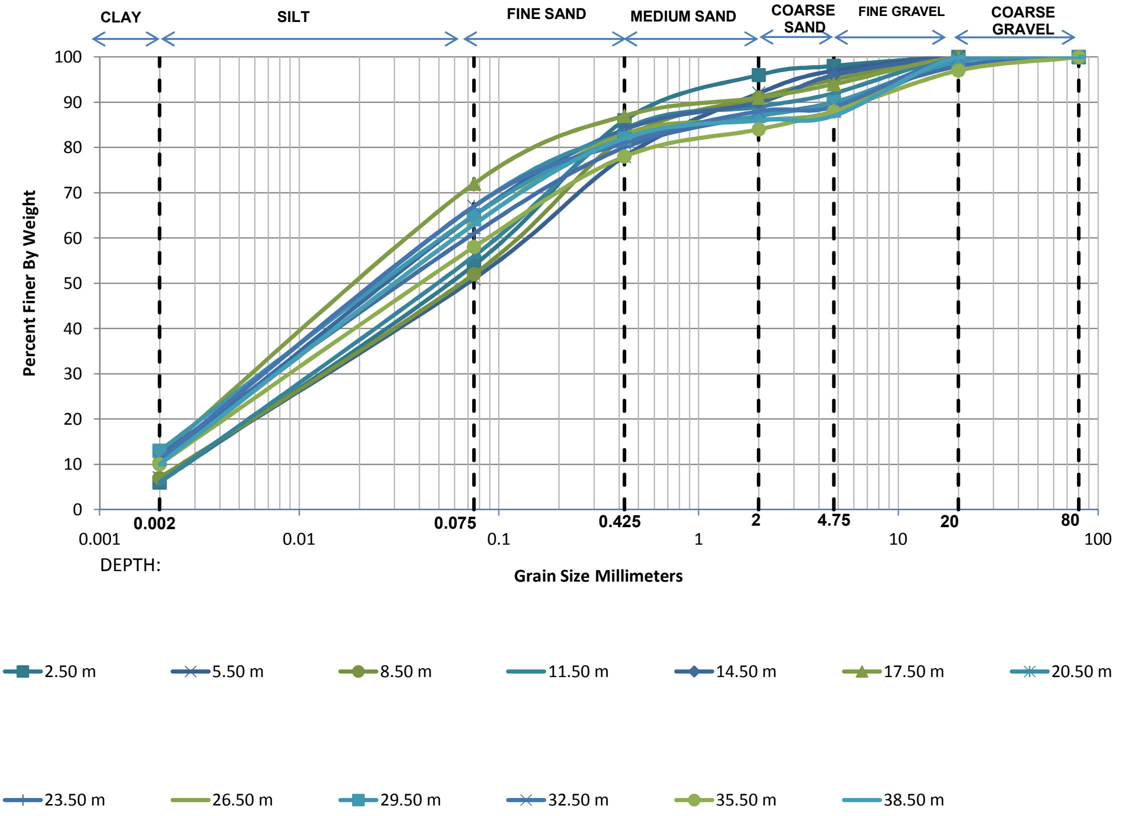
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

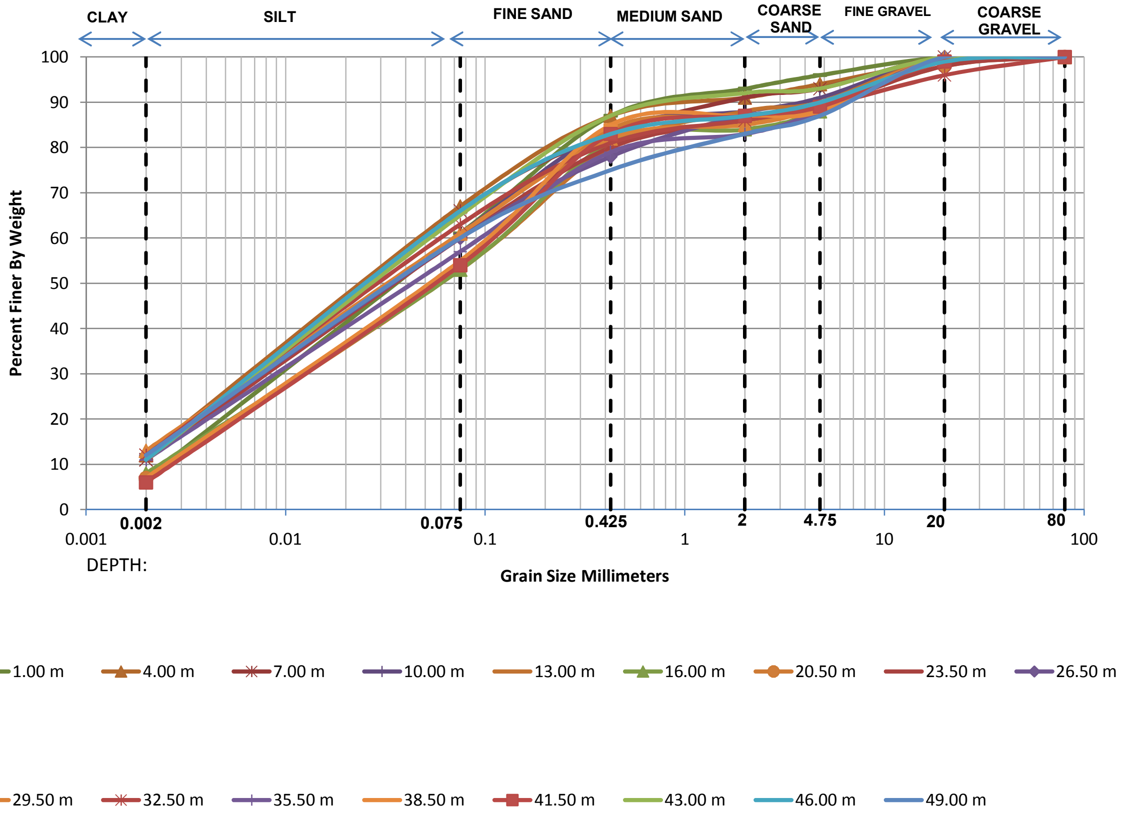
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

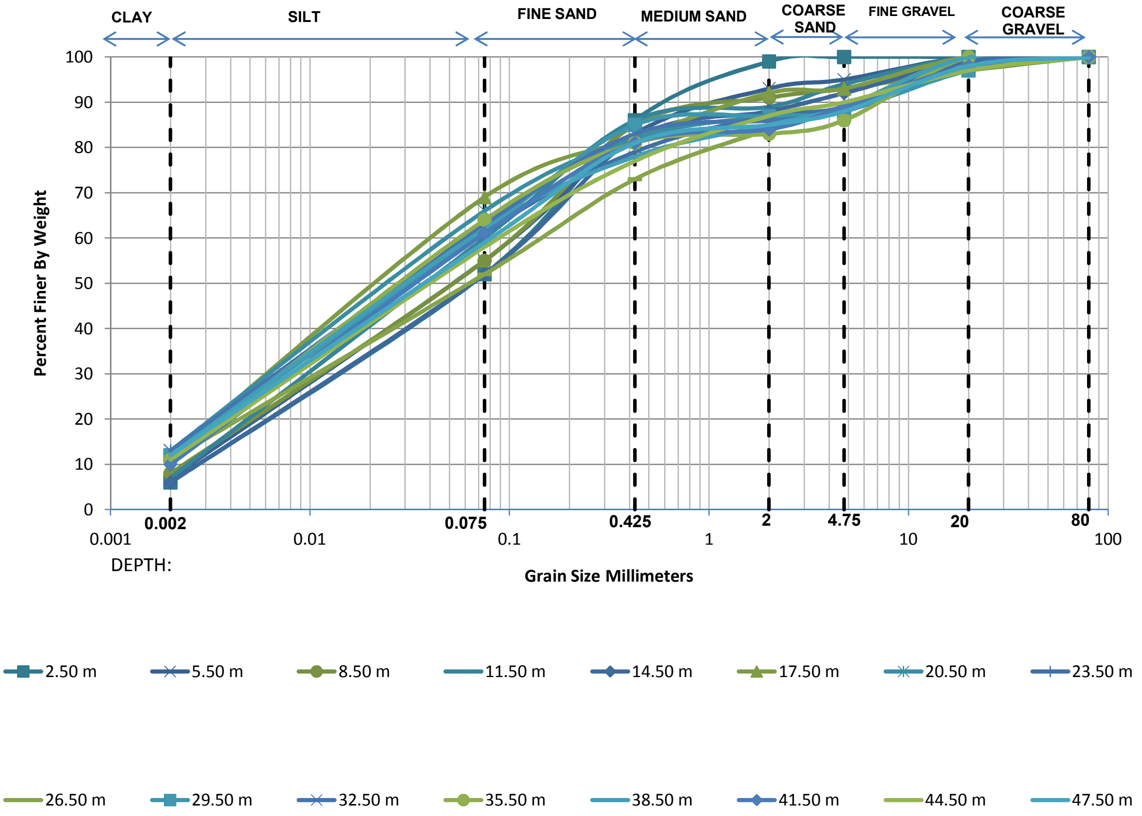
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

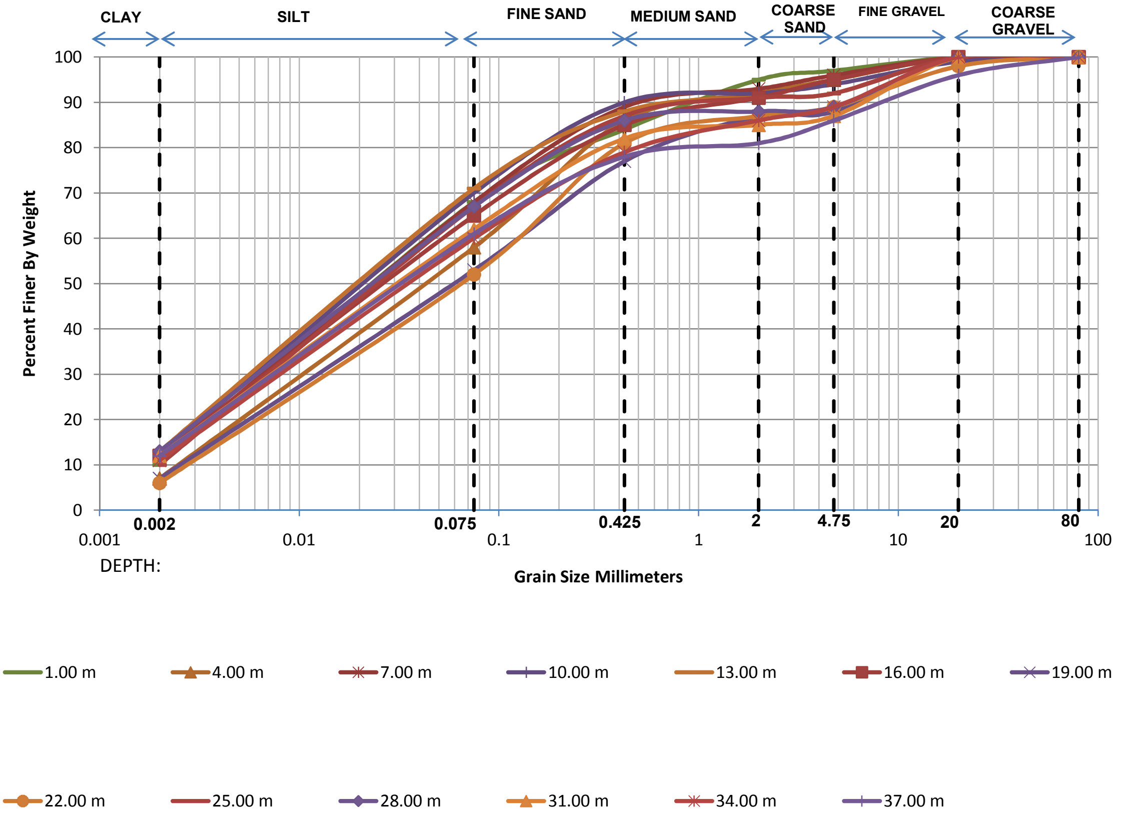
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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 | - | - |

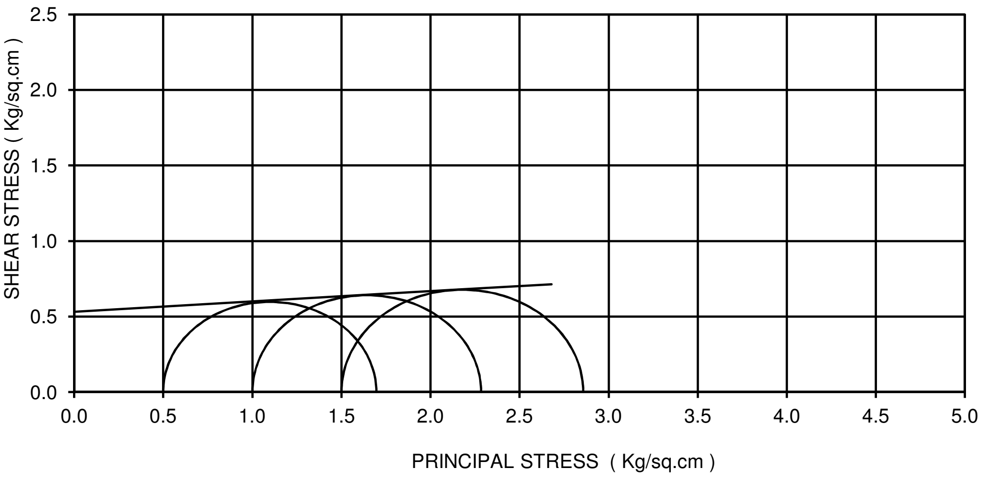
## GRAIN SIZE DISTRIBUTION CURVES

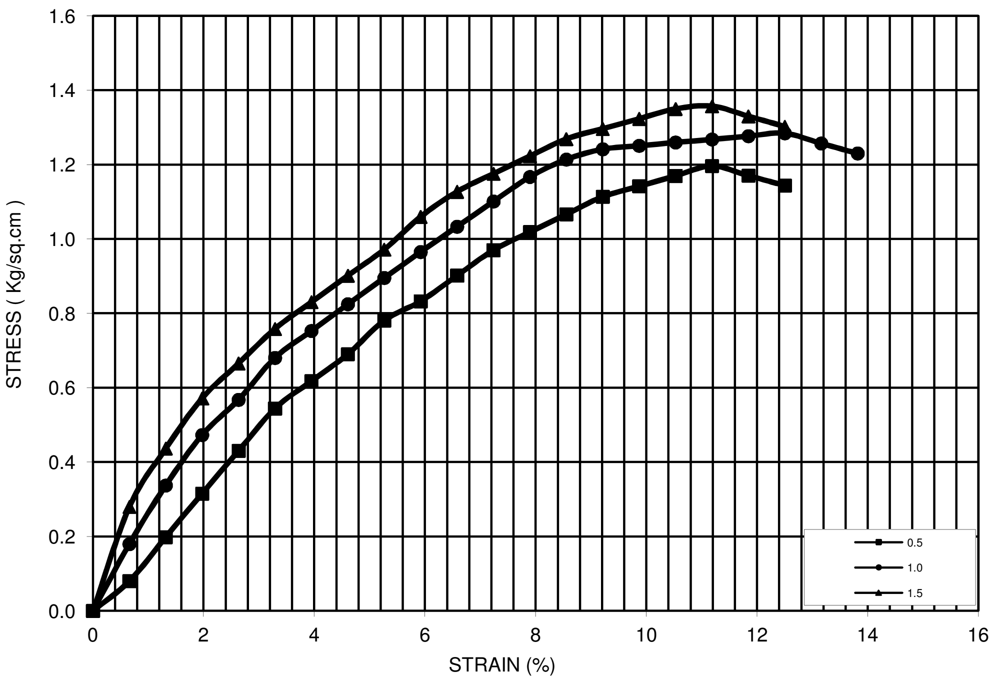
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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





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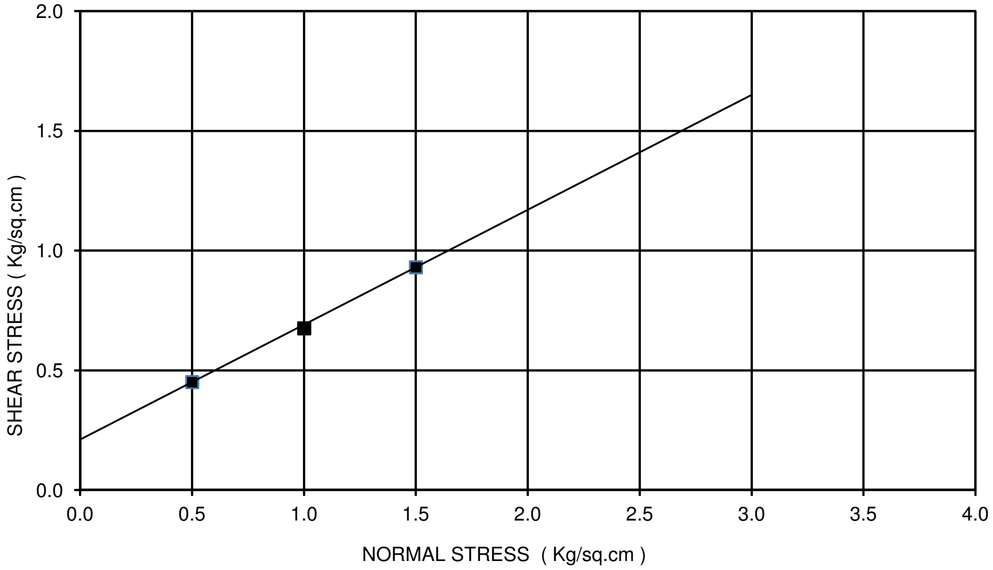
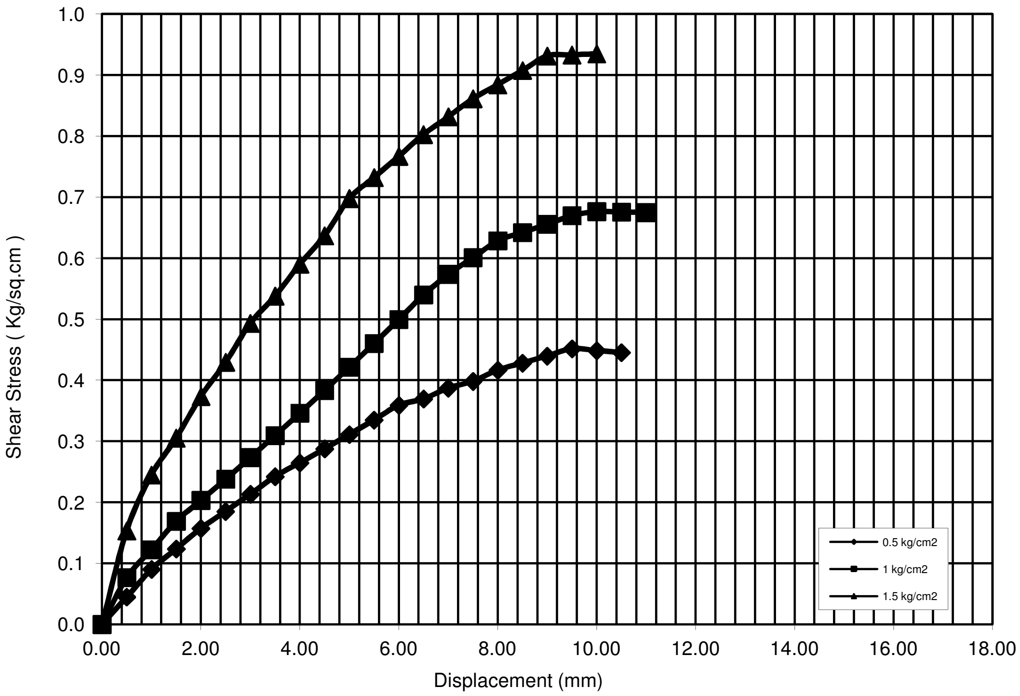
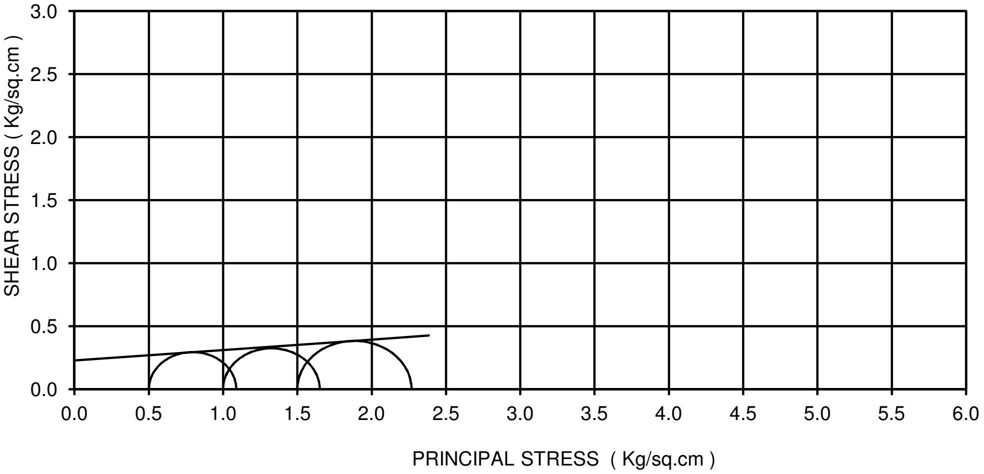
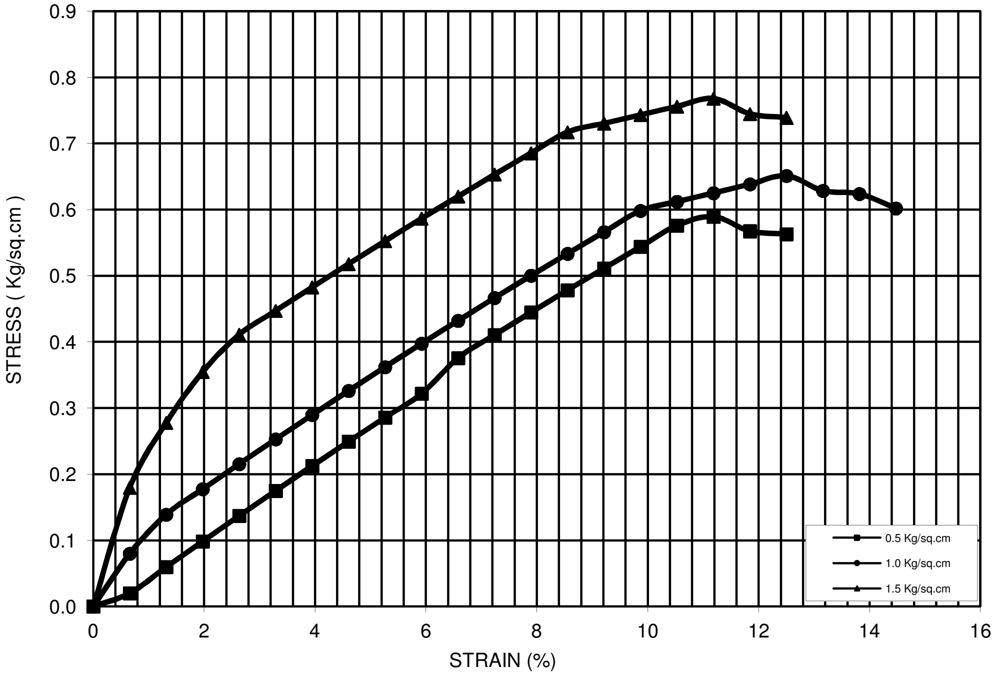
BORE HOLE NO: BH-A-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-3
DEPTH: 7.00 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



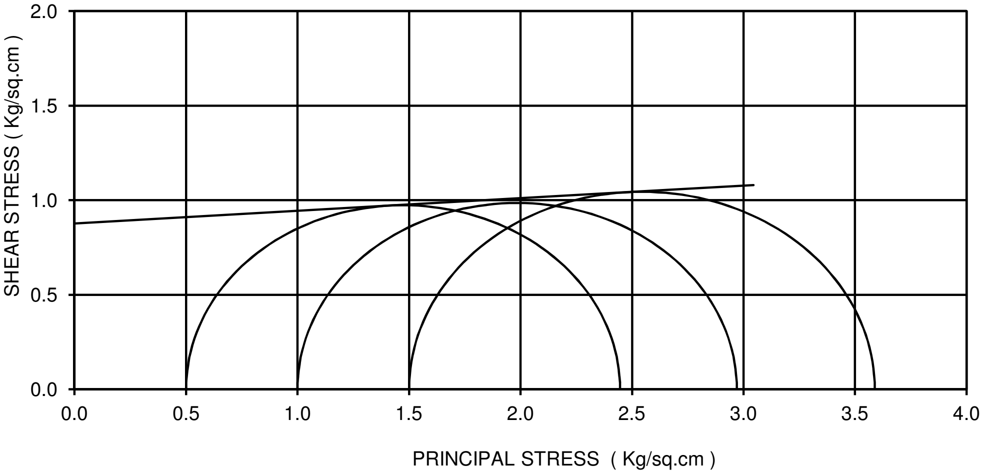


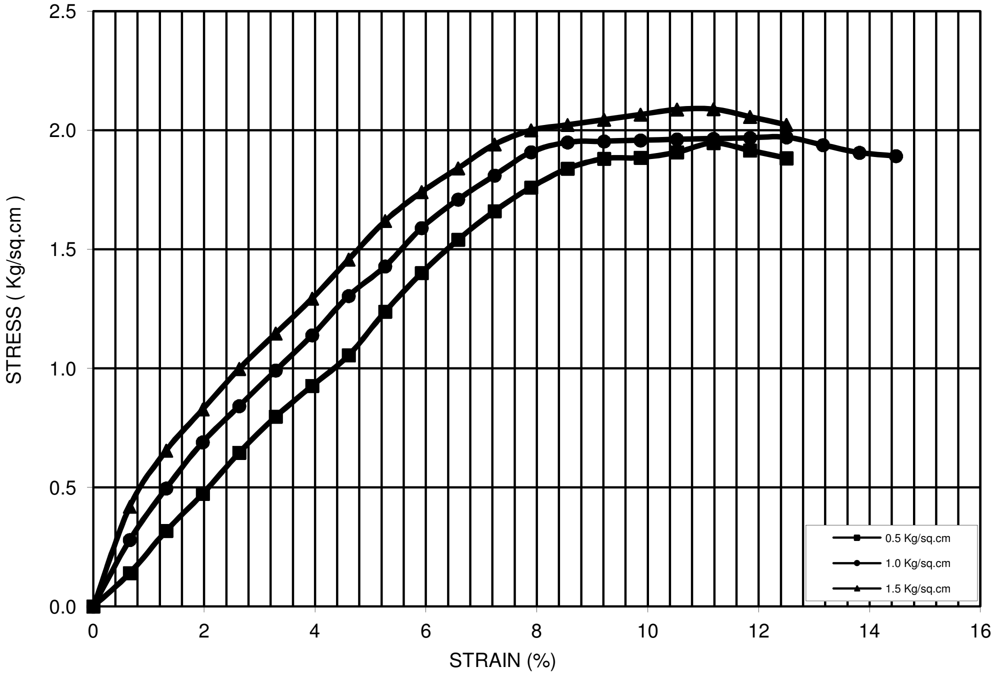
BORE HOLE NO: BH-P-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.23 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



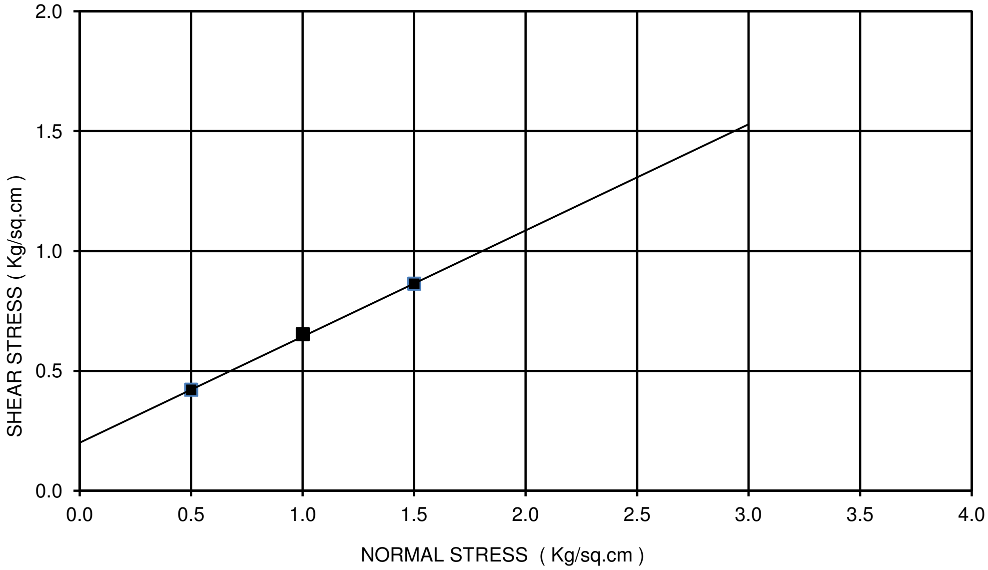


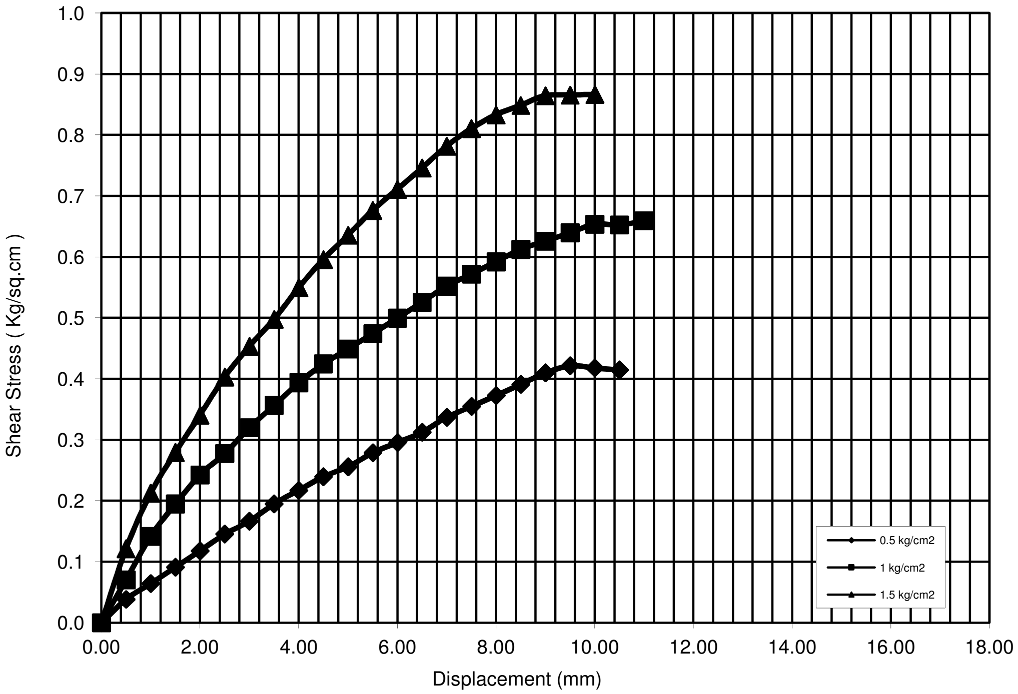
BORE HOLE NO: BH-P-1
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.88 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



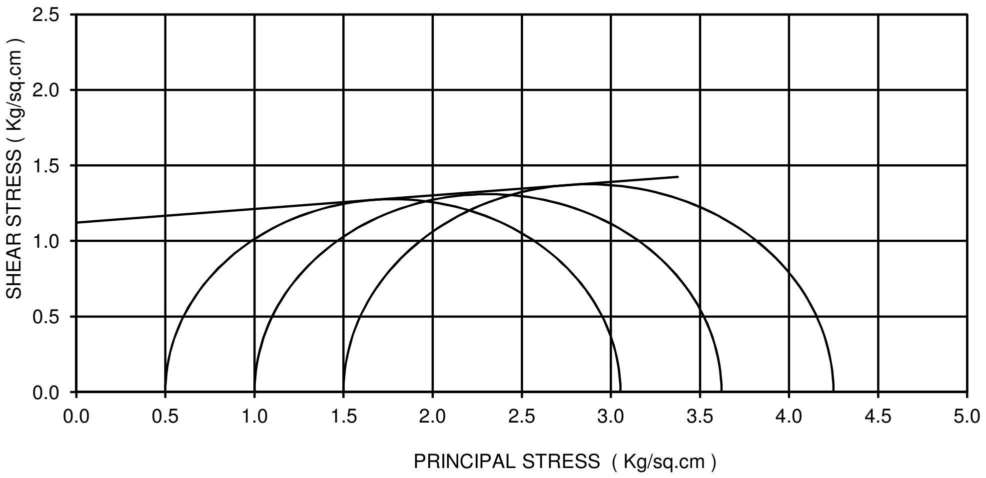


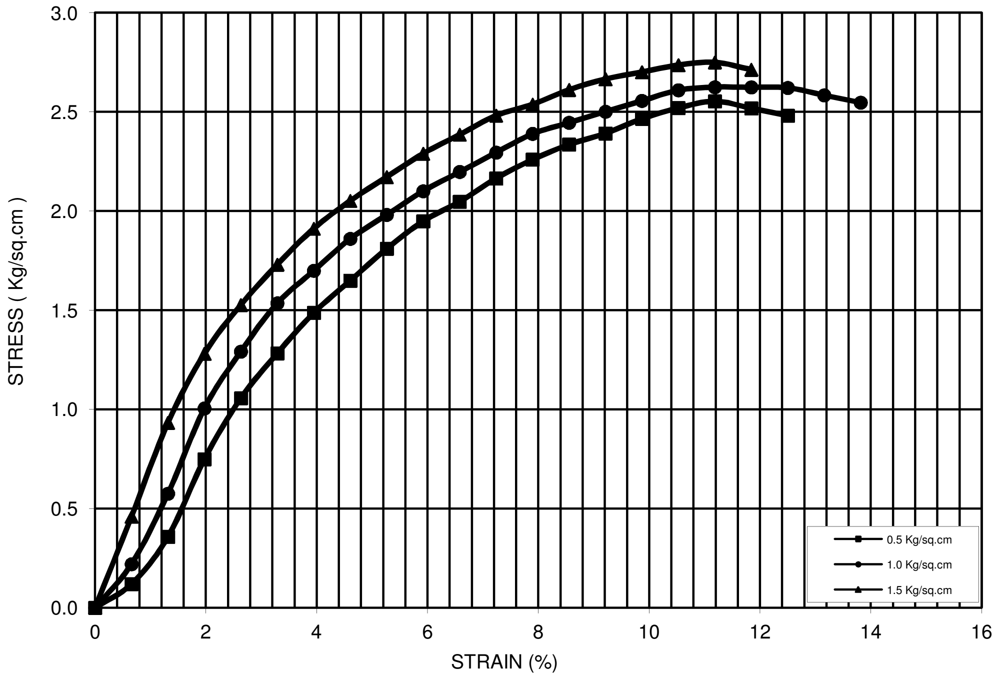
BORE HOLE NO: BH-P-2
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



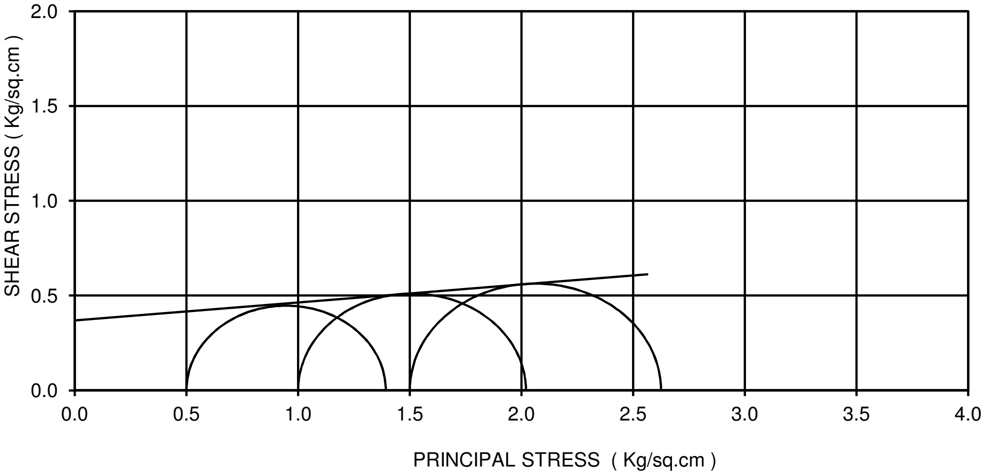


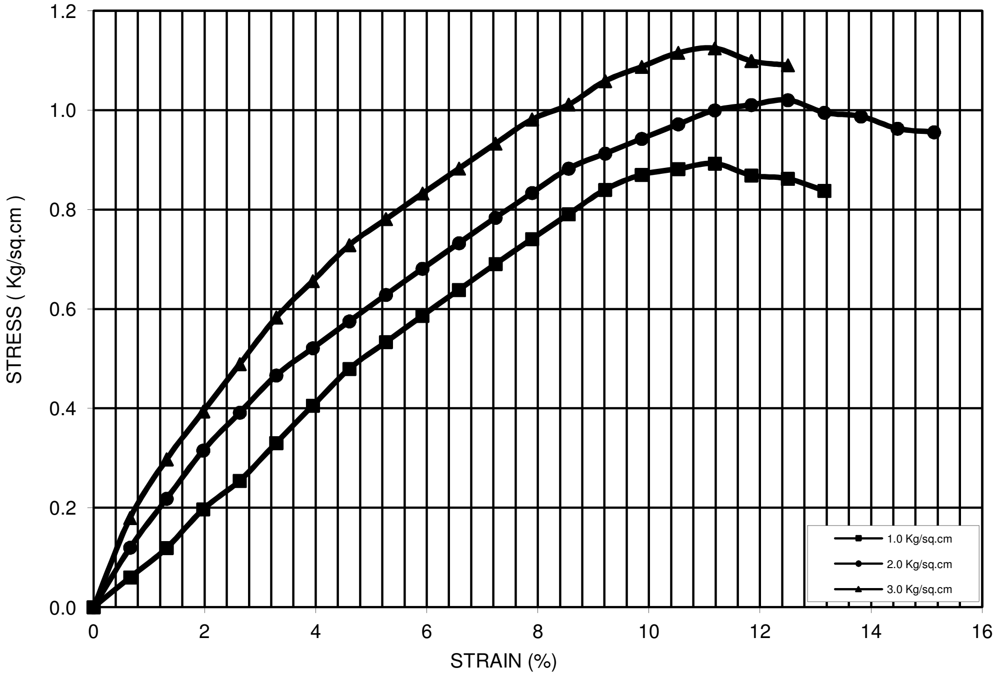
BORE HOLE NO: BH-P-2
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 4.00m
COHESION(C)= 1.12 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



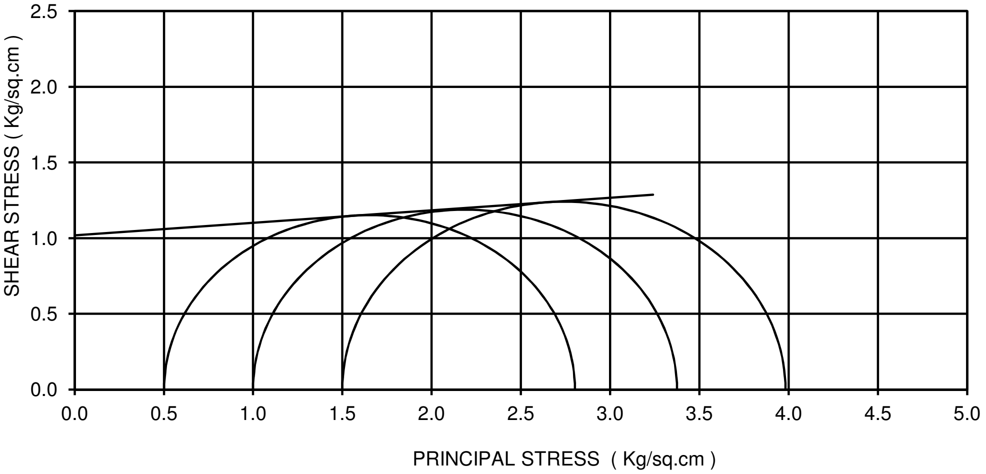


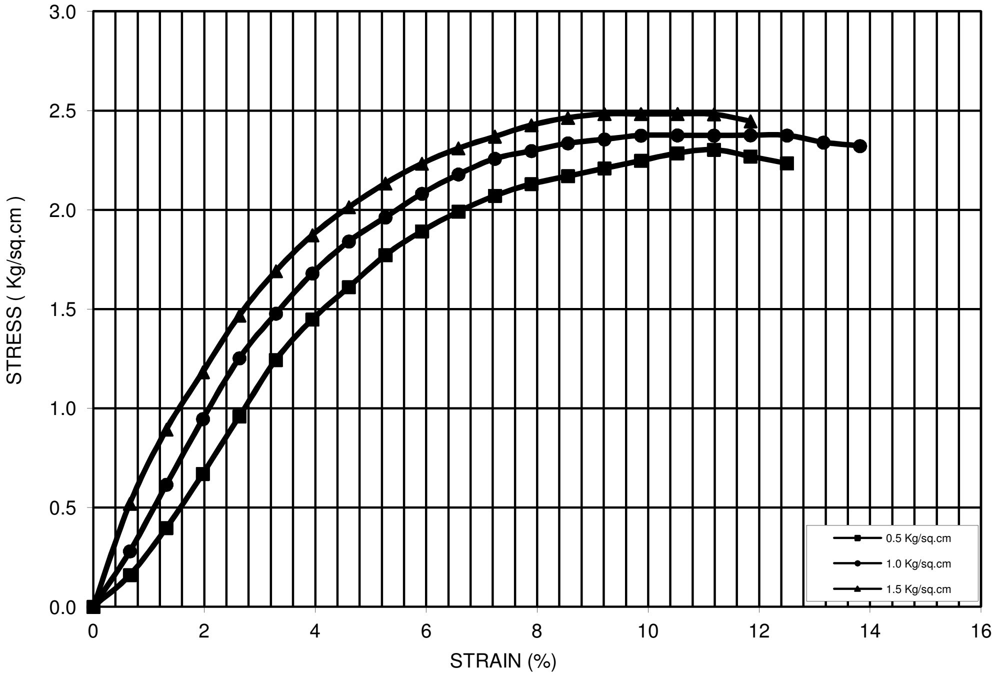
BORE HOLE NO: BH-P-3
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.37 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



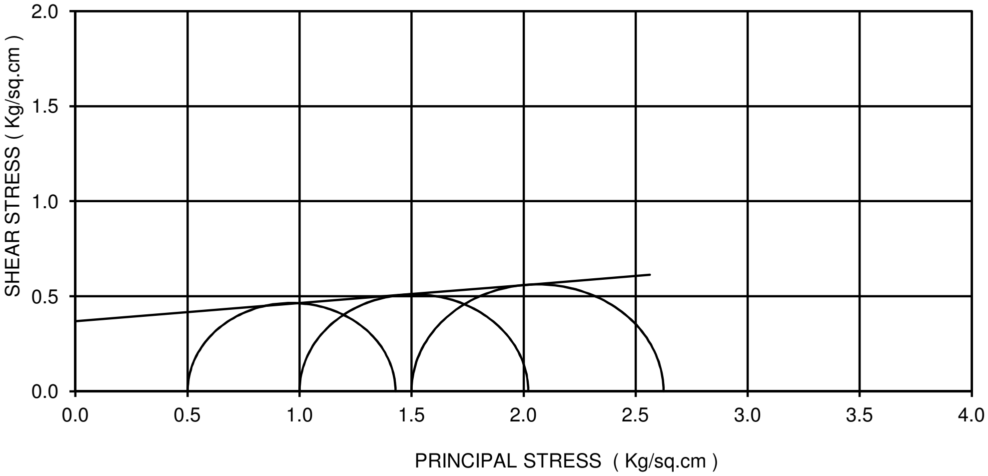


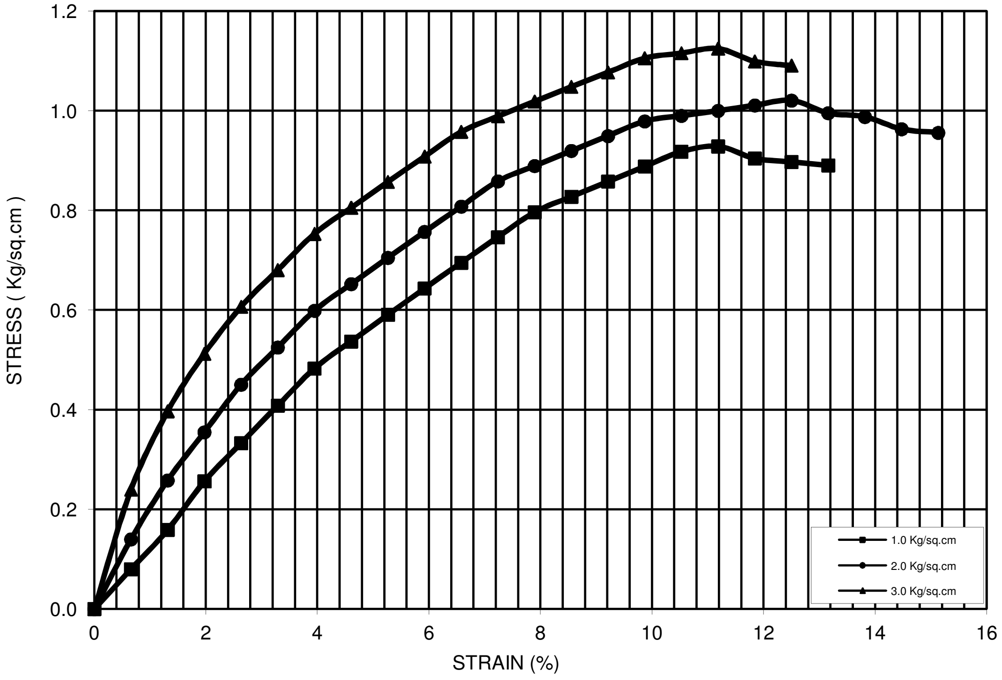
BORE HOLE NO: BH-P-3
CHAINAGE : 27+620 KM
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 1.02 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



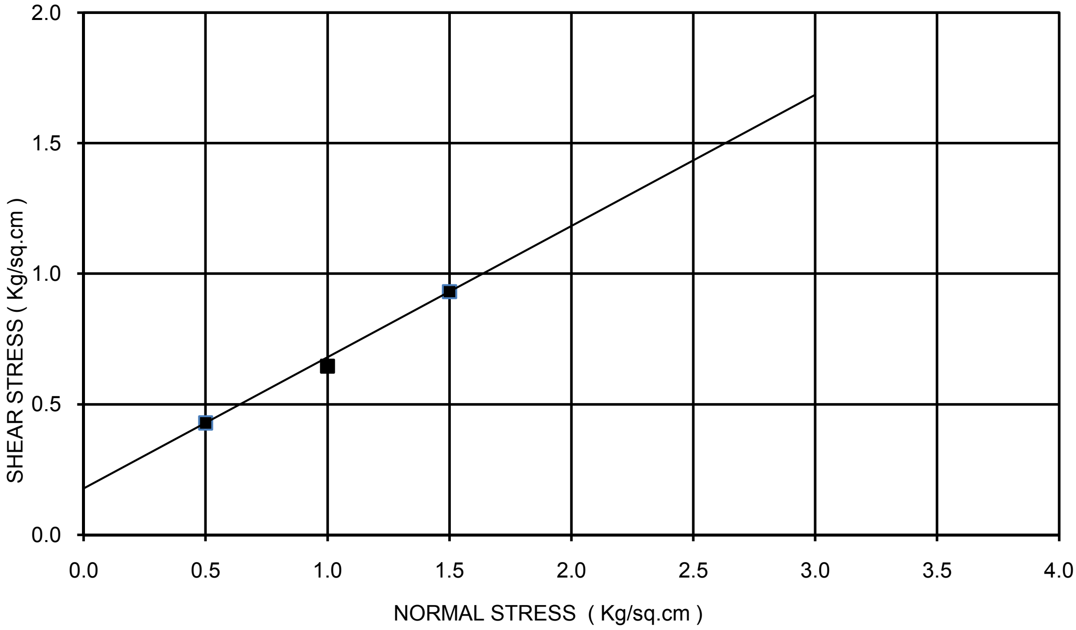


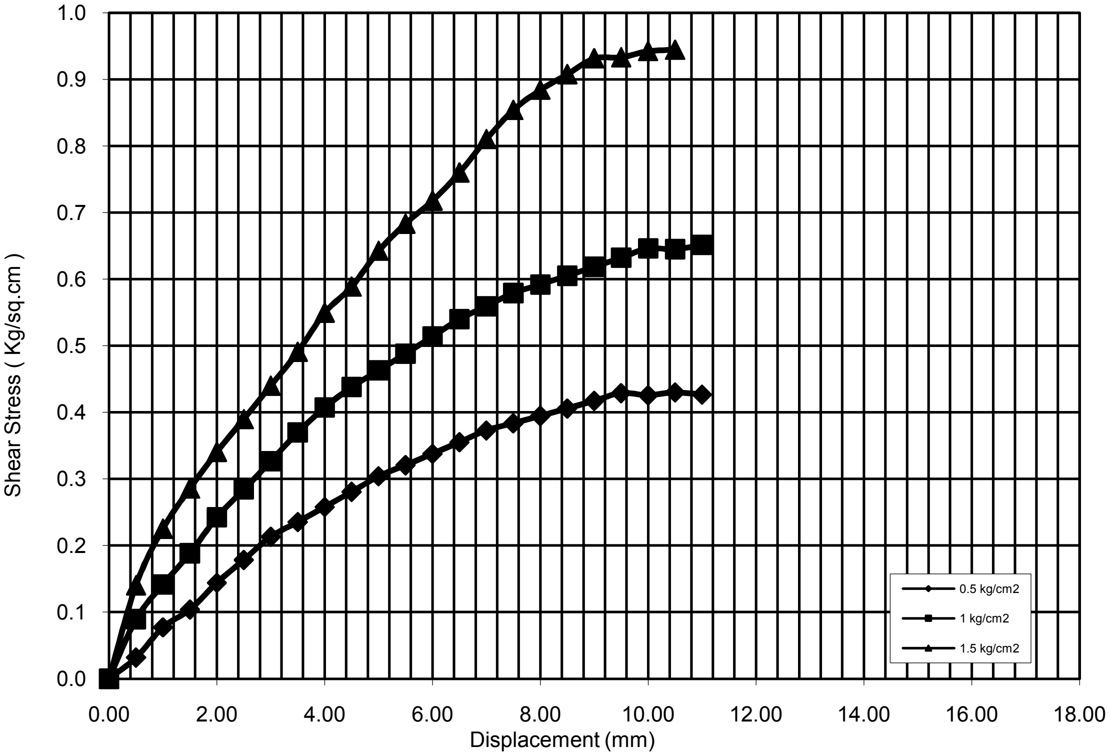
BORE HOLE NO: BH-P-4
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.37 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



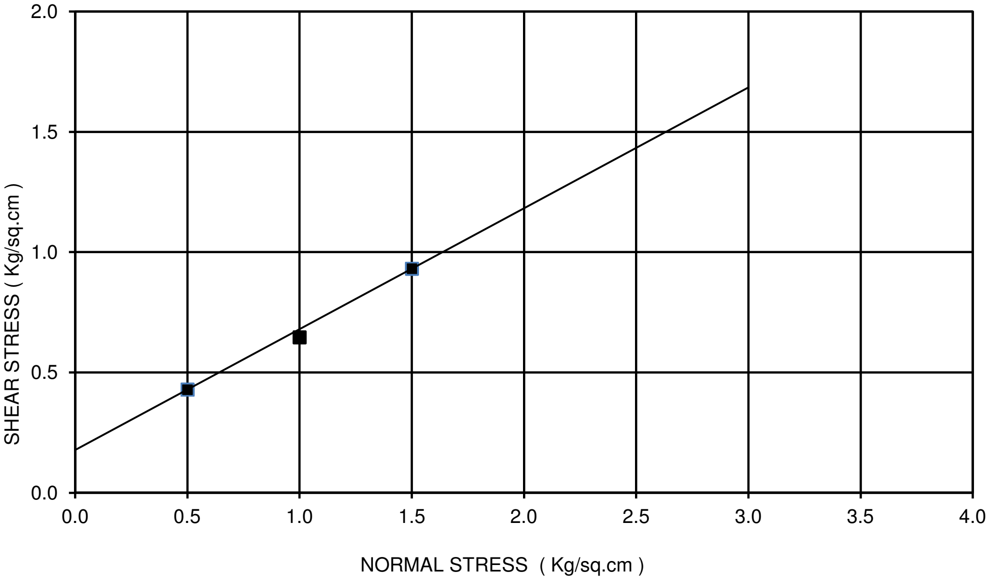


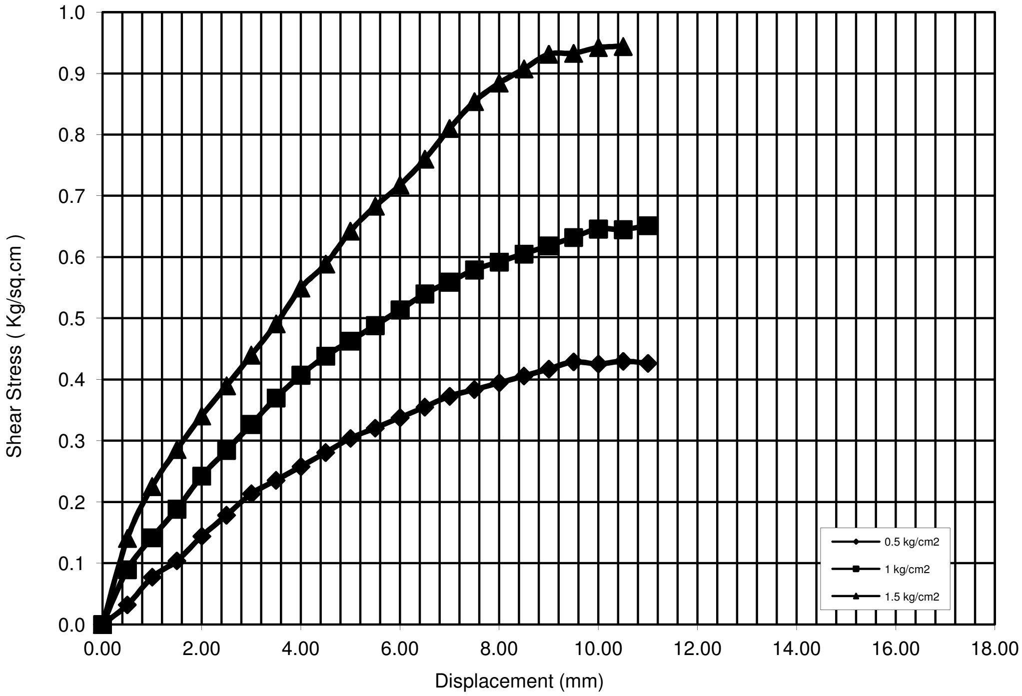
BORE HOLE NO: BH-P4
Chainage:- 27+620
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



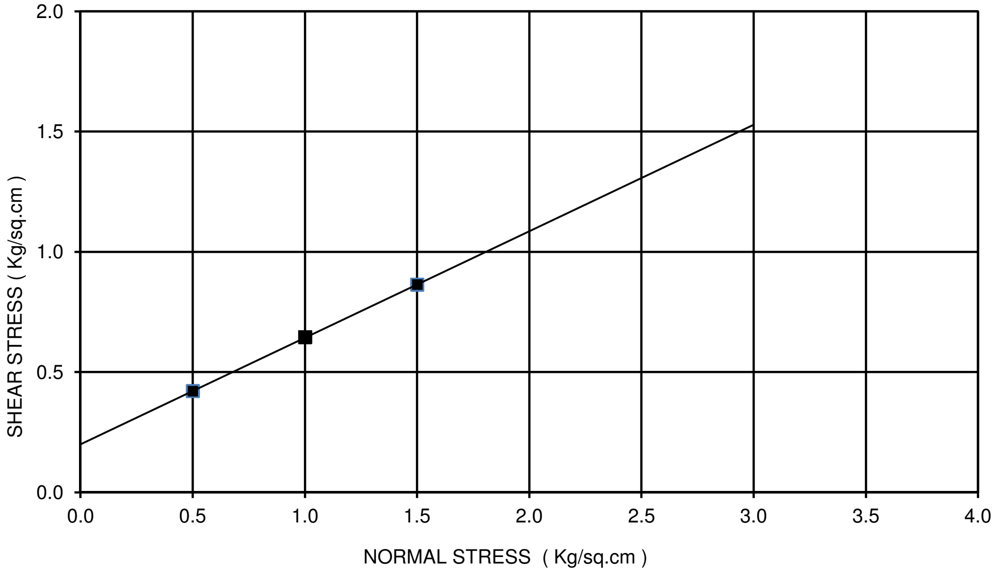


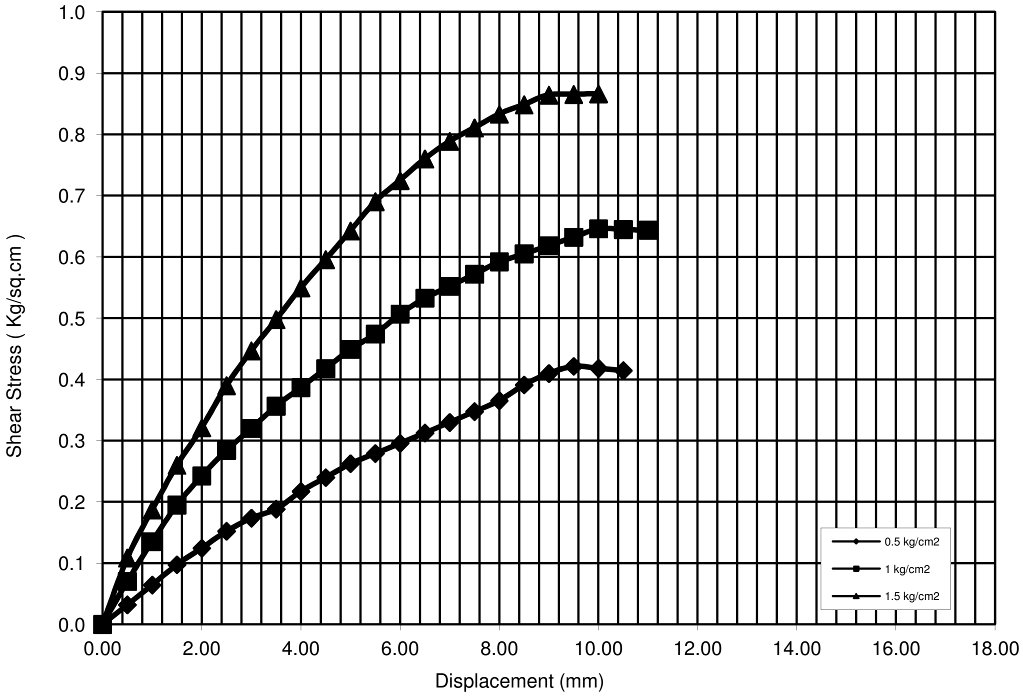
BORE HOLE NO: BH-A2
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



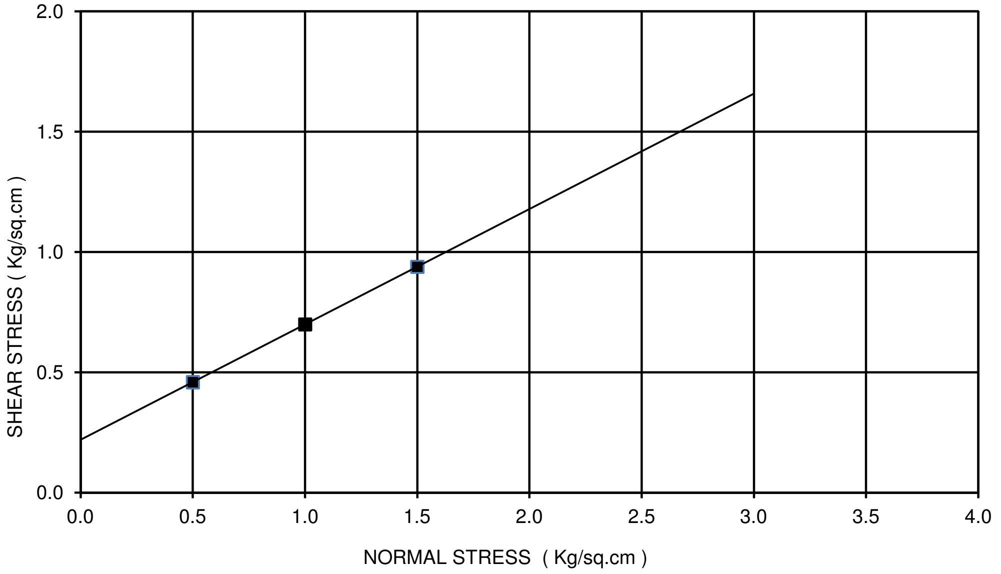


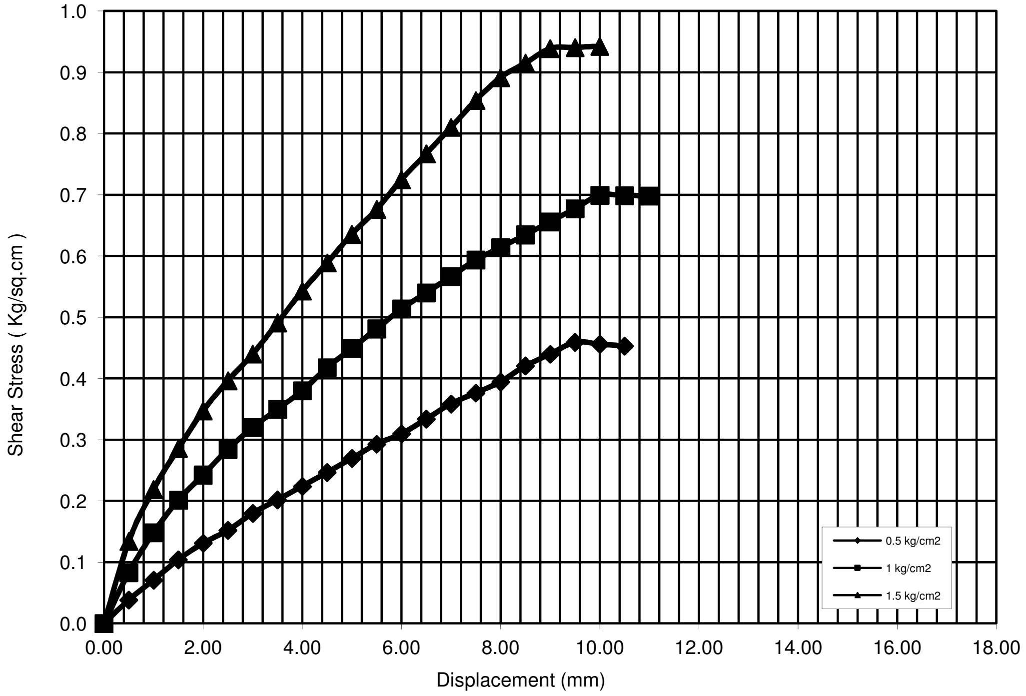
BORE HOLE NO: BH-A2
Chainage:- 27+620 km
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



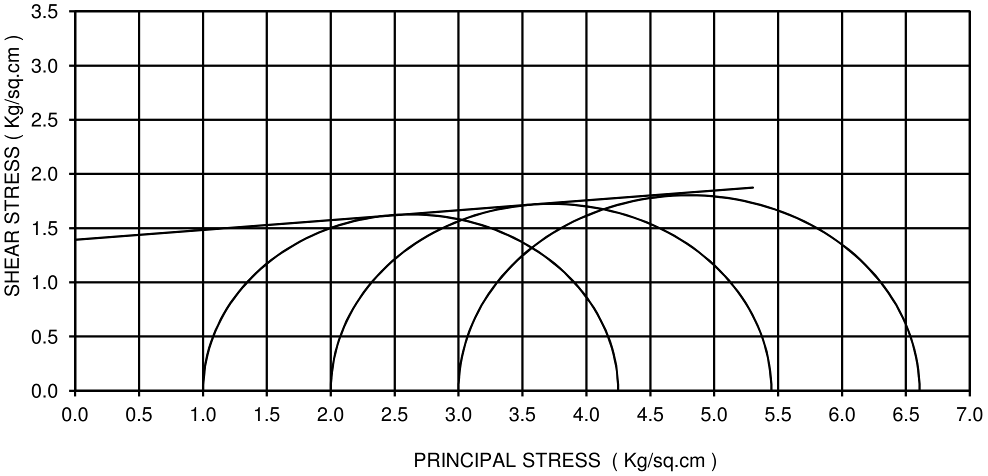


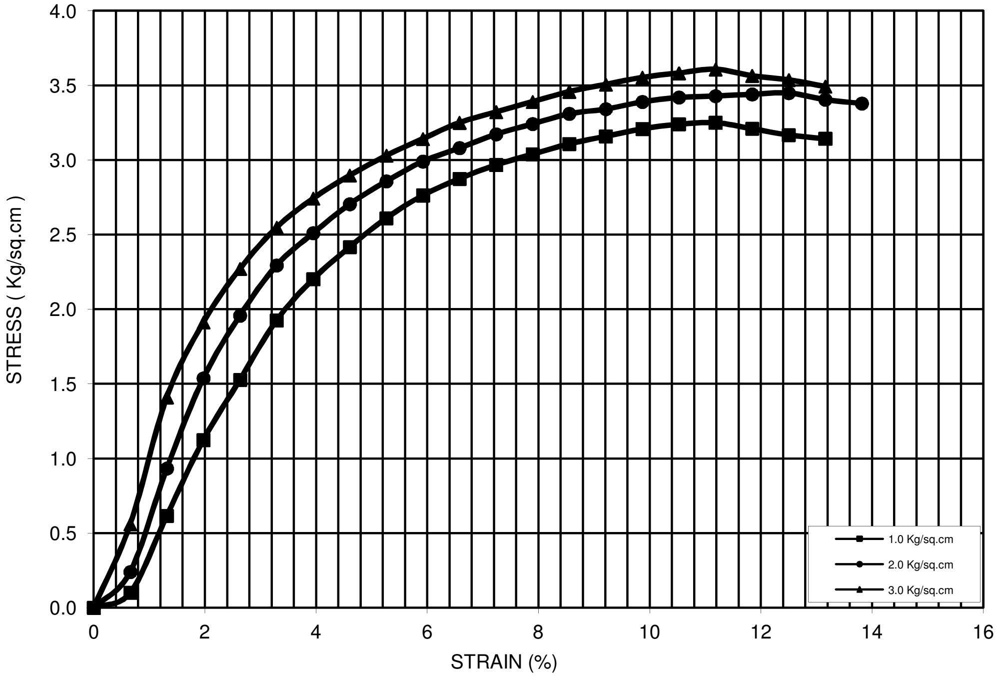
BORE HOLE NO: BH-A1
Chainage:- 28+075 km
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.22 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



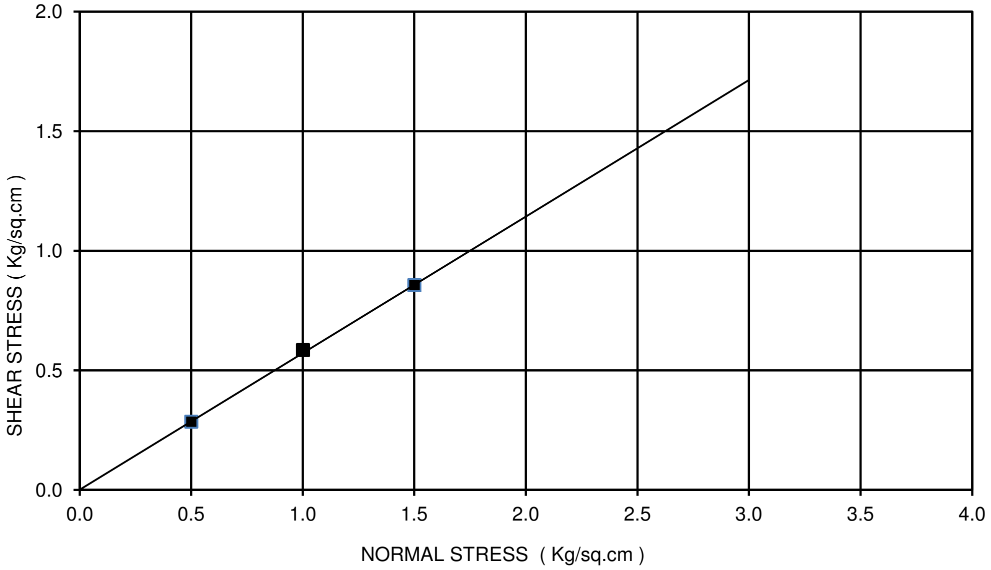


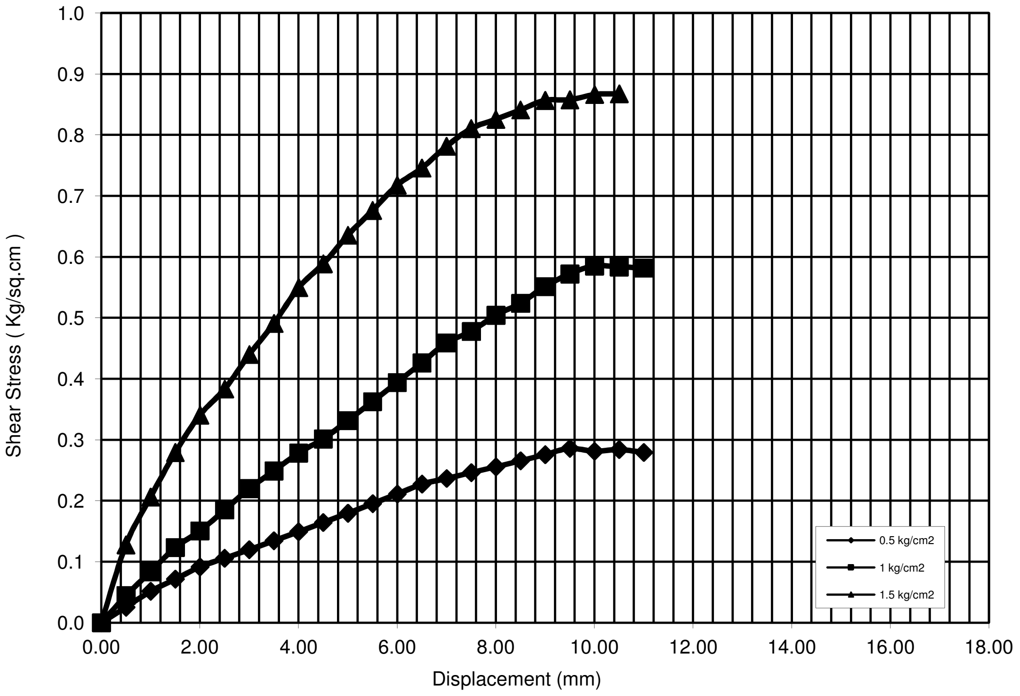
BORE HOLE NO: BH-A1
Chainage:- 28+075 km
SAMPLE NO.: UDS-5
DEPTH: 14.50m
COHESION(C)= 1.39 kg/sq.cm
ANGLE OF FRICTION(Phi): 5 deg
TYPE OF THE TEST: UUT



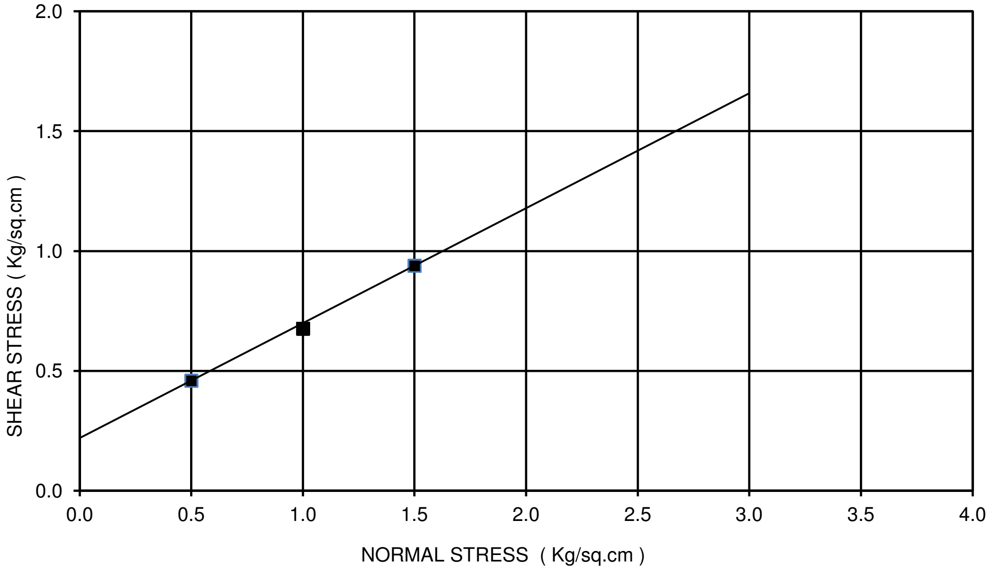


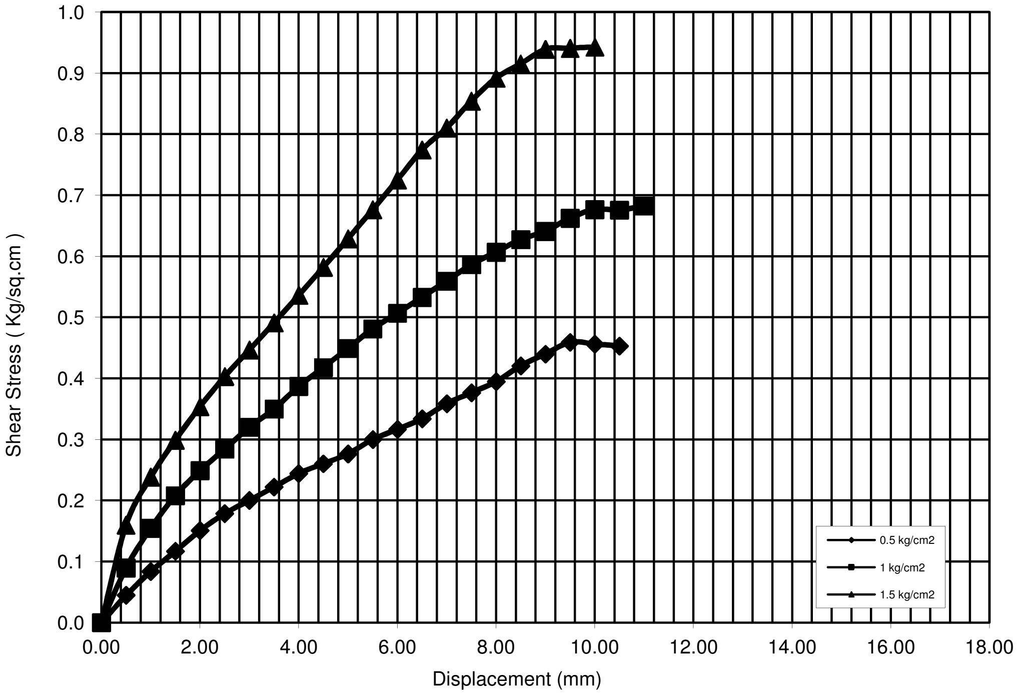
BORE HOLE NO: BH-P1
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.00 kg/sq.cm
ANGLE OF FRICTION(Phi): 30 deg
TYPE OF THE TEST: DST



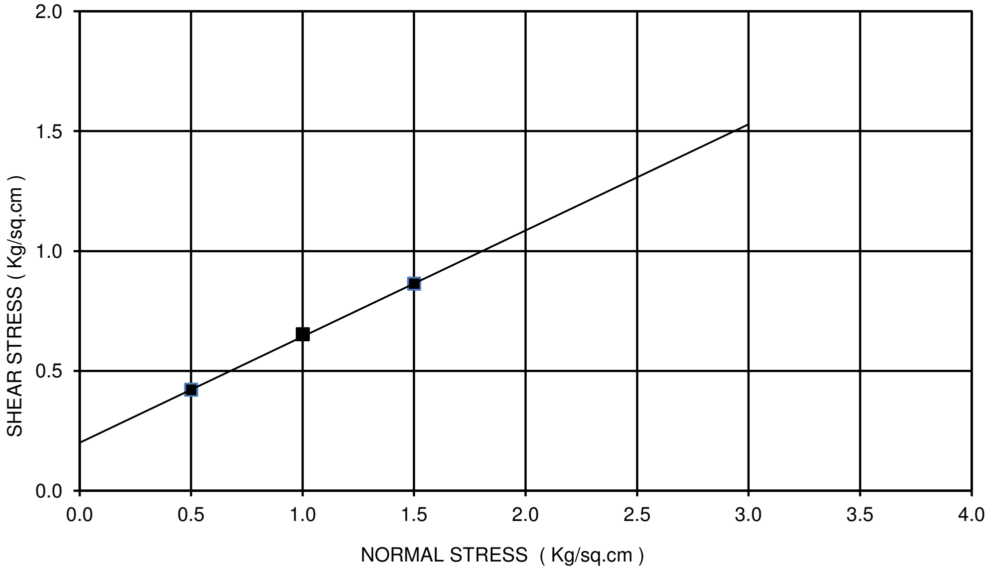


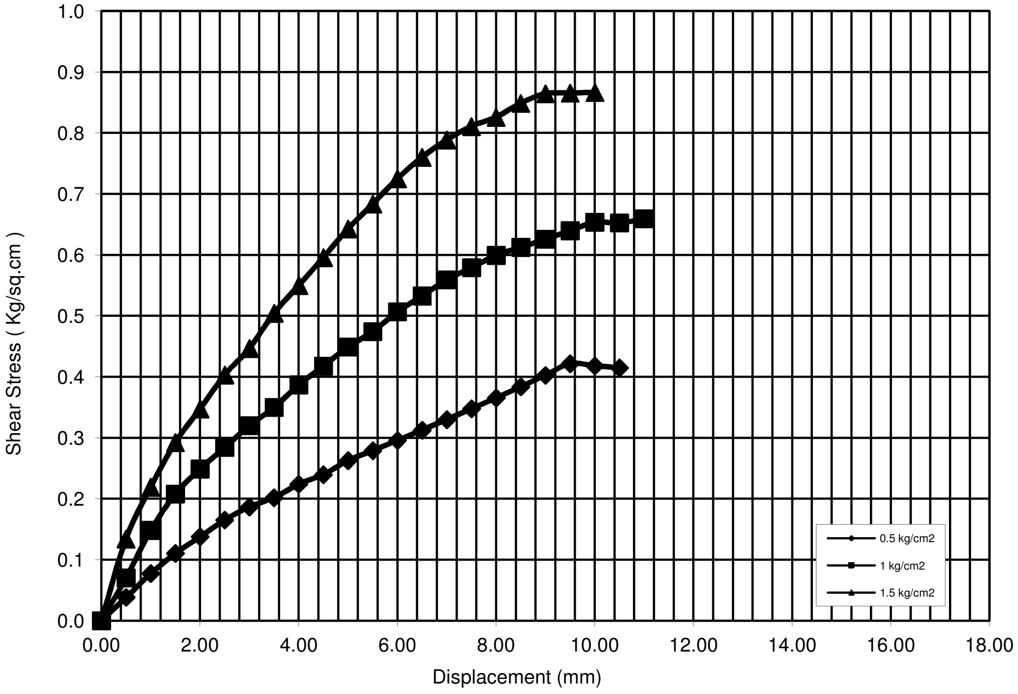
BORE HOLE NO: BH-P1
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.22 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



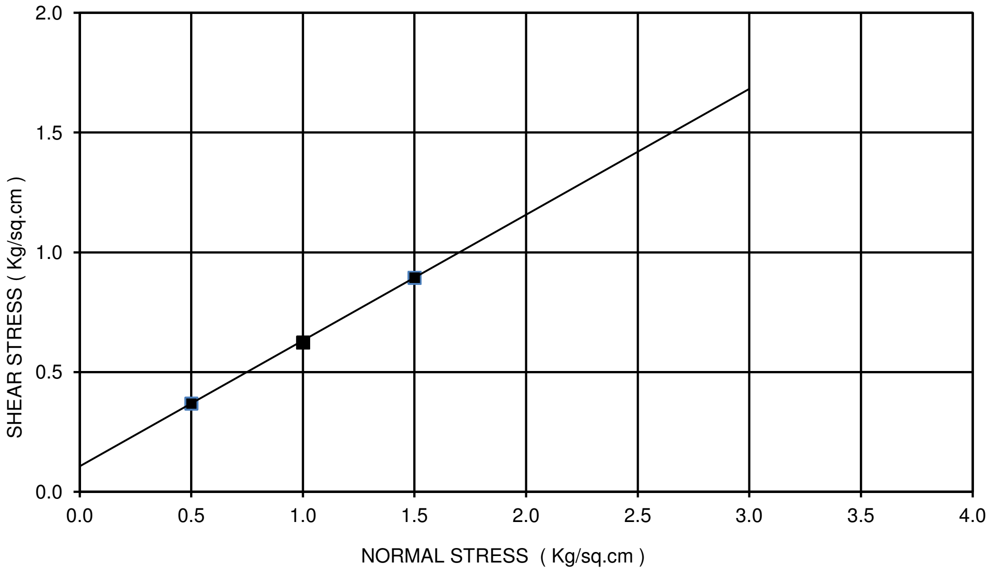


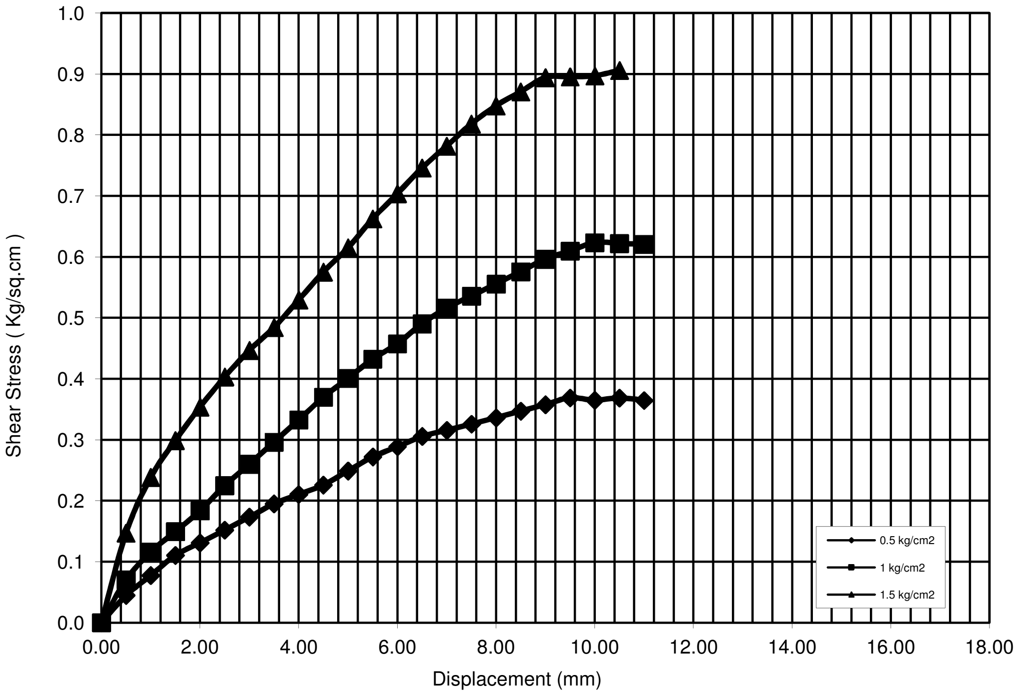
BORE HOLE NO: BH-P2
CHAINAGE : 28+075 KM
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST



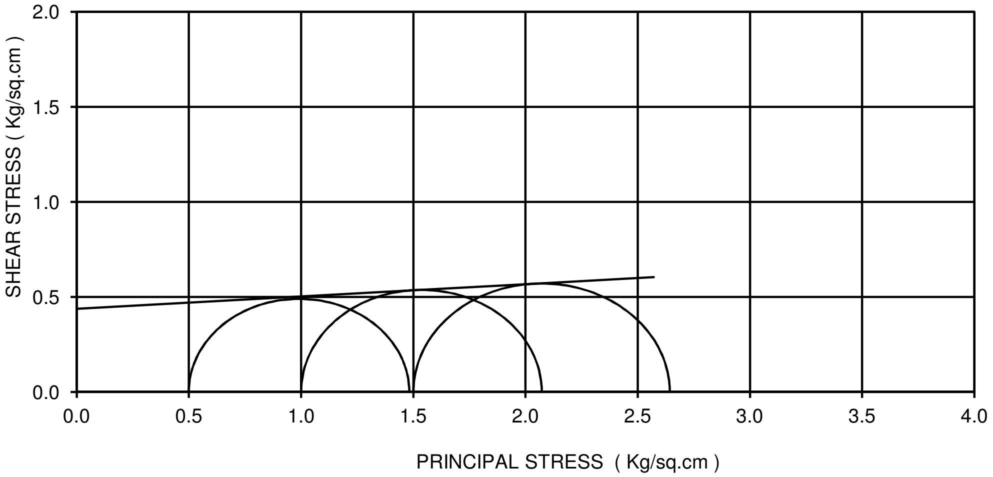


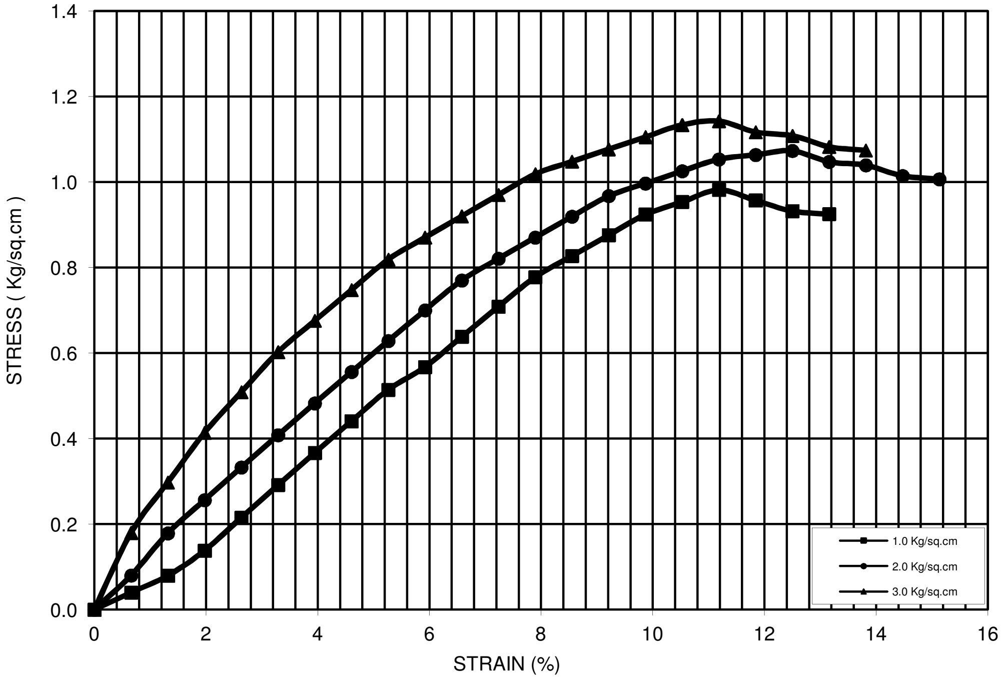
BORE HOLE NO: BH-P2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.11 kg/sq.cm
ANGLE OF FRICTION(Phi): 28 deg
TYPE OF THE TEST: DST



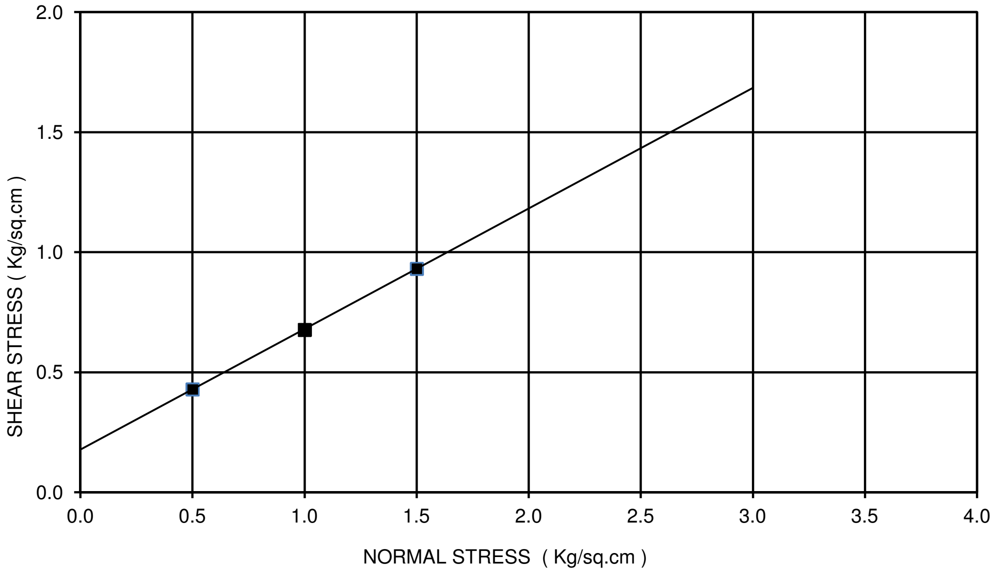


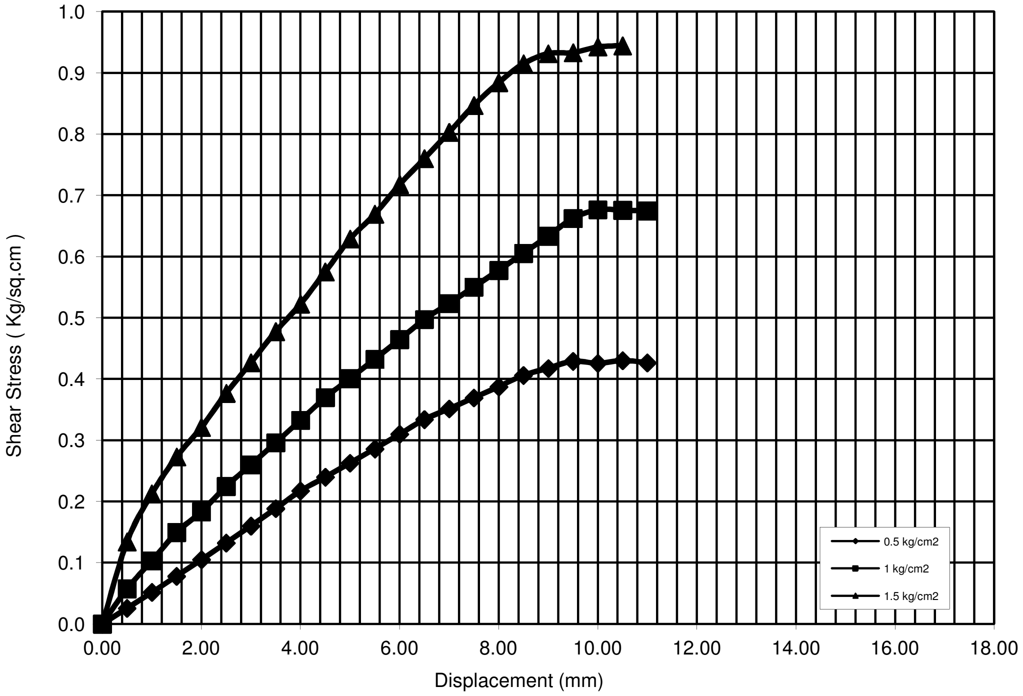
BORE HOLE NO: BH-A2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.44 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



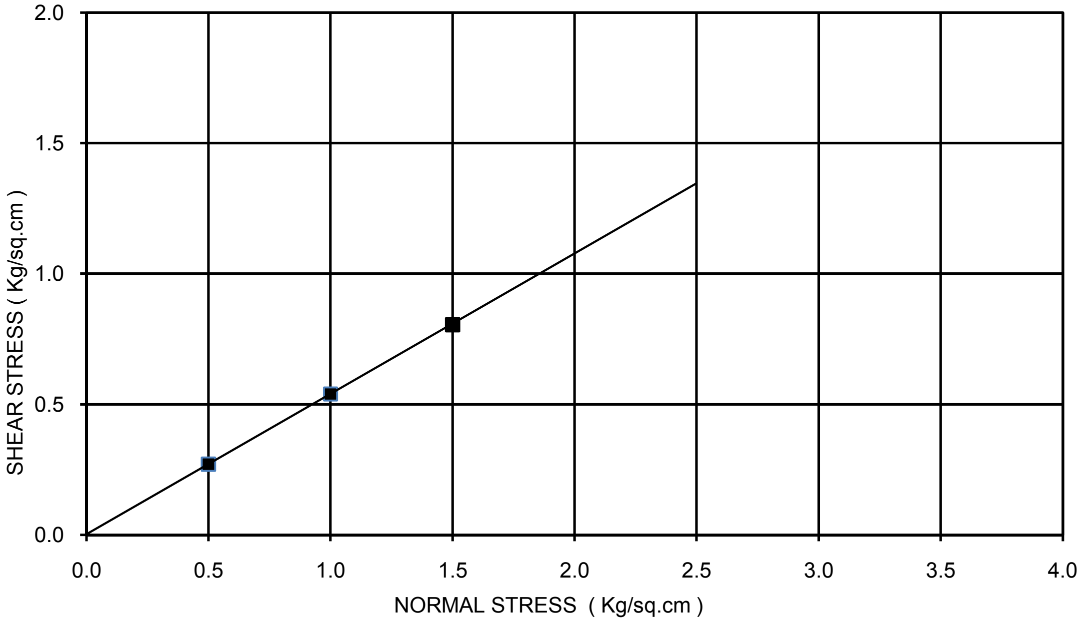


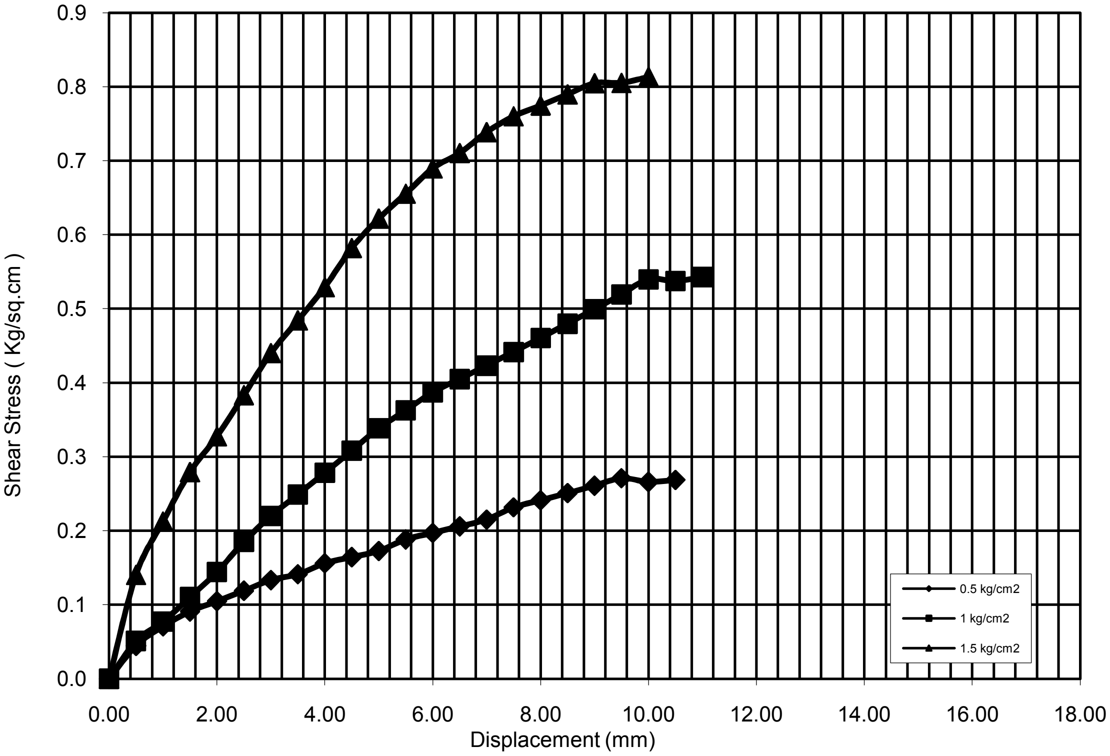
BORE HOLE NO: BH-A2
CHAINAGE : 28+075 km
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.18 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST





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





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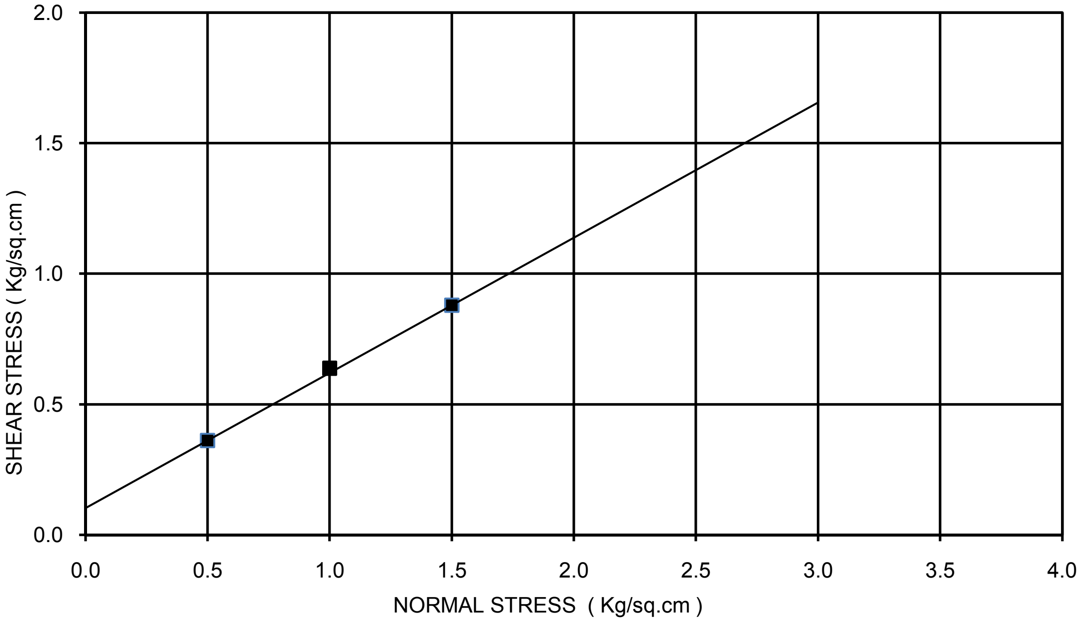
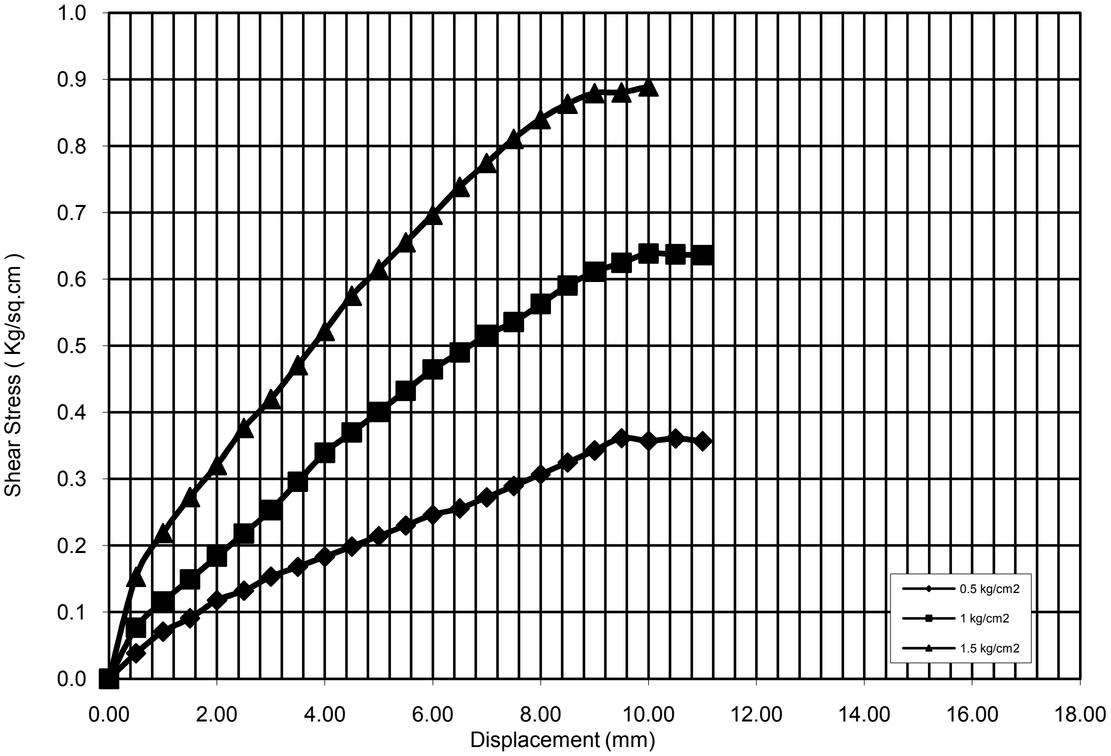
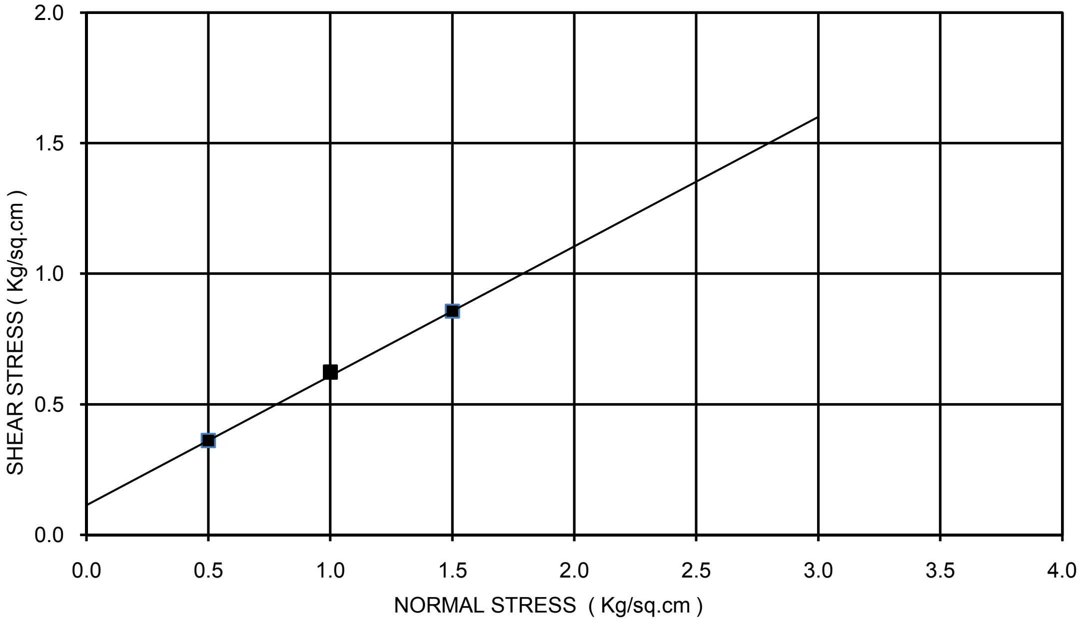
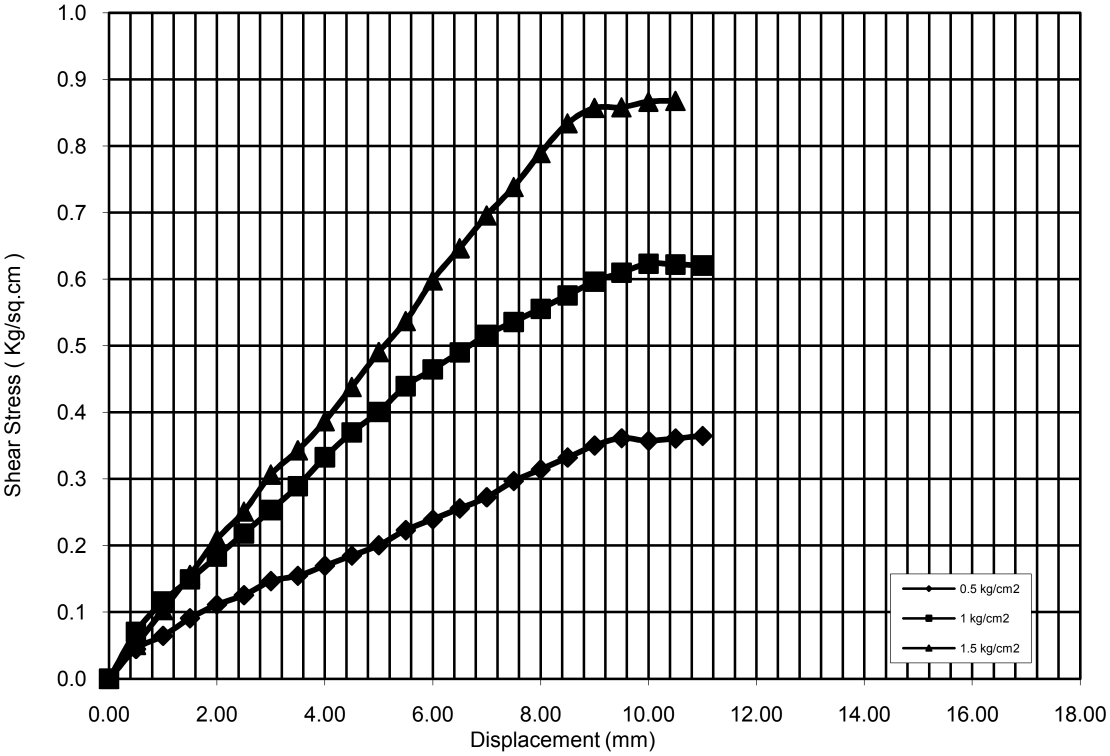
BORE HOLE NO: BH-A1
Chainage:- 28+360
SAMPLE NO.: UDS-3
DEPTH: 8.50 m
COHESION(C)= 0.10 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



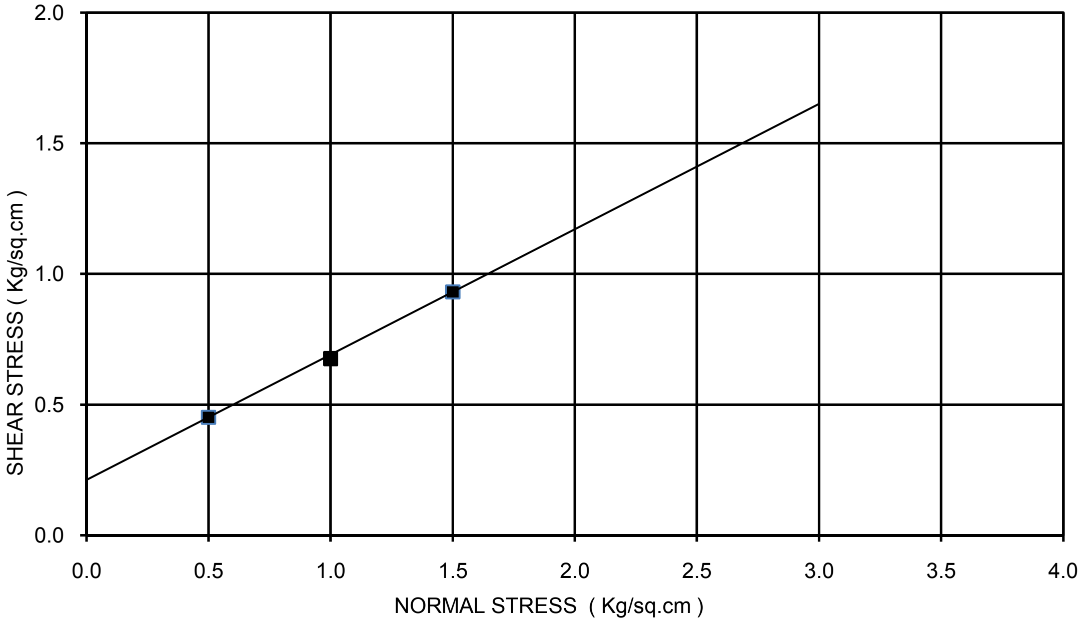


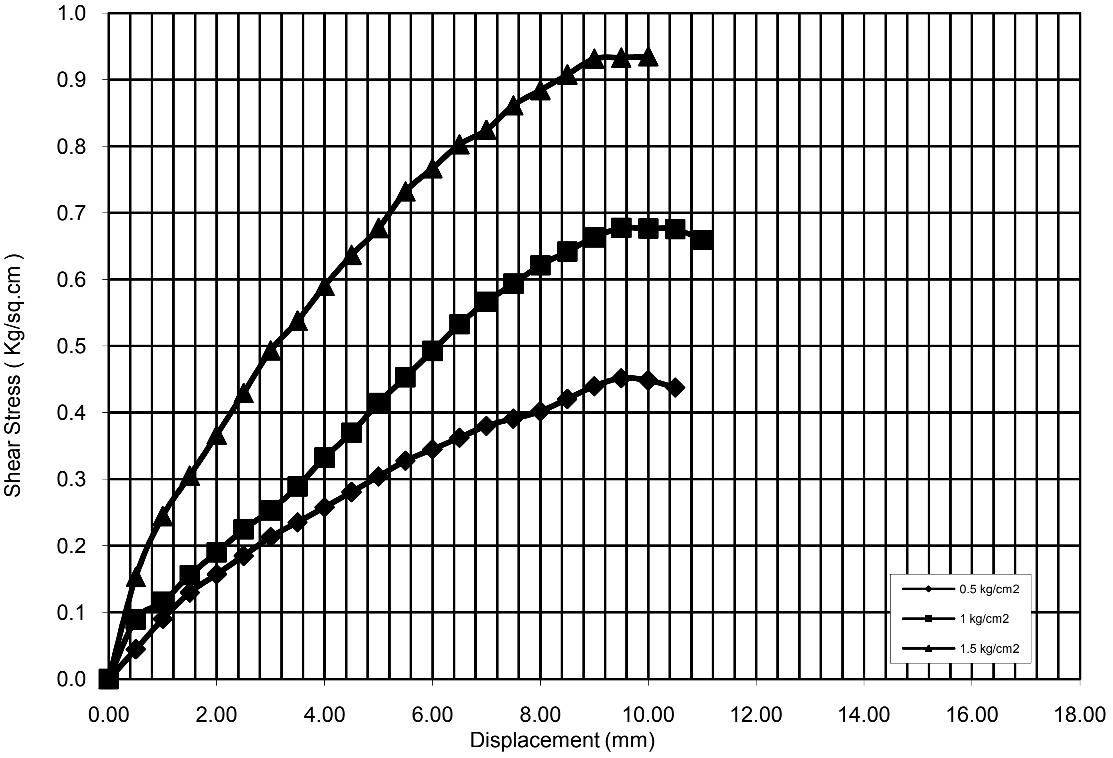
BORE HOLE NO: BH-P1
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.11 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



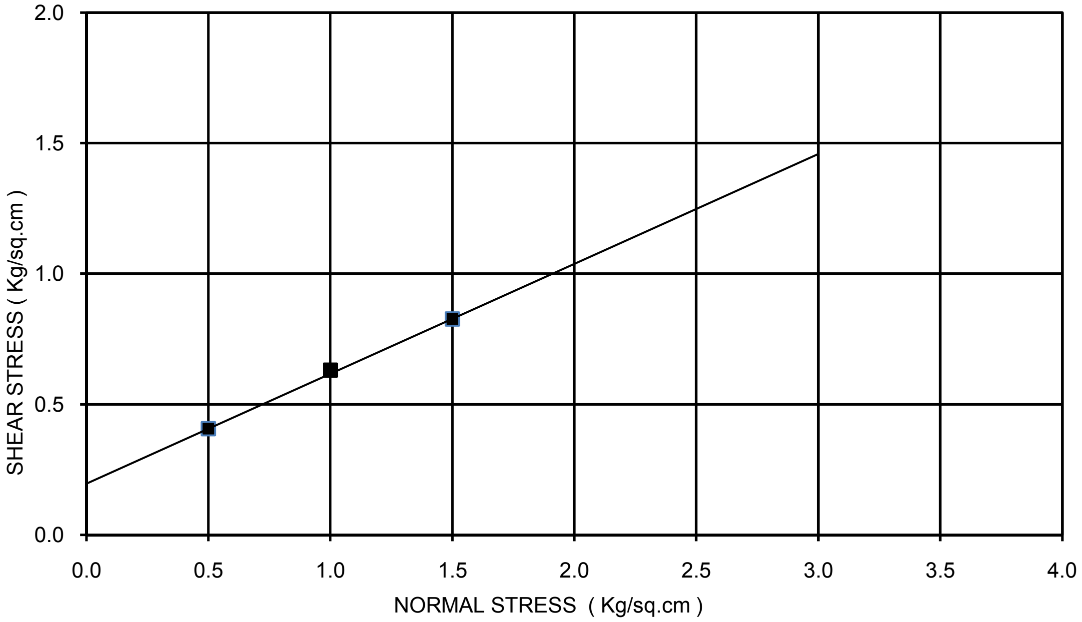


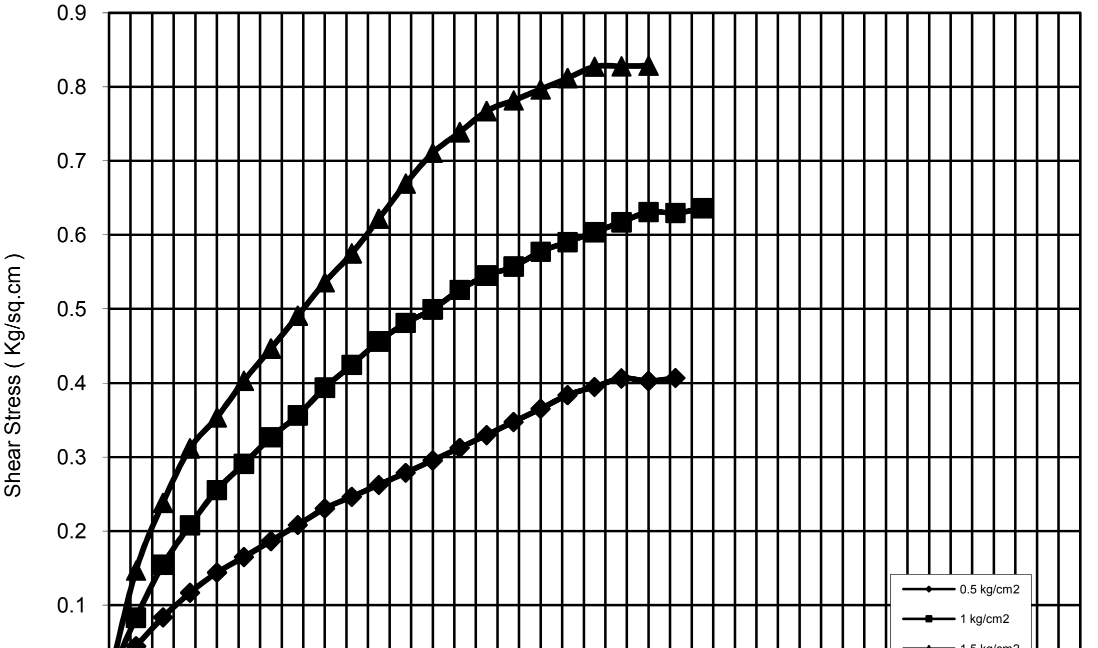
BORE HOLE NO: BH-P1
Chainage:- 28+360
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



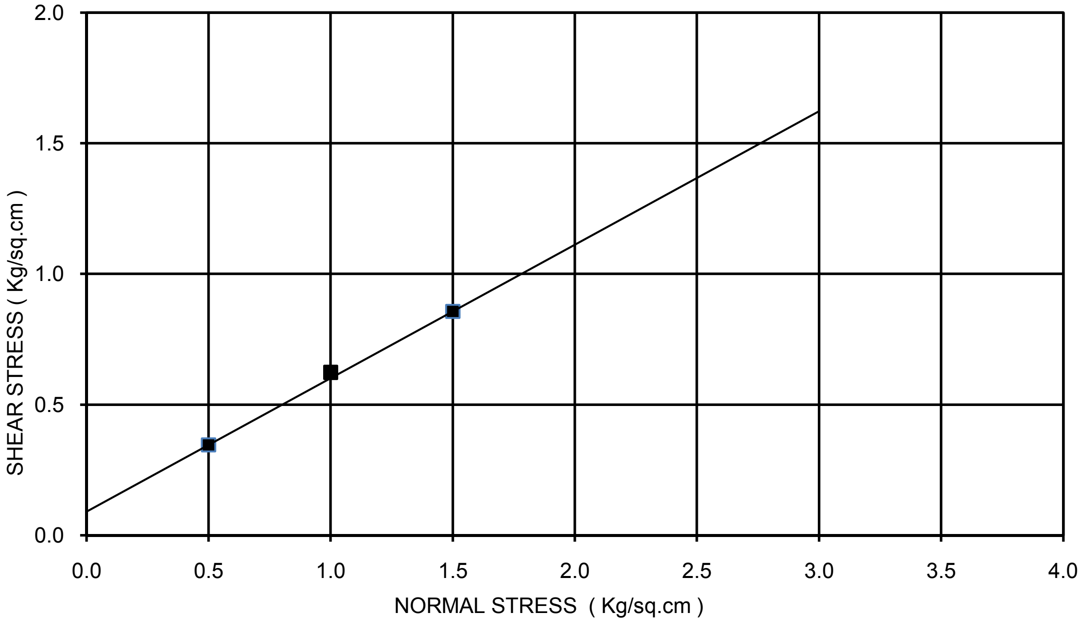


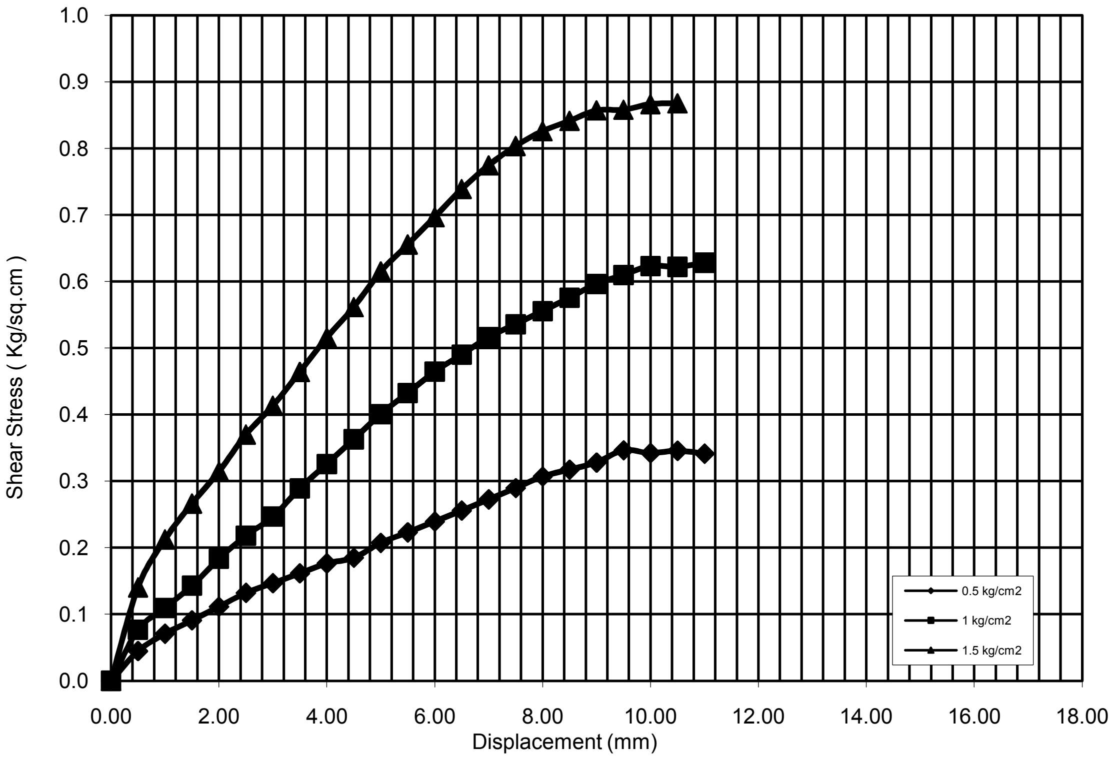
BORE HOLE NO: BH-P2
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 23 deg
TYPE OF THE TEST: DST





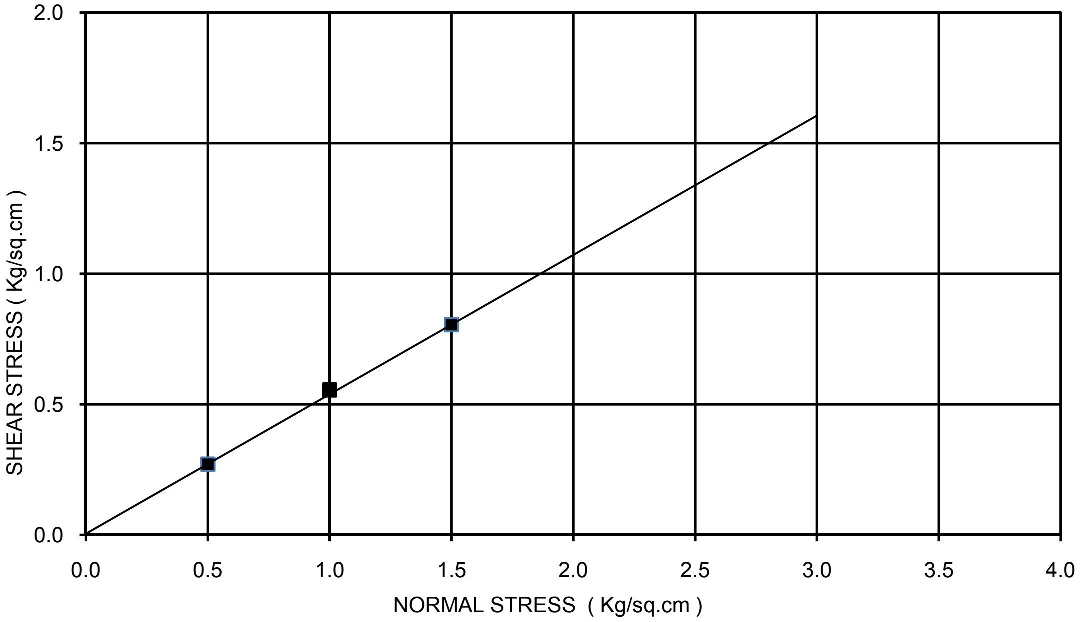
BORE HOLE NO: BH-P2
Chainage:- 28+360
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.09 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST

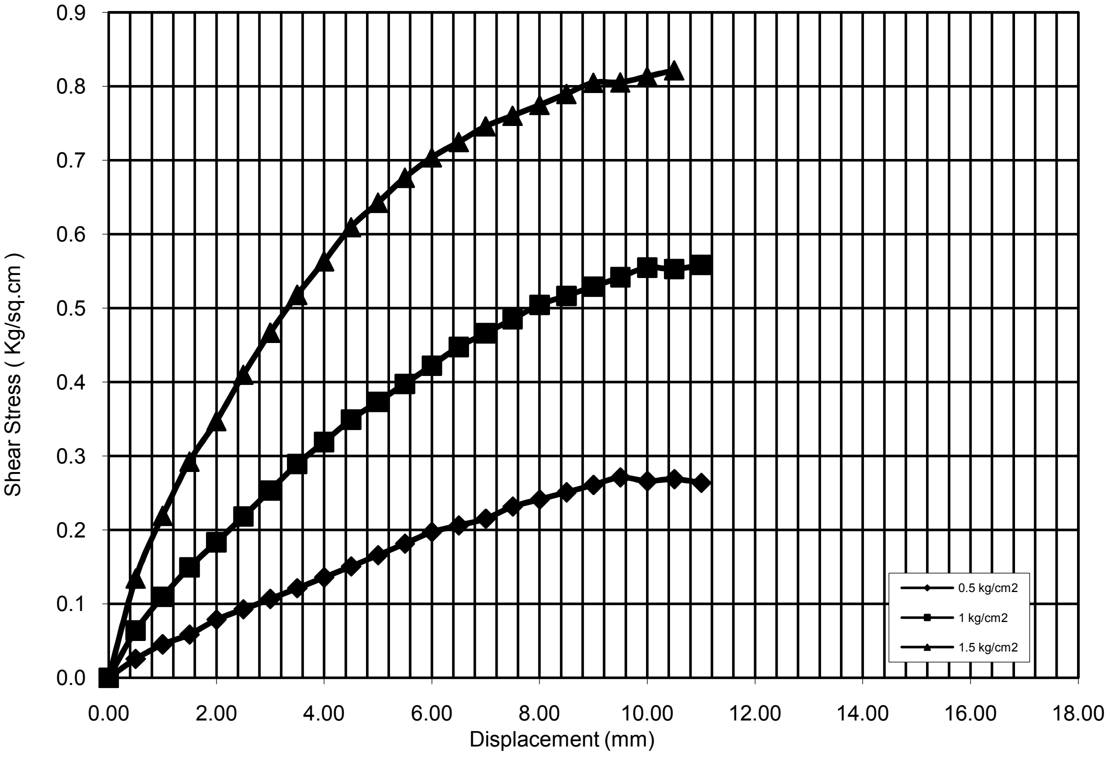




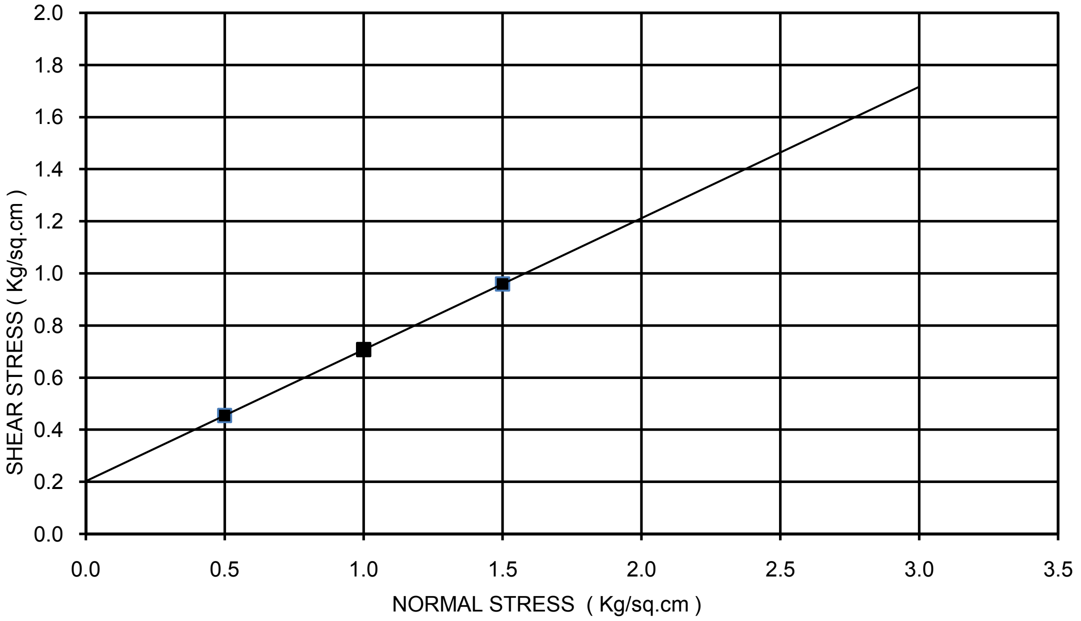
CEG Test House and Research Centre Pvt. Ltd.

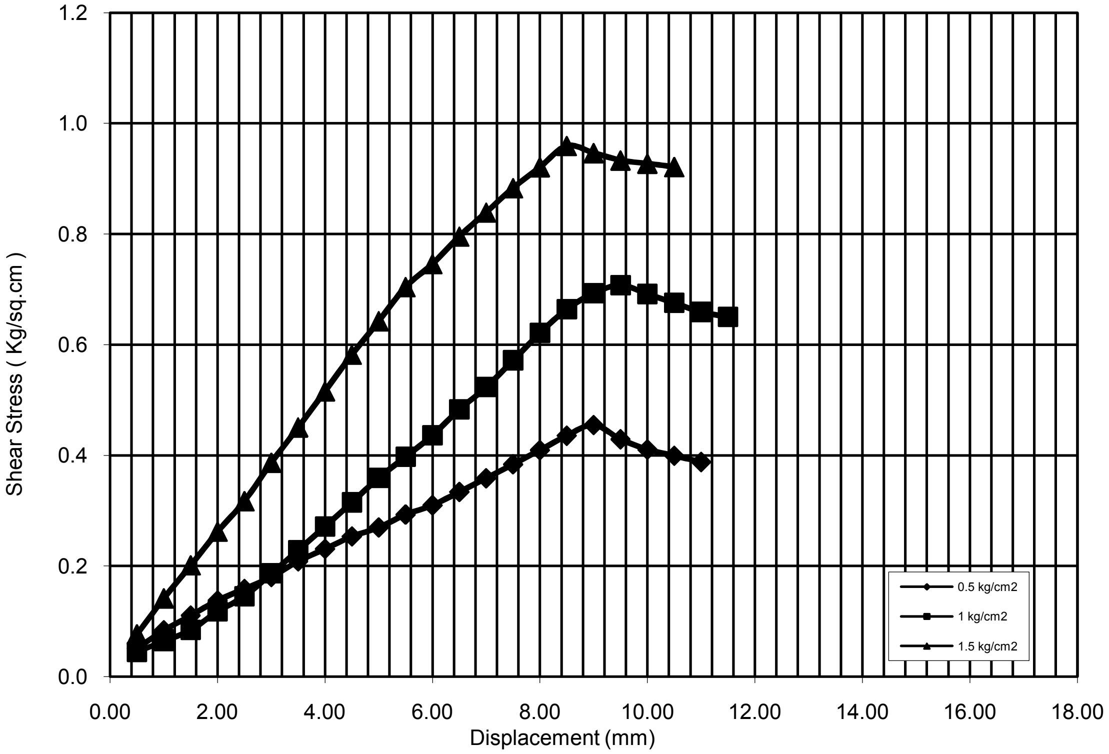
BORE HOLE NO: BH-A2
Chainage:- 28+360
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.00 kg/sq.cm
ANGLE OF FRICTION(Phi): 28 deg
TYPE OF THE TEST: DST



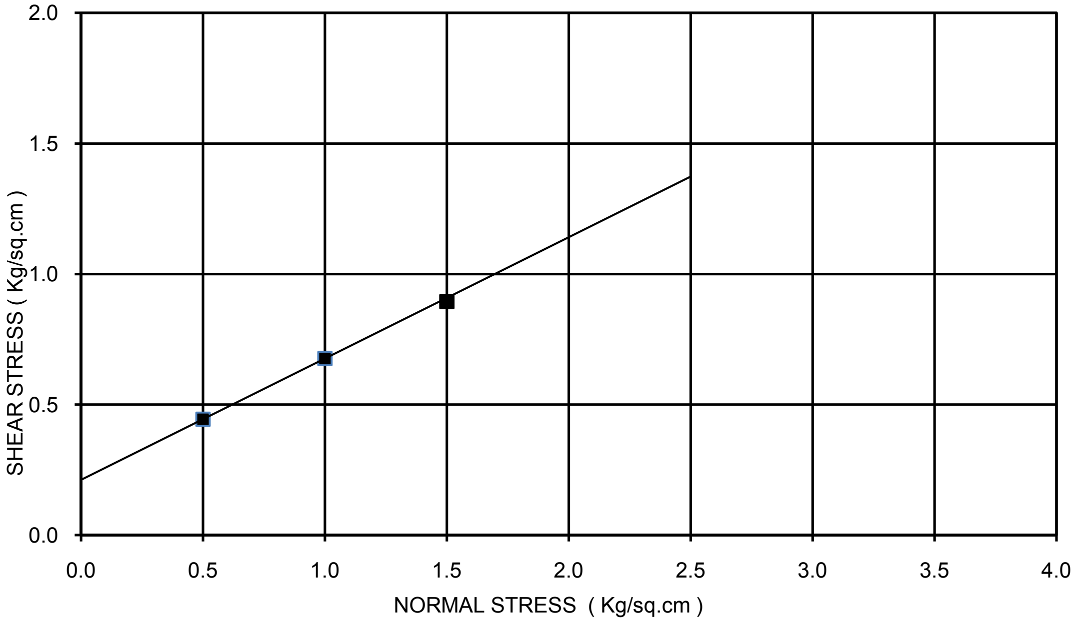


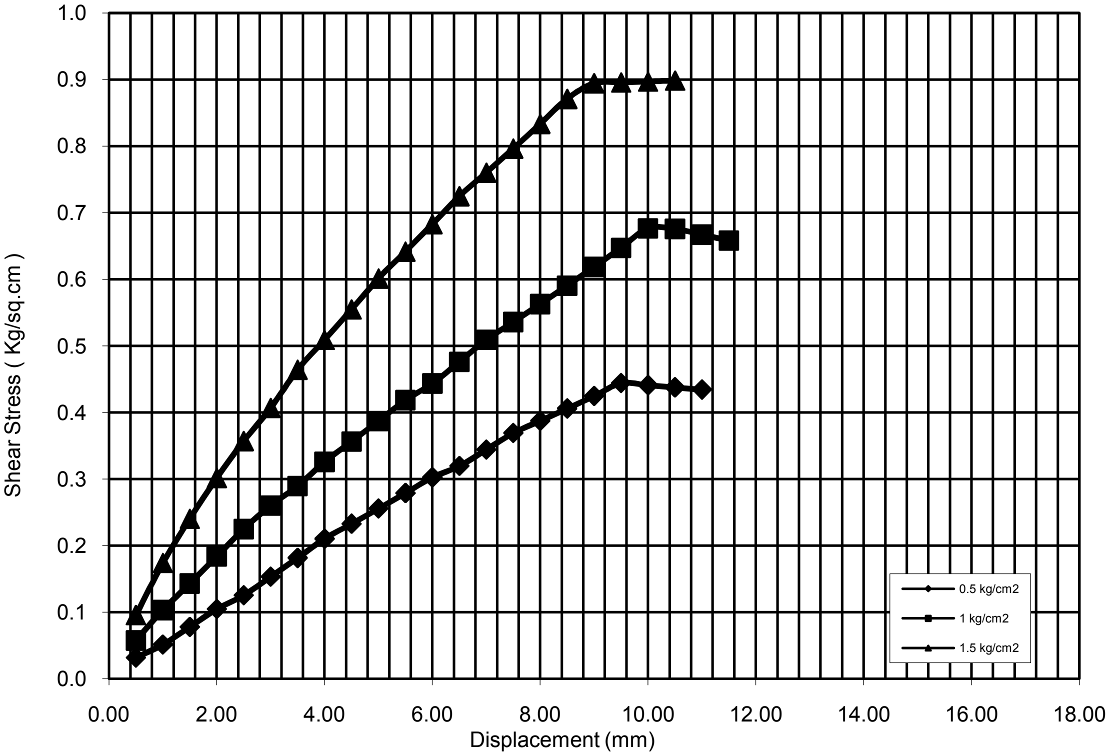
BORE HOLE NO: BH-A2
CHAINAGE : - 28+360
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.2 kg/sq.cm
ANGLE OF FRICTION(Phi): 27 deg
TYPE OF THE TEST: DST



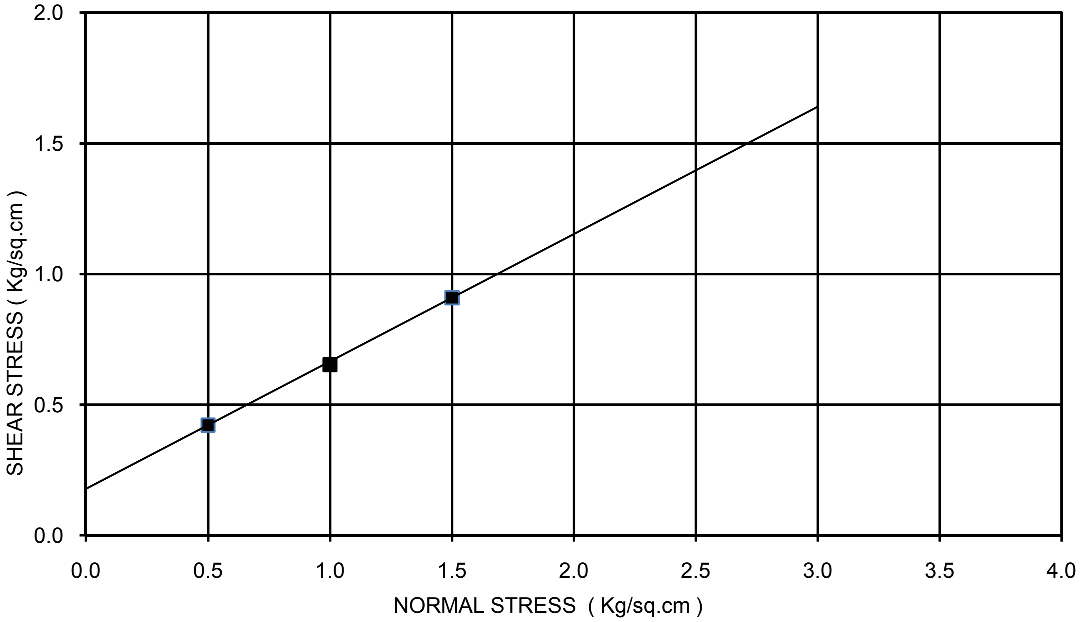


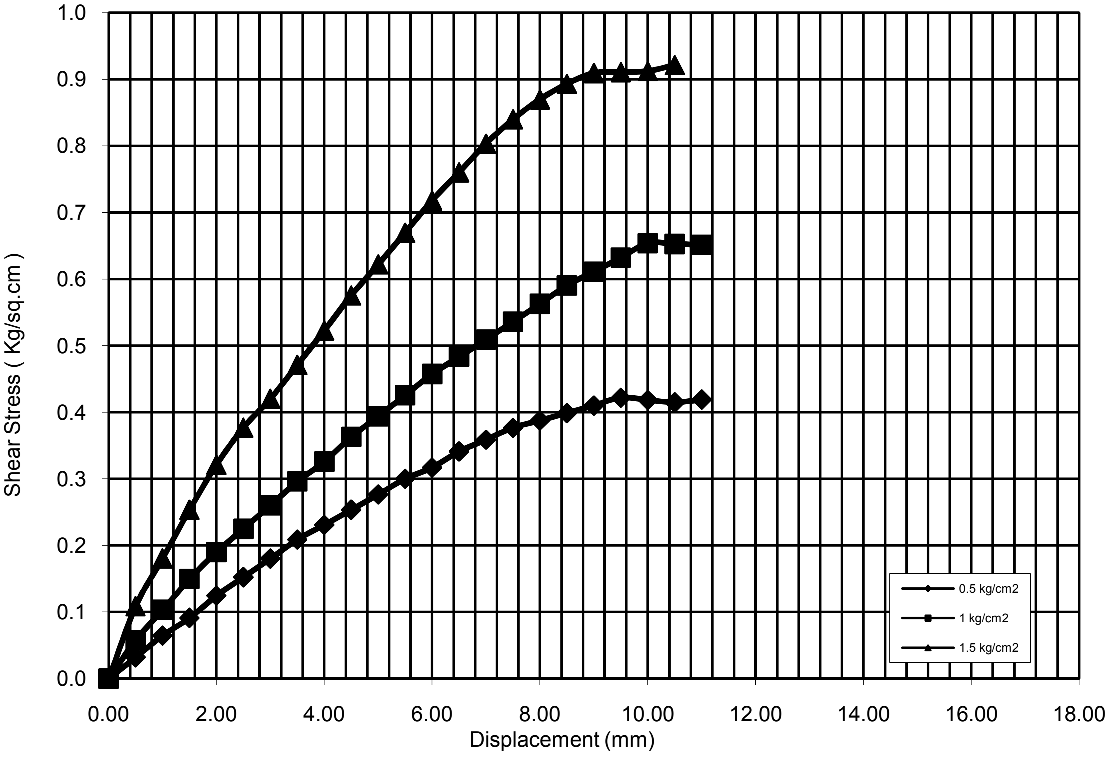
BORE HOLE NO: BH-A1
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.21 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST



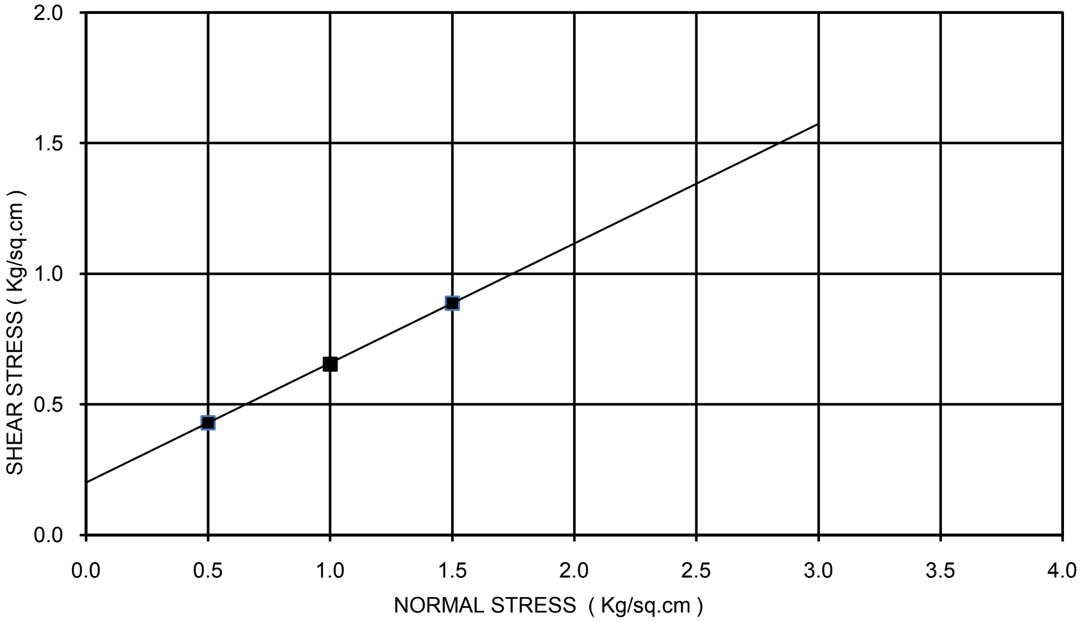


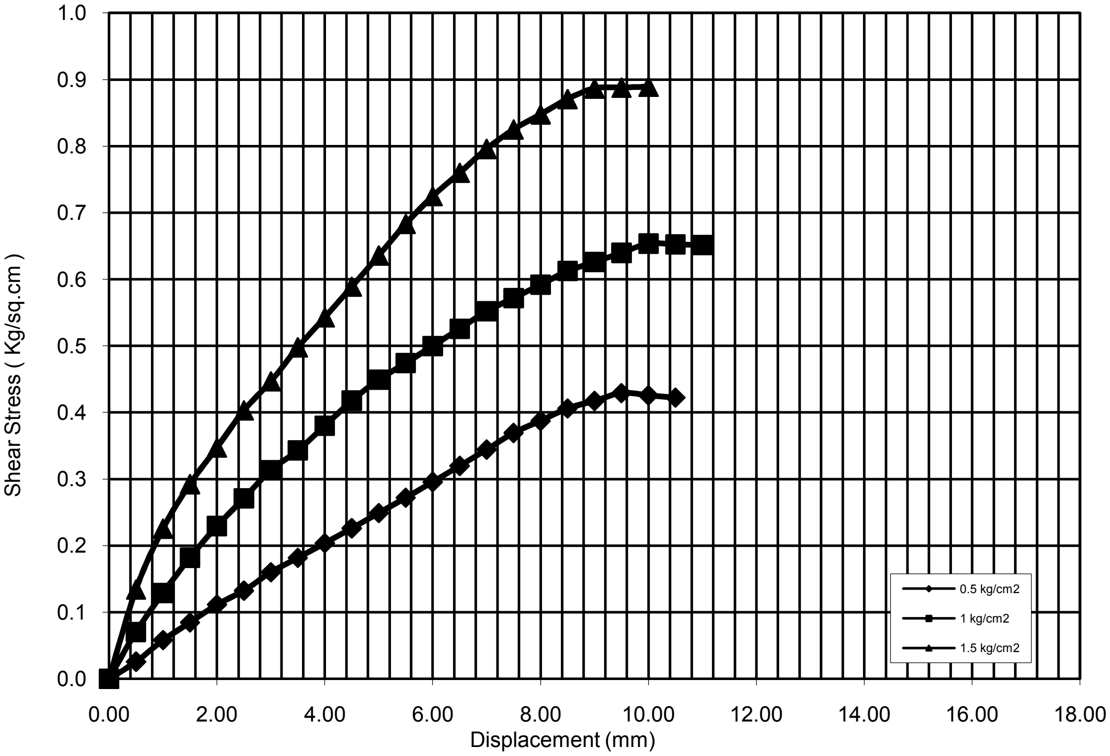
BORE HOLE NO: BH-A1
Chainage: 28+900
SAMPLE NO.: UDS-3
DEPTH: 8.50 m
COHESION(C)= 0.18 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST



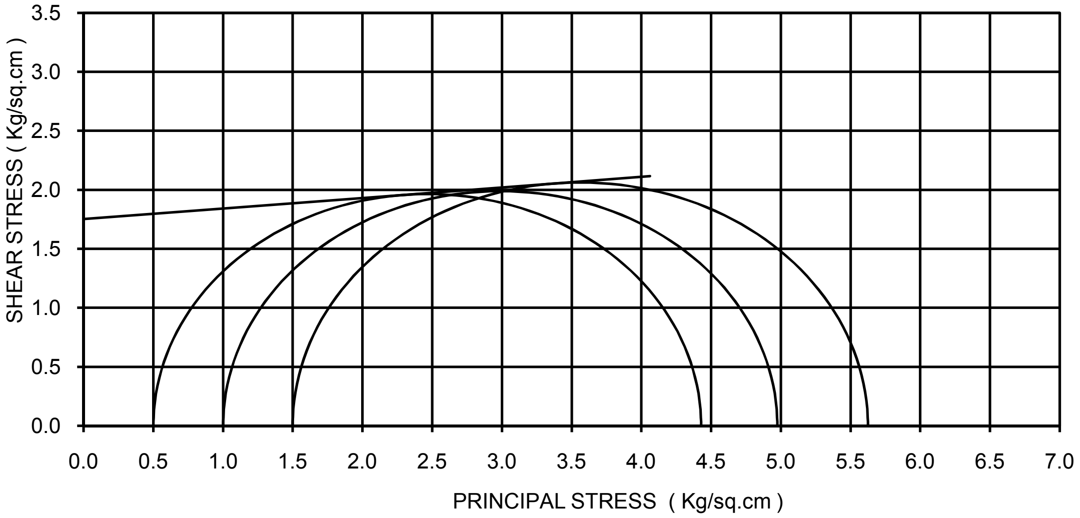


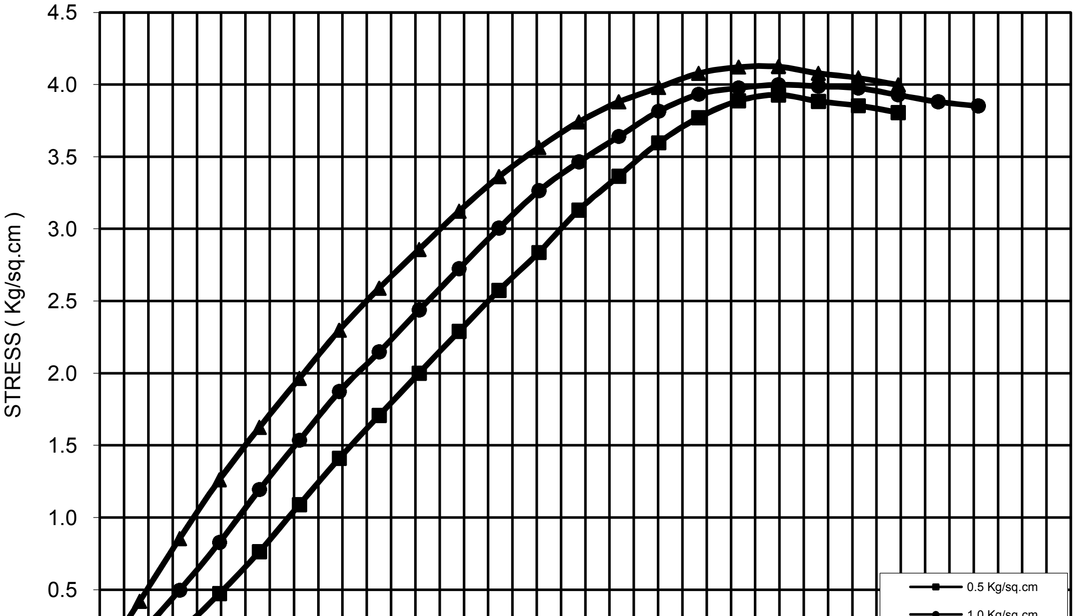
BORE HOLE NO: BH-P1
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST





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





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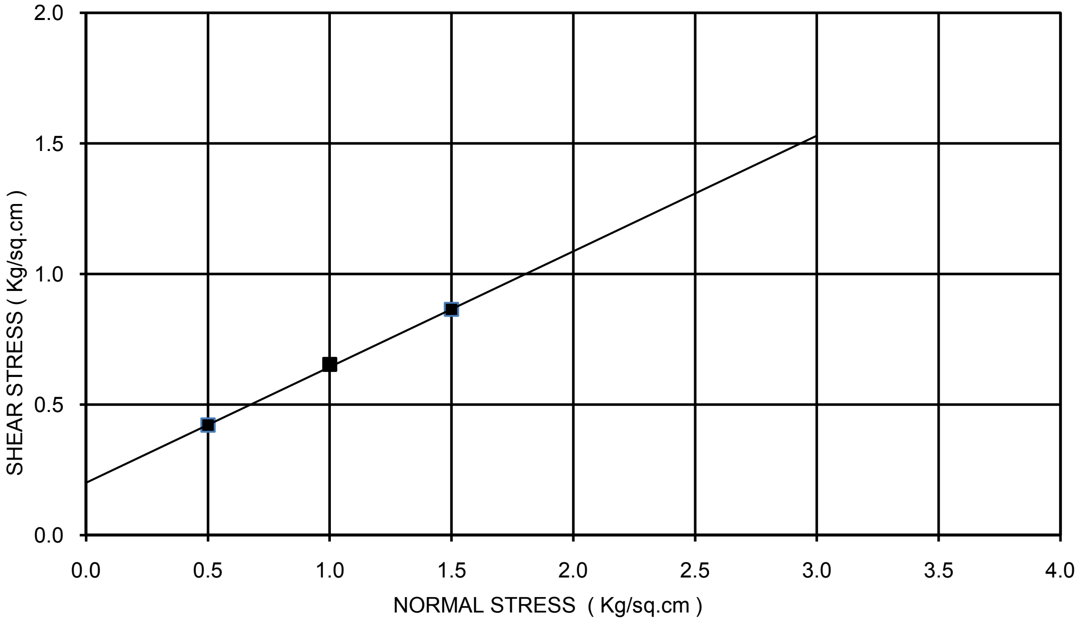
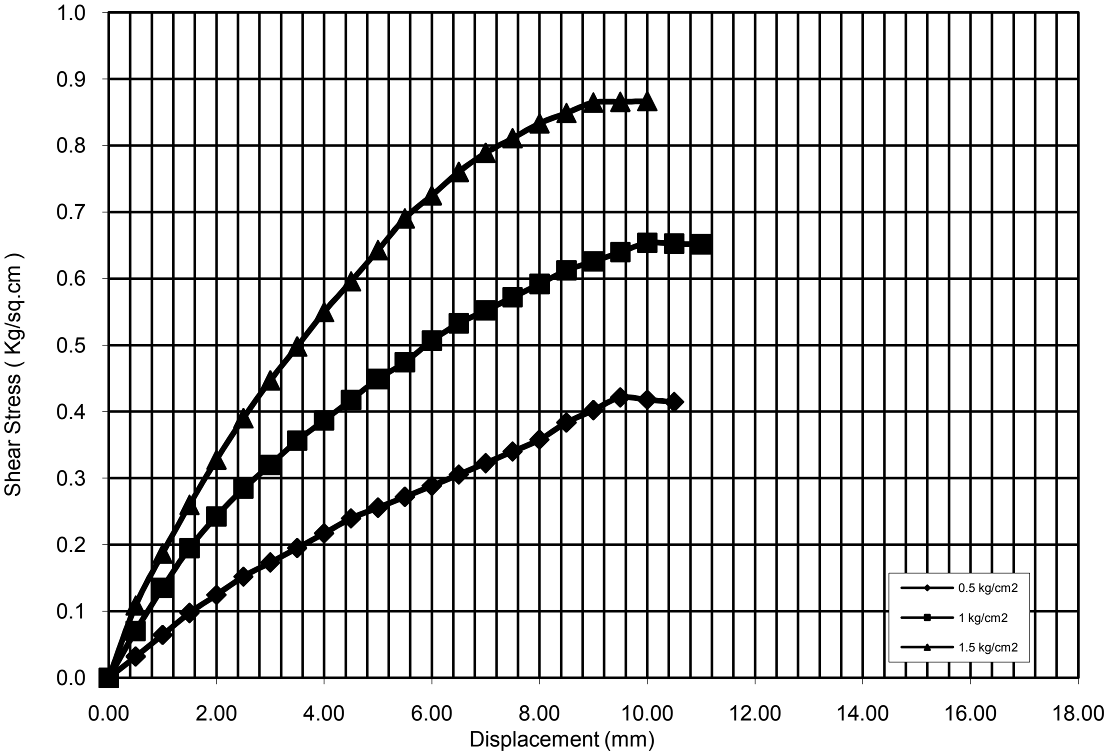
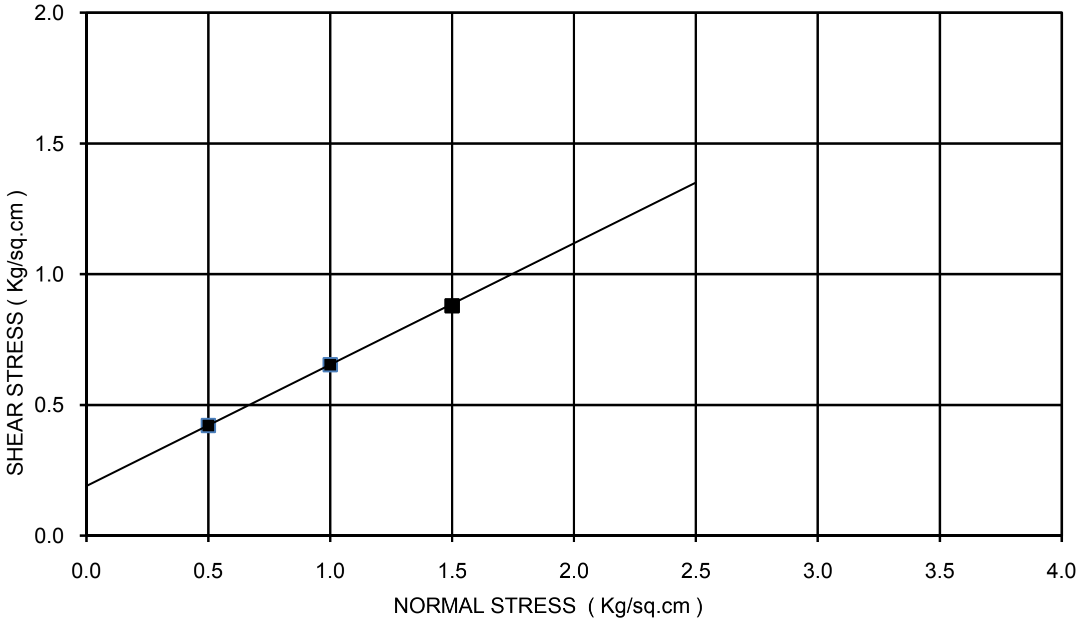
BORE HOLE NO: BH-P2
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 2.50 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 24 deg
TYPE OF THE TEST: DST

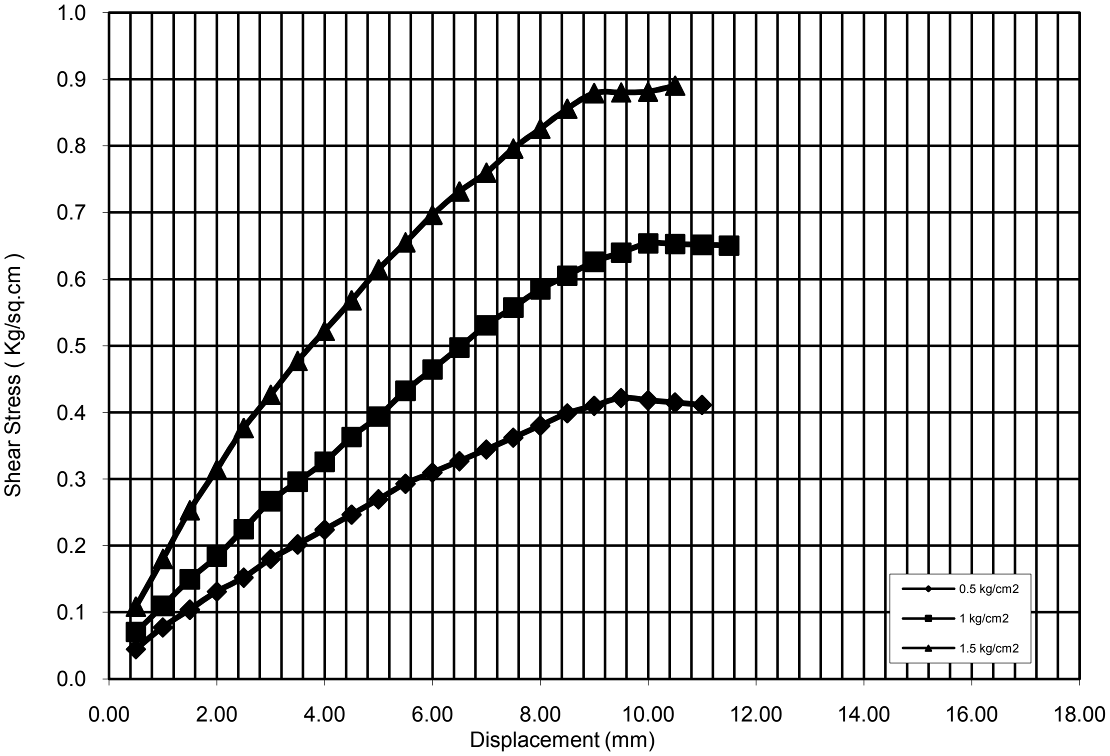




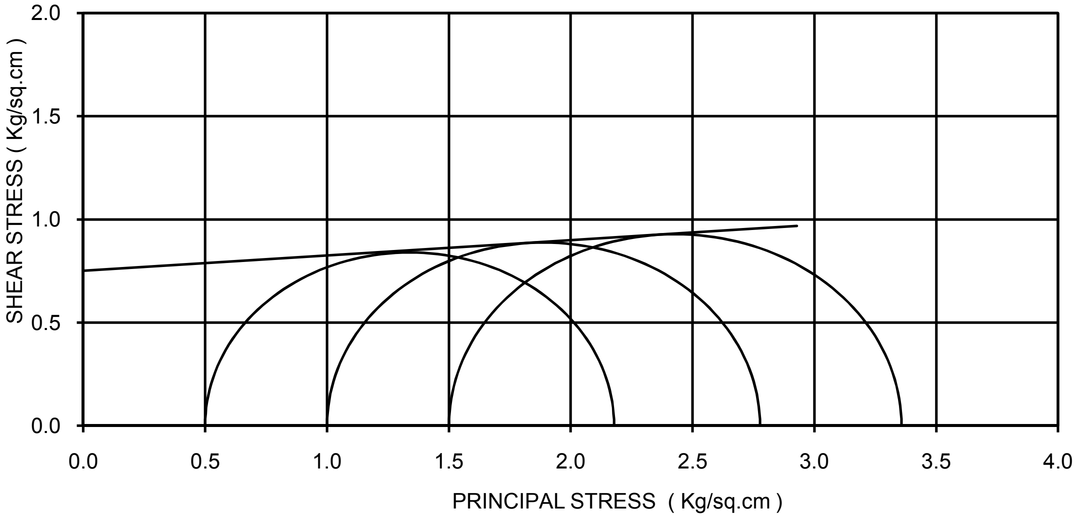
CEG Test House and Research Centre Pvt. Ltd.

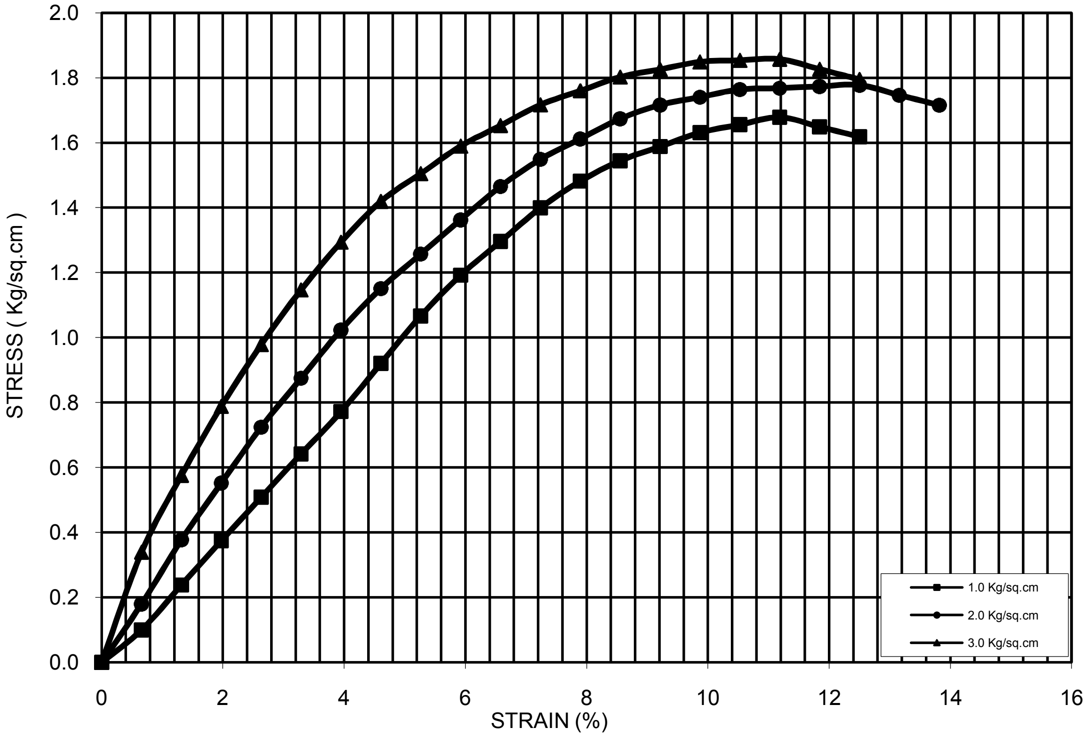
BORE HOLE NO: BH-P2
Chainage: 28+900
SAMPLE NO.: UDS-2
DEPTH: 5.50 m
COHESION(C)= 0.19 kg/sq.cm
ANGLE OF FRICTION(Phi): 25 deg
TYPE OF THE TEST: DST



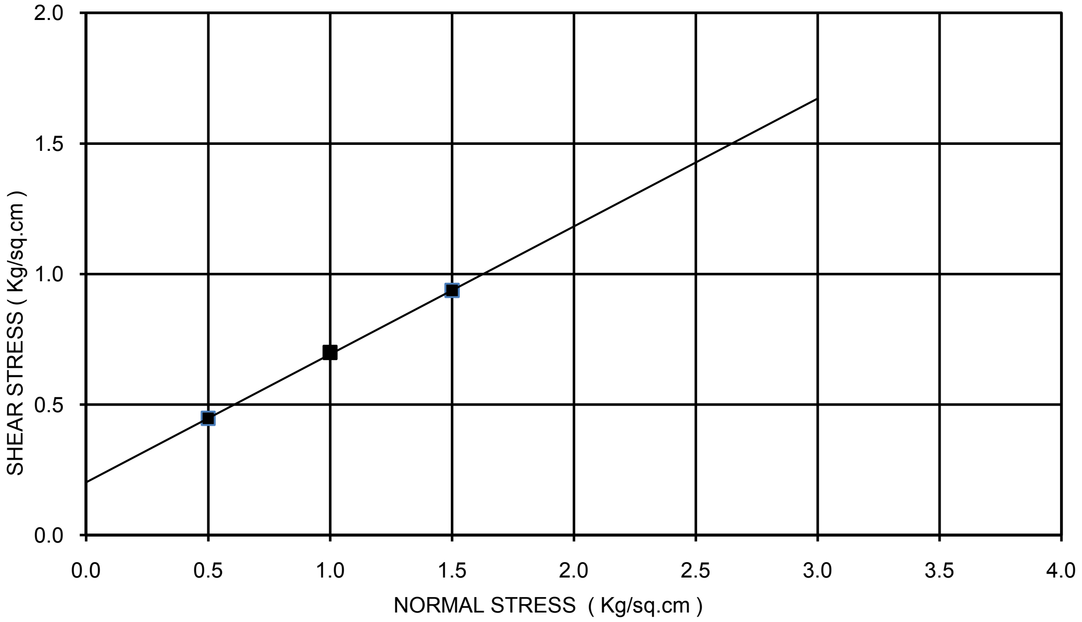


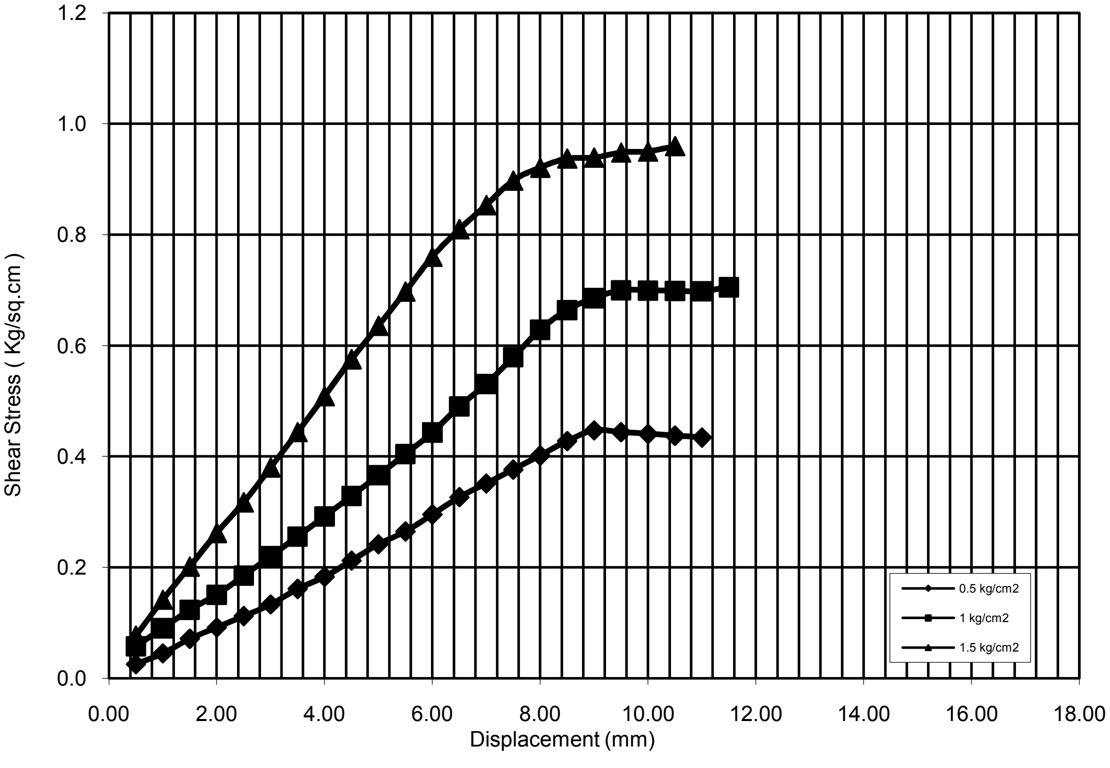
BORE HOLE NO: BH-A2
Chainage: 28+900
SAMPLE NO.: UDS-1
DEPTH: 1.00 m
COHESION(C)= 0.75 kg/sq.cm
ANGLE OF FRICTION(Phi): 4 deg
TYPE OF THE TEST: UUT



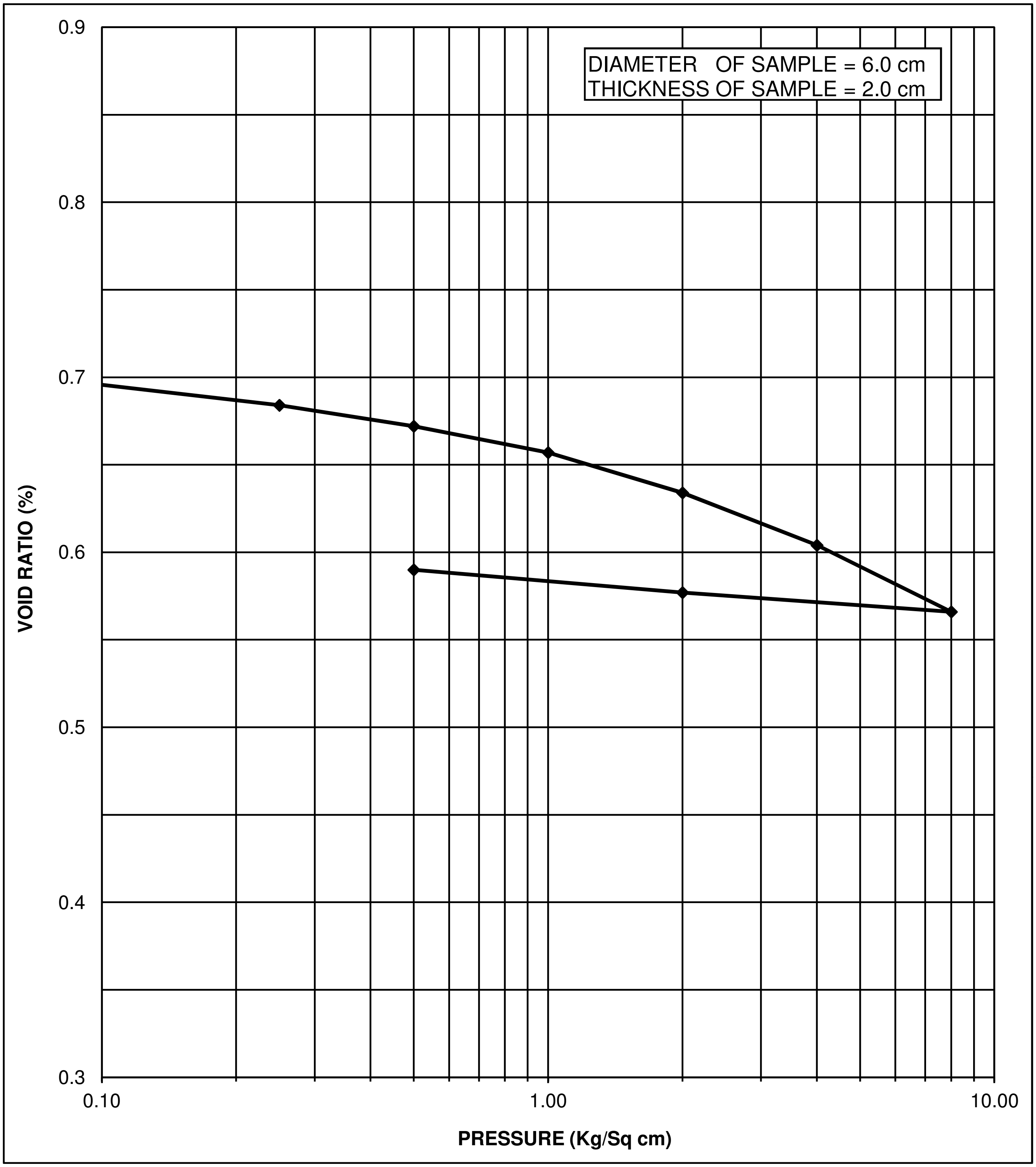


BORE HOLE NO: BH-A2
Chainage: 28+900
SAMPLE NO.: UDS-2
DEPTH: 4.00 m
COHESION(C)= 0.20 kg/sq.cm
ANGLE OF FRICTION(Phi): 26 deg
TYPE OF THE TEST: DST





CEG Test House and Research Centre Pvt. Ltd.



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 %

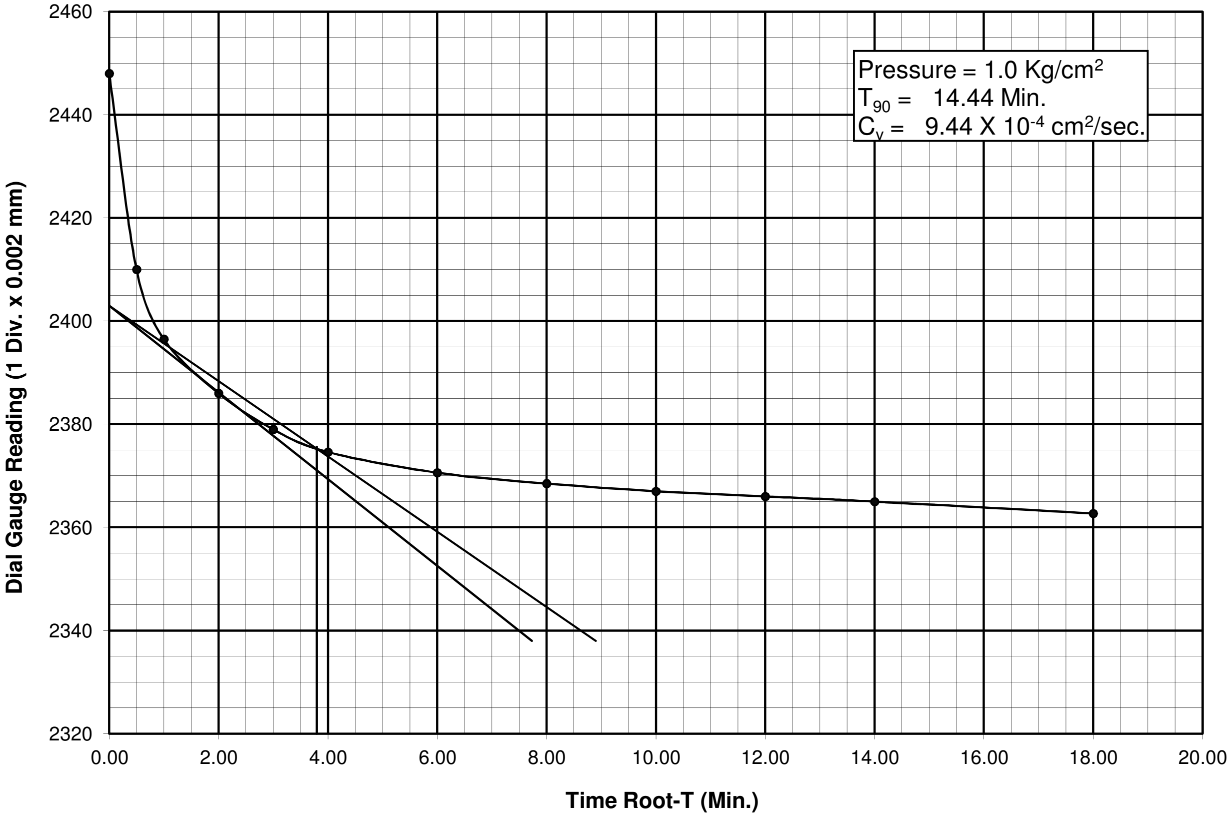
DRY DENSITY = 1.58 gm/cm$^3$

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


Pressure = 1.0 Kg/cm$^2$
$T_{90}$ = 14.44 Min.
$C_v$ = 9.44 X $10^{-4}$ cm$^2$/sec.

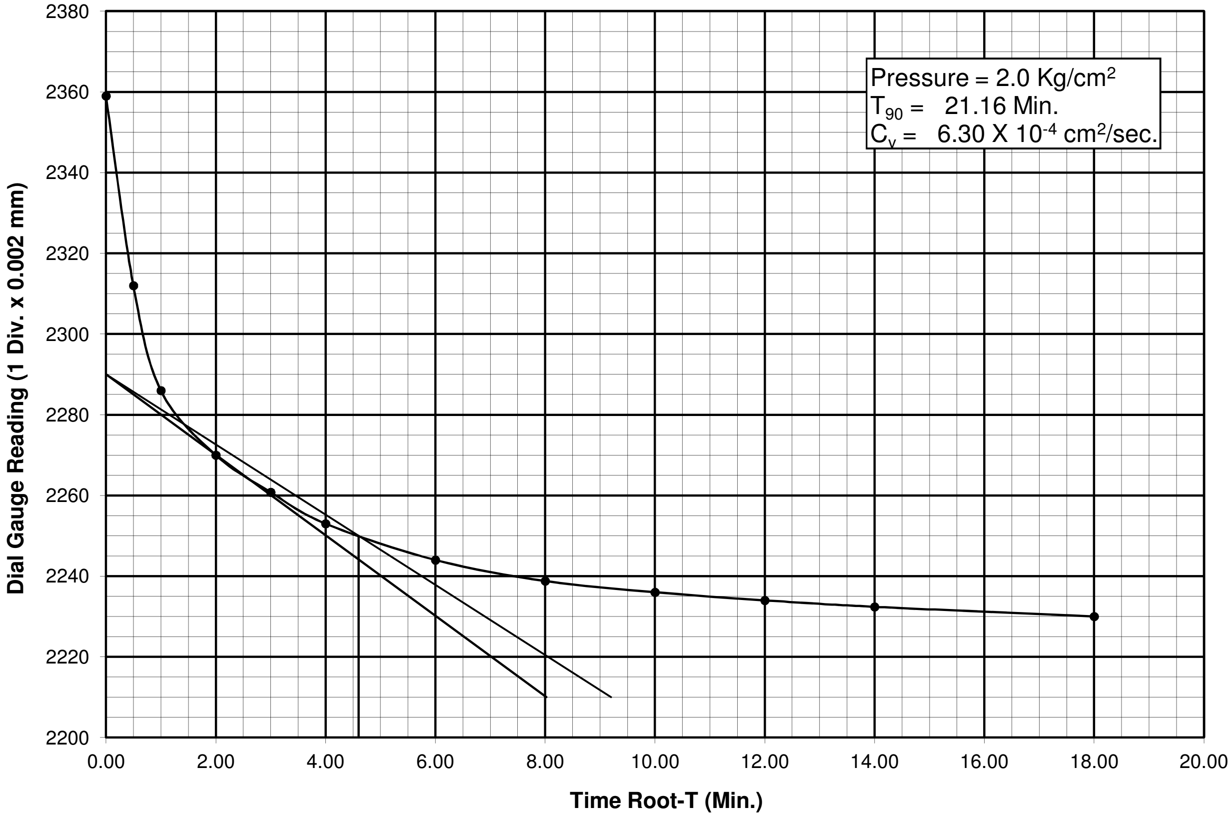
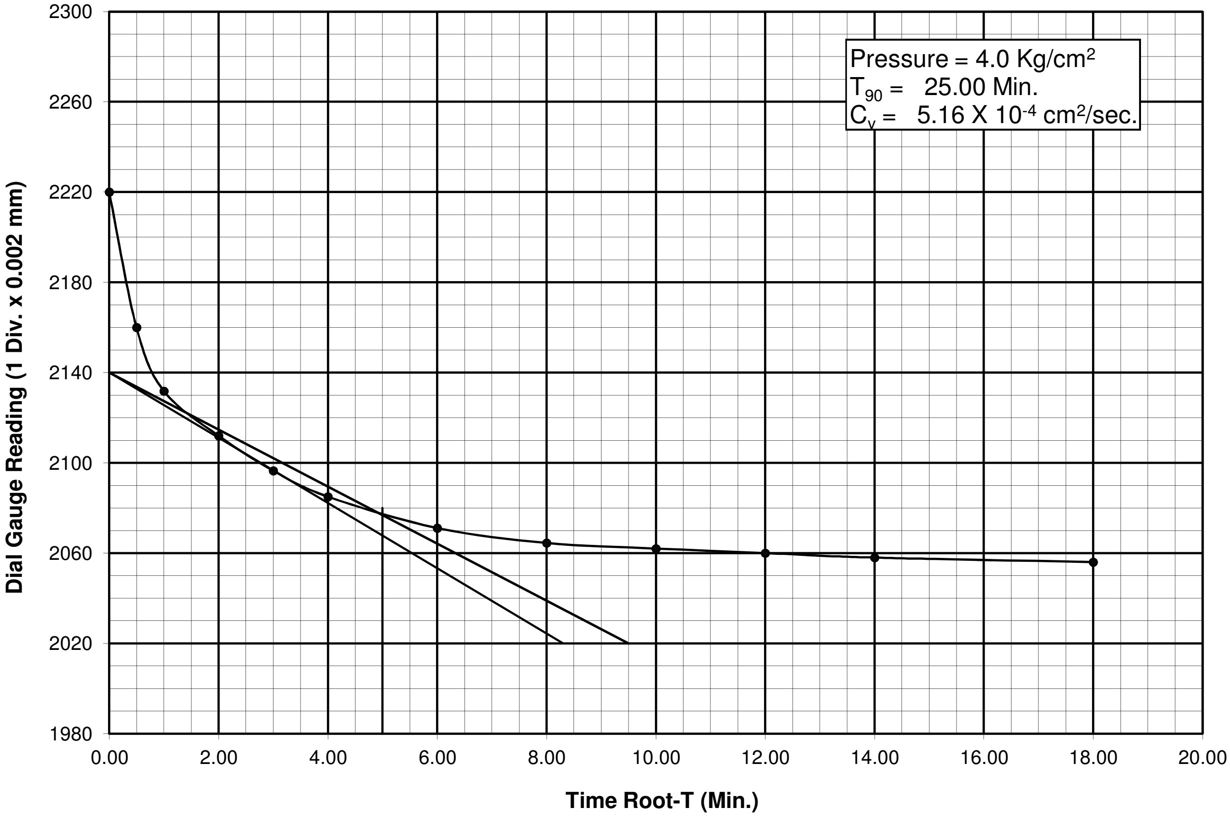
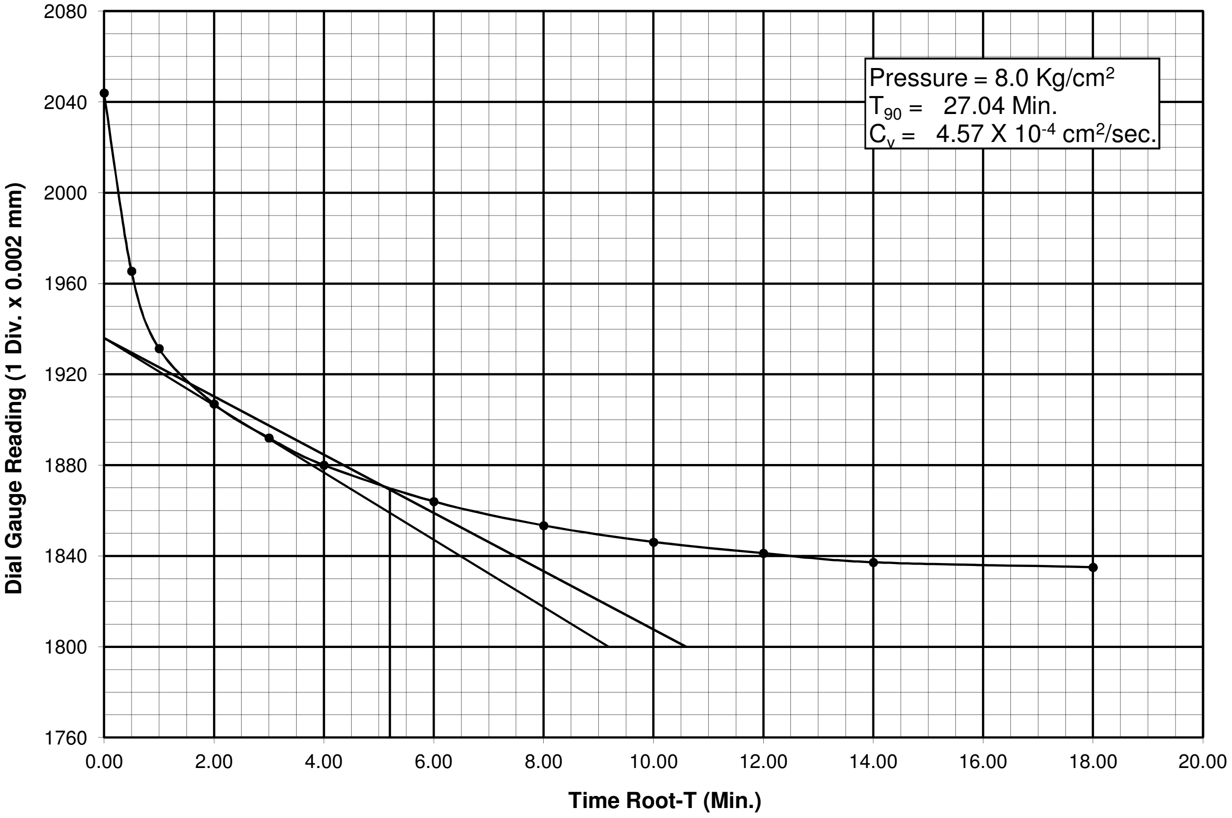

Pressure = 2.0 Kg/cm$^2$
$T_{90}$ = 21.16 Min.
$C_v$ = 6.30 X $10^{-4}$ cm$^2$/sec.

Figure No. -

CHAINAGE: = 27+620
BORE HOLE NO. = BH-P1
SAMPLE NO. = UDS-3
DEPTH = 7.50 M

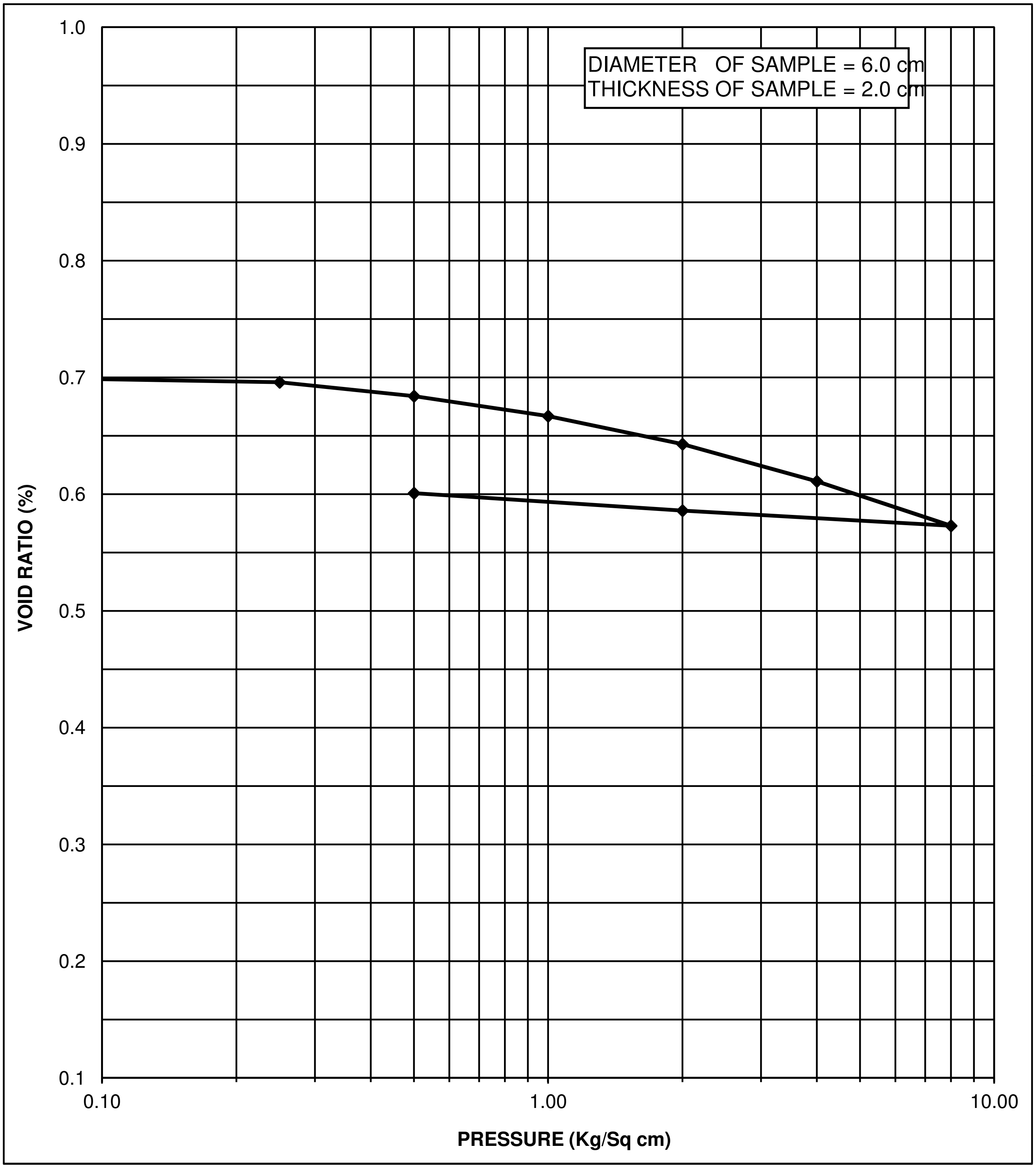


Pressure = 4.0 Kg/cm$^2$
$T_{90}$ = 25.00 Min.
$C_v$ = 5.16 X $10^{-4}$ cm$^2$/sec.



Pressure = 8.0 Kg/cm$^2$
$T_{90}$ = 27.04 Min.
$C_v$ = 4.57 X $10^{-4}$ cm$^2$/sec.

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 %

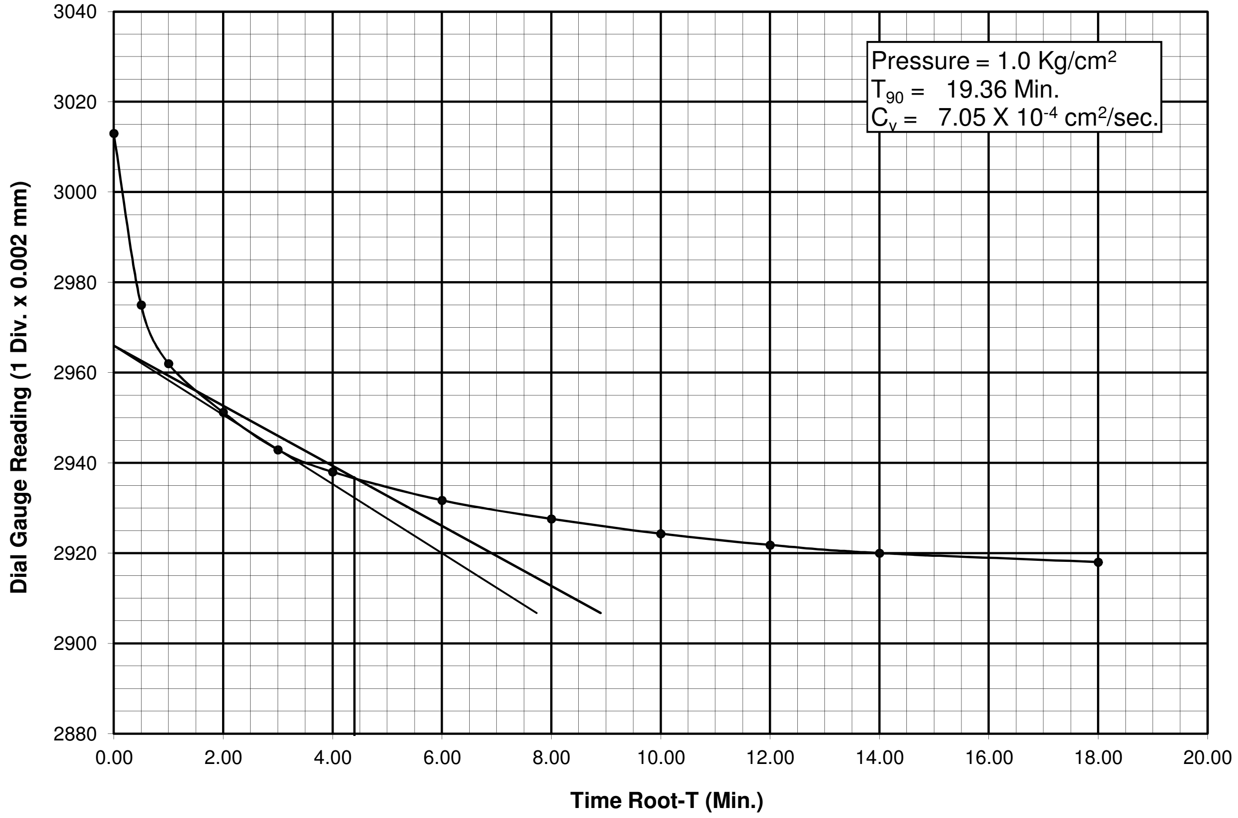
DRY DENSITY = 1.57 gm/cm$^3$

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


Pressure = 1.0 Kg/cm$^2$
$T_{90}$ = 19.36 Min.
$C_v$ = 7.05 X $10^{-4}$ cm$^2$/sec.

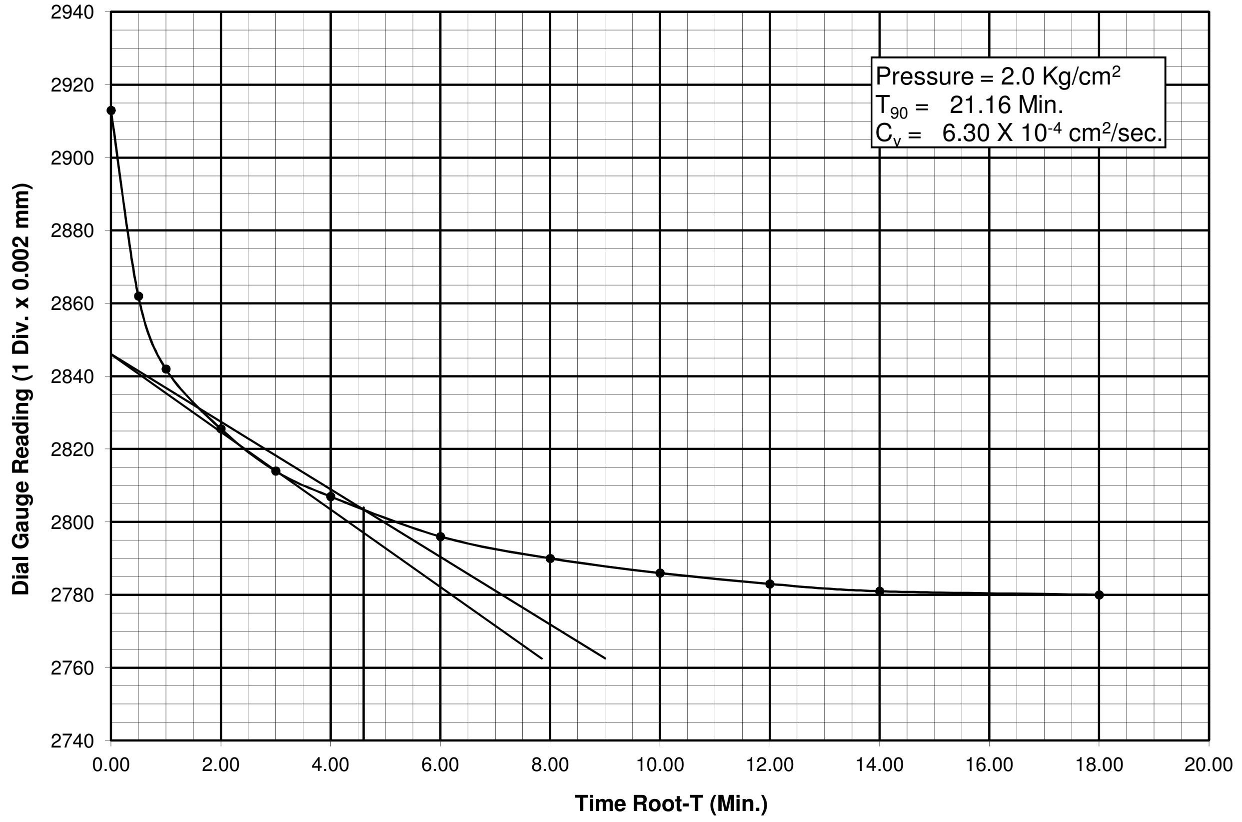
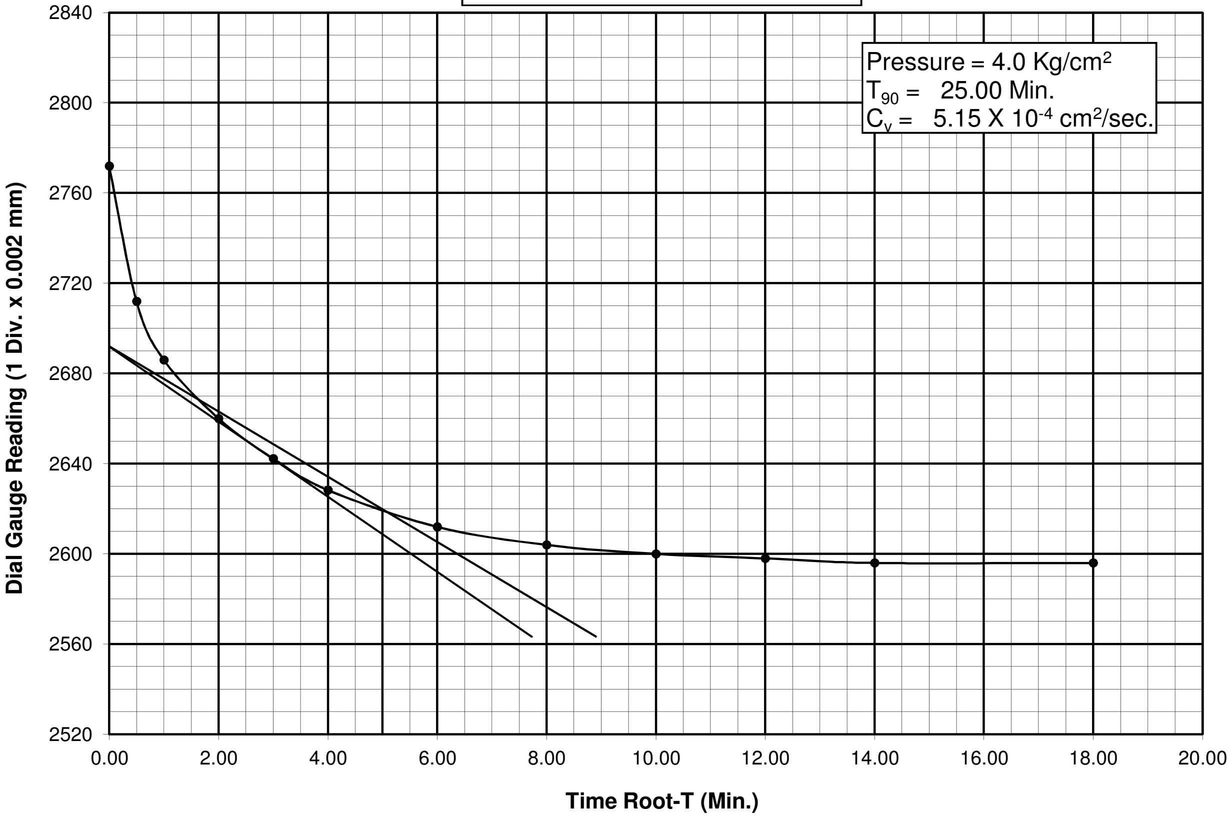

Pressure = 2.0 Kg/cm$^2$
$T_{90}$ = 21.16 Min.
$C_v$ = 6.30 X $10^{-4}$ cm$^2$/sec.

Figure No. -

CHAINAGE = 28+075
BORE HOLE NO. = BH-P1
SAMPLE NO. = UDS-3
DEPTH = 7.00 M



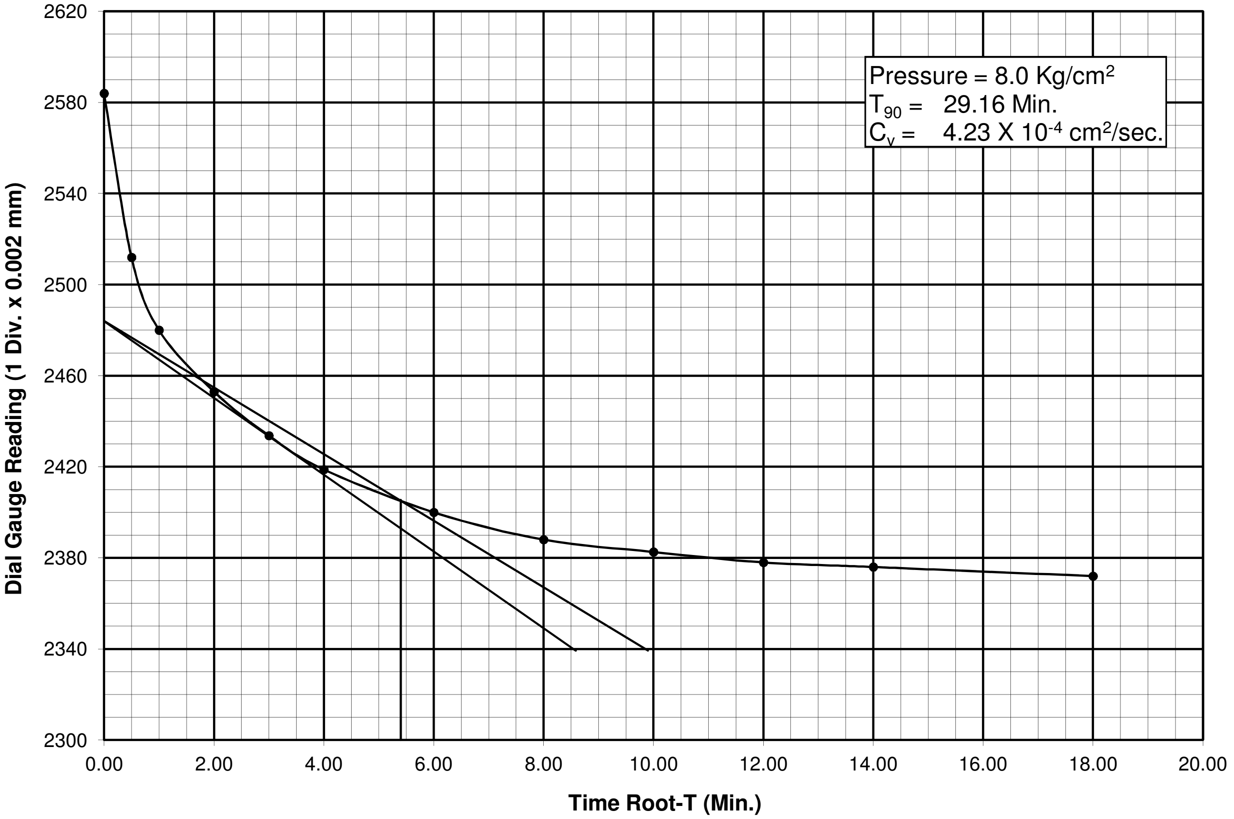
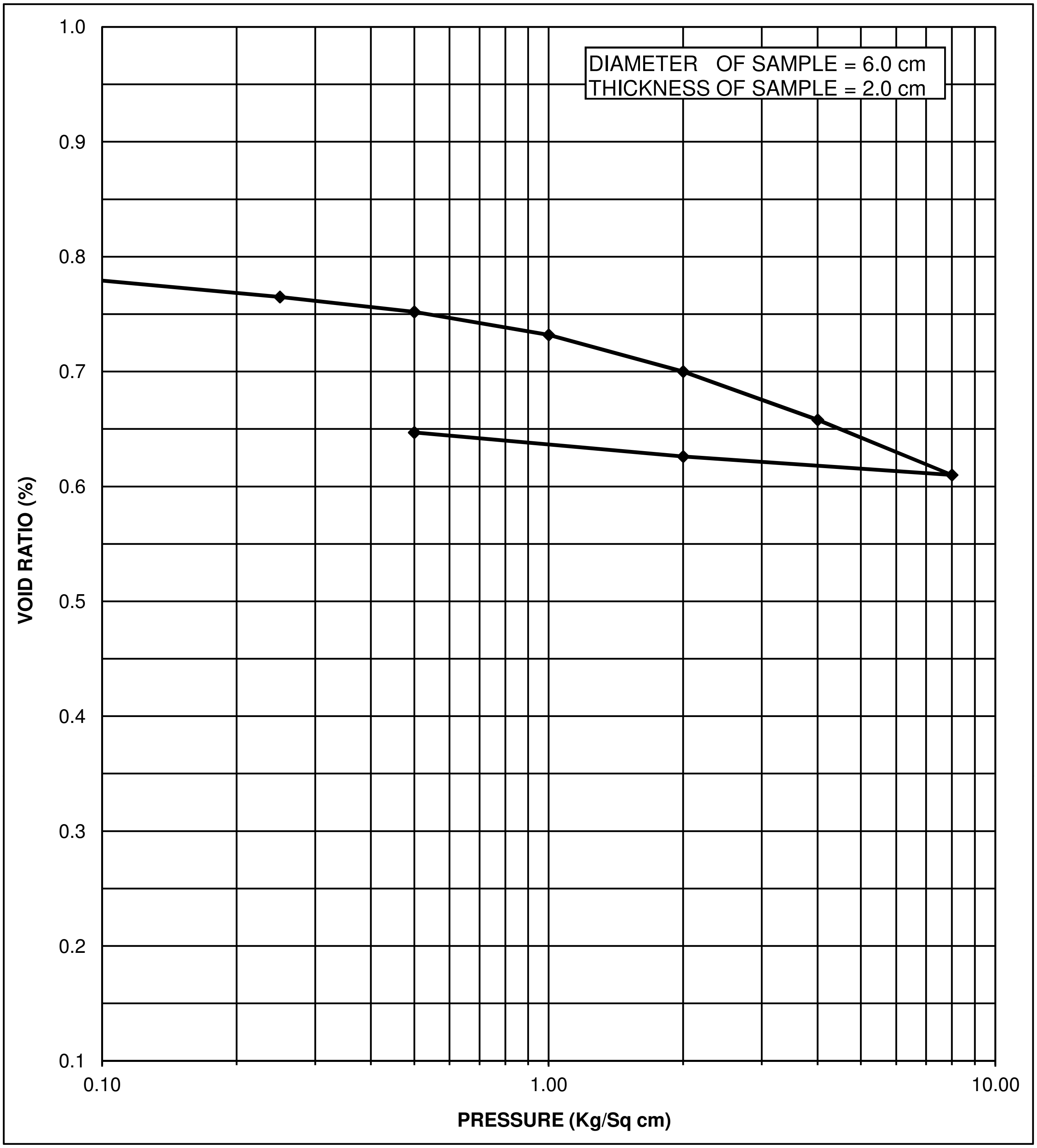


Figure No. -



CHAINAGE = 28+075

BORE HOLE NO. = BH-A2

SAMPLE NO. = UDS-1

DEPTH = 1.00 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 12.64 %

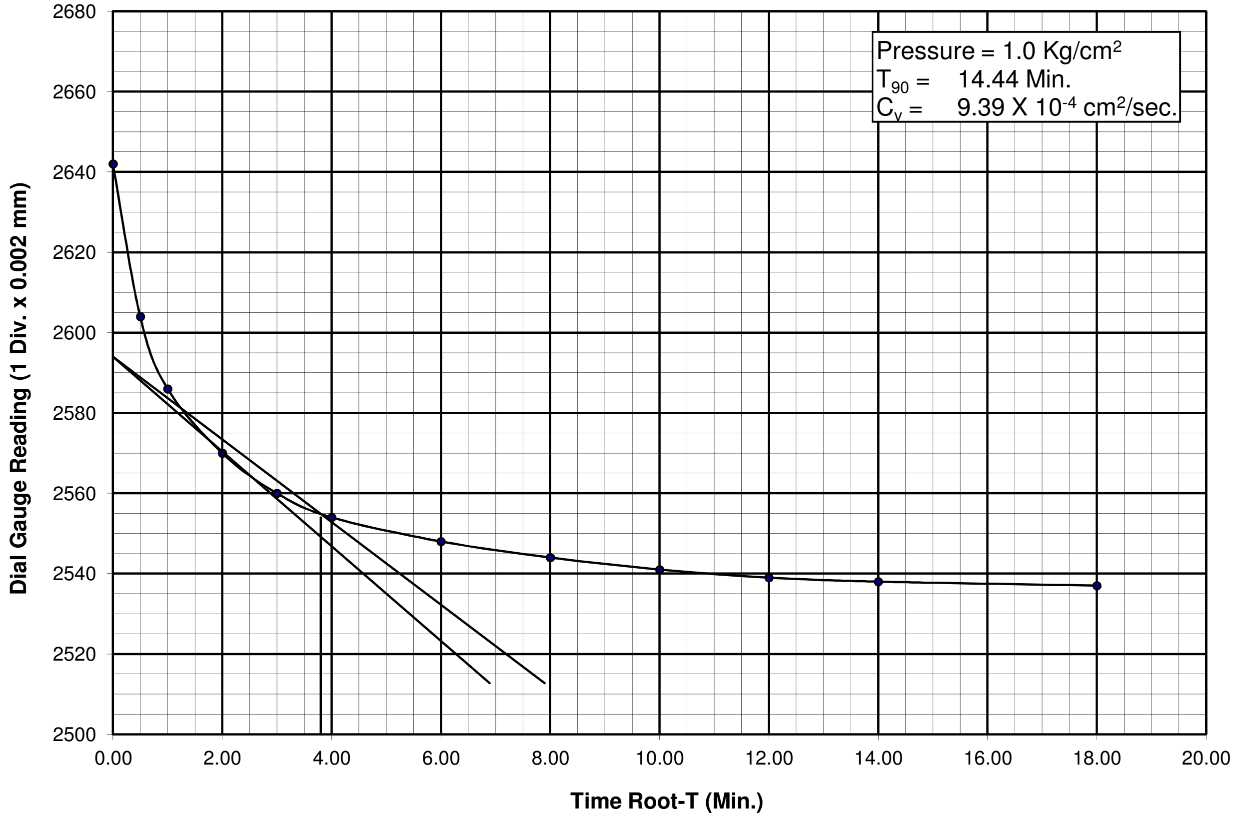
DRY DENSITY = 1.50 gm/cm$^3$

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


Pressure = 1.0 Kg/cm$^2$
$T_{90}$ = 14.44 Min.
$C_v$ = 9.39 X $10^{-4}$ cm$^2$/sec.

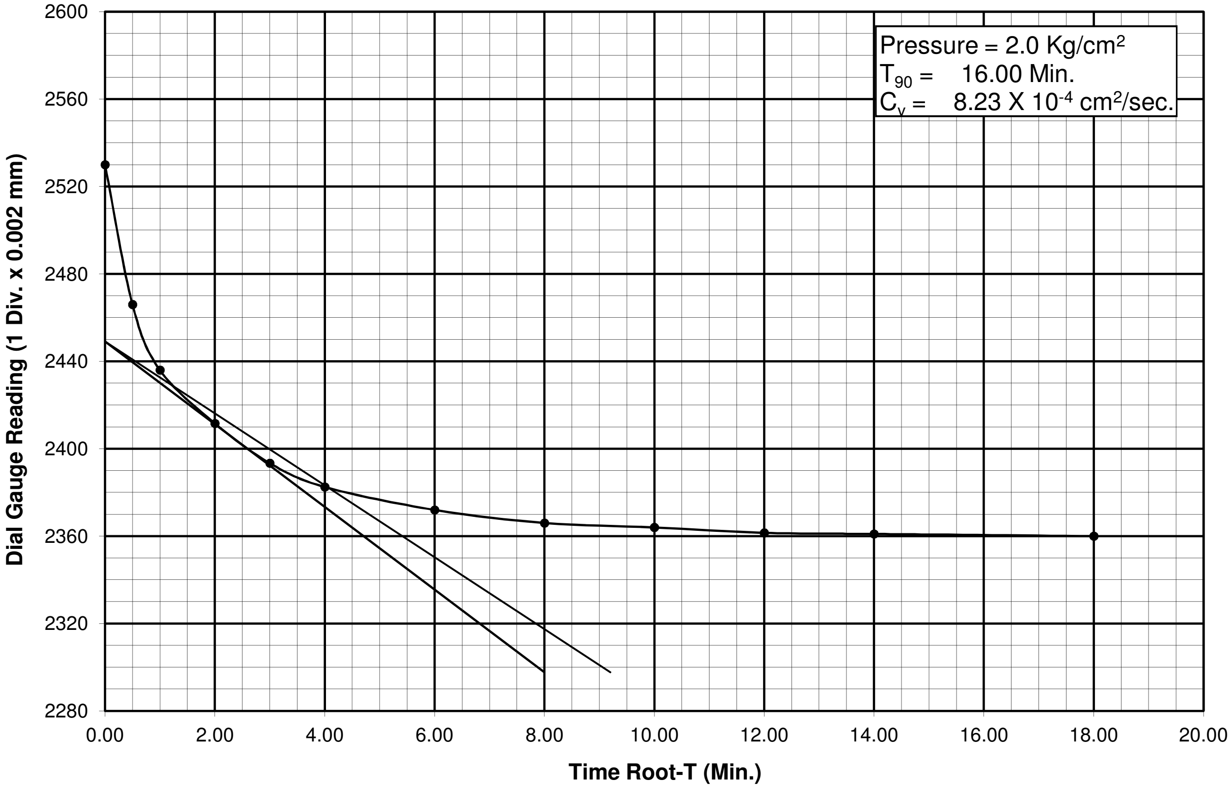
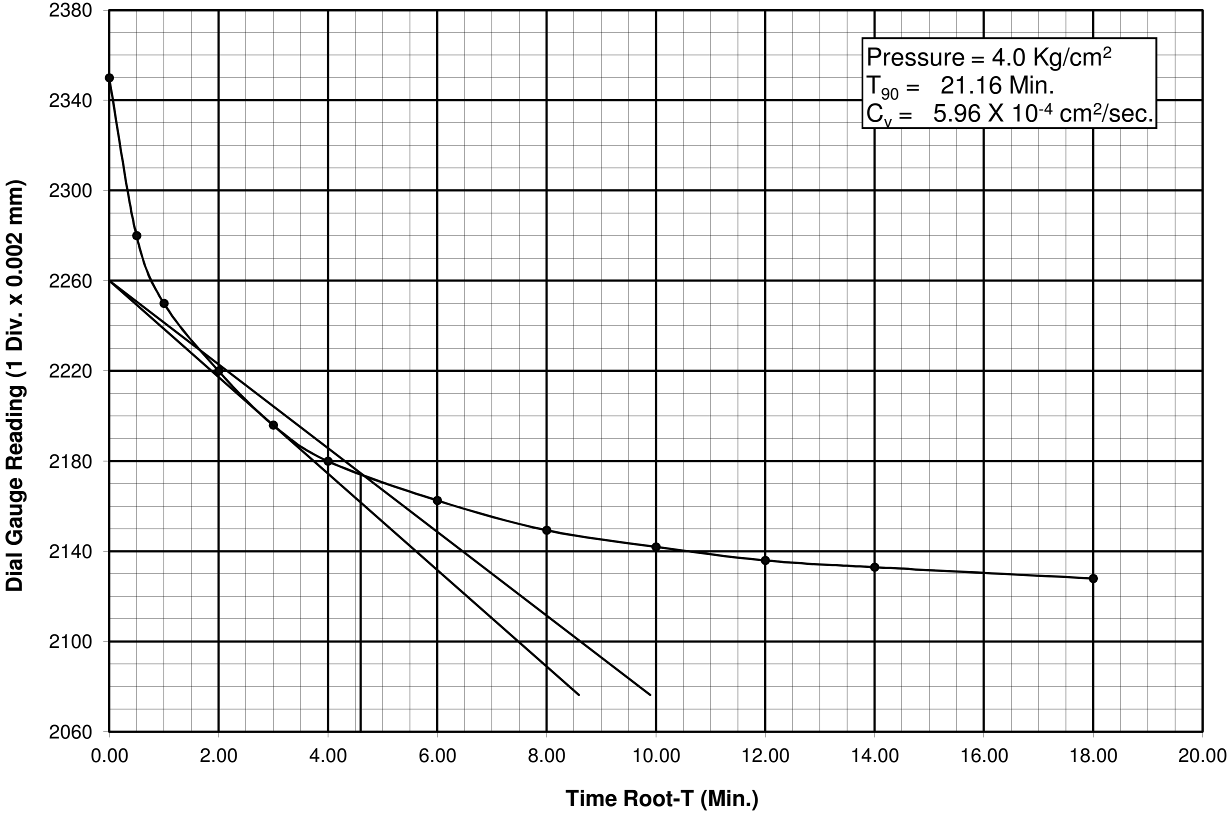

Pressure = 2.0 Kg/cm$^2$
$T_{90}$ = 16.00 Min.
$C_v$ = 8.23 X $10^{-4}$ cm$^2$/sec.

Figure No. -

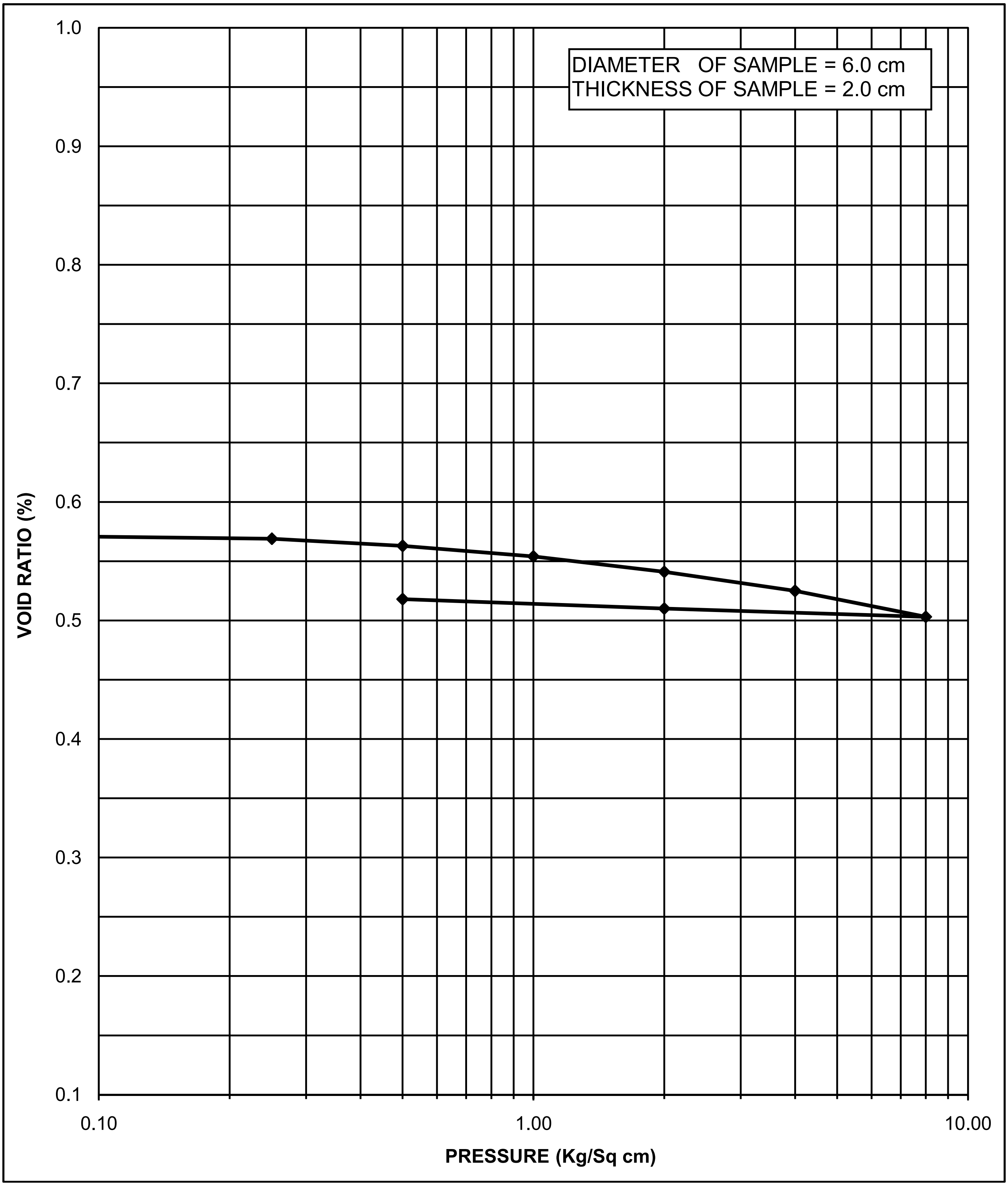
CHAINAGE = 28+075
BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-2
DEPTH = 4.50 M



Pressure = 4.0 Kg/cm$^2$
$T_{90}$ = 21.16 Min.
$C_v$ = 5.96 X $10^{-4}$ cm$^2$/sec.

Pressure = 8.0 Kg/cm$^2$
$T_{90}$ = 25.00 Min.
$C_v$ = 4.78 X $10^{-4}$ cm$^2$/sec.

Figure No. -



BORE HOLE NO. = BH-P2

SAMPLE NO. = UDS-7

DEPTH = 20.50 M

TYPY OF SOIL = CL

INITIAL WATER CONTENT = 17.20 %

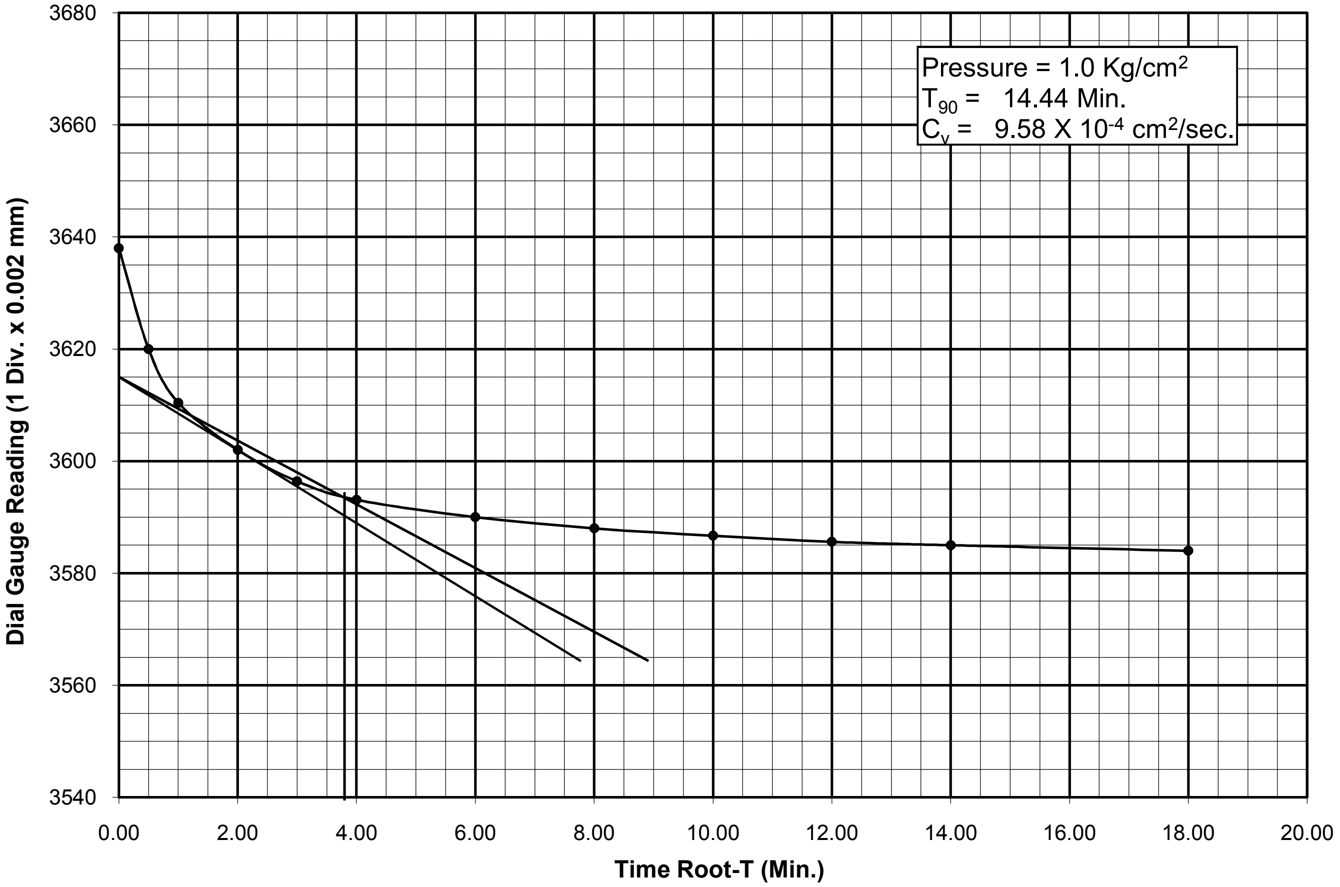
DRY DENSITY = 1.70 gm/cm$^3$

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



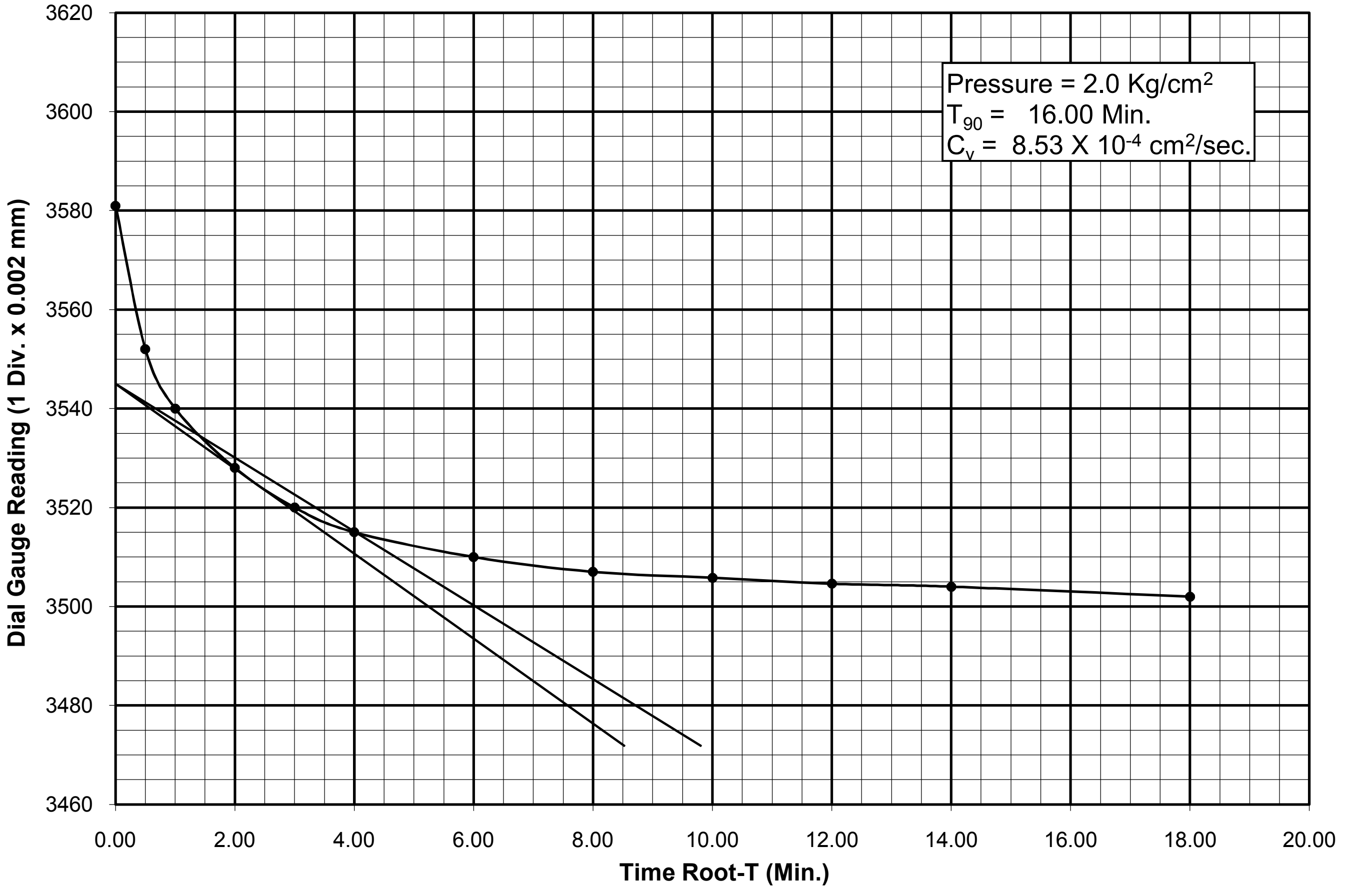
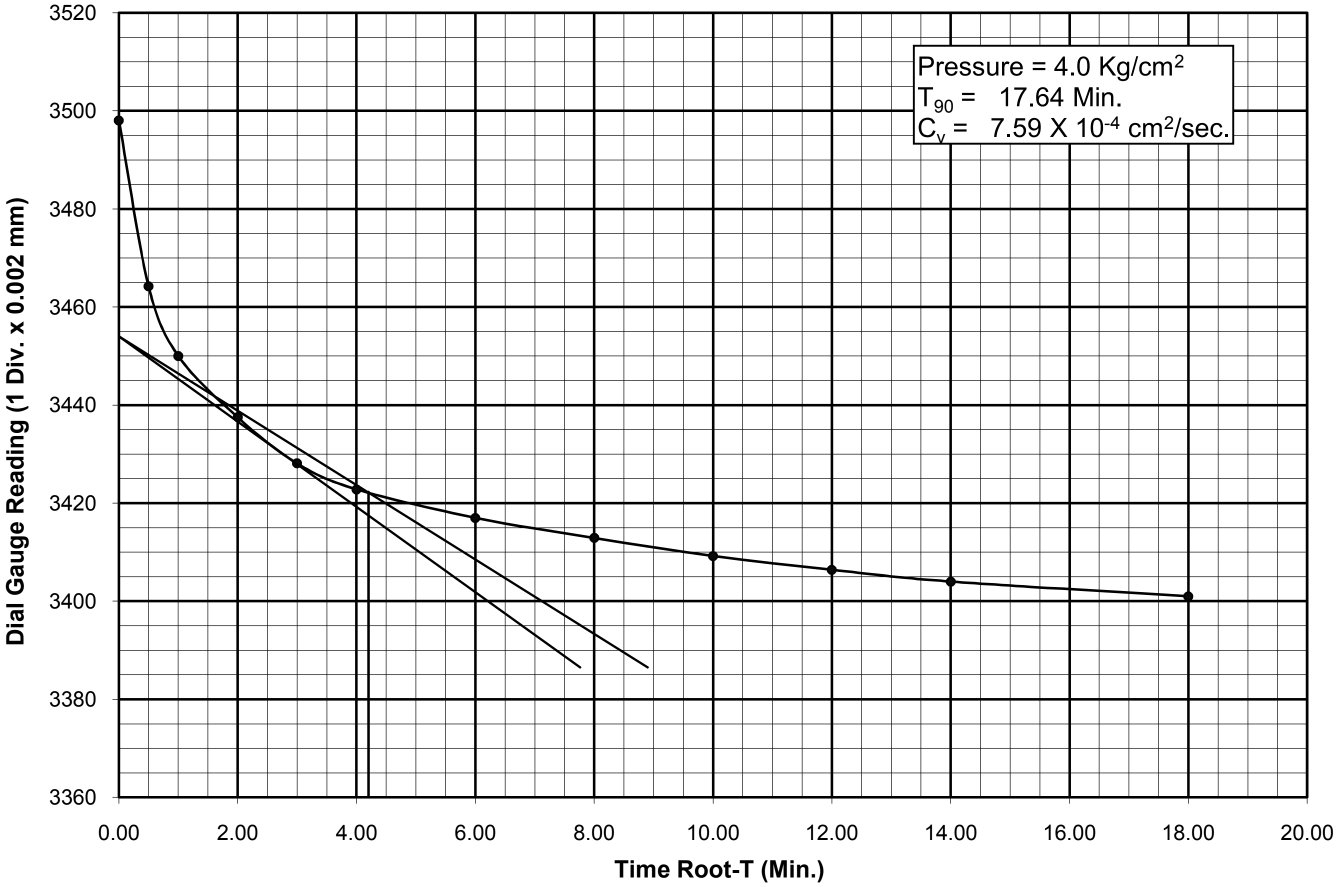


Figure No. -

BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-7
DEPTH = 20.50 M



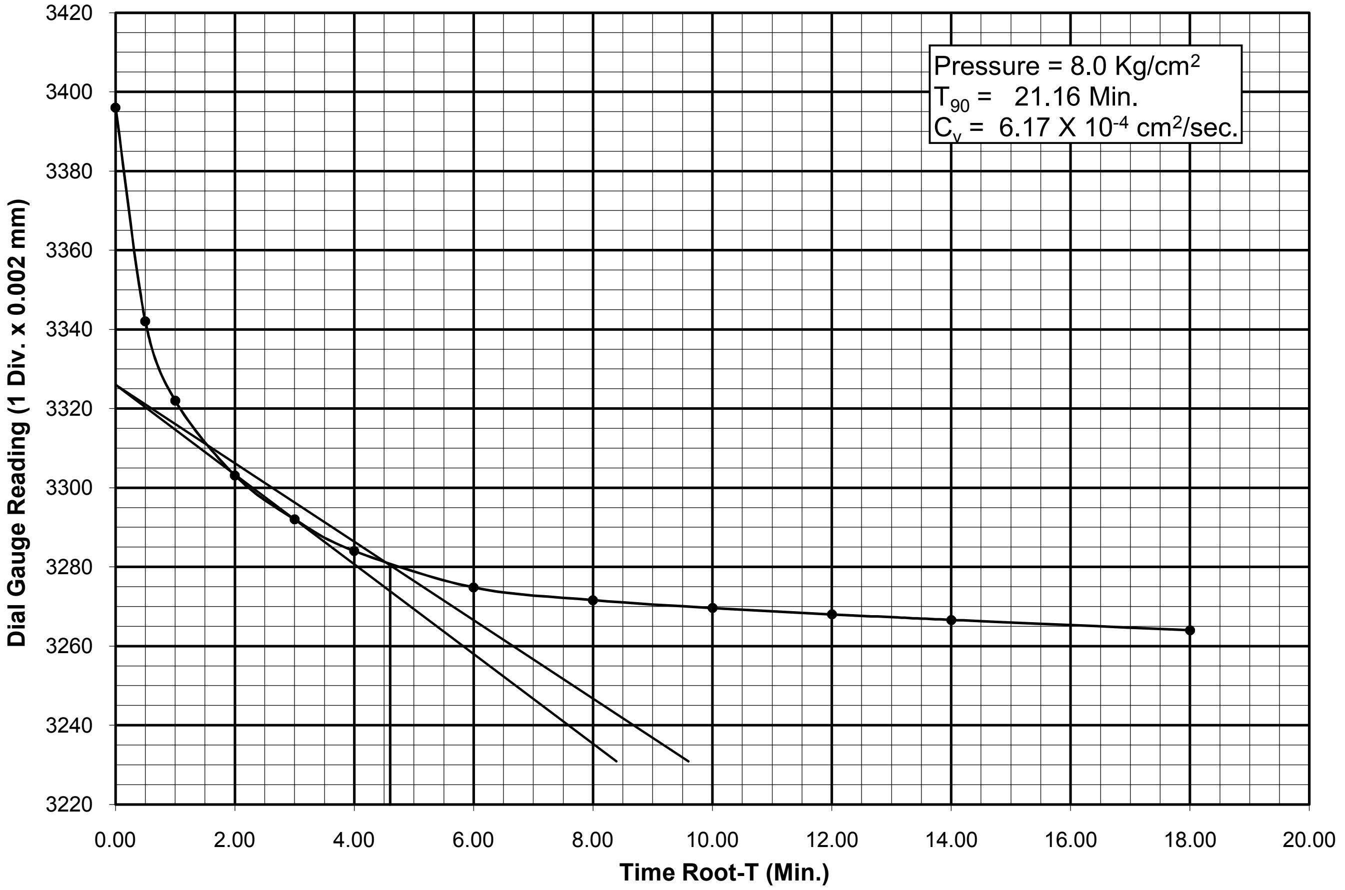
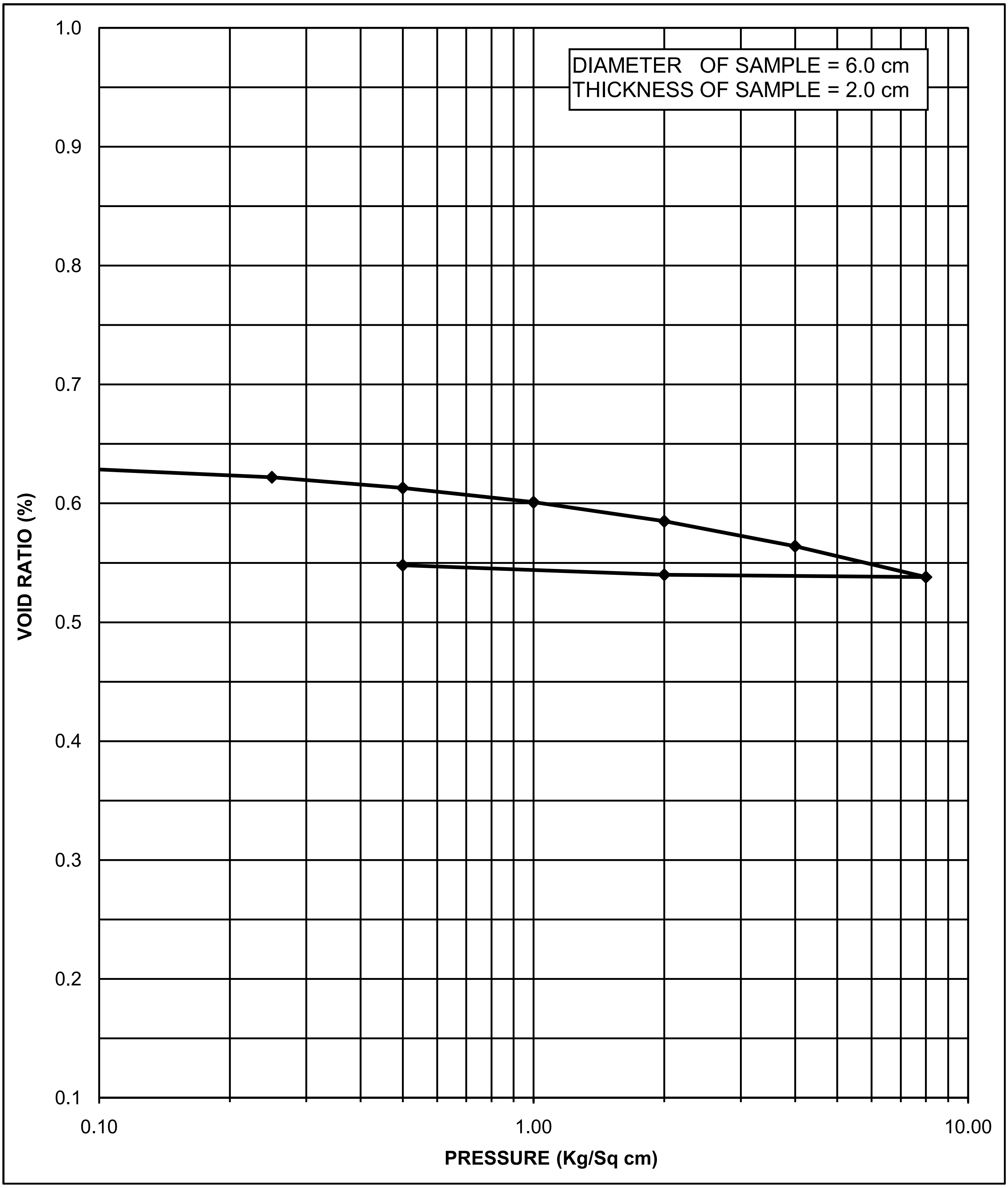


Figure No. -



BORE HOLE NO. = BH-A2

SAMPLE NO. = UDS-5

DEPTH = 13.00 M

TYPE OF SOIL = CL

INITIAL WATER CONTENT = 15.90 %

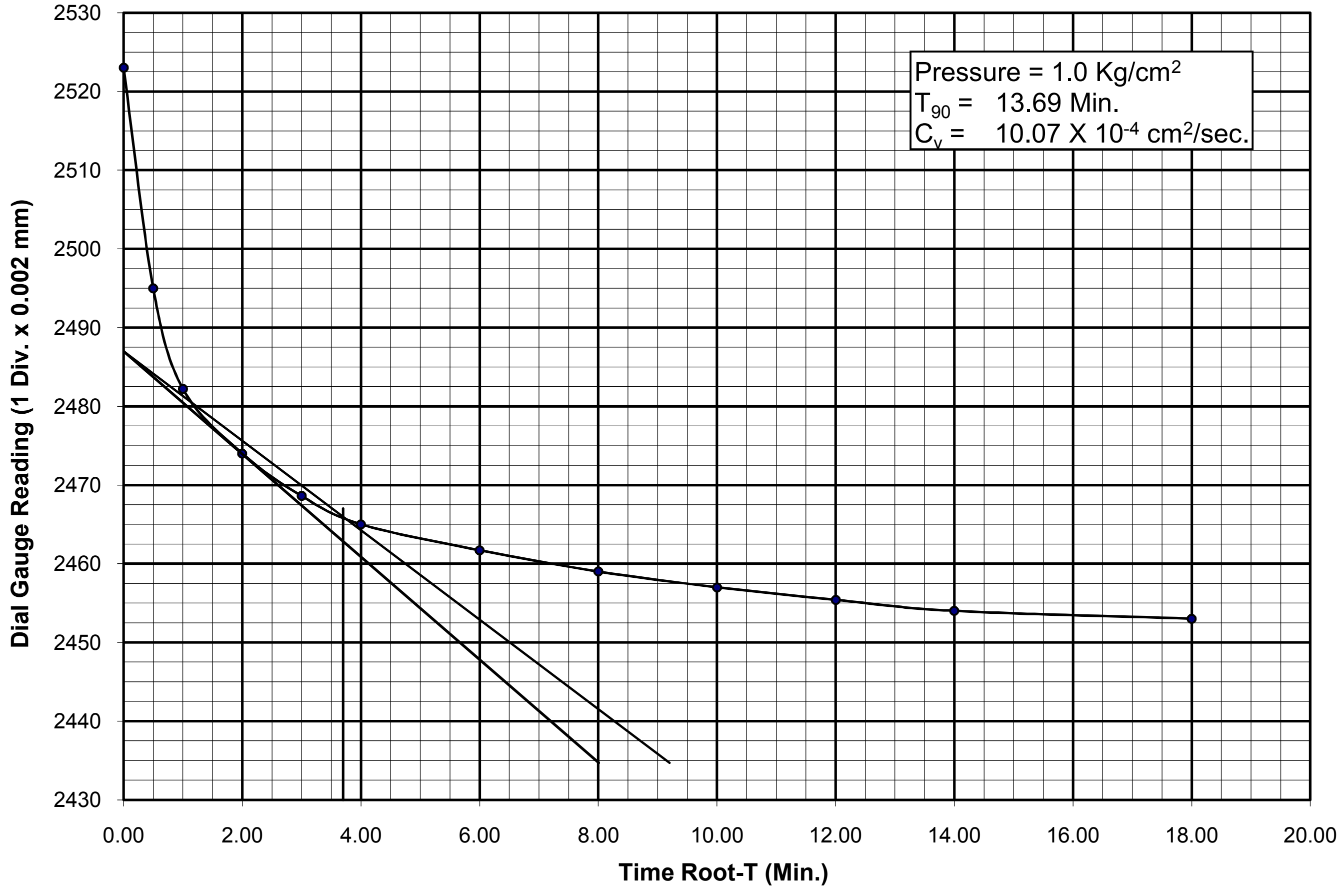
DRY DENSITY = 1.64 gm/cm$^3$

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


Pressure = 1.0 Kg/cm$^2$
$T_{90}$ = 13.69 Min.
$C_v$ = 10.07 X $10^{-4}$ cm$^2$/sec.

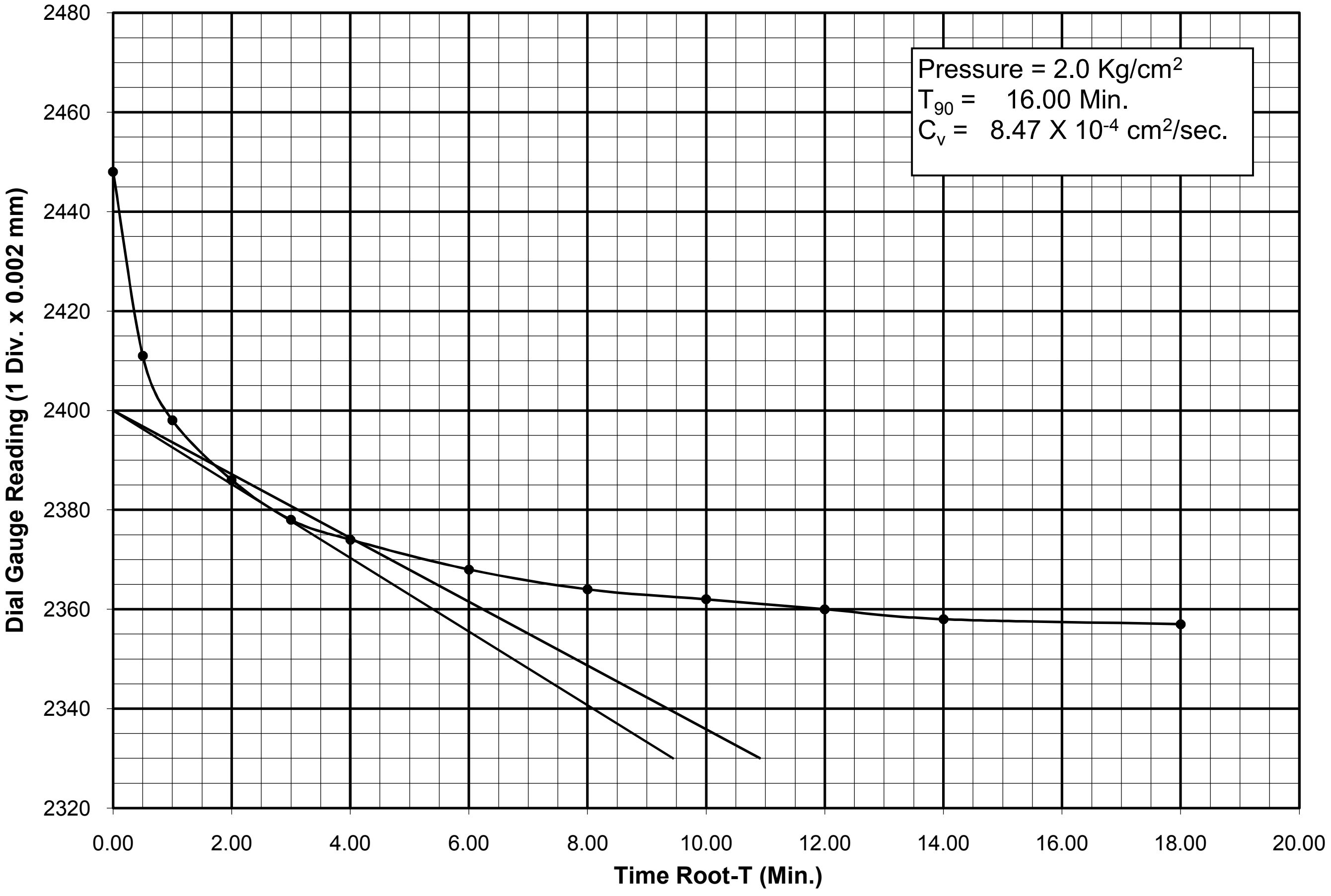
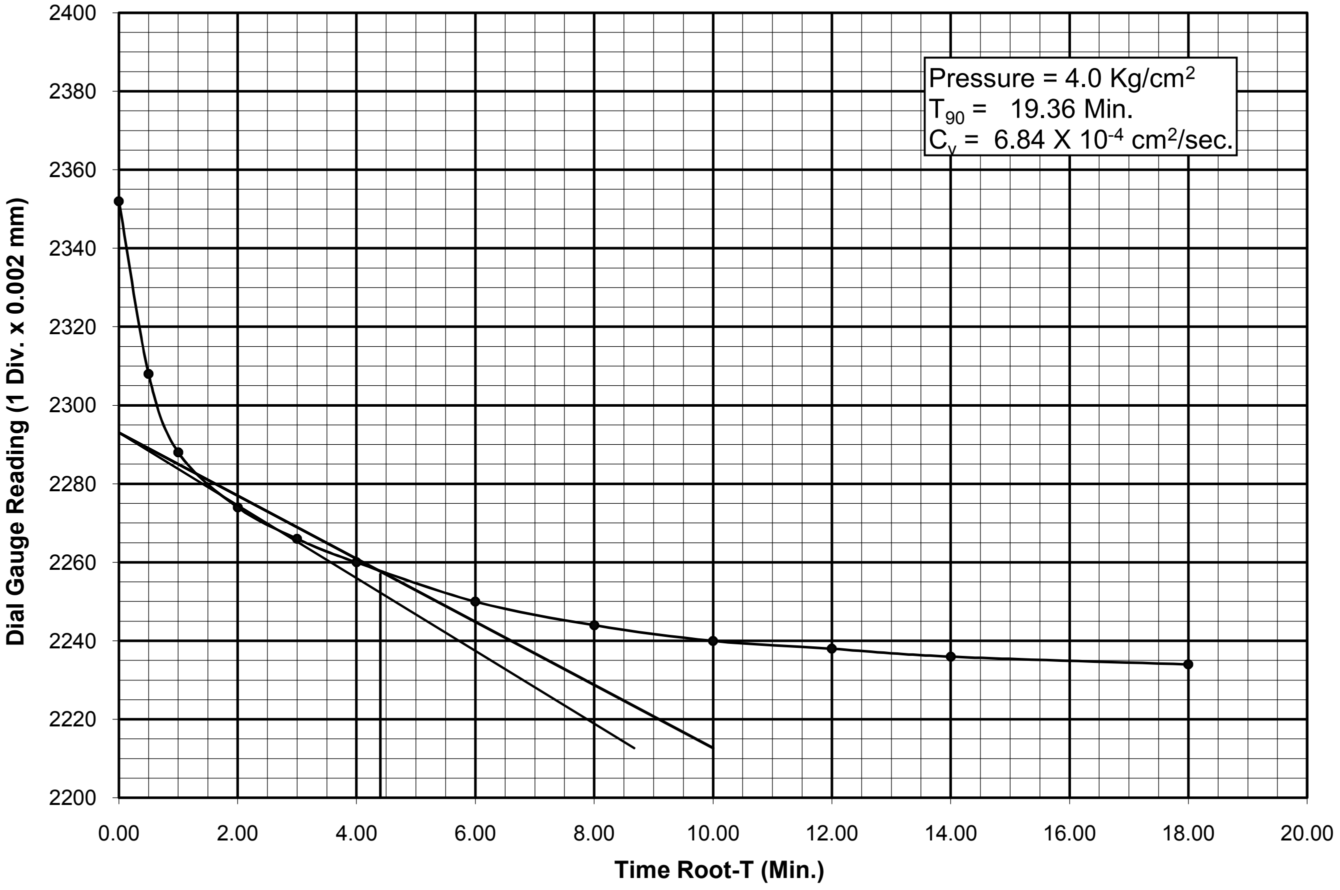

Pressure = 2.0 Kg/cm$^2$
$T_{90}$ = 16.00 Min.
$C_v$ = 8.47 X $10^{-4}$ cm$^2$/sec.

Figure No. -

BORE HOLE NO. = BH-A2
SAMPLE NO. = UDS-5
DEPTH = 13.00 M


Pressure = 4.0 Kg/cm$^2$
$T_{90}$ = 19.36 Min.
$C_v$ = 6.84 X $10^{-4}$ cm$^2$/sec.

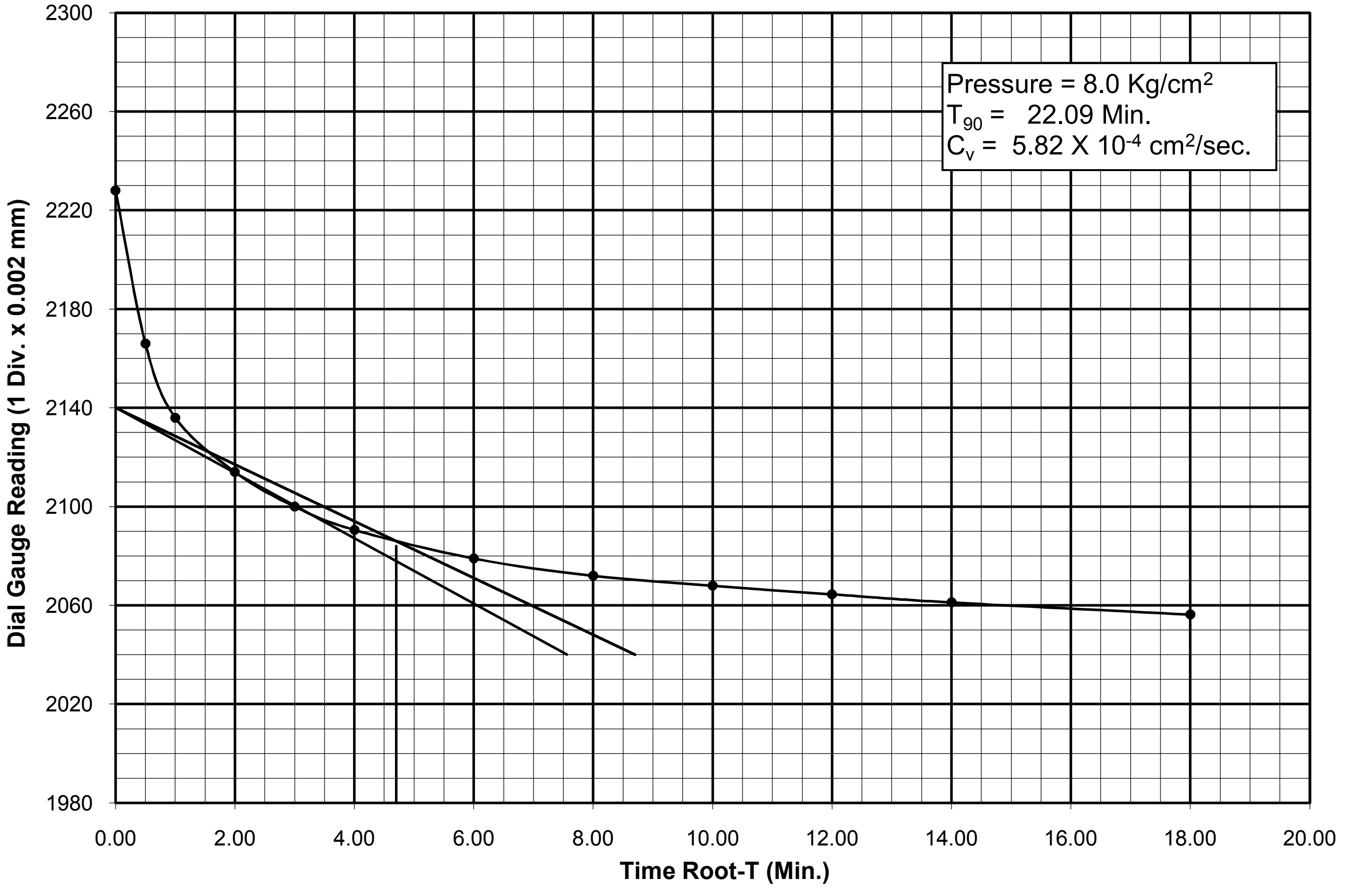

Pressure = 8.0 Kg/cm$^2$
$T_{90}$ = 22.09 Min.
$C_v$ = 5.82 X $10^{-4}$ cm$^2$/sec.

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**

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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

**On Rock Samples**

  - 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:

$$N' = 15 + \frac{1}{2}(N-15)$$

**(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<br>• Liquid Limit<br>• Plastic Limit | <br>IS: 2720 (Part - 5)<br>IS: 2720 (Part - 5) | <br>√<br>√ | <br>√<br>√ |
| Specific Gravity | IS : 2720 (Part – 3) | √ | - |
| Direct Shear Test | IS : 2720 (Part – 13) | √ | - |
| Triaxial compressive shear test | IS : 2720<br>(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 ($\gamma_b$) = W/V

Dry density ($\gamma_d$) = $\gamma_b$/ (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;

$\mu$ = 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,

$q_d = c\, N_c\, s_c\, d_c\, i_c + q\, (N_q-1)\, s_q\, d_q\, i_q + (1/2)\, B\, \gamma\, N_\gamma\, s_\gamma\, d_\gamma\, i_\gamma\, W'$

The ultimate net bearing capacity in case of local shear failure is given by following expression,

$q'_d = (2/3)\, c\, N'_c\, s_c\, d_c\, i_c + q\, (N'_q-1)\, s_q\, d_q\, i_q + (1/2)\, B\, \gamma\, N'_\gamma\, s_\gamma\, d_\gamma\, i_\gamma\, W'$

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 $\phi > 10^o$

$N_\phi = \tan^2(\pi/4 + \phi/2)$

$\phi'$ 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, $cm^2/kg$

$\Delta P$ = 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: $m_v = 1/(f_2N)$ | | | | |
|---|---|---|---|---|---|---|
| | | 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

$\gamma$ = effective unit weight of the soil at pile tip in kN/m$^3$

$N_\gamma$ & $N_q$ = bearing capacity factors depending upon the angle of internal friction $\Phi$ at pile tip ($N_\gamma$ 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)

$\delta_i$ = 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)**

$$Q_u = cp*Nc*A_p + \Sigma\alpha_i*c_i*A_{si}$$

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

$\alpha_i$ = 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. **Fixed Head Condition**

$$Q = (12 * E * I * Y) / (L_1 + L_f)^3$$

ii. **Free Head Condition**

$$Q = (3 * E * I * Y) / (L_1 + L_f)^3$$

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$^2$.

***<u>Notes:</u>* -**

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 | 2.0 | 158.0 | 134.0 | 9.6 |
| | | | | 22.0 | | 185.0 | 150.0 | |
| | | | | 24.0 | | 200.0 | 166.0 | |
| | | | | 26.0 | | 214.0 | 182.0 | |
| | | | | 28.0 | | 229.0 | 198.0 | |
| | | | | 30.0 | | 244.0 | 214.0 | |
| | | | 1.2 | 20.0 | | 205.0 | 172.0 | 13.4 |
| | | | | 22.0 | | 241.0 | 193.0 | |
| | | | | 24.0 | | 260.0 | 214.0 | |
| | | | | 26.0 | | 278.0 | 234.0 | |
| | | | | 28.0 | | 296.0 | 255.0 | |
| | | | | 30.0 | | 315.0 | 276.0 | |
| | | BH-A2 | 1.0 | 20.0 | | 163.0 | 136.0 | 13.2 |
| | | | | 22.0 | | 178.0 | 153.0 | |
| | | | | 24.0 | | 195.0 | 171.0 | |
| | | | | 26.0 | | 242.0 | 191.0 | |
| | | | | 28.0 | | 261.0 | 210.0 | |
| | | | | 30.0 | | 286.0 | 231.0 | |
| | | | 1.2 | 20.0 | | 212.0 | 175.0 | 17.2 |
| | | | | 22.0 | | 231.0 | 197.0 | |
| | | | | 24.0 | | 252.0 | 220.0 | |
| | | | | 26.0 | | 315.0 | 246.0 | |
| | | | | 28.0 | | 339.0 | 271.0 | |
| | | | | 30.0 | | 364.0 | 297.0 | |
| 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 | |
| | | | | 26.0 | | 259.0 | 198.0 | |
| | | | | 28.0 | | 279.0 | 218.0 | |
| | | | | 30.0 | | 299.0 | 239.0 | |
| | | | 1.2 | 20.0 | | 206.0 | 179.0 | 19.3 |

| 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 |
| | | | | 22.0 | | 232.0 | 200.0 | |
| | | | | 24.0 | | 312.0 | 226.0 | |
| | | | | 26.0 | | 336.0 | 252.0 | |
| | | | | 28.0 | | 361.0 | 279.0 | |
| | | | | 30.0 | | 385.0 | 305.0 | |
| 16+042 | 16+727 | BH-A2 | 1.0 | 20.0 | 2.0 | 164.0 | 128.0 | 9.4 |
| | | | | 22.0 | | 183.0 | 144.0 | |
| | | | | 24.0 | | 198.0 | 161.0 | |
| | | | | 26.0 | | 213.0 | 177.0 | |
| | | | | 28.0 | | 228.0 | 194.0 | |
| | | | | 30.0 | | 243.0 | 210.0 | |
| | | | 1.2 | 20.0 | | 215.0 | 164.0 | 14.0 |
| | | | | 22.0 | | 234.0 | 185.0 | |
| | | | | 24.0 | | 257.0 | 207.0 | |
| | | | | 26.0 | | 276.0 | 228.0 | |
| | | | | 28.0 | | 295.0 | 249.0 | |
| | | | | 30.0 | | 314.0 | 271.0 | |
| 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 | |
| | | | | 26.0 | | 260.0 | 201.0 | |
| | | | | 28.0 | | 282.0 | 223.0 | |
| | | | | 30.0 | | 305.0 | 246.0 | |
| | | | 1.2 | 20.0 | | 212.0 | 173.0 | 16.6 |
| | | | | 22.0 | | 241.0 | 202.0 | |
| | | | | 24.0 | | 341.0 | 235.0 | |
| | | | | 26.0 | | 373.0 | 267.0 | |
| | | | | 28.0 | | 405.0 | 299.0 | |
| | | | | 30.0 | | 437.0 | 331.0 | |
| | | BH-A2 | 1.0 | 20.0 | 2.0 | 160.0 | 136.0 | 15.1 |
| | | | | 22.0 | | 183.0 | 151.0 | |
| | | | | 24.0 | | 197.0 | 167.0 | |
| | | | | 26.0 | | 218.0 | 188.0 | |
| | | | | 28.0 | | 278.0 | 211.0 | |

| 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<br>Fixed Head |
| | | | | 30.0 | | 301.0 | 234.0 | |
| | | | 1.2 | 20.0 | | 207.0 | 175.0 | 21.9 |
| | | | | 22.0 | | 238.0 | 195.0 | |
| | | | | 24.0 | | 255.0 | 215.0 | |
| | | | | 26.0 | | 284.0 | 245.0 | |
| | | | | 28.0 | | 397.0 | 278.0 | |
| | | | | 30.0 | | 430.0 | 311.0 | |

**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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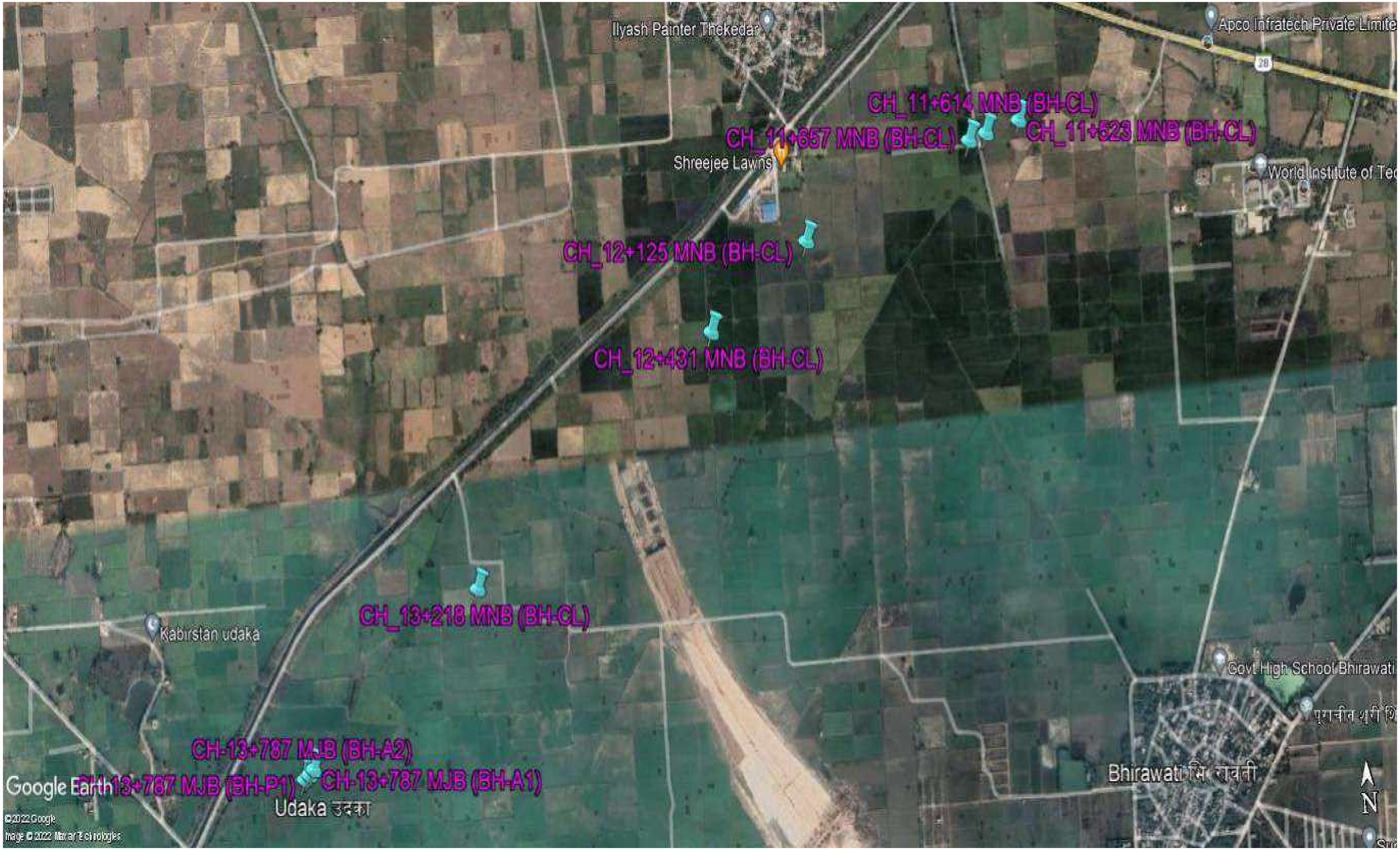
## Abbreviations

| | |
|---|---|
| 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 |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Apco Infratech Private Limite
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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
प्राचीन श्री शि
CH-13+787 MJB (BH-A2)
CH-13+787 MJB (BH-P1)
CH-13+787 MJB (BH-A1)
Udaka उदका
Bhirawati भिरावती
N
Google Earth
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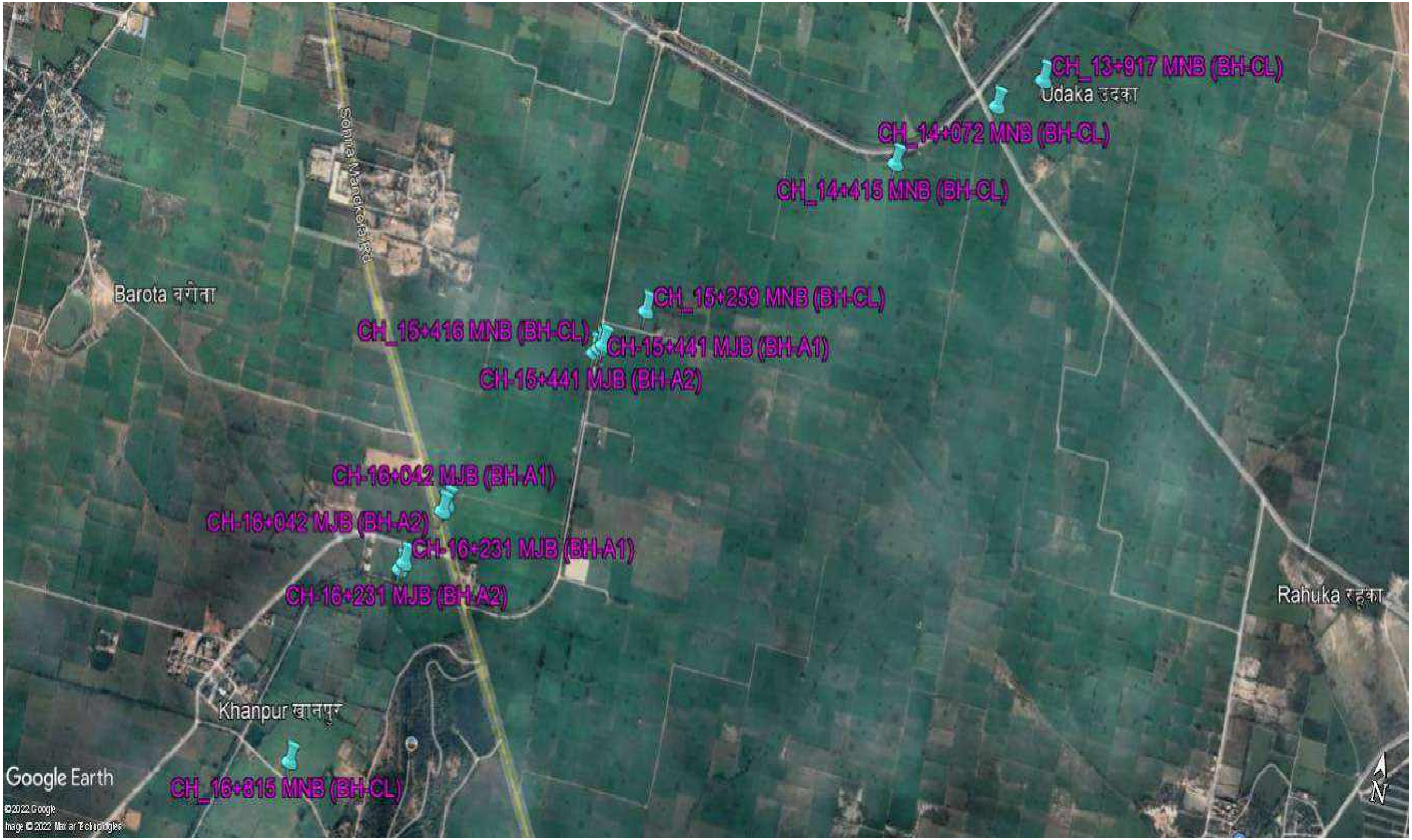
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Udaka उदका
CH_14+072 MNB (BH-CL)
CH_14+415 MNB (BH-CL)
Sohna Mandkola Rd
Barota बरोता
CH_15+259 MNB (BH-CL)
CH_15+416 MNB (BH-CL)
CH-15+441 MJB (BH-A1)
CH-15+441 MJB (BH-A2)
CH-16+042 MJB (BH-A1)
CH-16+042 MJB (BH-A2)
CH-16+231 MJB (BH-A1)
CH-16+231 MJB (BH-A2)
Rahuka रहूका
Khanpur खानपुर
CH_16+615 MNB (BH-CL)
N
Google Earth
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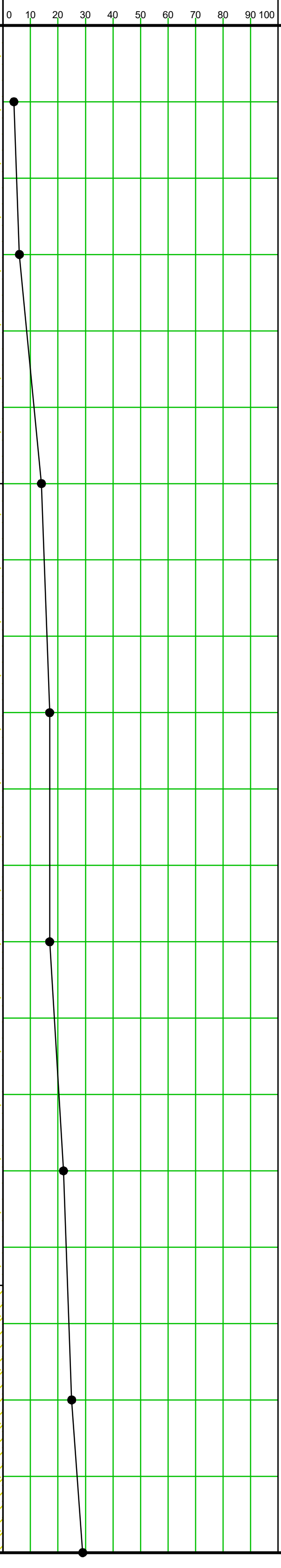
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 0.0 | | DS | | | | | Brown, Loose, Silty sand | SM | | | |
| 0.5 | 0.5 | SPT-1 | 2 | 2 | 2 | 4 | | | | | |
| 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 | 6 | 8 | 14 | | | | | |
| 3.5 | | | | | | | Brown, Medium dense, Silty sand | SM | | | |
| 4.0 | | | | | | | | | 4.22m | | |
| 4.5 | 4.5 | SPT-4 | 6 | 7 | 10 | 17 | | | | | |
| 5.0 | | | | | | | | | | | |
| | 5.25 | UDS-2 | | | | | | | | | |
| 5.5 | | | | | | | | | | | |
| 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 | | | | | | | Brown, Medium dense, Silty sand with clay | SM-SC | | | |
| 9.0 | 9 | SPT-7 | 8 | 11 | 14 | 25 | | | | | |
| 9.5 | | | | | | | | | | | |
| 10.0 | 10 | SPT-8 | 10 | 13 | 16 | 29 | | | | | |

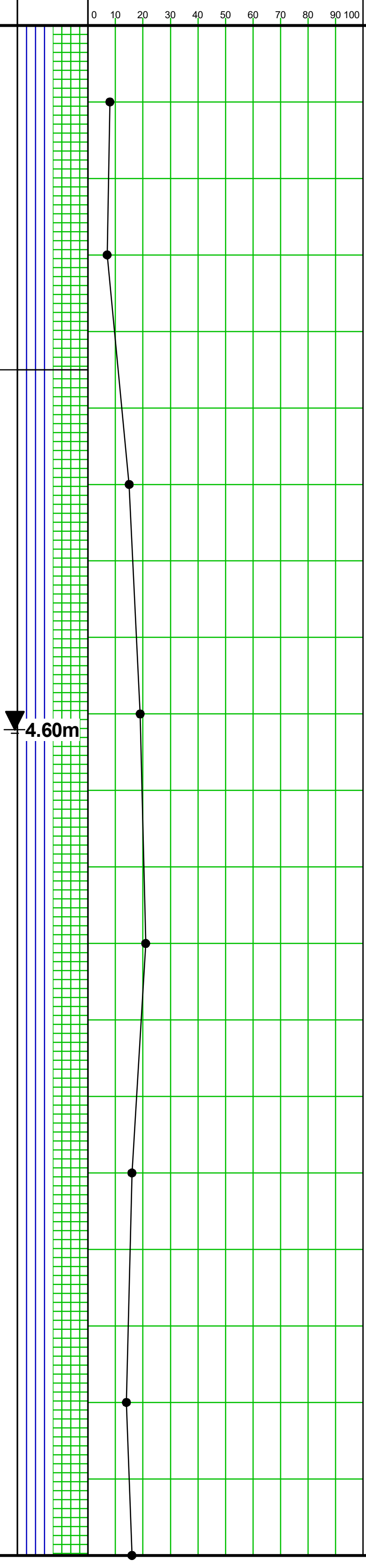


UDS*-UDS not recovered

# *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 | | | | | Brown, Loose, Sandy silt of low plasticity | ML-CL | | | |
| 0.5 | 0.5 | SPT-1 | 3 | 3 | 5 | 8 | | | | | |
| 1.0 | | | | | | | | | | | |
| 1.5 | 1.5 | SPT-2 | 2 | 3 | 4 | 7 | | | | | |
| 2.0 | | | | | | | | | | | |
| | 2.25 | UDS-1 | | | | | Brown, Medium dense, Sandy silt of low plasticity | ML-CL | | | |
| 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 | | | | | |
| 5.0 | | | | | | | | | | | |
| | 5.25 | UDS-2 | | | | | | | | | |
| 5.5 | | | | | | | | | | | |
| 6.0 | 6 | SPT-5 | 6 | 8 | 13 | 21 | | | | | |
| 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 | | | | | |

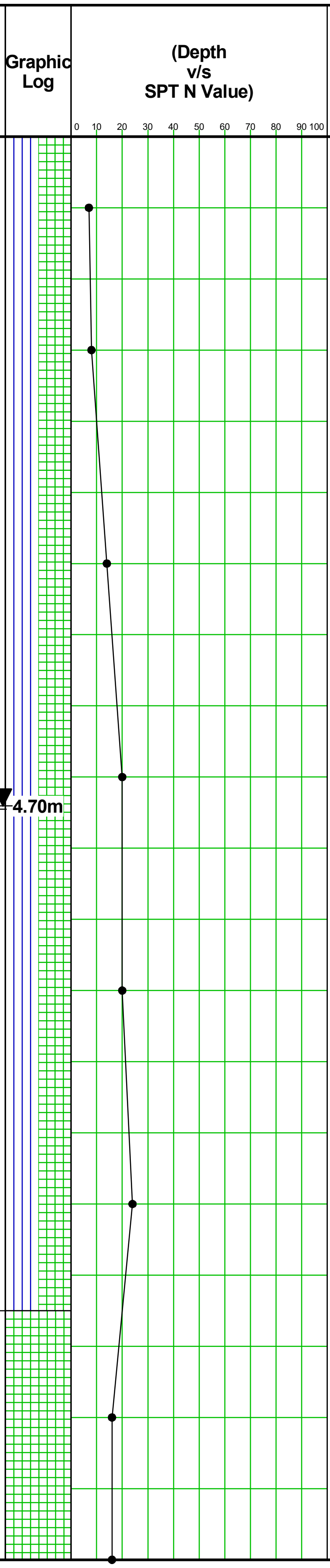


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Loose to medium dense, Sandy silt of low plasticity | ML-CL | |
| 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 | | | | | | | | | |
| 4.5 | 4.5 | SPT-4 | 5 | 9 | 11 | 20 | | | |
| 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 | | | | | Brown, Medium stiff to stiff, Silty clay of low plasticity | CL | |
| 8.5 | | | | | | | | | |
| 9.0 | 9 | SPT-7 | 5 | 6 | 10 | 16 | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-8 | 4 | 7 | 9 | 16 | | | |

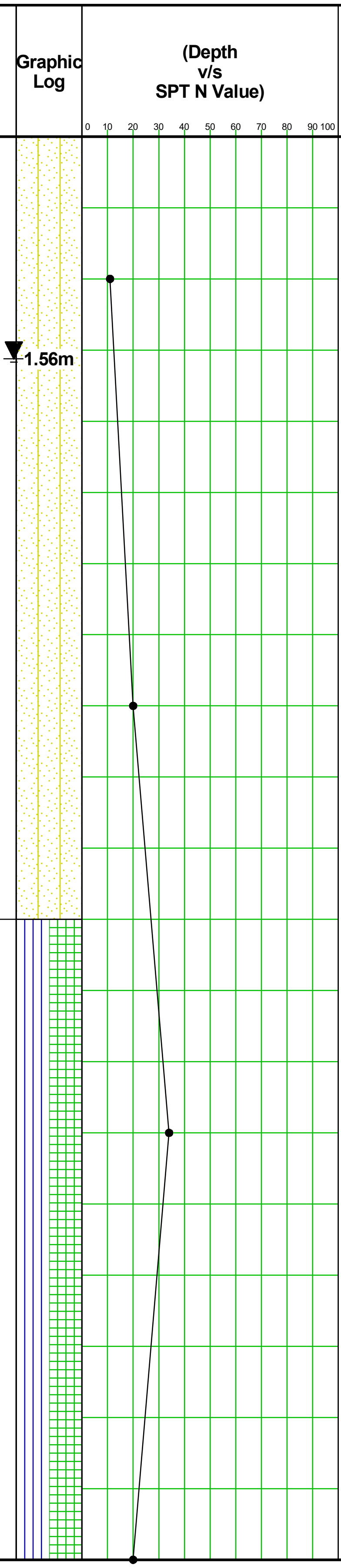


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Brown, Medium dense, Silty sand | SM | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 4 | 5 | 6 | 11 | | | |
| 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 | | | | | | | | | |
| 5.5 | 5.5 | UDS-2 | | | | | | | |
| 6.0 | | | | | | | Brown, Medium dense to dense, Sandy silt of low plasticity | ML-CL | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | SPT-3 | 8 | 15 | 19 | 34 | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 6 | 9 | 11 | 20 | | | |



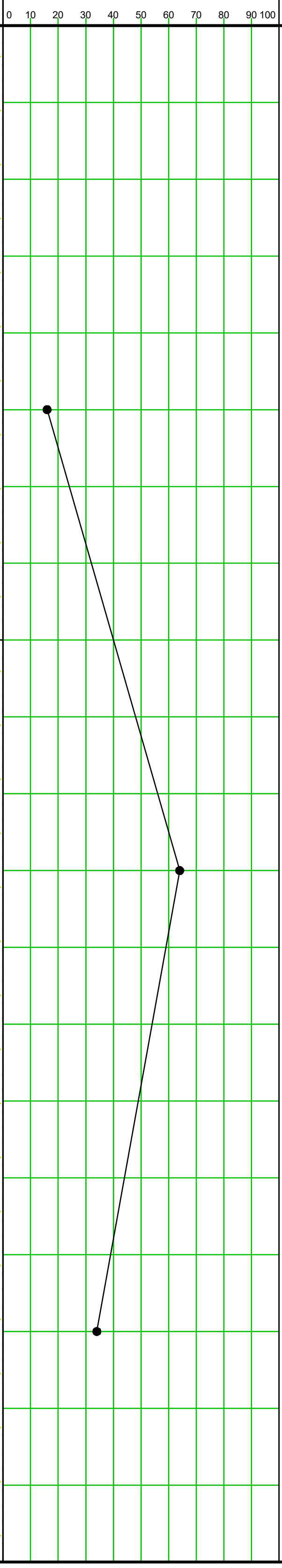
UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | |
| 0.0 | | DS | | | | | Brown, Medium dense, Silty sand | SM | | |
| 0.5 | | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | | |
| 1.5 | | | | | | | | | ▼1.50m | |
| 2.0 | | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 3 | 8 | 8 | 16 | | | | |
| 3.0 | | | | | | | | | | |
| 3.5 | | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Dense to very dense, Silty sand with gravel | SM | | |
| 4.5 | | | | | | | | | | |
| 5.0 | | | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 13 | 31 | 33 | 64 | | | | |
| 6.0 | | | | | | | | | | |
| 6.5 | | | | | | | | | | |
| 7.0 | 7 | UDS-3 | | | | | | | | |
| 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)

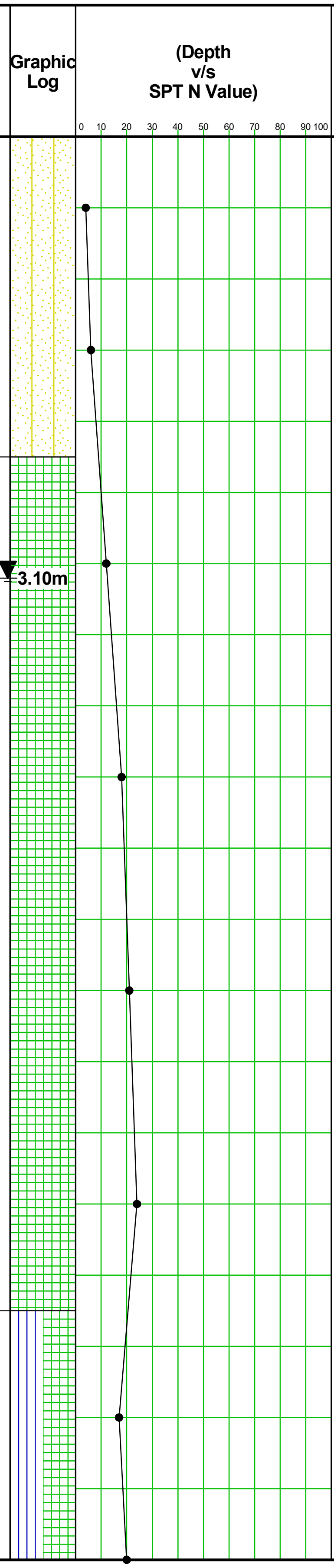


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 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 | | | | | | | Brown, Very stiff, Silty clay of low plasticity | CL | |
| 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 | | | | | | | |
| 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 | | | | | | | Brown, Medium dense, Sandy silt of low plasticity | ML-CL | |
| 9.0 | 9 | SPT-7 | 5 | 7 | 10 | 17 | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-8 | 6 | 9 | 11 | 20 | | | |



UDS*-UDS not recovered

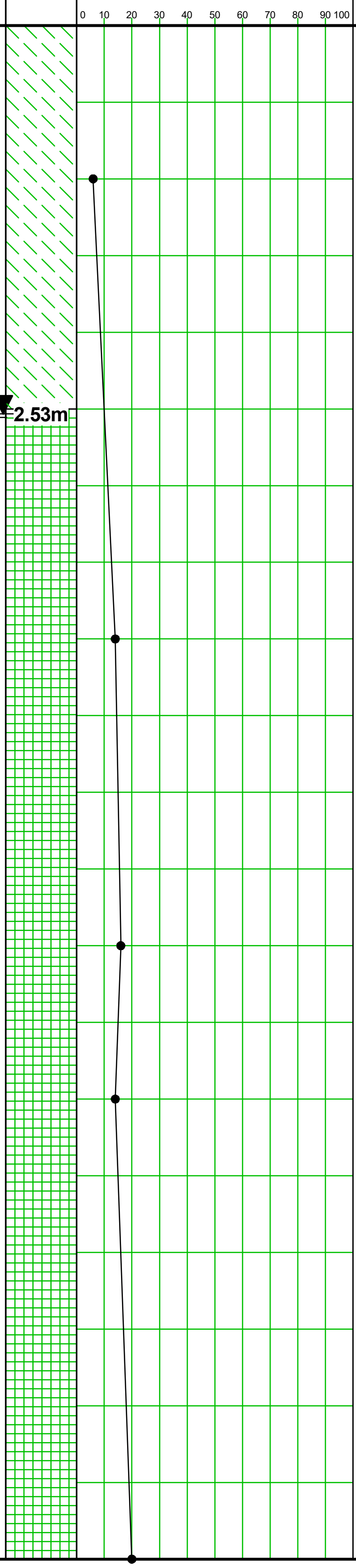
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana. | | *Client :*HRIDCL |
| *BH Location/Chainage :*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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Greyish brown, Medium stiff, Silty clay of medium plasticity | CI | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 2 | 3 | 3 | 6 | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | Greyish brown, Stiff to very stiff, Silty clay of low plasticity | CL | |
| 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 | | | |
| 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 | | | |

Graphic Log

(Depth v/s SPT N Value)

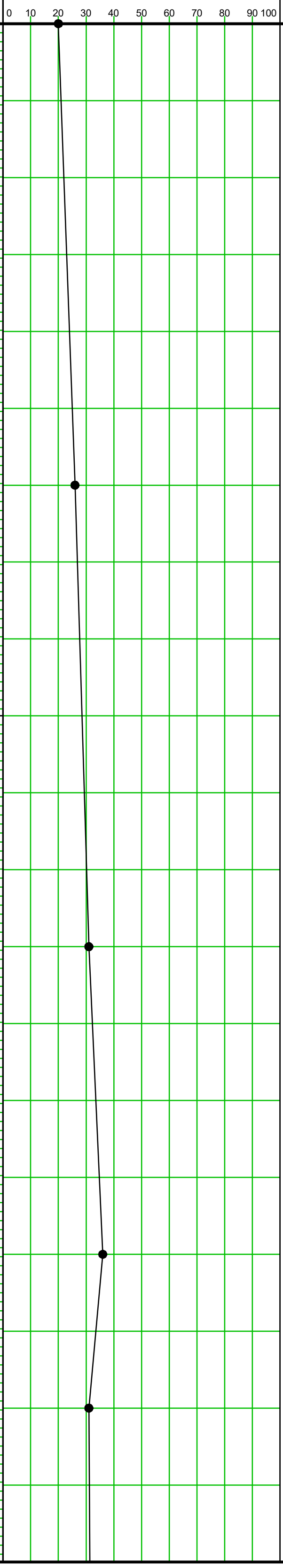


UDS*-UDS not recovered

# 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 | | | | | | | Greyish brown, Stiff to very stiff, Silty clay of low plasticity | CL | | | |
| 10.5 | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | |
| 11.5 | 11.5 | UDS-3 | | | | | | | | | |
| 12.0 | | | | | | | | | | | |
| 12.5 | | | | | | | | | | | |
| 13.0 | 13 | SPT-6 | 8 | 10 | 16 | 26 | | | | | |
| 13.5 | | | | | | | | | | | |
| 14.0 | | | | | | | | | | | |
| 14.5 | 14.5 | UDS-4 | | | | | Greyish brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 15.0 | | | | | | | | | | | |
| 15.5 | | | | | | | | | | | |
| 16.0 | 16 | SPT-7 | 13 | 15 | 16 | 31 | | | | | |
| 16.5 | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | |
| 17.5 | 17.5 | UDS* | | | | | | | | | |
| 18.0 | 18 | SPT-8 | 10 | 12 | 24 | 36 | | | | | |
| 18.5 | | | | | | | | | | | |
| 19.0 | 19 | SPT-9 | 11 | 15 | 16 | 31 | | | | | |
| 19.5 | | | | | | | | | | | |
| 20.0 | | | | | | | | | | | |

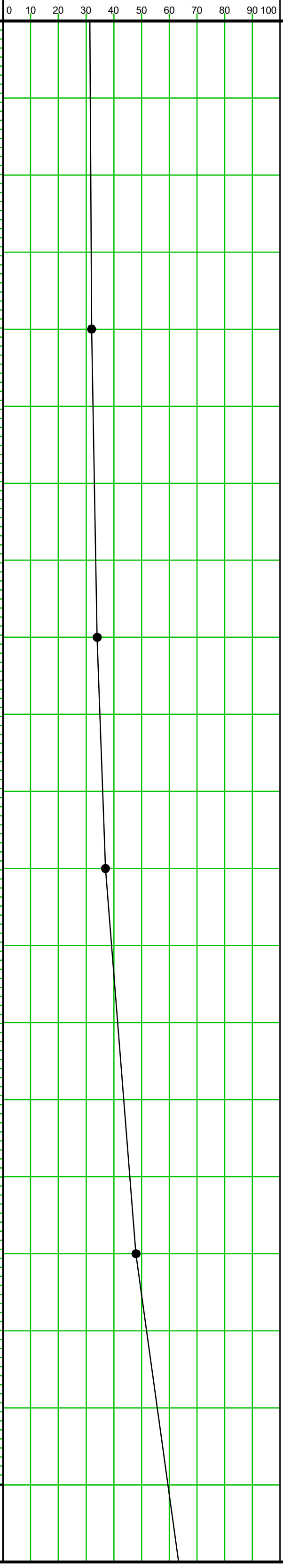


UDS*-UDS not recovered

# 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 | |

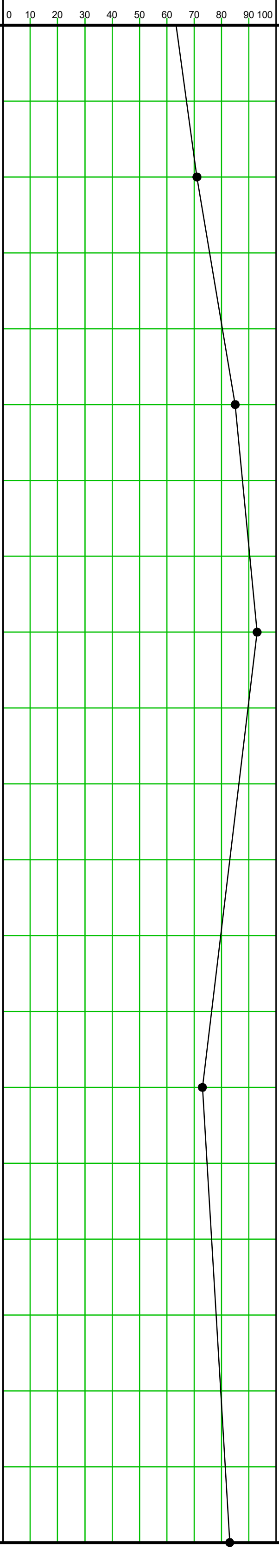
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm N1 | N2 | N3 | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Greyish brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | Greyish brown, Hard, Silty clay of medium plasticity with gravel | CI | | | |
| 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 :*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 | |

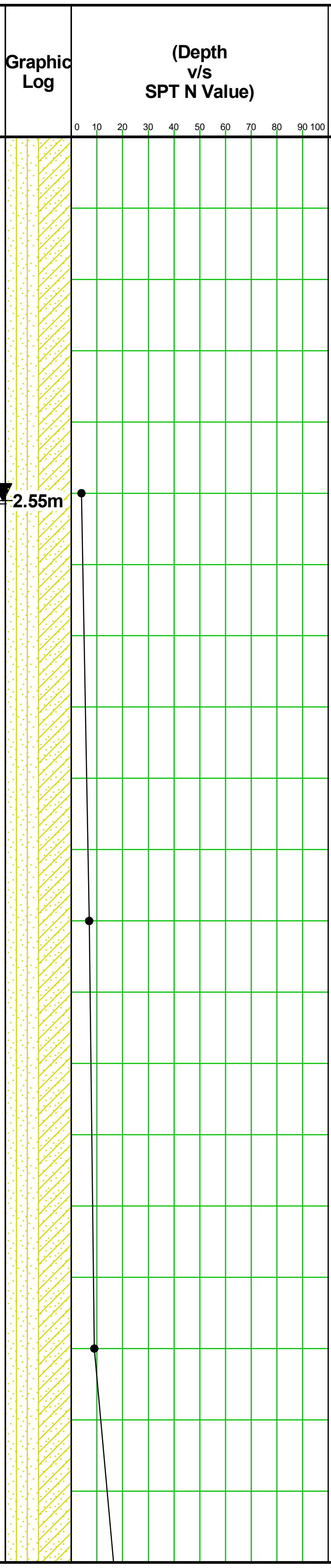
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 30.0 | | | | | | | Greyish brown, Hard, Silty clay of medium plasticity with gravel | CI | |  | |
| 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 | | | | | | | | | | | |
| 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 | |

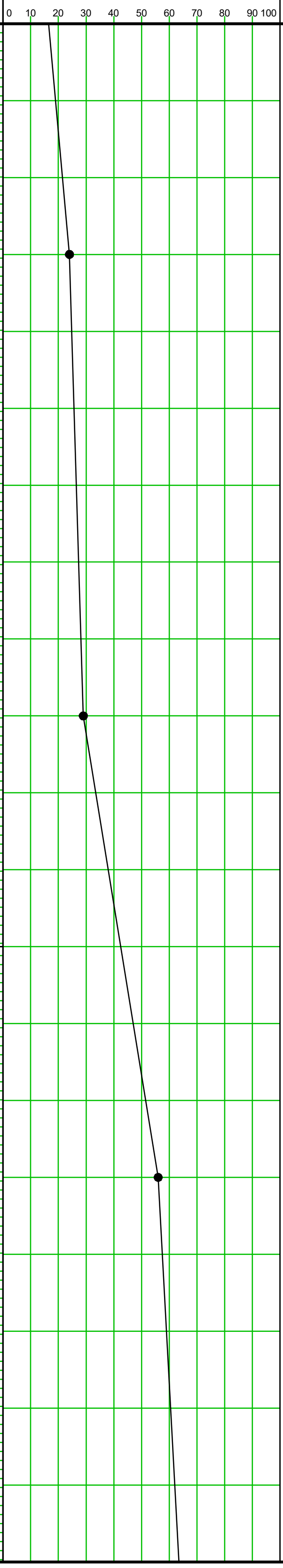
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm N1 | N2 | N3 | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Grey, Loose, Silty sand with clay | SM-SC | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 2 | 2 | 2 | 4 | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | | | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 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 | | | | | | | |



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 | |

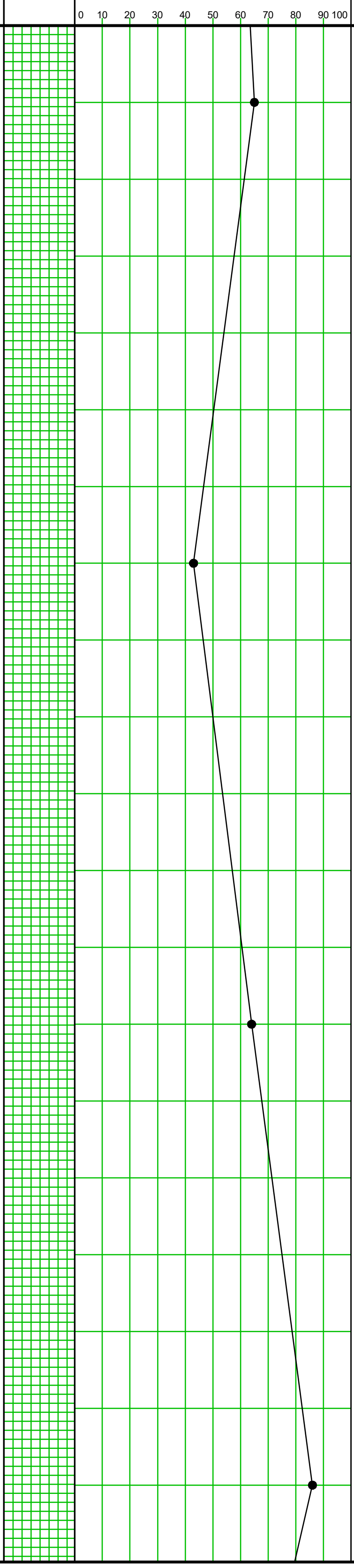
| **Depth (m)** | **In-Situ Sample Depth (m)** | **Sample Type** | **Blow counts per 15cm** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 10.0 | | | | | | | Greyish brown, Very stiff, Silty clay of low plasticity | CL | |  | |
| 10.5 | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | |
| 11.5 | 11.5 | SPT-4 | 6 | 10 | 14 | 24 | | | | | |
| 12.0 | | | | | | | | | | | |
| 12.5 | | | | | | | | | | | |
| 13.0 | 13 | UDS-5 | | | | | | | | | |
| 13.5 | | | | | | | | | | | |
| 14.0 | | | | | | | | | | | |
| 14.5 | 14.5 | SPT-5 | 7 | 12 | 17 | 29 | | | | | |
| 15.0 | | | | | | | | | | | |
| 15.5 | | | | | | | | | | | |
| 16.0 | 16 | UDS-6 | | | | | Greyish brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 16.5 | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | |
| 17.5 | 17.5 | SPT-6 | 12 | 22 | 34 | 56 | | | | | |
| 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 :*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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 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 | | | | | | | | | | | |

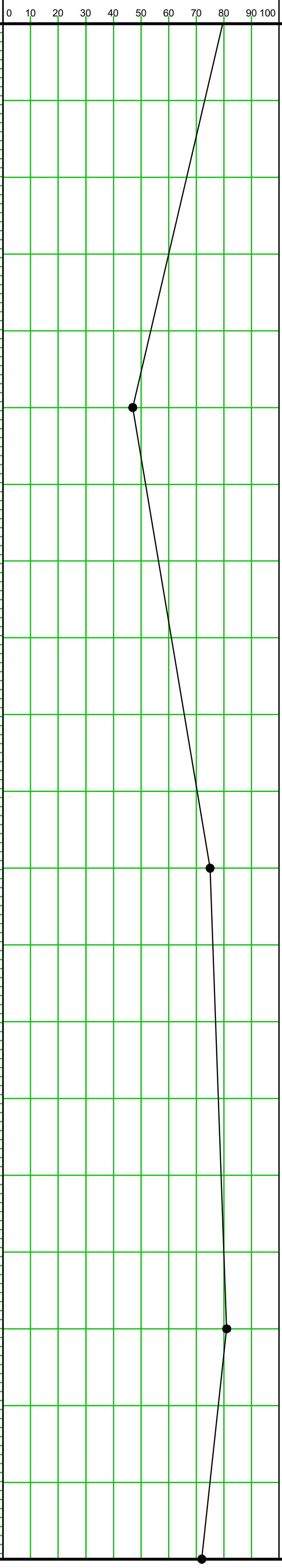


UDS*-UDS not recovered

# 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 | | | | | | | Greyish brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

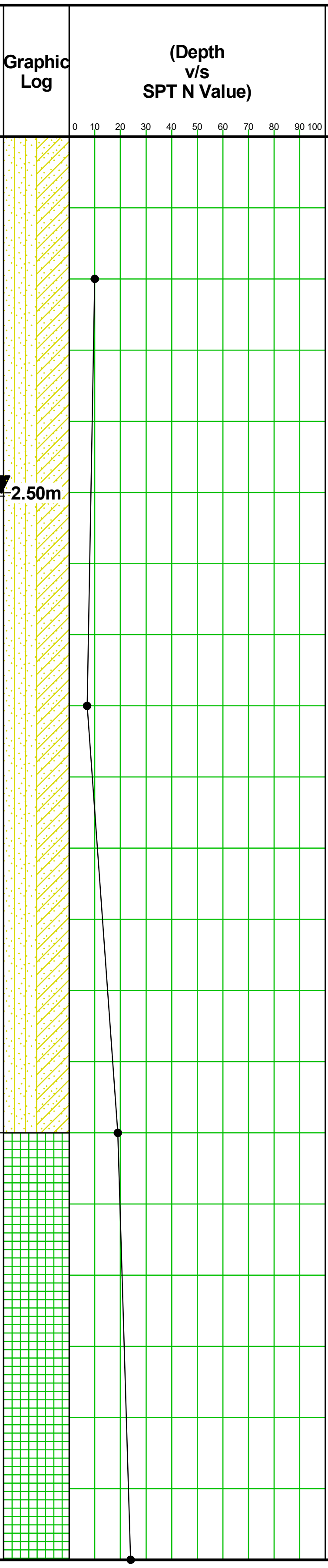


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS | | | | | Grey, Loose, Silty sand with clay | SM-SC | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 8 | 4 | 6 | 10 | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 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 | | | | | | | Greyish brown, Very stiff to hard, Silty clay of low plasticity | CL | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 7 | 9 | 15 | 24 | | | |

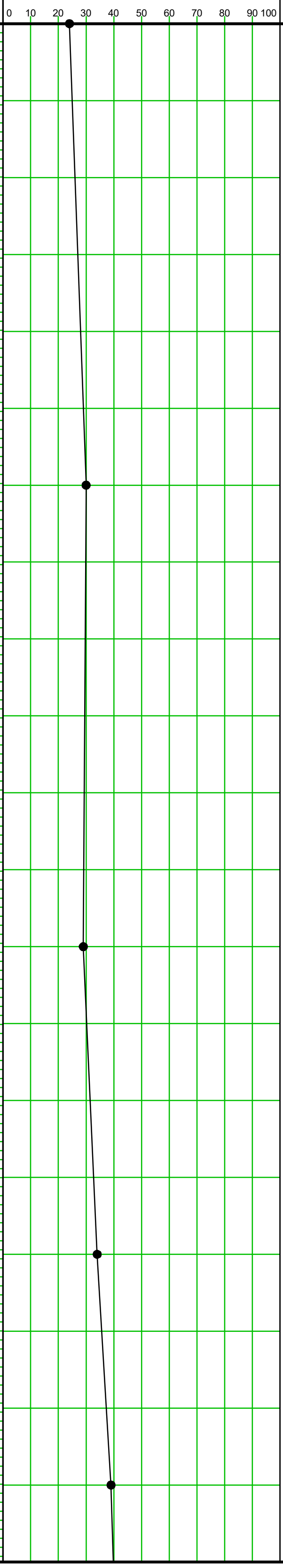


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 10.0 | | | | | | | Greyish brown, Very stiff to hard, Silty clay of low plasticity | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |



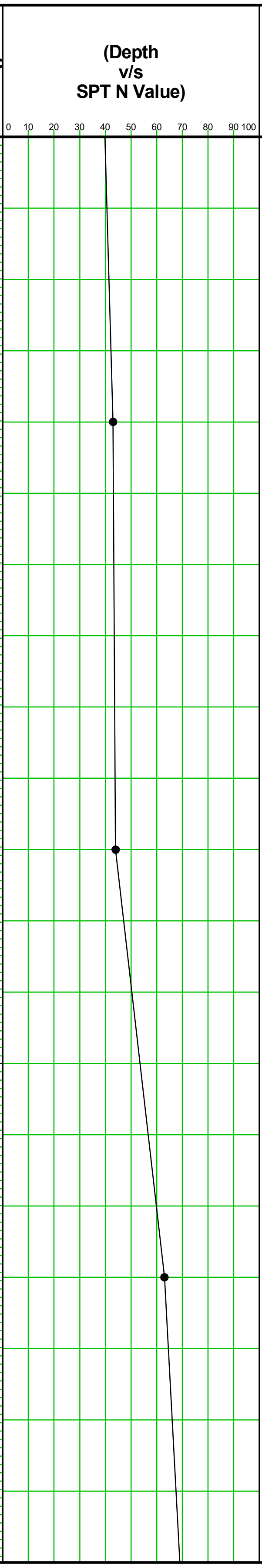
UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Greyish brown, Very stiff to hard, Silty clay of low plasticity | CL | | |
| 20.5 | 20.5 | UDS-6 | | | | | | | | |
| 21.0 | | | | | | | | | | |
| 21.5 | | | | | | | | | | |
| 22.0 | 22 | SPT-9 | 12 | 14 | 29 | 43 | | | | |
| 22.5 | | | | | | | | | | |
| 23.0 | | | | | | | | | | |
| 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 | | | | | Greyish brown, Hard, Silty clay of low plasticity with gravel | CL | | |
| 27.0 | | | | | | | | | | |
| 27.5 | | | | | | | | | | |
| 28.0 | 28 | SPT-11 | 12 | 25 | 38 | 63 | | | | |
| 28.5 | | | | | | | | | | |
| 29.0 | | | | | | | | | | |
| 29.5 | 29.5 | UDS-9 | | | | | | | | |
| 30.0 | | | | | | | | | | |

(Depth v/s SPT N Value)

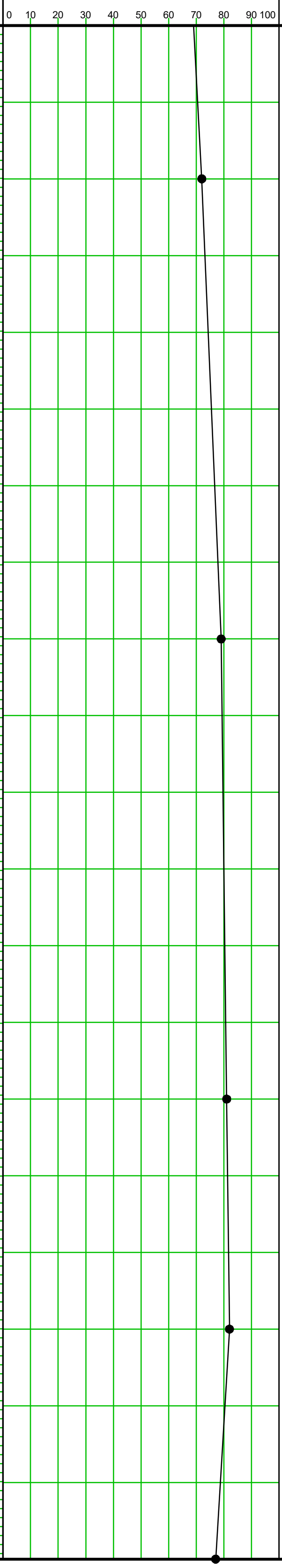


UDS*-UDS not recovered

# 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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 30.0 | | | | | | | Greyish brown, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | | | |
| 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 | | | | | |

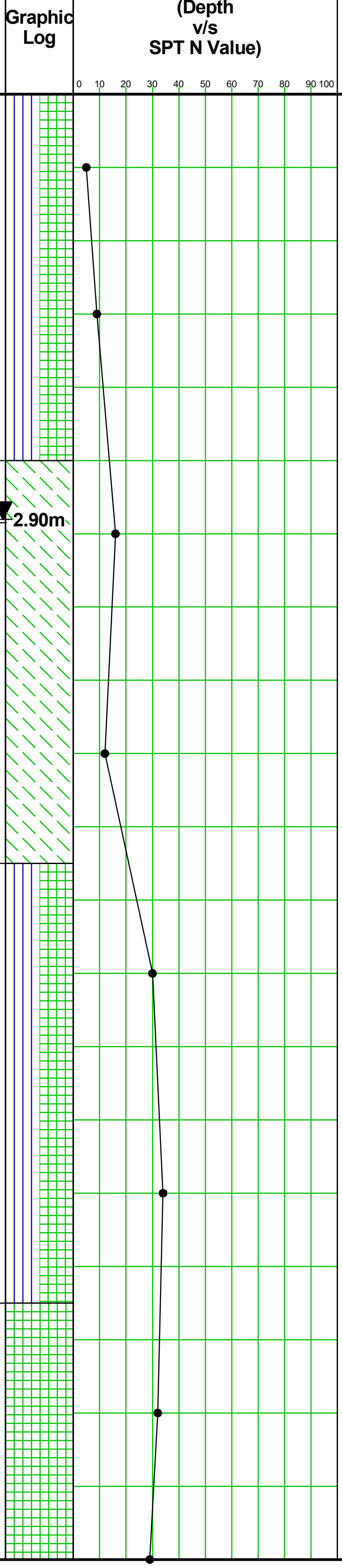


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 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 | | | | | | | | | |
| | 2.25 | UDS-1 | | | | | | | |
| 2.5 | | | | | | | Grey, Very stiff, Silty clay of medium plasticity | CI | |
| 3.0 | 3 | SPT-3 | 5 | 6 | 10 | 16 | | | |
| 3.5 | | | | | | | | | |
| 4.0 | | | | | | | | | |
| 4.5 | 4.5 | SPT-4 | 4 | 5 | 7 | 12 | | | |
| 5.0 | | | | | | | | | |
| | 5.25 | UDS-2 | | | | | | | |
| 5.5 | | | | | | | Grey, Dense, Sandy silt of low plasticity | ML-CL | |
| 6.0 | 6 | SPT-5 | 8 | 12 | 18 | 30 | | | |
| 6.5 | | | | | | | | | |
| 7.0 | | | | | | | | | |
| 7.5 | 7.5 | SPT-6 | 7 | 10 | 24 | 34 | | | |
| 8.0 | | | | | | | | | |
| | 8.25 | UDS-3 | | | | | | | |
| 8.5 | | | | | | | Grey, Very stiff to hard, Silty clay of low plasticity | CL | |
| 9.0 | 9 | SPT-7 | 7 | 13 | 19 | 32 | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | SPT-8 | 5 | 12 | 17 | 29 | | | |

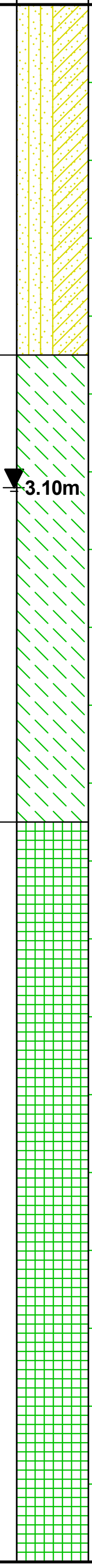


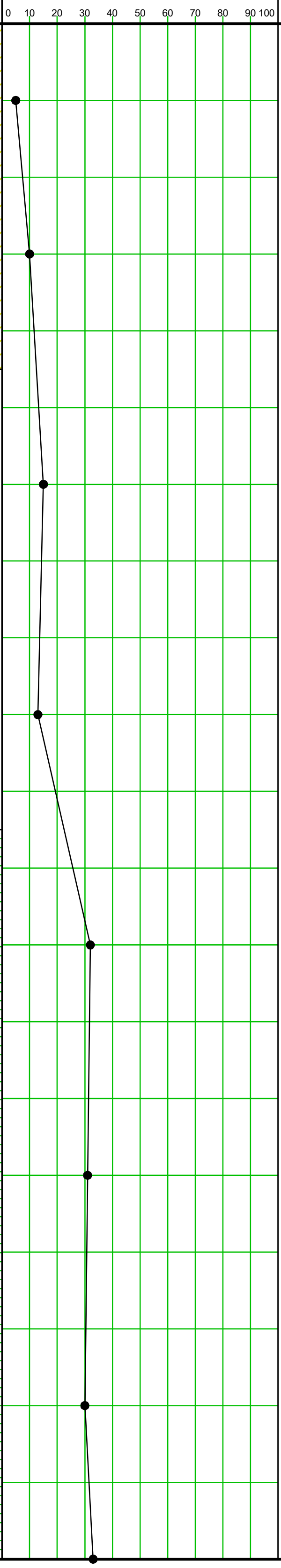
UDS*-UDS not recovered

# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana. | | *Client :*HRIDCL |
| *BH Location/Chainage :*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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 0.0 | | DS | | | | | Brownish grey, Loose, Silty sand with clay | SM-SC | | | |
| 0.5 | 0.5 | SPT-1 | 2 | 2 | 3 | 5 | | | | | |
| 1.0 | | | | | | | | | | | |
| 1.5 | 1.5 | SPT-2 | 3 | 4 | 6 | 10 | | | | | |
| 2.0 | | | | | | | | | | | |
| | 2.25 | UDS-1 | | | | | | | | | |
| 2.5 | | | | | | | Brownish grey, Very stiff, Silty clay of medium plasticity | CI | | | |
| 3.0 | 3 | SPT-3 | 4 | 6 | 9 | 15 | | | | | |
| 3.5 | | | | | | | | | | | |
| 4.0 | | | | | | | | | | | |
| 4.5 | 4.5 | SPT-4 | 3 | 5 | 8 | 13 | | | | | |
| 5.0 | | | | | | | | | | | |
| | 5.25 | UDS-2 | | | | | | | | | |
| 5.5 | | | | | | | Brownish grey, Hard, Silty clay of low plasticity | CL | | | |
| 6.0 | 6 | SPT-5 | 9 | 12 | 20 | 32 | | | | | |
| 6.5 | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | |
| 7.5 | 7.5 | SPT-6 | 11 | 13 | 18 | 31 | | | | | |
| 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 | | | | | |



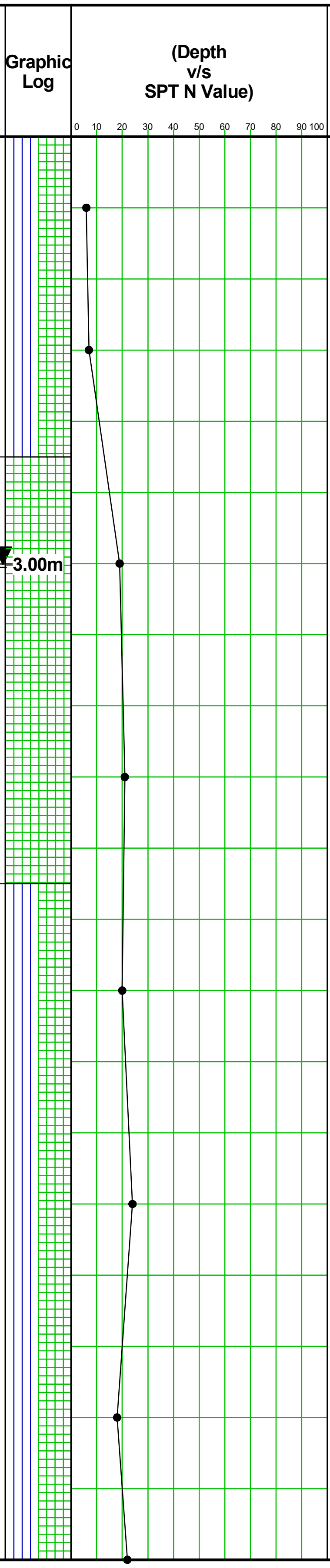


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 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 | | | | | Brown, Very stiff, Silty clay of low plasticity | CL | |
| 2.5 | | | | | | | | | |
| 3.0 | 3 | SPT-3 | 5 | 7 | 12 | 19 | | | |
| 3.5 | | | | | | | | | |
| 4.0 | | | | | | | | | |
| 4.5 | 4.5 | SPT-4 | 4 | 8 | 13 | 21 | | | |
| 5.0 | | | | | | | | | |
| | 5.25 | UDS-2 | | | | | Brown, Medium dense, Sandy silt of low plasticity | ML-CL | |
| 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 | | | |
| 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 | | | |

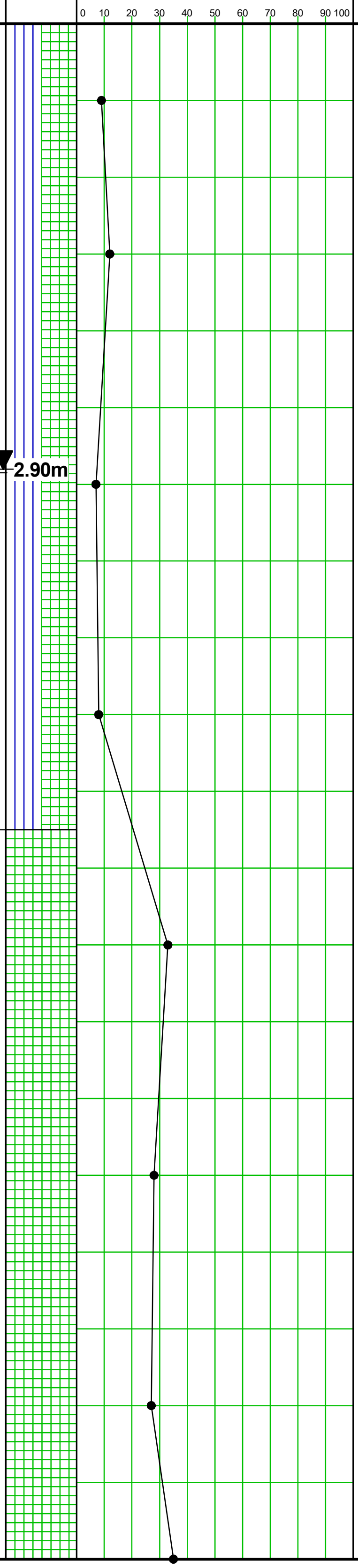


UDS*-UDS not recovered

# 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 | | | | | Brown, Loose to medium dense, Sandy silt of low plasticity | ML-CL | | | |
| 0.5 | 0.5 | SPT-1 | 2 | 4 | 5 | 9 | | | | | |
| 1.0 | | | | | | | | | | | |
| 1.5 | 1.5 | SPT-2 | 3 | 5 | 7 | 12 | | | | | |
| 2.0 | | | | | | | | | | | |
| | 2.25 | UDS-1 | | | | | | | | | |
| 2.5 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |
| | 5.25 | UDS-2 | | | | | | | | | |
| 5.5 | | | | | | | Brown, Very stiff, Silty clay of low plasticity | CL | | | |
| 6.0 | 6 | SPT-5 | 9 | 13 | 20 | 33 | | | | | |
| 6.5 | | | | | | | | | | | |
| 7.0 | | | | | | | | | | | |
| 7.5 | 7.5 | SPT-6 | 8 | 10 | 18 | 28 | | | | | |
| 8.0 | | | | | | | | | | | |
| | 8.25 | UDS-3 | | | | | | | | | |
| 8.5 | | | | | | | | | | | |
| 9.0 | 9 | SPT-7 | 7 | 12 | 15 | 27 | | | | | |
| 9.5 | | | | | | | | | | | |
| 10.0 | 10 | SPT-8 | 8 | 13 | 22 | 35 | | | | | |

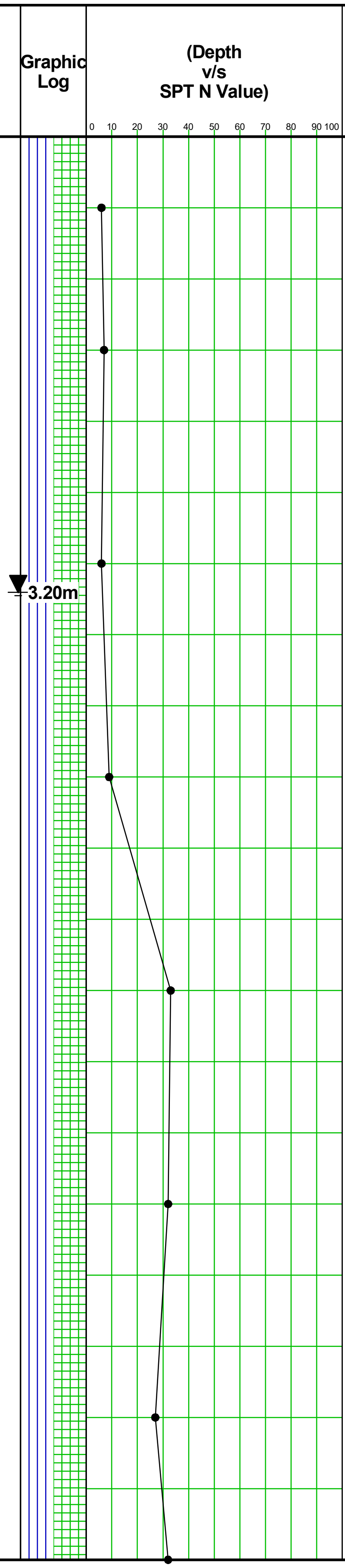


UDS*-UDS not recovered

# 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 | | | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | |
| 0.0 | | DS | | | | | Brown, Loose to dense, Sandy silt of low plasticity | ML-CL | |
| 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 | | | |
| 3.5 | | | | | | | | | |
| 4.0 | | | | | | | | | |
| 4.5 | 4.5 | SPT-4 | 2 | 4 | 5 | 9 | | | |
| 5.0 | | | | | | | | | |
| | 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 | | | |

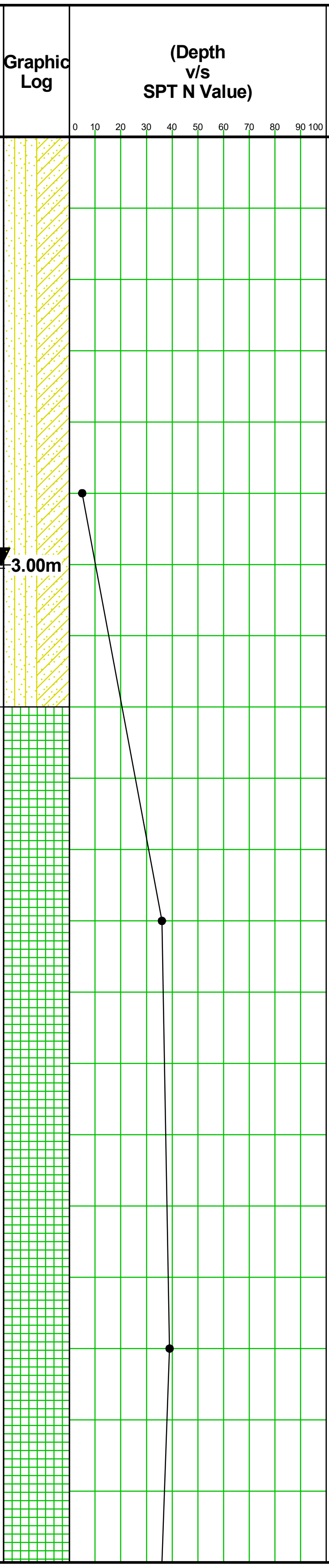


UDS*-UDS not recovered

# *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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS-1 | | | | | Brown, Loose, Silty sand with clay | SM-SC | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 2 | 2 | 3 | 5 | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 5.5 | 5.5 | SPT-2 | 11 | 15 | 21 | 36 | | | |
| 6.0 | | | | | | | | | |
| 6.5 | | | | | | | | | |
| 7.0 | 7 | UDS-3 | | | | | | | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 12 | 17 | 22 | 39 | | | |
| 9.0 | | | | | | | | | |
| 9.5 | | | | | | | | | |
| 10.0 | 10 | UDS-4 | | | | | | | |

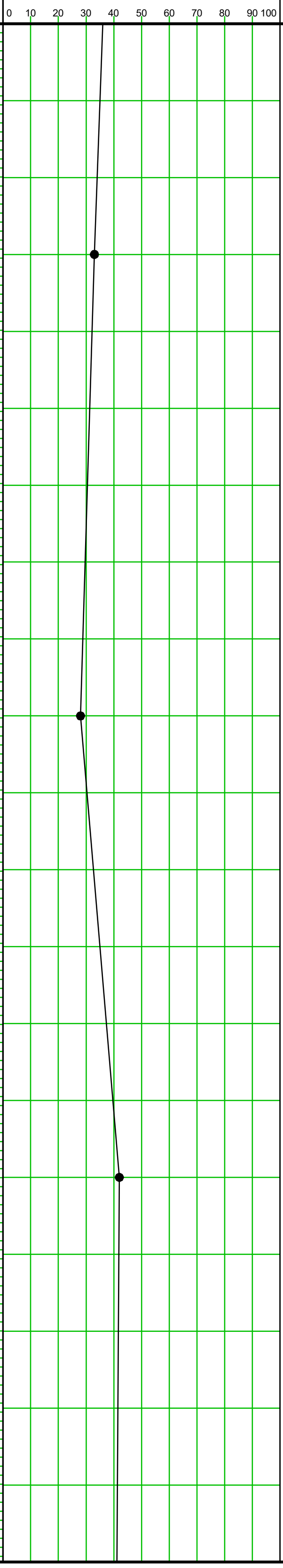


UDS*-UDS not recovered

# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana. | | *Client :*HRIDCL |
| *BH Location/Chainage :*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 | |

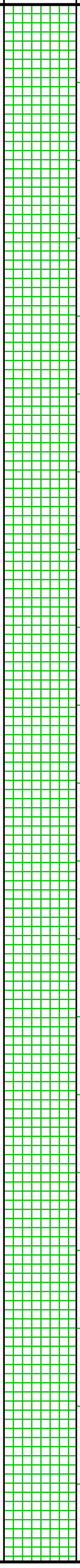
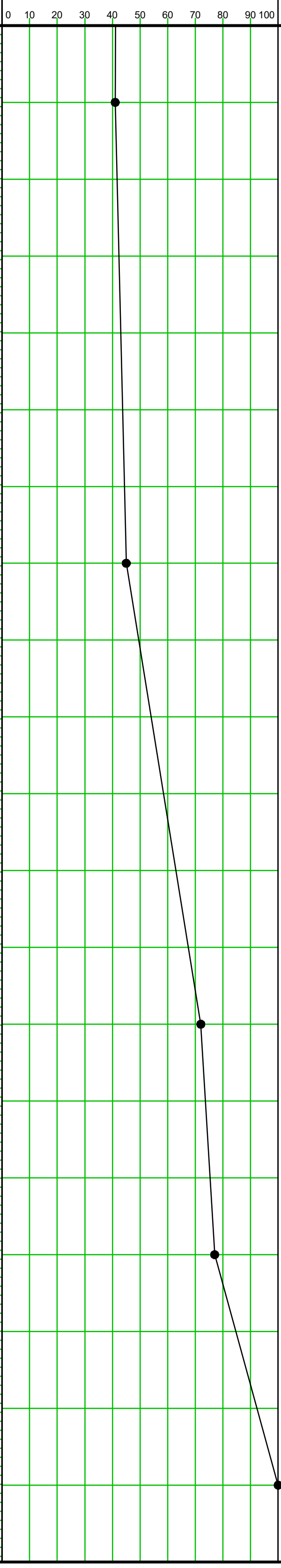
| **Depth (m)** | **In-Situ Sample Depth (m)** | **Sample Type** | **Blow counts per 15cm** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 10.0 | | | | | | | | | | | |
| 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 | |

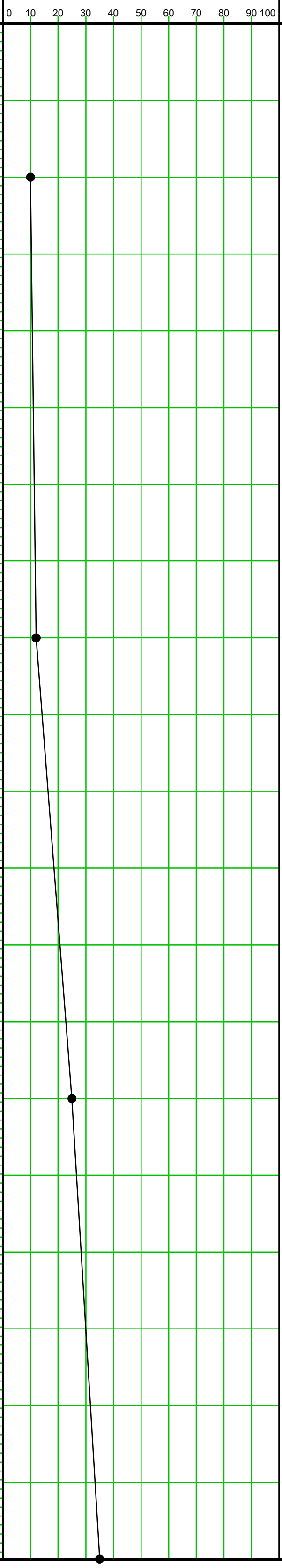
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm N1 | N2 | N3 | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Brown, Hard, Silty clay of low plasticity with gravel | CL |  |  | |
| 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 | | | | | | | | | |
| 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 | | | | | Brown, Stiff, Silty clay of low plasticity | CL | | | |
| 0.5 | | | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 3 | 4 | 6 | 10 | | | | | |
| 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 | | | | | | | | | | | |
| 5.5 | 5.5 | UDS-2 | | | | | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | CL | | | |
| 6.0 | | | | | | | | | | | |
| 6.5 | | | | | | | | | | | |
| 7.0 | 7 | SPT-3 | 6 | 10 | 15 | 25 | | | | | |
| 7.5 | | | | | | | | | | | |
| 8.0 | | | | | | | | | | | |
| 8.5 | 8.5 | UDS-3 | | | | | | | | | |
| 9.0 | | | | | | | | | | | |
| 9.5 | | | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 7 | 15 | 20 | 35 | | | | | |



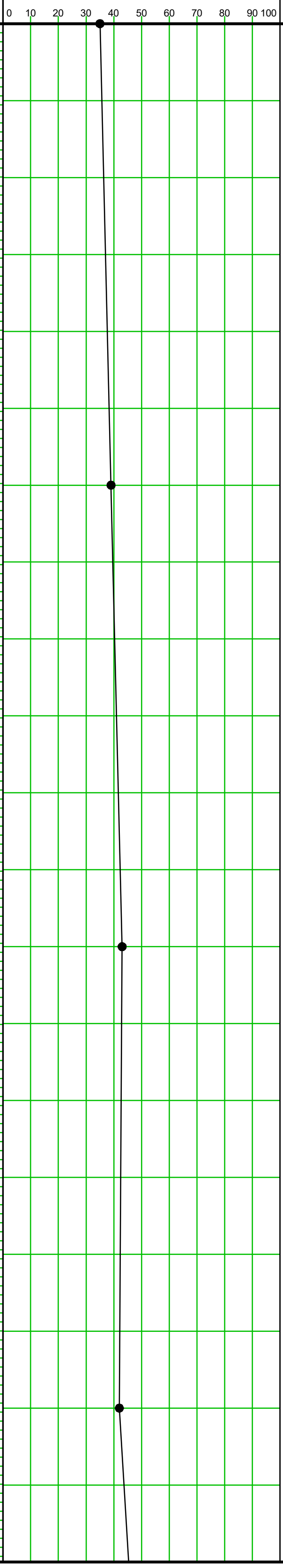
UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | CL | | |
| 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 | | | | | | | | | | |
| 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 | | | | | | | | | | |

(Depth v/s SPT N Value)



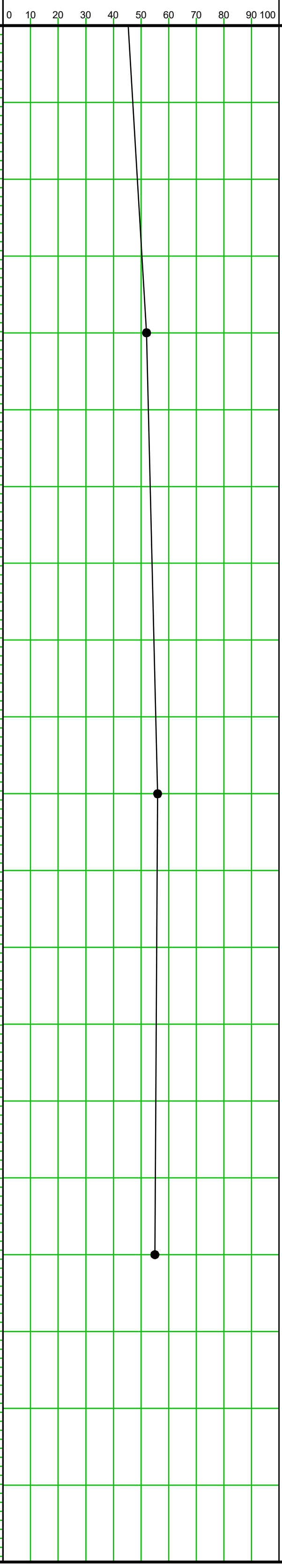
UDS*-UDS not recovered

# *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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | |
| 20.0 | | | | | | | Brown, Very stiff to hard, Silty clay of low plasticity with gravel | CL | | |
| 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 | | | | |
| 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 | | | | | | | | | |

(Depth v/s SPT N Value)



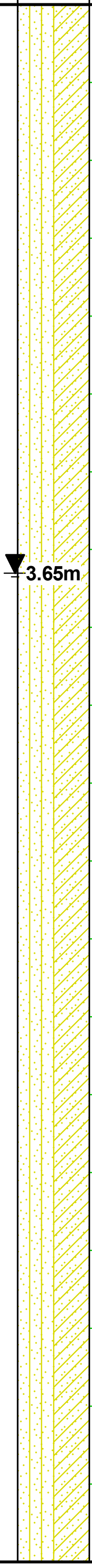
UDS*-UDS not recovered

# FIELD BOREHOLE LOG

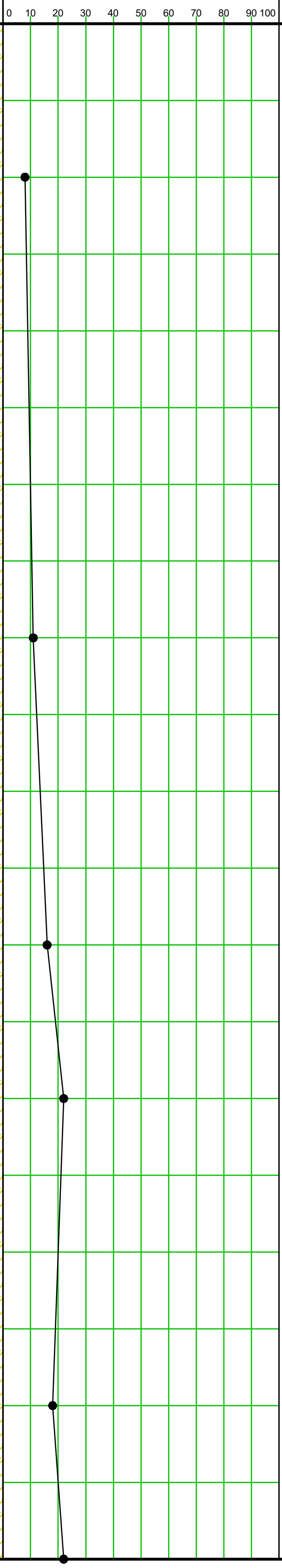
| | | |
|---|---|---|
| *Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana. | | *Client :*HRIDCL |
| *BH Location/Chainage :*16+042 | *Northing :*3121279.064 m | *Easting :*705482.626 m |
| *Reduced Level (m):*(+)194.075 | *BH. No. :*BH-A1 | *BH Termination Depth (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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS-1 | | | | | Brown, Loose to medium dense, Silty sand with clay | SM-SC | |
| 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 | | | | | | | | | |
| 4.0 | 4 | SPT-2 | 3 | 4 | 7 | 11 | | | |
| 4.5 | | | | | | | | | |
| 5.0 | | | | | | | | | |
| 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 | | | |

**Graphic Log**



**(Depth v/s SPT N Value)**

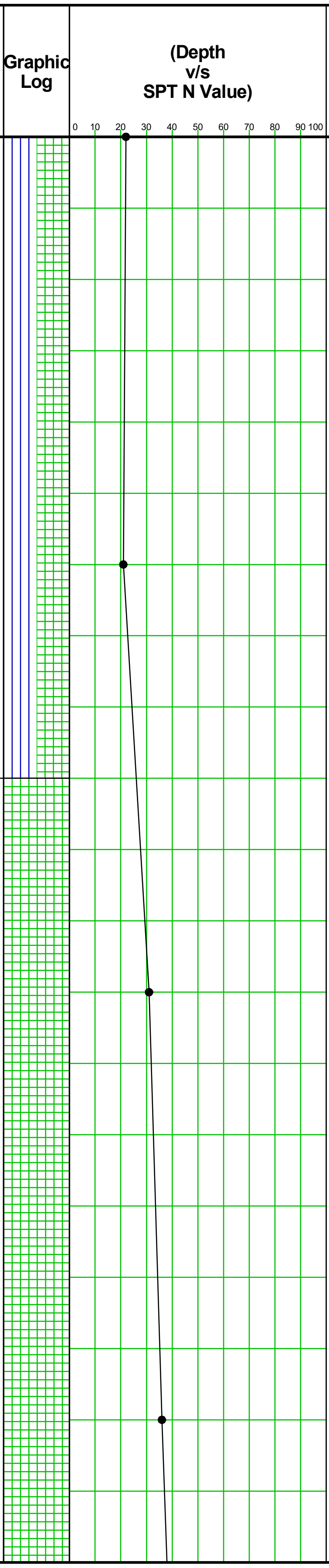


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Brown, Medium dense, Sandy silt of low plasticity | ML-CL | |
| 10.5 | | | | | | | | | |
| 11.0 | | | | | | | | | |
| 11.5 | 11.5 | UDS-2 | | | | | | | |
| 12.0 | | | | | | | | | |
| 12.5 | | | | | | | | | |
| 13.0 | 13 | SPT-7 | 8 | 9 | 12 | 21 | | | |
| 13.5 | | | | | | | | | |
| 14.0 | | | | | | | | | |
| 14.5 | 14.5 | UDS-3 | | | | | | | |
| 15.0 | | | | | | | Brown yellowish, Hard, Silty clay of low plasticity with gravel | CL | |
| 15.5 | | | | | | | | | |
| 16.0 | 16 | SPT-8 | 9 | 14 | 17 | 31 | | | |
| 16.5 | | | | | | | | | |
| 17.0 | | | | | | | | | |
| 17.5 | 17.5 | UDS-4 | | | | | | | |
| 18.0 | | | | | | | | | |
| 18.5 | | | | | | | | | |
| 19.0 | 19 | SPT-9 | 10 | 15 | 21 | 36 | | | |
| 19.5 | | | | | | | | | |
| 20.0 | | | | | | | | | |



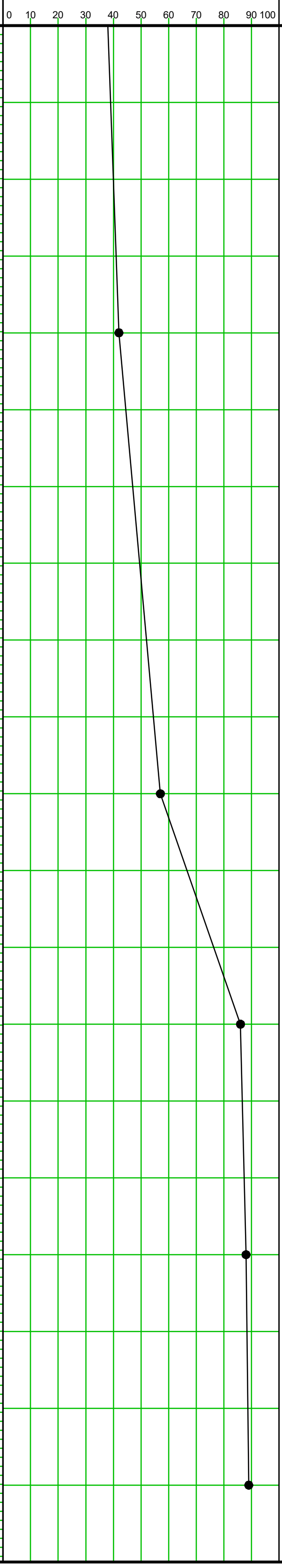
UDS*-UDS not recovered

# *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 | 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 | | | | | | | | |

(Depth v/s SPT N Value)

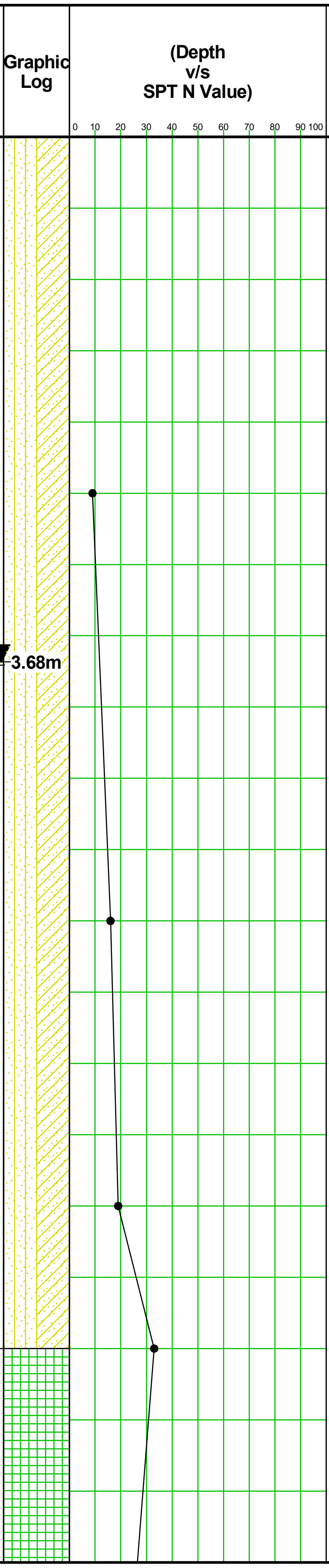


UDS*-UDS not recovered

# 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 | |

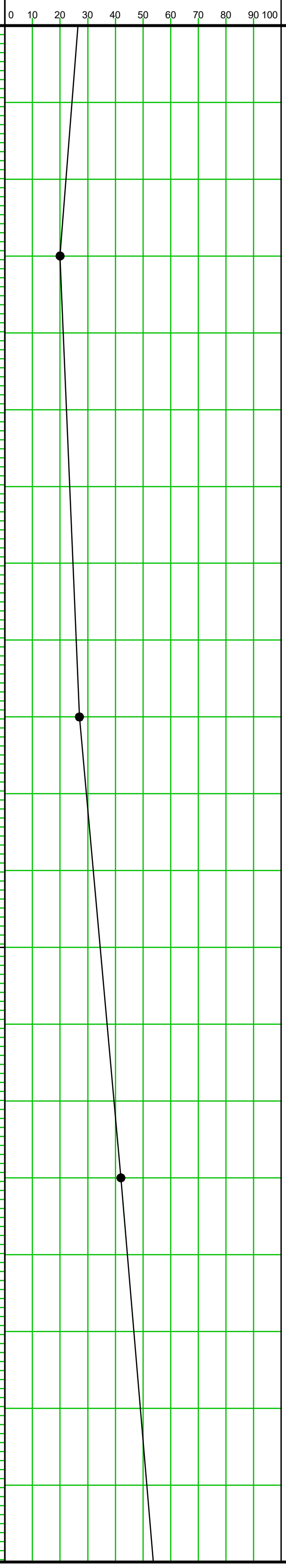
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm N1 | N2 | N3 | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS-1 | | | | | Brown, Loose to medium dense, Silty sand with clay | SM-SC | |
| 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 | | | | | | | | | |
| 4.0 | 4 | UDS-2 | | | | | | | |
| 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 | Brown yellowish, Very stiff to hard, Silty clay of low plasticity | 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 :*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 | |

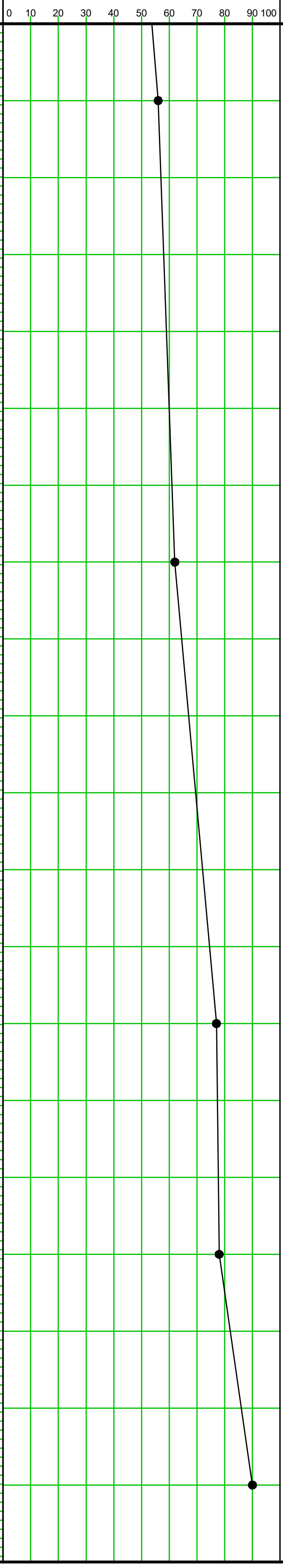
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 10.0 | | | | | | | Brown yellowish, Very stiff to hard, Silty clay of low plasticity | CL | |  | |
| 10.5 | | | | | | | | | | | |
| 11.0 | | | | | | | | | | | |
| 11.5 | 11.5 | SPT-5 | 8 | 9 | 11 | 20 | | | | | |
| 12.0 | | | | | | | | | | | |
| 12.5 | | | | | | | | | | | |
| 13.0 | 13 | UDS-5 | | | | | | | | | |
| 13.5 | | | | | | | | | | | |
| 14.0 | | | | | | | | | | | |
| 14.5 | 14.5 | SPT-6 | 10 | 12 | 15 | 27 | | | | | |
| 15.0 | | | | | | | | | | | |
| 15.5 | | | | | | | | | | | |
| 16.0 | 16 | UDS-6 | | | | | Brown yellowish, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 16.5 | | | | | | | | | | | |
| 17.0 | | | | | | | | | | | |
| 17.5 | 17.5 | SPT-7 | 15 | 18 | 24 | 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 :*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 | | | | | | | Brown yellowish, Hard, Silty clay of low plasticity with gravel | CL | | | |
| 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 | | | | | | | | | |
| 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 | | | | | | | | | |

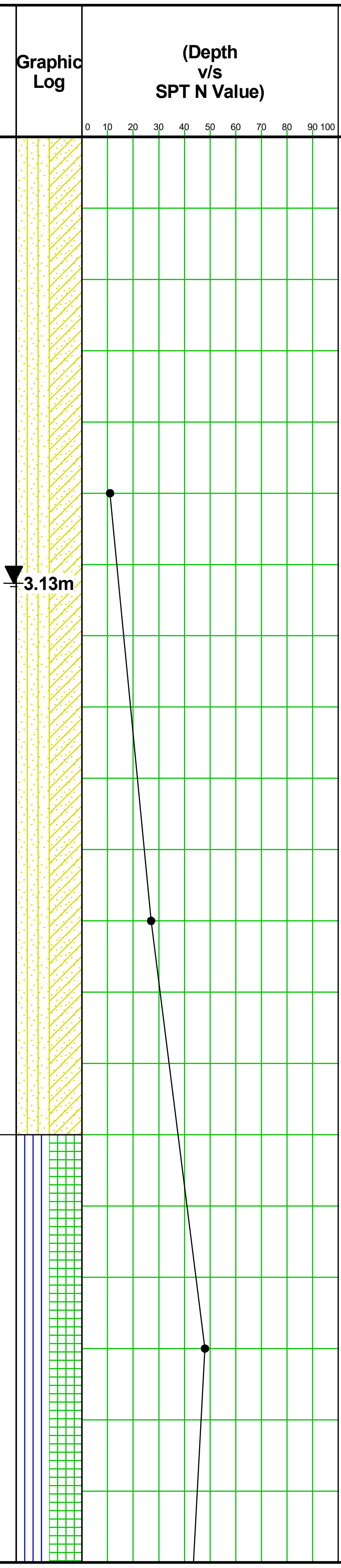


UDS*-UDS not recovered

# 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 | |

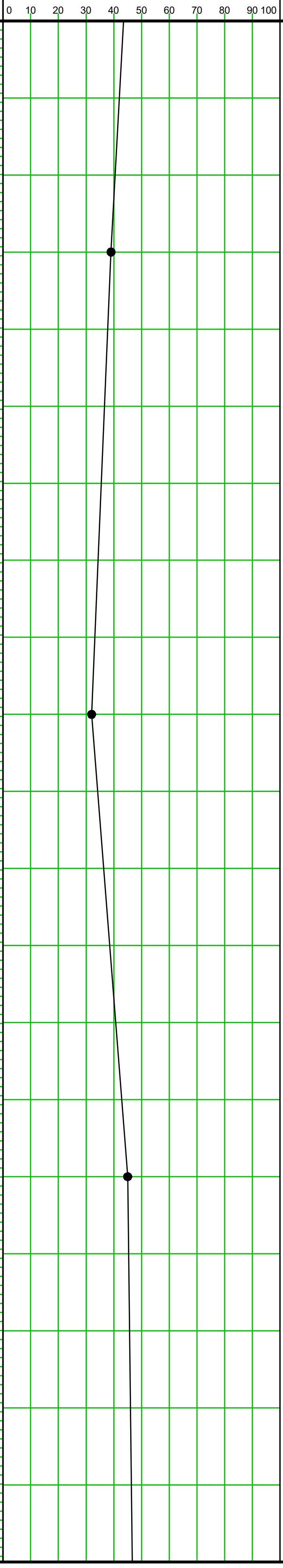
| Depth (m) | In-Situ Sample Depth (m) | Sample Type | Blow counts per 15cm N1 | N2 | N3 | SPT N Value | Strata Description | IS Classification | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS-1 | | | | | Greyish brown, Medium dense, Silty sand with clay | SM-SC | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | UDS-1 | | | | | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | SPT-1 | 2 | 4 | 7 | 11 | | | |
| 3.0 | | | | | | | | | |
| 3.5 | | | | | | | | | |
| 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 | | | | | Greyish brown, Dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 7.5 | | | | | | | | | |
| 8.0 | | | | | | | | | |
| 8.5 | 8.5 | SPT-3 | 12 | 22 | 26 | 48 | | | |
| 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 :*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** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Graphic Log** | **(Depth v/s SPT N Value)** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | | | |
| 10.0 | | | | | | | Greyish brown, Hard, Silty clay of low plasticity with gravel | CL | |  | |
| 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 | | | | | | | | | | | |
| 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 | | | | | | | | | | | |

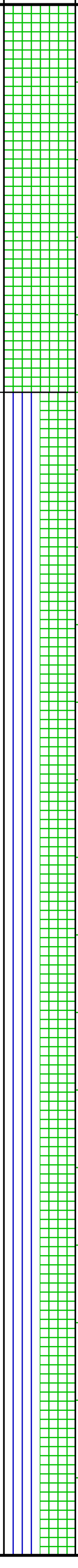
UDS*-UDS not recovered

# FIELD BOREHOLE LOG

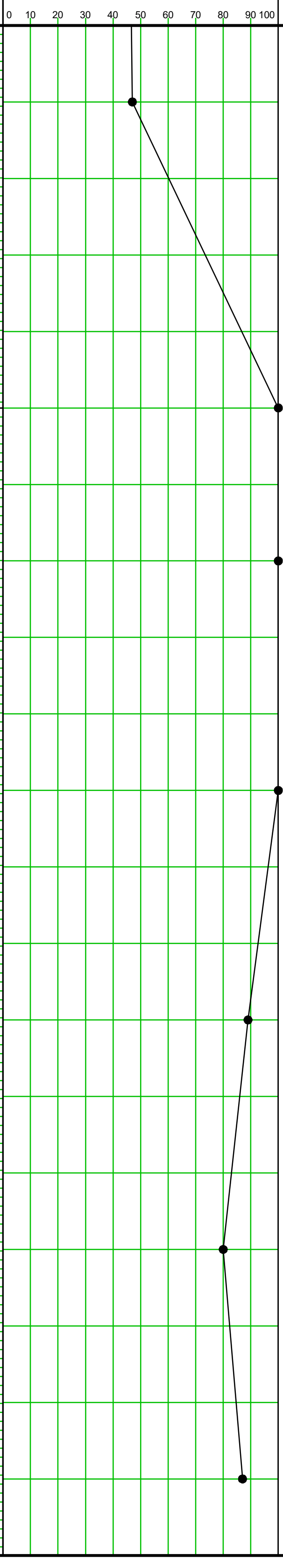
| | | |
|---|---|---|
| *Project Name :*GTI for (HORC) project from Palwal to Harsana Kalan in the state of Haryana. | | *Client :*HRIDCL |
| *BH Location/Chainage :*16+231 | *Northing :*3121114.308 m | *Easting :*705836.344 m |
| *Reduced Level (m):*(+)192.968 | *BH. No. :*BH-A1 | *BH Termination Depth (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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | Greyish brown, Hard, Silty clay of low plasticity with gravel | CL | |
| 20.5 | 20.5 | SPT-7 | 11 | 18 | 29 | 47 | | | |
| 21.0 | | | | | | | | | |
| 21.5 | | | | | | | | | |
| 22.0 | 22 | UDS* | | | | | | | |
| 22.5 | 22.5 | SPT-8 | 30 | 64 | 36 (10cm) | >100 | | | |
| 23.0 | | | | | | | Greyish brown, Very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 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 | | | |
| 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 | | | | | | | |

Graphic Log



(Depth v/s SPT N Value)



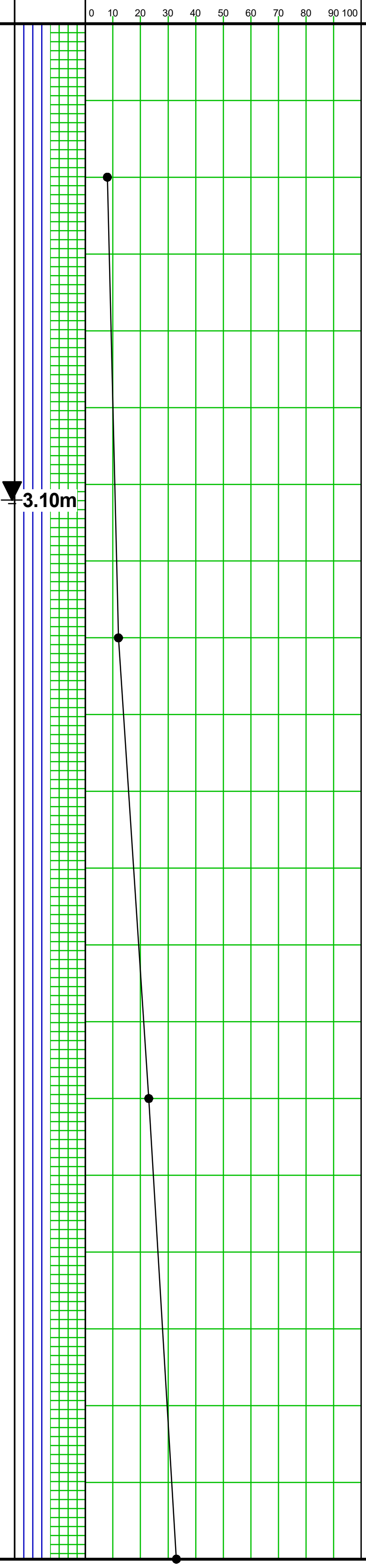
UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | DS-1 | | | | | Greyish brown, Loose to medium dense, Sandy silt of low plasticity | ML-CL | |
| 0.5 | | | | | | | | | |
| 1.0 | 1 | SPT-1 | 3 | 4 | 4 | 8 | | | |
| 1.5 | | | | | | | | | |
| 2.0 | | | | | | | | | |
| 2.5 | 2.5 | UDS-1 | | | | | | | |
| 3.0 | | | | | | | | | |
| 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 | 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 | | | |

Graphic Log | (Depth v/s SPT N Value)

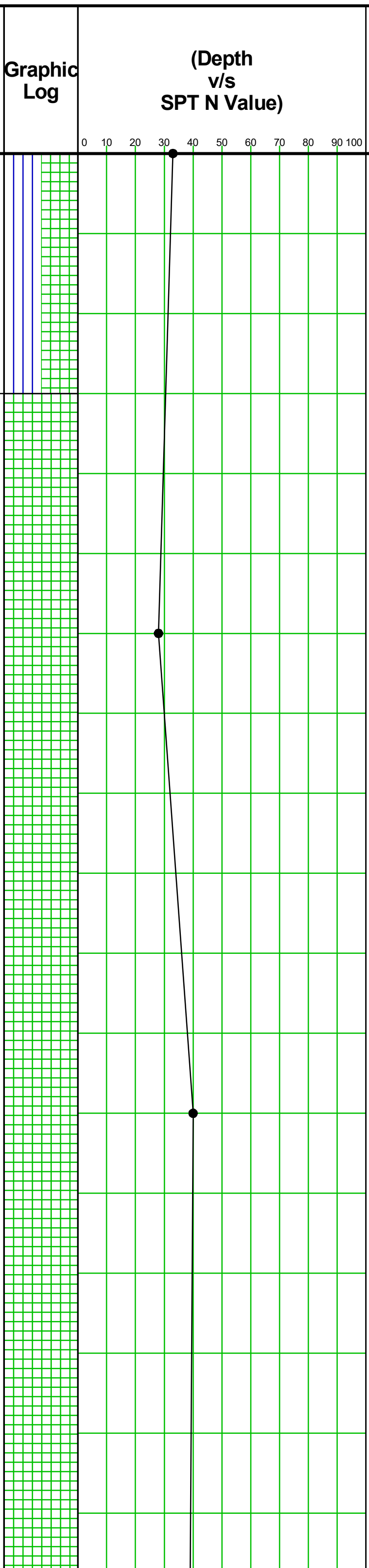


UDS*-UDS not recovered

# 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 | Special Observations |
|---|---|---|---|---|---|---|---|---|---|
| 10.0 | | | | | | | Greyish brown, Loose to medium dense, Sandy silt of low plasticity | ML-CL | |
| 10.5 | | | | | | | | | |
| 11.0 | | | | | | | | | |
| 11.5 | 11.5 | UDS-4 | | | | | Greyish brown, Very stif to Hard, Silty clay of low plasticity with gravel | CL | |
| 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 | | | | | | | | | |
| 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 | | | | | | | | | |

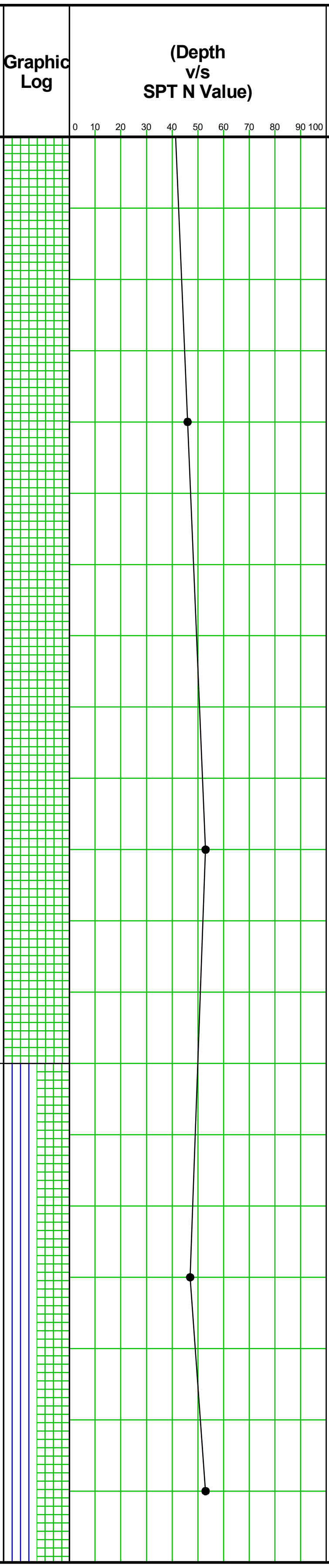


UDS*-UDS not recovered

# 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 | |

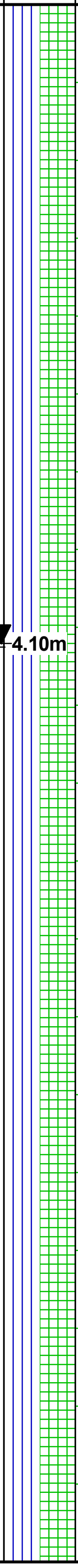
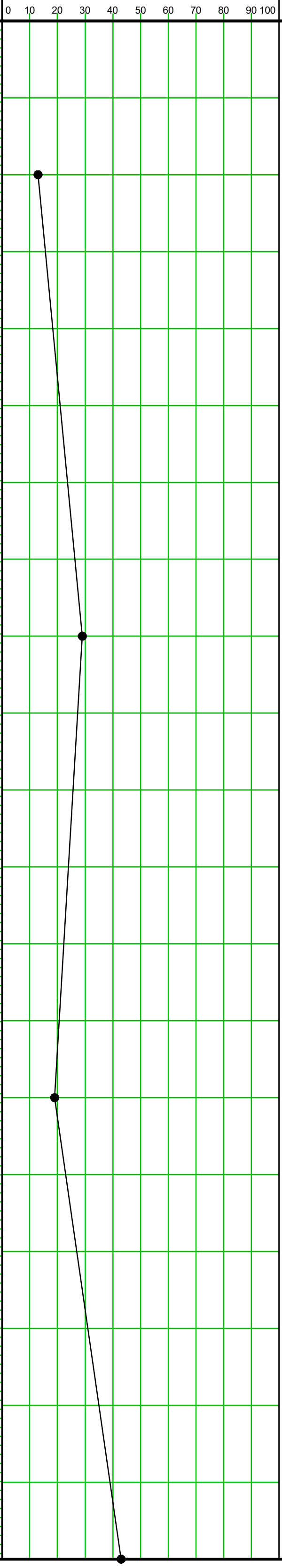
| **Depth (m)** | **In-Situ Sample Depth (m)** | **Sample Type** | **Blow counts per 15cm** | | | **SPT N Value** | **Strata Description** | **IS Classification** | **Special Observations** |
|---|---|---|---|---|---|---|---|---|---|
| | | | **N1** | **N2** | **N3** | | | | |
| 20.0 | | | | | | | Greyish brown, Very stif to 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 | 21 | 25 | 46 | | | |
| 22.5 | | | | | | | | | |
| 23.0 | | | | | | | | | |
| 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 | | | | | | | Greyish brown, Dense to very dense, Sandy silt of low plasticity with gravel | ML-CL | |
| 27.5 | | | | | | | | | |
| 28.0 | 28 | SPT-10 | 16 | 20 | 27 | 47 | | | |
| 28.5 | | | | | | | | | |
| 29.0 | | | | | | | | | |
| 29.5 | 29.5 | SPT-11 | 17 | 24 | 29 | 53 | | | |
| 30.0 | 30 | DS-2 | | | | | | | |



UDS*-UDS not recovered

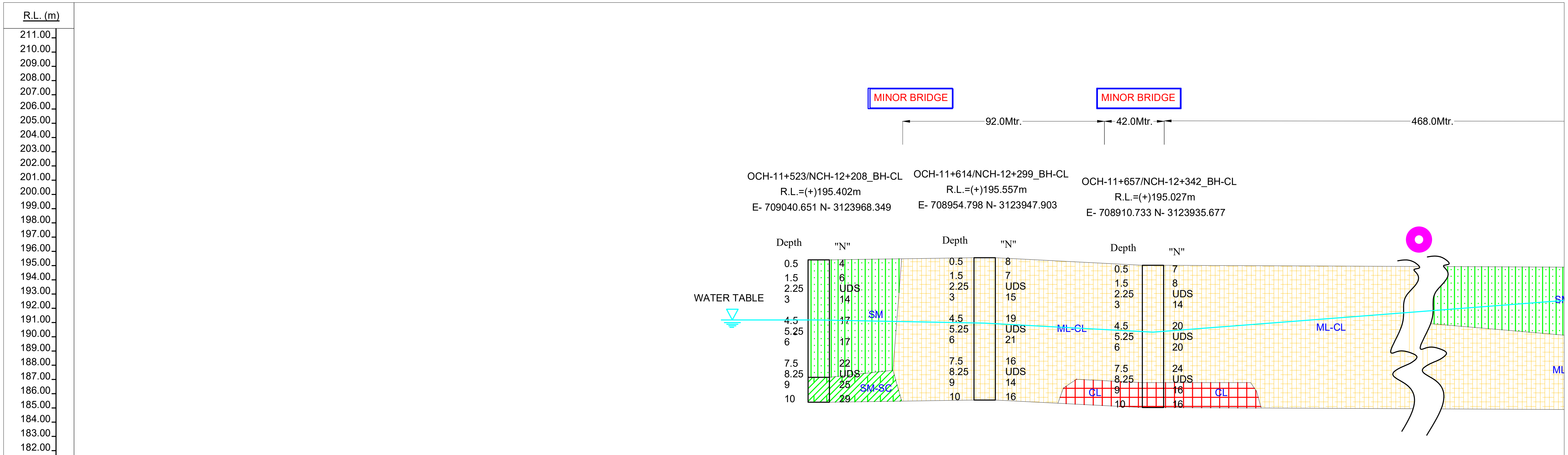
# FIELD BOREHOLE LOG

| | | |
|---|---|---|
| *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 | | | SPT N Value | Strata Description | IS Classification | Graphic Log | (Depth v/s SPT N Value) | Special Observations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | N1 | N2 | N3 | | | | | | |
| 0.0 | | DS | | | | | Brown, Medium dense to dense, Sandy silt of low plasticity | ML-CL |  |  | |
| 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 | | | | | |
| 4.5 | | | | | | | | | | | |
| 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 | | | | | | | | | |
| 9.0 | | | | | | | | | | | |
| 9.5 | | | | | | | | | | | |
| 10.0 | 10 | SPT-4 | 14 | 19 | 24 | 43 | | | | | |

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 (mm) | 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-11+523<br>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 | 8.07 | 8.07 | |
| | | 2.7 X 2.7 | 2.00 | 12.90 | 8.55 | 8.55 | |
| OCH-11+523<br>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 | 15.64 | 10.56 | |
| | | 2.7 X 2.7 | 2.00 | 12.90 | 17.10 | 12.90 | |

| Chainage | BH No. | Size (mm) | 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-11+614<br>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<br>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 (mm) | 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-11+657<br>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<br>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 | |

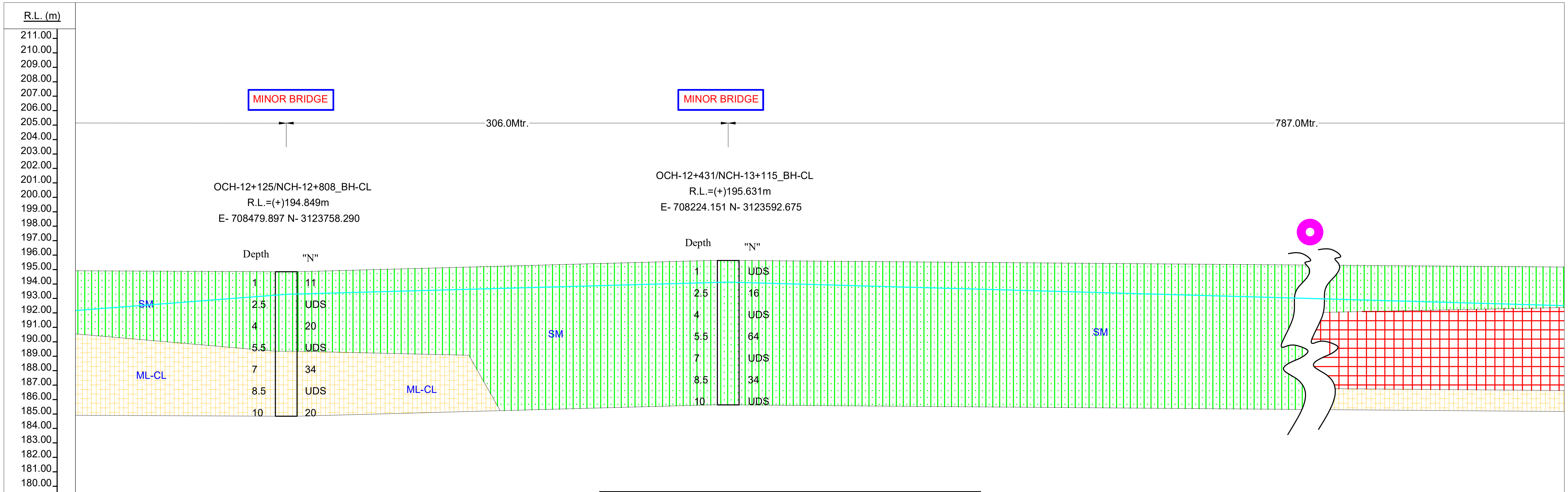
| SYMBOL | DESCRIPTION |
|---|---|
| 🟩 | SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line) |
| ▨ | SM-SC -Clayey Sand (Having fines Less Than 50% and in the hatched zone (4<PI<7) |
| ▦ | ML-CL -Sandy with clay (Having fines greater than 50% and in the hatched zone (LL<35 & 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 (mm) | 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-12+125<br>NCH-12+808 | BH-CL | 2.7 X 2.7 | 1.00 | 8.56 | 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 | 11.55 | |
| OCH-12+125<br>NCH-12+808 | BH-CL | 2.7 X 2.7 | 1.00 | 8.56 | 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 | |

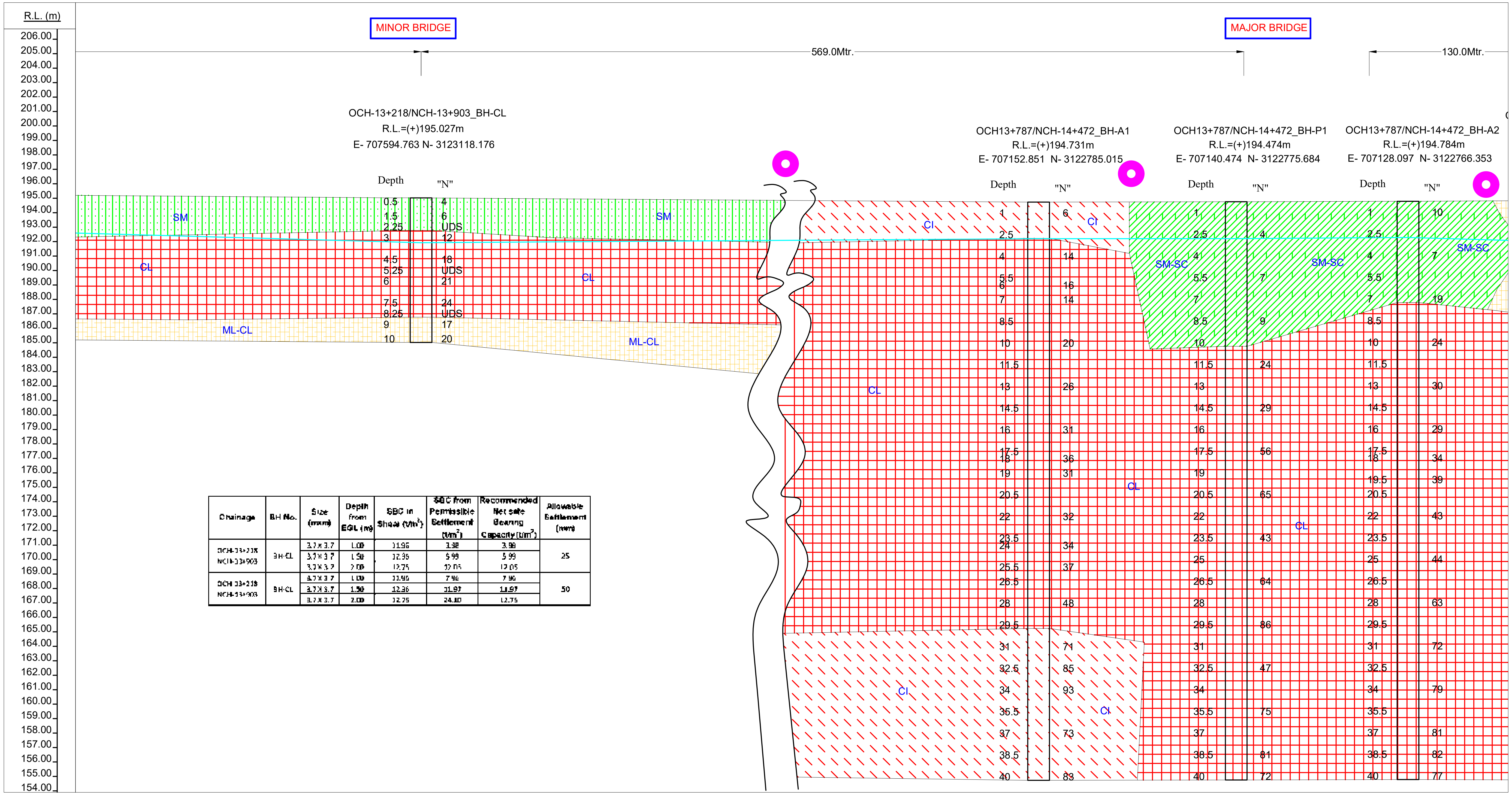
| Chainage | BH No. | Size (mm) | Depth from EGL (m) | SBC in Shear (t/m²) | SBC from Permissible Settlement (t/m²) | Recommended Net safe Bearing Capacity (t/m²) | Allowable Settlement (mm) |
|---|---|---|---|---|---|---|---|
| OCH-12+431<br>NCH-13+115 | BH CL | 3.7 X 3.7 | 1.00 | 10.01 | 14.37 | 10.01 | 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<br>NCH-13+115 | BH-CL | 3.7 X 3.7 | 1.00 | 10.01 | 18.73 | 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) | | |
| ▦ | 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-13+218<br>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<br>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:-

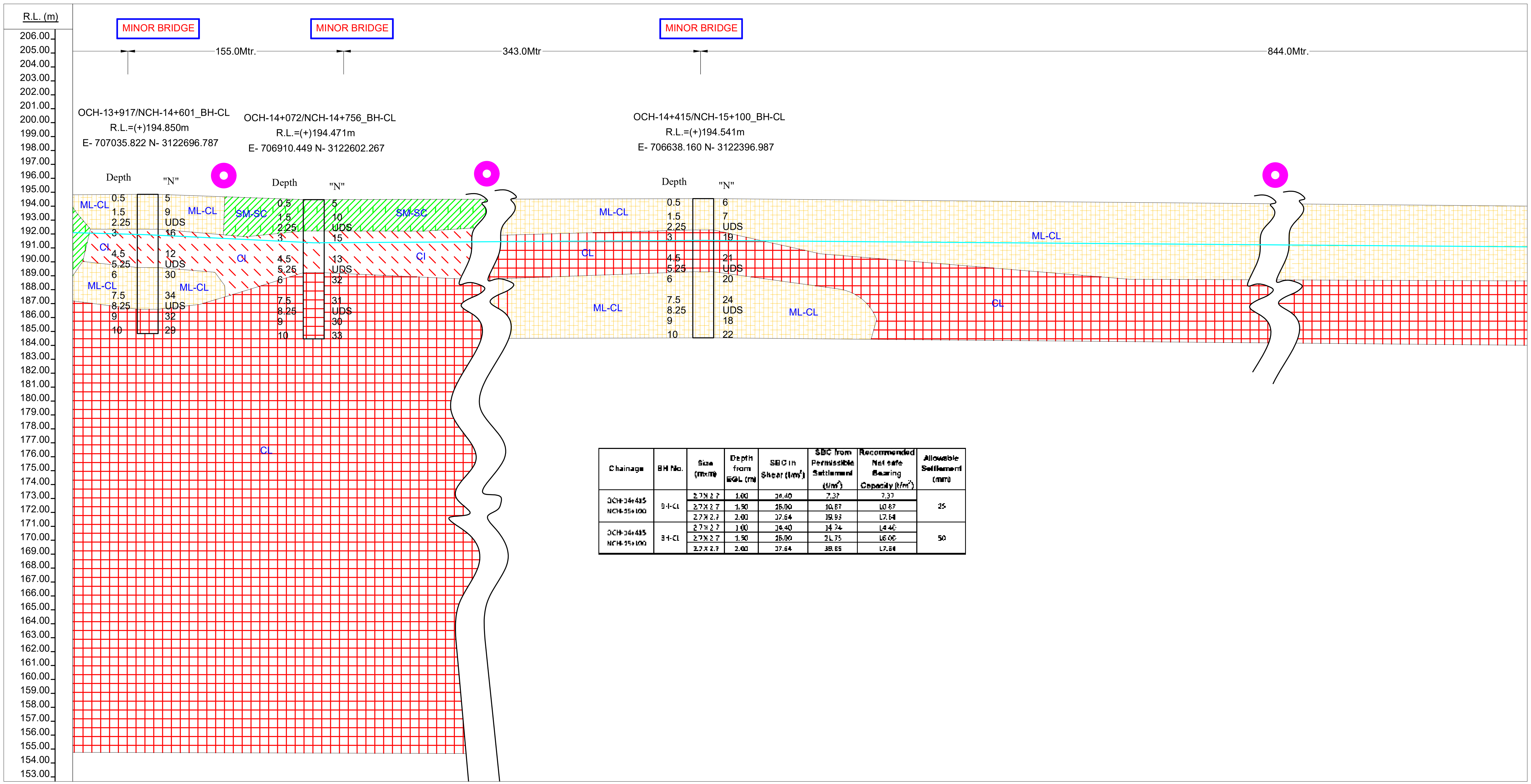
1. The soil stratum in some of the bore holes is found to be liquefiable up to certain depth as given in table 2.1. For these locations the SBC has been re-evaluated considering the soil parameters for replaced/ compacted soil. The modified SBC for the same is provided in the table 4.3 & table 4.4.
2. Bore holes which are liquefied greater than 4m depth, Some other suitable ground improvement methods may be adopted.

| 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<br>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<br>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 | 13.09 | 11.36 | |
| | | 7.2 X 7.2 | 4.00 | 11.77 | 14.25 | 11.77 | |
| OCH-13+787<br>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<br>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<br>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<br>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 | |

| 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-14+415<br>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 | 17.64 | 19.93 | 17.64 | |
| OCH-14+415<br>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+907<br>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+907<br>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 | |

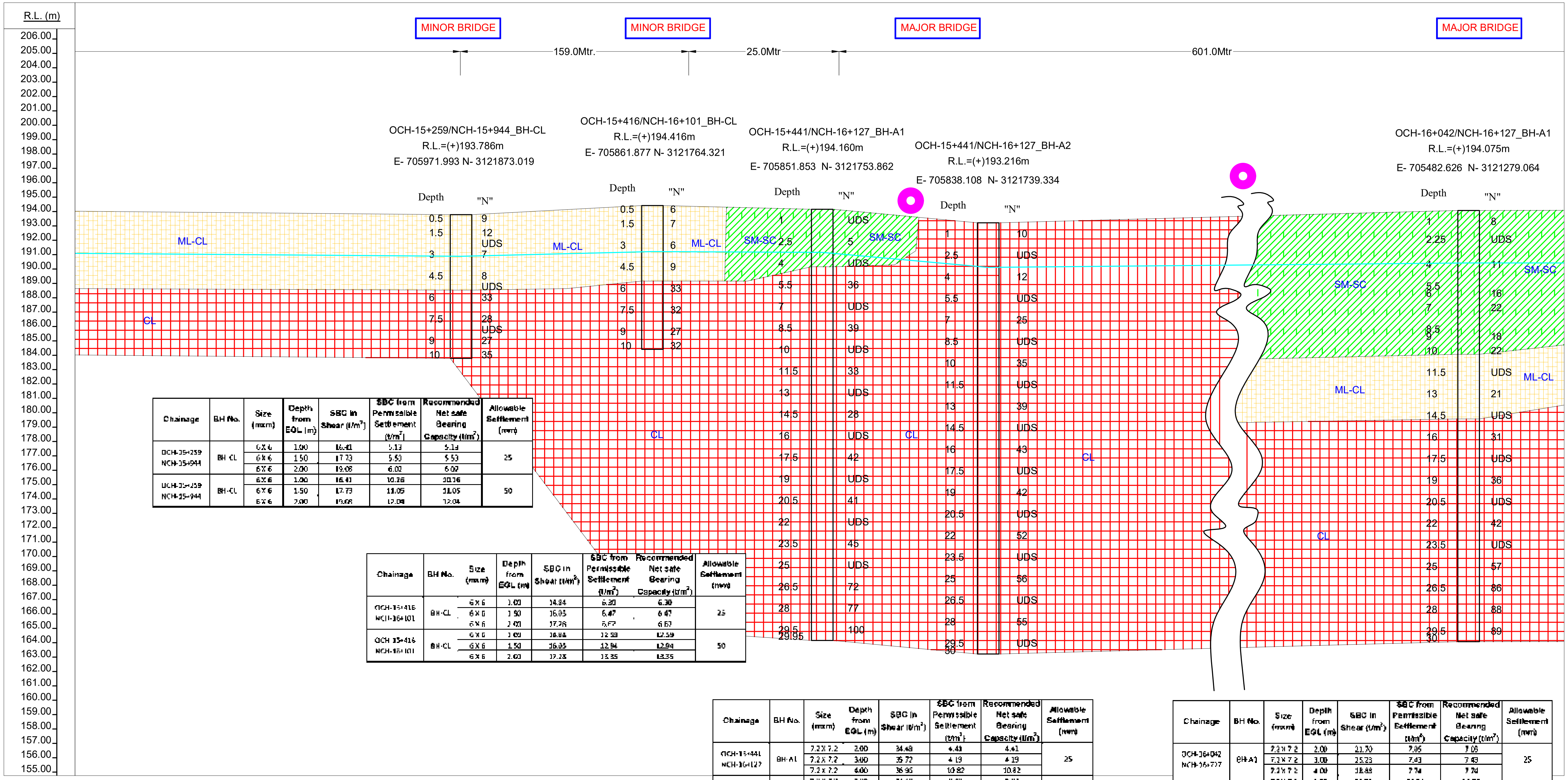
| Chainage | BH No. | Size (mxm) | Depth from EGL (m) | SBC in Shear (t/m²) | SBC from Permissible Settlement (t/m²) | Recommended Net safe Bearing Capacity (t/m²) | Allowable Settlement (mm) |
|---|---|---|---|---|---|---|---|
| OCH-14+072<br>NCH-14+756 | BH-CL | 6 X 6 | 1.00 | 10.95 | 5.33 | 5.33 | 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<br>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:-

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 (mm) | 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<br>NCH-15+944 | BH-CL | 6X6 | 1.00 | 16.41 | 5.13 | 5.13 | 25 |
| | | 6X6 | 1.50 | 17.73 | 5.53 | 5.53 | |
| | | 6X6 | 2.00 | 19.08 | 6.02 | 6.02 | |
| OCH-15+259<br>NCH-15+944 | BH-CL | 6X6 | 1.00 | 16.41 | 10.26 | 10.26 | 50 |
| | | 6X6 | 1.50 | 17.73 | 11.05 | 11.05 | |
| | | 6X6 | 2.00 | 19.08 | 12.04 | 12.04 | |

| Chainage | BH No. | Size (mm) | 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<br>NCH-16+101 | BH-CL | 6X6 | 1.00 | 14.84 | 6.30 | 6.30 | 25 |
| | | 6X6 | 1.50 | 16.05 | 6.47 | 6.47 | |
| | | 6X6 | 2.00 | 17.28 | 6.67 | 6.67 | |
| OCH-15+416<br>NCH-16+101 | BH-CL | 6X6 | 1.00 | 14.84 | 12.59 | 12.59 | 50 |
| | | 6X6 | 1.50 | 16.05 | 12.94 | 12.94 | |
| | | 6X6 | 2.00 | 17.28 | 13.35 | 13.35 | |

| Chainage | BH No. | Size (mm) | 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<br>NCH-16+127 | BH-A1 | 7.2X7.2 | 2.00 | 34.48 | 4.41 | 4.41 | 25 |
| | | 7.2X7.2 | 3.00 | 35.72 | 4.19 | 4.19 | |
| | | 7.2X7.2 | 4.00 | 36.96 | 10.82 | 10.82 | |
| OCH-15+441<br>NCH-16+127 | BH-A1 | 7.2X7.2 | 2.00 | 34.49 | 8.83 | 8.83 | 50 |
| | | 7.2X7.2 | 3.00 | 35.72 | 17.42 | 17.42 | |
| | | 7.2X7.2 | 4.00 | 36.96 | 21.64 | 21.64 | |
| OCH-15+441<br>NCH-16+127 | BH-A2 | 7.2X7.2 | 2.00 | 8.73 | 8.30 | 8.30 | 25 |
| | | 7.2X7.2 | 3.00 | 9.05 | 8.75 | 8.75 | |
| | | 7.2X7.2 | 4.00 | 9.38 | 9.24 | 9.24 | |
| OCH-15+441<br>NCH-16+127 | BH-A2 | 7.2X7.2 | 2.00 | 8.73 | 15.60 | 8.73 | 50 |
| | | 7.2X7.2 | 3.00 | 9.05 | 17.50 | 9.05 | |
| | | 7.2X7.2 | 4.00 | 9.38 | 18.48 | 9.39 | |

| Chainage | BH No. | Size (mm) | 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<br>NCH-16+727 | BH-A1 | 7.2X7.2 | 2.00 | 21.70 | 7.05 | 7.05 | 25 |
| | | 7.2X7.2 | 3.00 | 25.23 | 7.43 | 7.43 | |
| | | 7.2X7.2 | 4.00 | 28.88 | 7.74 | 7.74 | |
| OCH-16+042<br>NCH-16+727 | BH-A1 | 7.2X7.2 | 2.00 | 21.70 | 28.21 | 21.70 | 50 |
| | | 7.2X7.2 | 3.00 | 25.23 | 14.87 | 14.87 | |
| | | 7.2X7.2 | 4.00 | 28.88 | 15.46 | 15.46 | |

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.

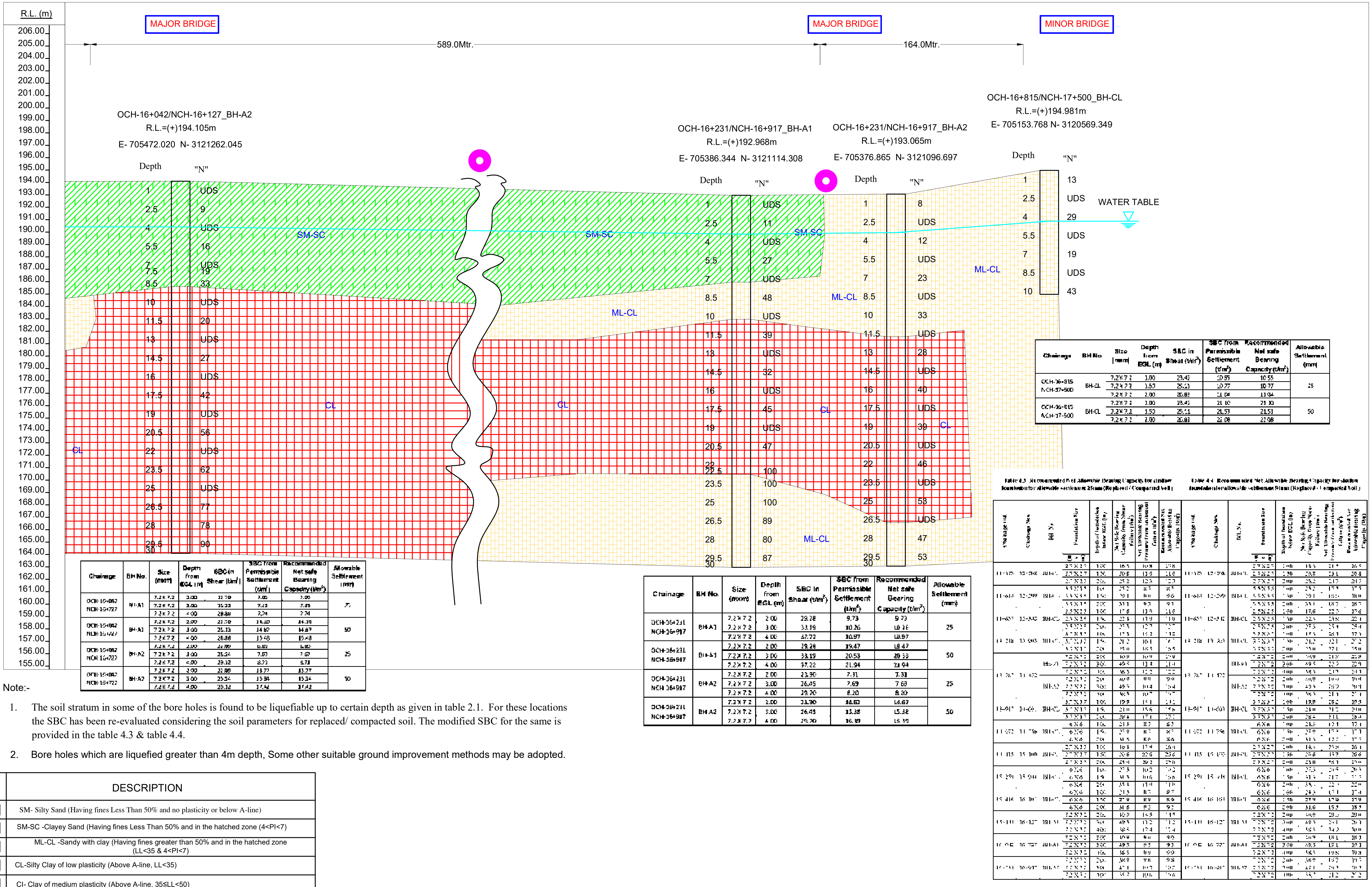
| SYMBOL | DESCRIPTION |
|---|---|
| 🟩 | SM- Silty Sand (Having fines Less Than 50% and no plasticity or below A-line) |
| ▨ | SM-SC -Clayey Sand (Having fines Less Than 50% and in the hatched zone (4<PI<7) |
| 🟨 | ML-CL -Sandy with clay (Having fines greater than 50% and in the hatched zone (LL<35 & 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 (mm) | 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<br>NCH-16+727 | BH-A1 | 7.2 X 7.2 | 2.00 | 21.70 | 7.00 | 7.00 | 25 |
| | | 7.2 X 7.2 | 3.00 | 25.33 | 7.43 | 7.43 | |
| | | 7.2 X 7.2 | 4.00 | 28.88 | 7.74 | 7.74 | |
| OCH-16+042<br>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 | 25.33 | 14.87 | 14.87 | |
| | | 7.2 X 7.2 | 4.00 | 28.88 | 15.48 | 15.48 | |
| OCH-16+042<br>NCH-16+727 | BH-A2 | 7.2 X 7.2 | 2.00 | 21.00 | 6.83 | 6.83 | 25 |
| | | 7.2 X 7.2 | 3.00 | 25.54 | 7.07 | 7.07 | |
| | | 7.2 X 7.2 | 4.00 | 29.12 | 8.71 | 8.71 | |
| OCH-16+042<br>NCH-16+727 | BH-A2 | 7.2 X 7.2 | 2.00 | 21.00 | 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 (mm) | 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<br>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 | 37.72 | 10.97 | 10.97 | |
| OCH-16+231<br>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<br>NCH-16+917 | BH-A2 | 7.2 X 7.2 | 2.00 | 23.30 | 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<br>NCH-16+917 | BH-A2 | 7.2 X 7.2 | 2.00 | 23.30 | 14.63 | 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 (mm) | 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<br>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 | 25.13 | 10.77 | 10.77 | |
| | | 7.2 X 7.2 | 2.00 | 26.83 | 11.04 | 11.04 | |
| OCH-16+815<br>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 | 25.13 | 21.53 | 21.53 | |
| | | 7.2 X 7.2 | 2.00 | 26.83 | 22.08 | 22.08 | |

Table 4.3 Recommended Net Allowable Bearing Capacity for shallow foundation for Allowable settlement 25mm (Replaced / Compacted Soil)

Table 4.4 Recommended Net Allowable Bearing Capacity for shallow foundation for allowable settlement 50mm (Replaced / Compacted Soil)

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 |

# 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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 30-10-2021 | to | 30-10-2021 | 11+523<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 30-10-2021 | to | 30-10-2021 | 11+614<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

# 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<br>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
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 06-10-2021 | to | 06-10-2021 | 12+125<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 06-10-2021 | to | 06-10-2021 | 12+431<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

# 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<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| DS | 0.00 | - | - | Brown, Loose, Silty sand | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| SPT-1 | 0.50 | 4 | 7 | | 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 | - | - | Brown, Very stiff, Silty clay of low plasticity | 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 | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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.

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 09-11-2021 | to | 10-11-2021 | 13+787<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 09-11-2021 | to | 10-11-2021 | 13+787<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | Liquid Limit | Plastic Limit | Plasticity Index | Shrinkage Limit | | | | | Type of Test | Cohesion C (kg/cm$^2$) | Angle of Friction ($\varphi^o$) | | | | 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 ($C_c$) |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 7.10<br>4.97<br>3.89<br>3.08 | 1.84<br>1.24<br>0.78<br>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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 08-11-2021 | to | 09-11-2021 | 13+787<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| DS | 0.00 | - | - | Grey, Loose, Silty sand with clay | - | ▨ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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 | - | - | | 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 | - | - | Greyish brown, Very stiff, Silty clay of low plasticity | 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 | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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 | - | - | Greyish brown, Hard, Silty clay of low plasticity with gravel | 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 | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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:-
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** |
| | | 08-11-2021 | to | 09-11-2021 | 13+787<br>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** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Sand** | | | **Gravel** | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | **Clay** | **Silt** | **Fine** | **Medium** | **Coarse** | **Fine** | **Coarse** | **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 ($C_c$)** |
| 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 | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | Greyish brown, Very stiff to hard, Silty clay of low plasticity | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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 | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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 | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 31-10-2021 | to | 31-10-2021 | 13+917<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 7.73<br>5.29<br>3.77<br>3.12 | 2.14<br>1.88<br>1.24<br>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

# 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<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 5.89<br>4.88<br>3.90<br>3.13 | 2.37<br>1.72<br>1.16<br>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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 31-10-2021 | to | 31-10-2021 | 14+415<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 31-10-2021 | to | 31-10-2021 | 15+259<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 31-10-2021 | to | 31-10-2021 | 15+416<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 10-11-2021 | to | 11-11-2021 | 15+441<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| DS-1 | 0.00 | - | - | Brown, Loose, Silty sand with clay | - | ▨ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| UDS-1 | 1.00 | - | - | | 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 | - | - | Brown, Hard, Silty clay of low plasticity with gravel | 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 | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 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:-
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** |
| | | 10-11-2021 | to | 11-11-2021 | 15+441<br>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** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Sand** | | | **Gravel** | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | **Clay** | **Silt** | **Fine** | **Medium** | **Coarse** | **Fine** | **Coarse** | **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 ($C_c$)** |
| 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 | - | - | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 10-11-2021 | to | 11-11-2021 | 15+441<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | Liquid Limit | Plastic Limit | Plasticity Index | Shrinkage Limit | | | | | Type of Test | Cohesion C (kg/cm$^2$) | Angle of Friction ($\varphi^o$) | | | | 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 ($C_c$) |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 8.54<br>6.28<br>4.71<br>4.14 | 2.03<br>1.82<br>1.16<br>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 | - | - | - | - | - | - | - | - | - | - | - | - |

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** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10-11-2021 | to | 11-11-2021 | 15+441<br>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** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Sand** | | | **Gravel** | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | **Clay** | **Silt** | **Fine** | **Medium** | **Coarse** | **Fine** | **Coarse** | **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 ($C_c$)** |
| 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 | | - | | - | ▦ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 08-10-2021 | to | 09-10-2021 | 16+042<br>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 ($\varphi^o$) | | | | 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 | - | - | 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 | - | - | - | - | - | - | - | - |

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 | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 08-10-2021 | to | 09-10-2021 | 16+042<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 08-10-2021 | to | 09-10-2021 | 16+042<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 9.46<br>6.91<br>6.14<br>5.01 | 1.84<br>1.18<br>0.88<br>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 | - | - | - | - | - | - | - | - |

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 | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 08-10-2021 | to | 09-10-2021 | 16+042<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 11-11-2021 | to | 12-11-2021 | 16+231<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | Liquid Limit | Plastic Limit | Plasticity Index | Shrinkage Limit | | | | | Type of Test | Cohesion C (kg/cm$^2$) | Angle of Friction ($\varphi^o$) | | | | 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 ($C_c$) |
| 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<br>1.0-2.0<br>2.0-4.0<br>4.0-8.0 | 9.51<br>6.36<br>5.22<br>4.01 | 1.70<br>1.28<br>0.84<br>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.

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 11-11-2021 | to | 12-11-2021 | 16+231<br>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 | - | - | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

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** |
| | | 11-11-2021 | to | 12-11-2021 | 16+231<br>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** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | **Sand** | | | **Gravel** | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | **Clay** | **Silt** | **Fine** | **Medium** | **Coarse** | **Fine** | **Coarse** | **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 ($C_c$)** |
| 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.

CEGTH
CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. | 11-11-2021 | to | 12-11-2021 | 16+231<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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.

CEG TEST HOUSE

# SOIL CHARACTERISTICS

| Project | Date of Boring | | | Chainage (km.)/Location | B.H. No. | Depth of Water Table | Termination Depth | Cordinates (E,N) | | R.L. | Ref. Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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. | 04-10-2021 | to | 20-10-2021 | 16+815<br>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 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sand | | | Gravel | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | Clay | Silt | Fine | Medium | Coarse | Fine | Coarse | 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 ($C_c$) |
| 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 | | - | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

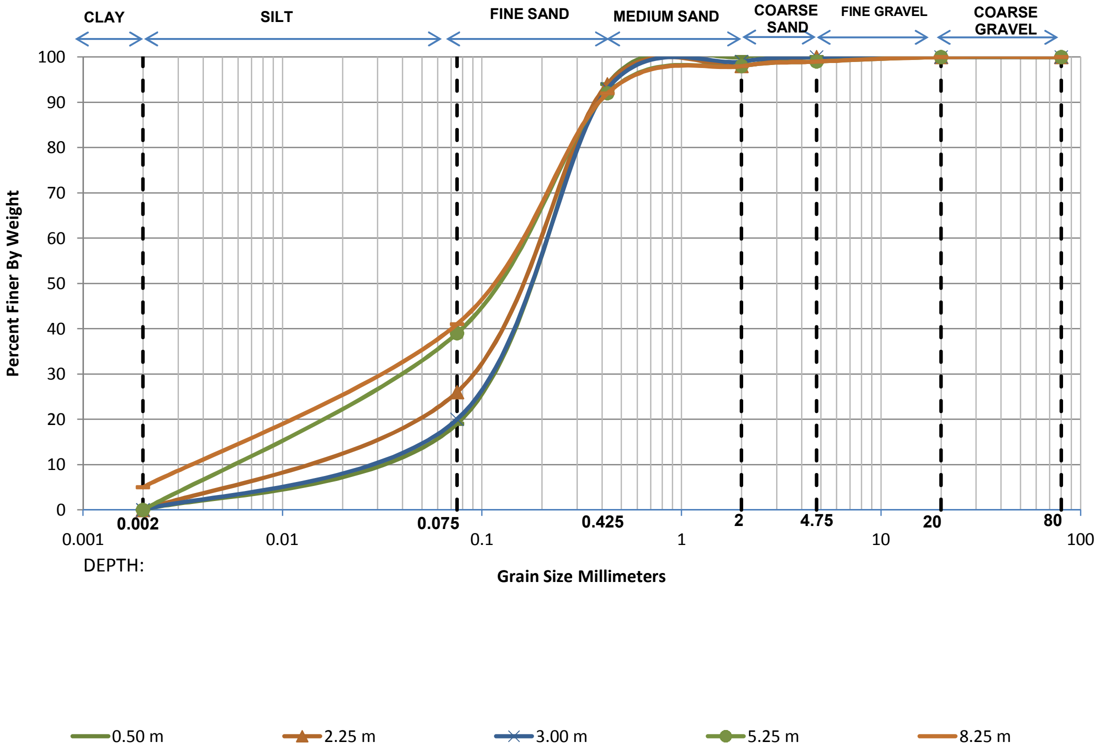
Abbreviations:-
DS-Disturbed Sample, SPT-Standard Penetration Test, UDS-Undisturbed Sample, UDS*-UDS not recovered, DST-Direct Shear Test, UUT-Unconsolidated Undrained Triaxial Shear Test, DST+ - Direct Shear Test on Remoulded Sample, UUT+ - Unconsolidated Undrained Tri-axial Test on Remoulded Sample.

# 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

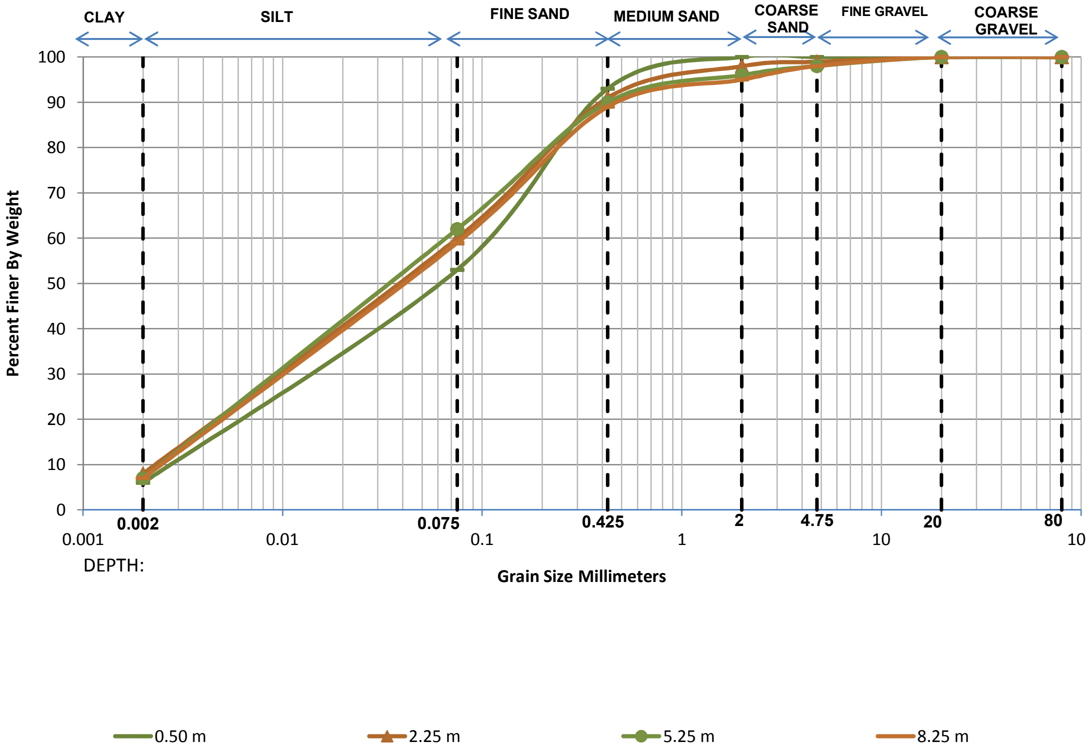
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

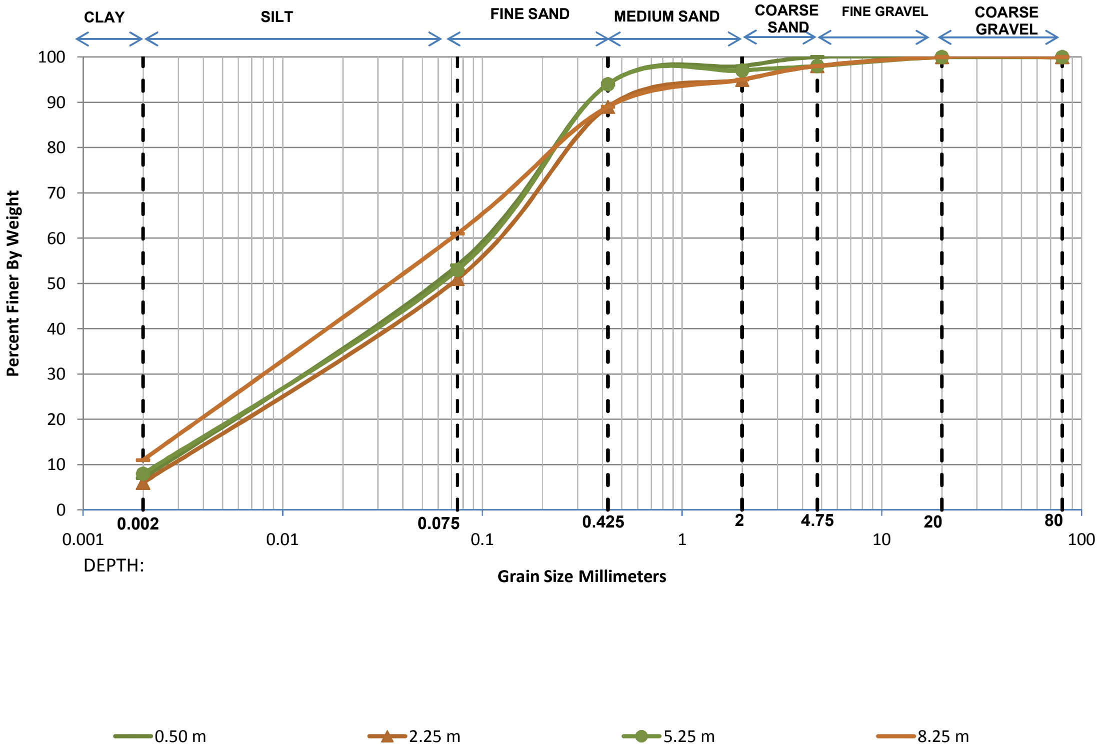
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

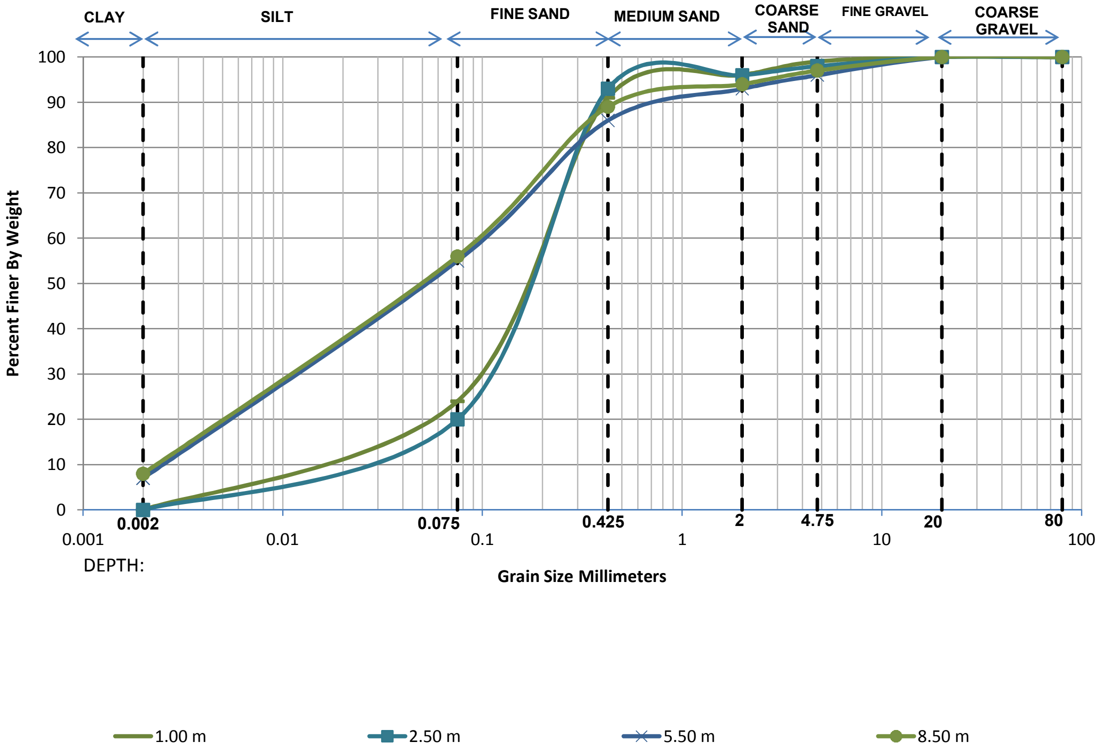
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

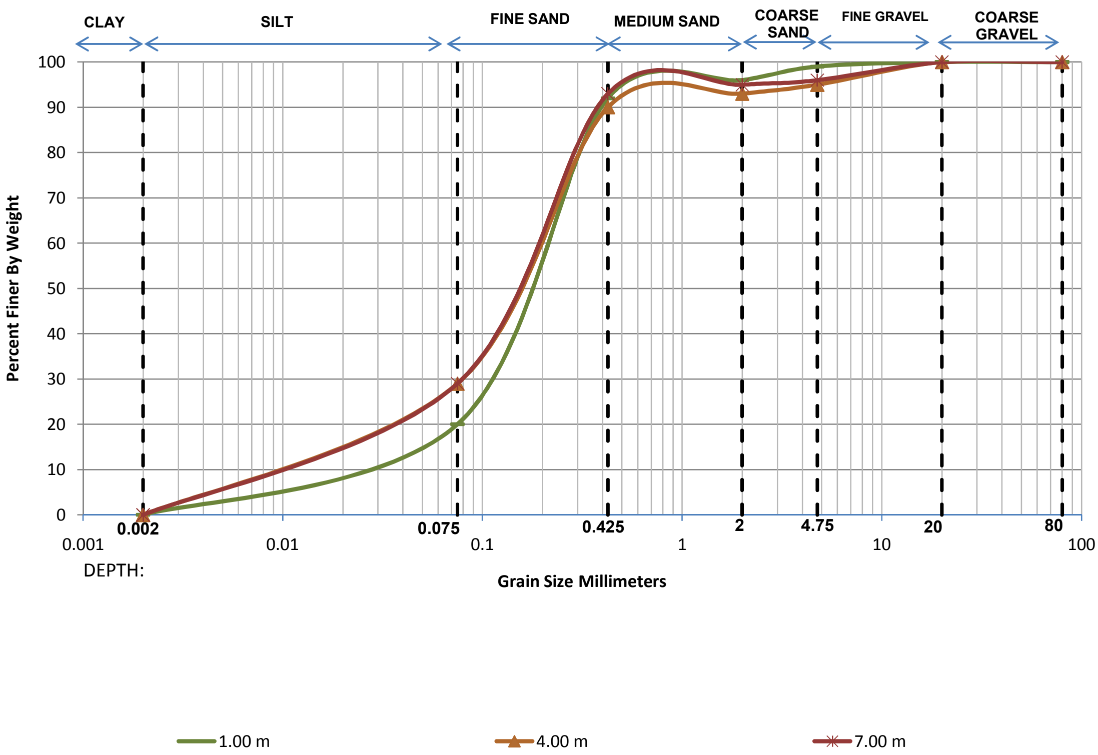
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

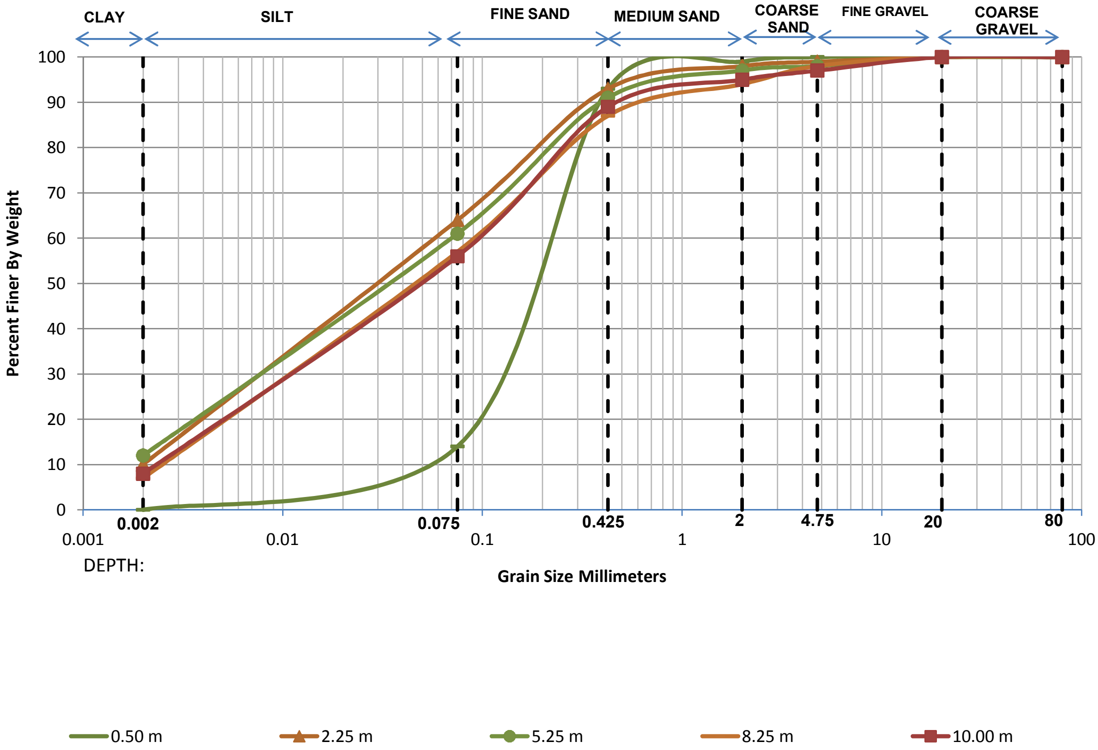
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

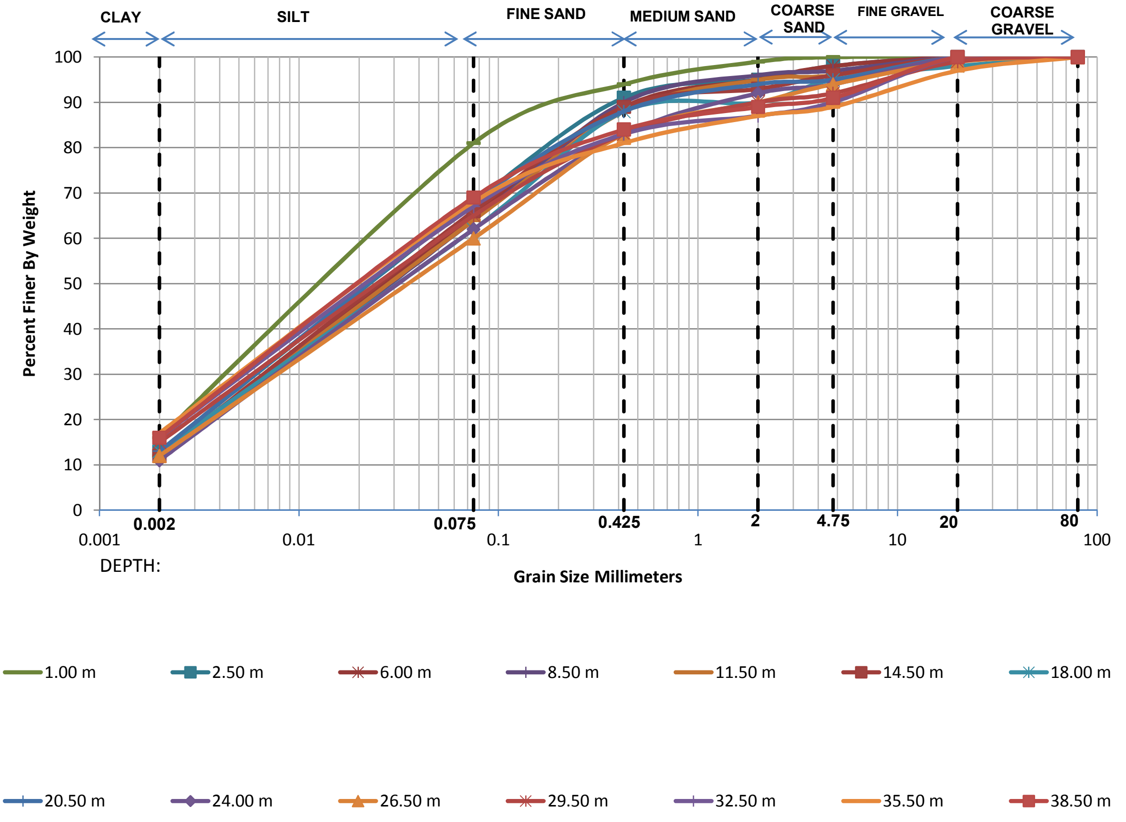
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

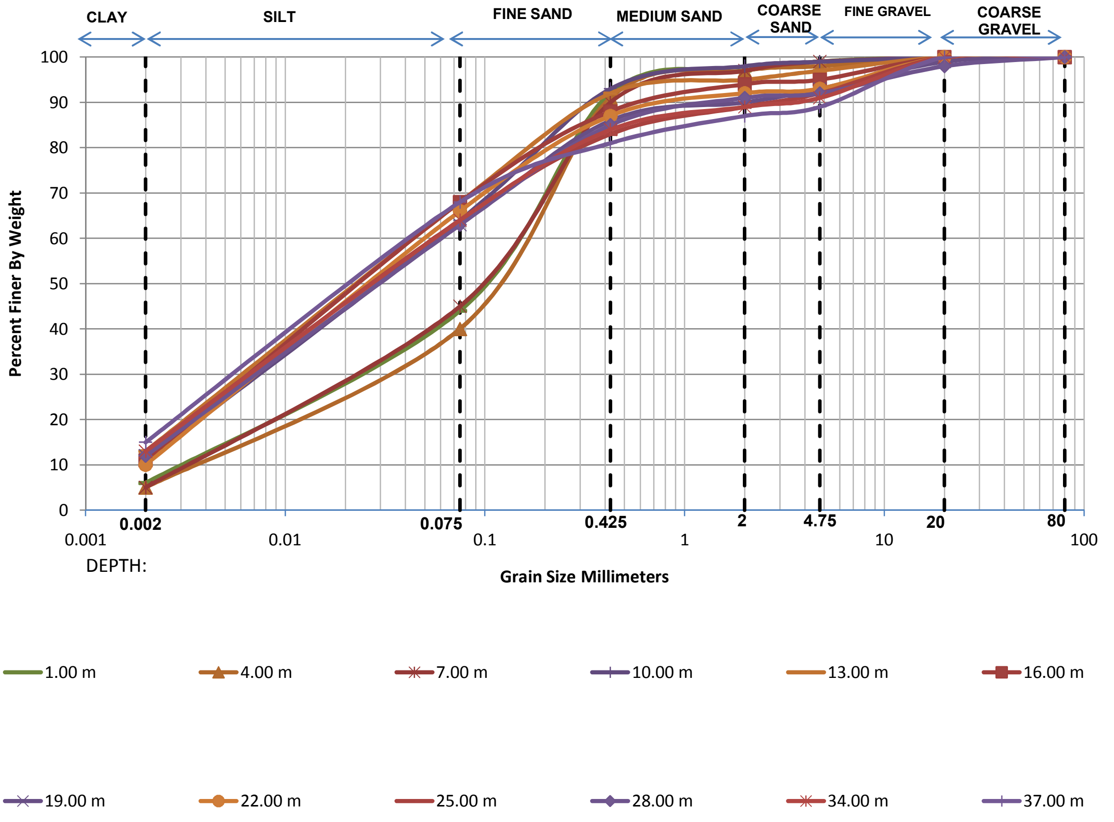
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

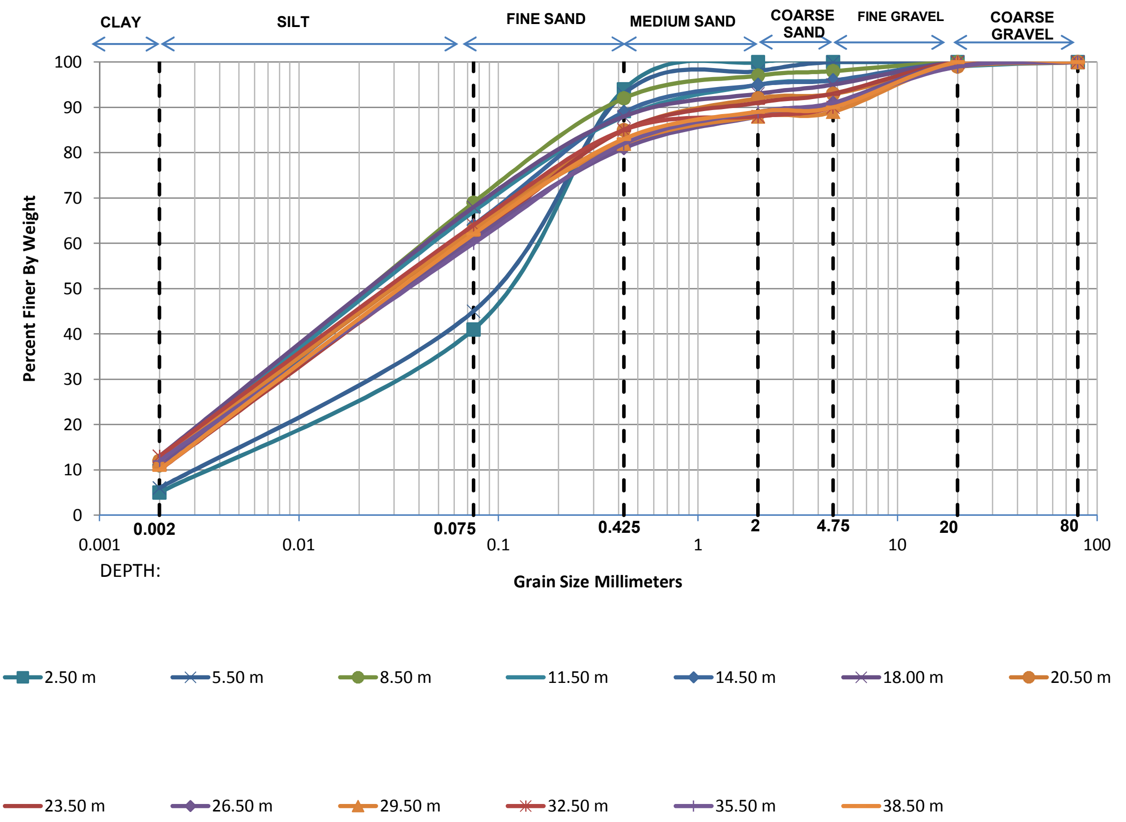
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

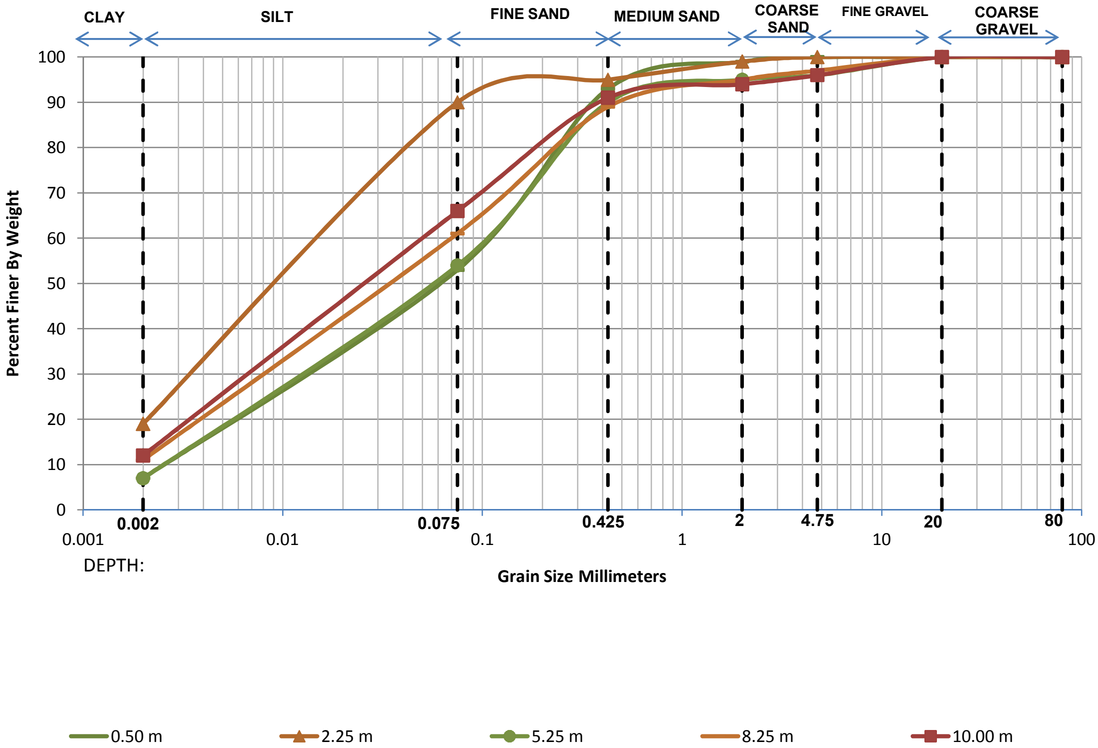
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

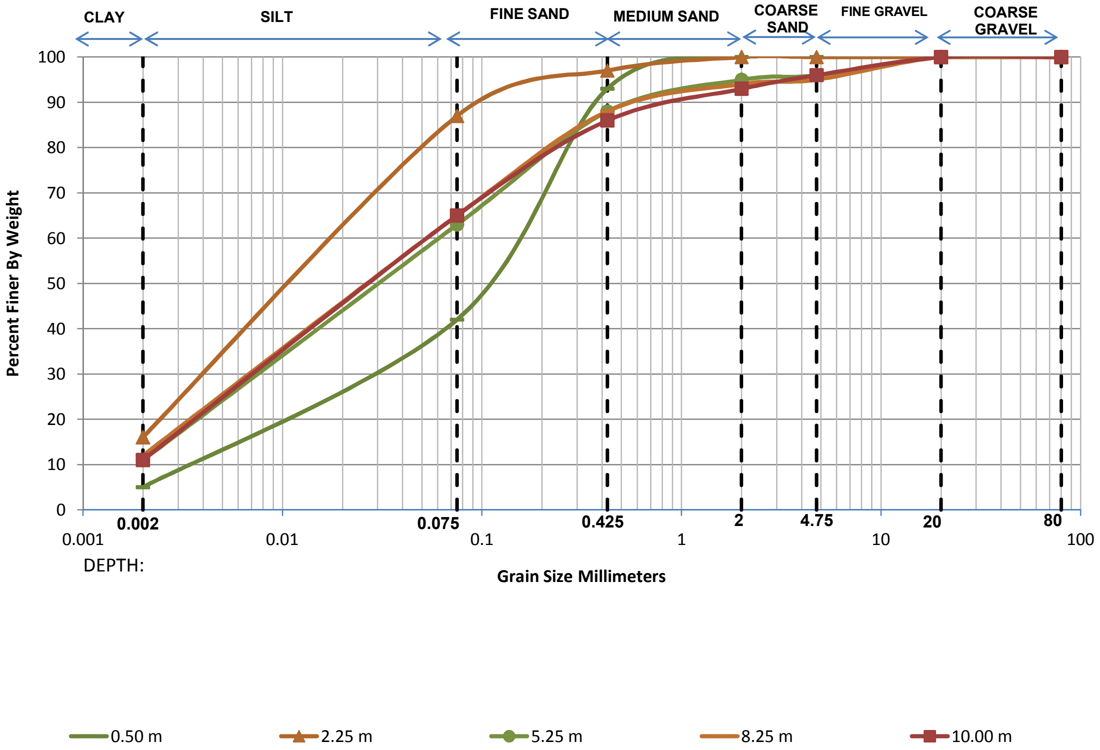
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR network in the state of Haryana. |
| **Location/Chainage** | 13+917 Minor Bridge |
| **B.H. No.** | BH-CL |



| Depth | Clay | Silt | Grain Size Distribution % wt retained | | | | | D10 | D30 | D60 | Cu | Cc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 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

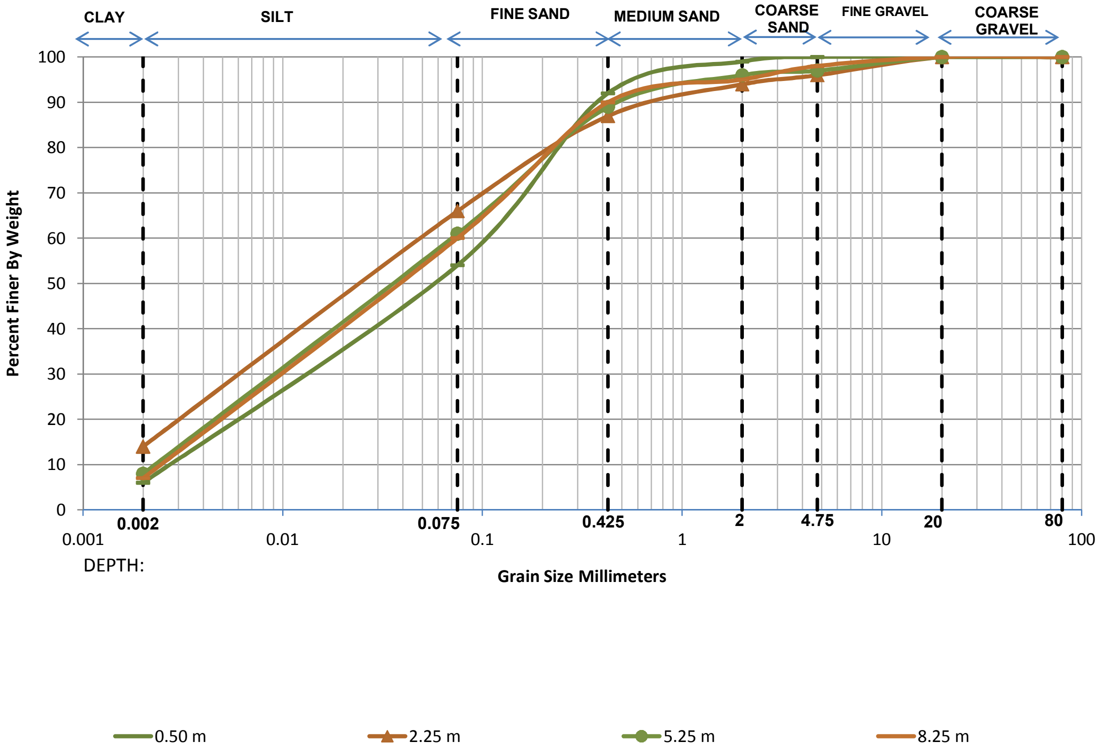
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

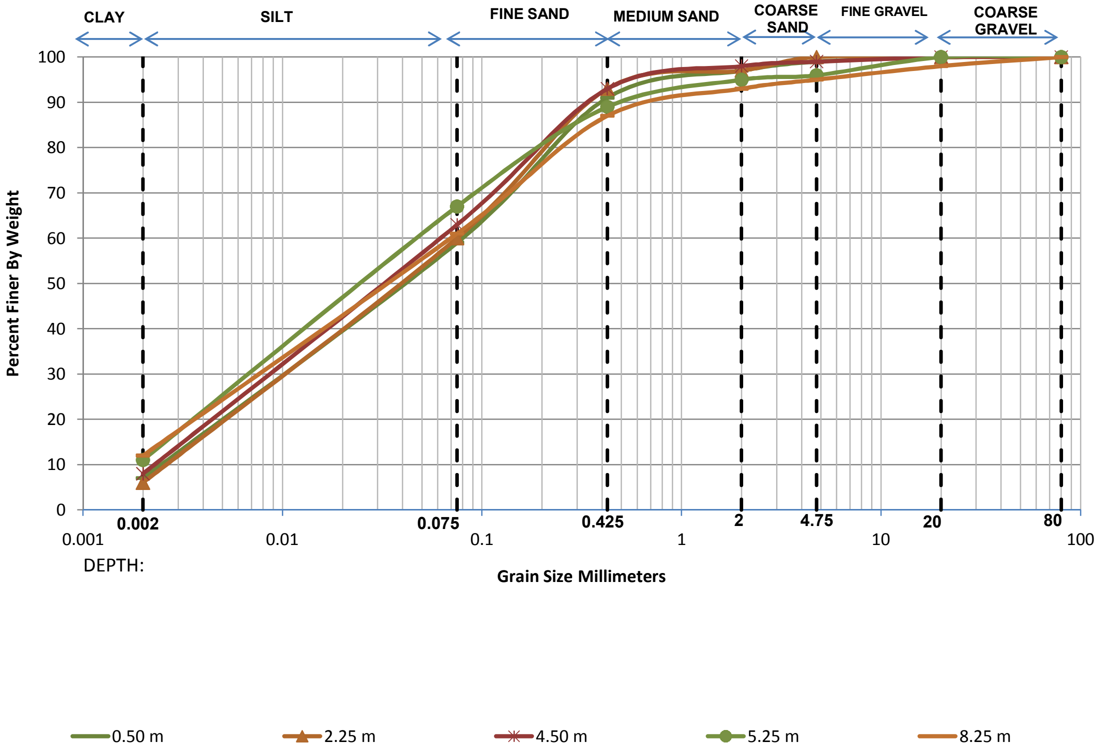
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

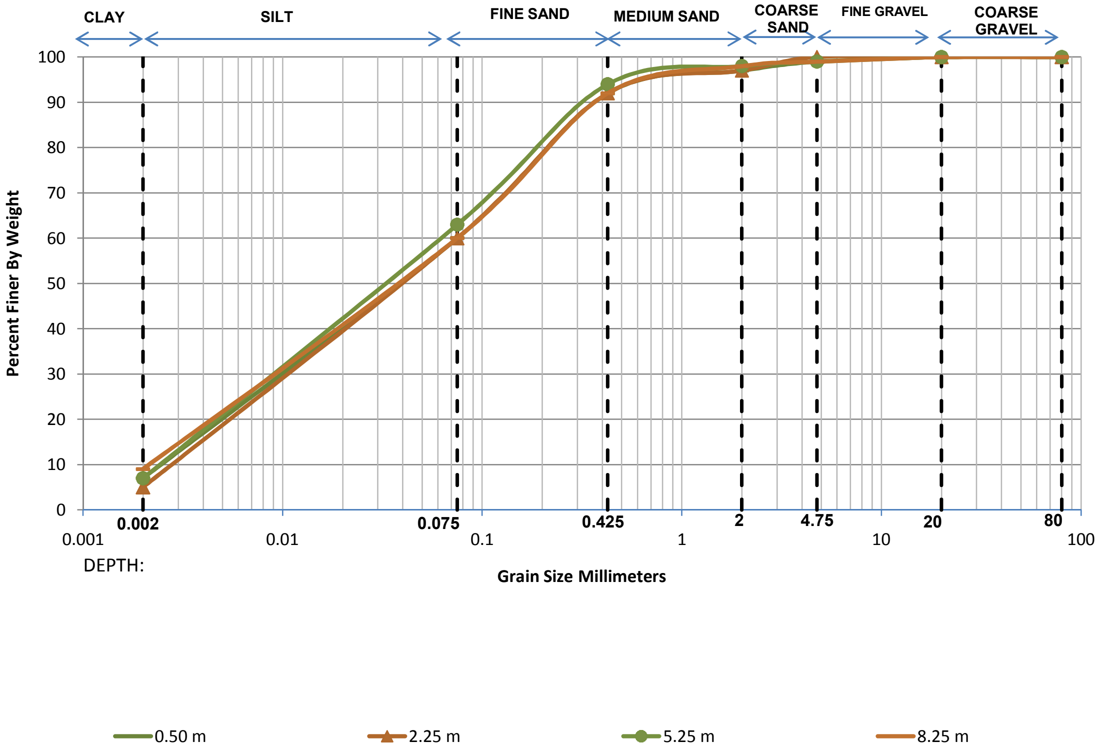
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

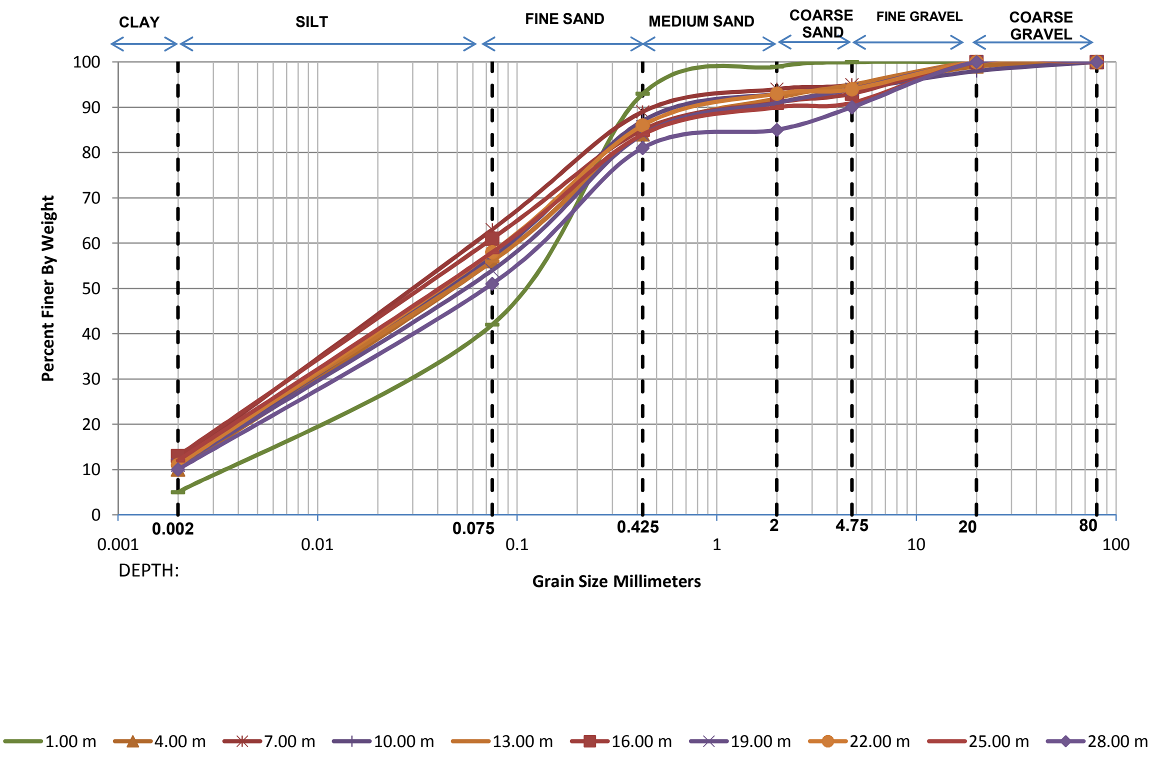
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

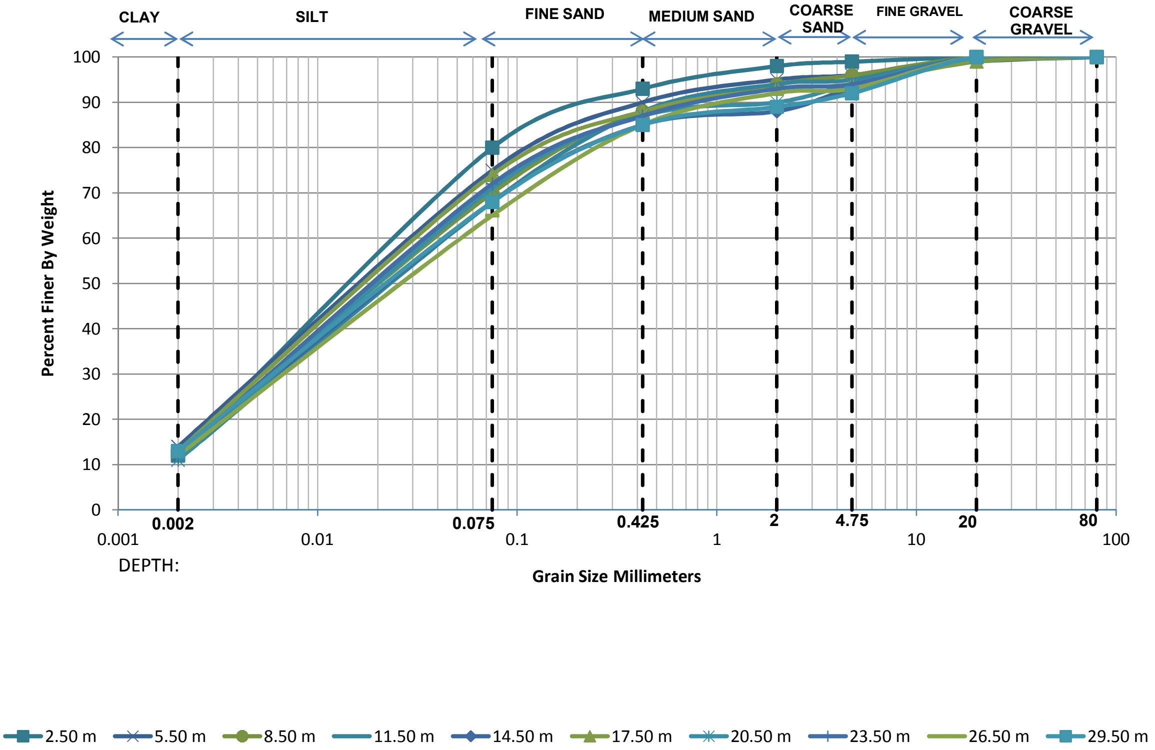
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

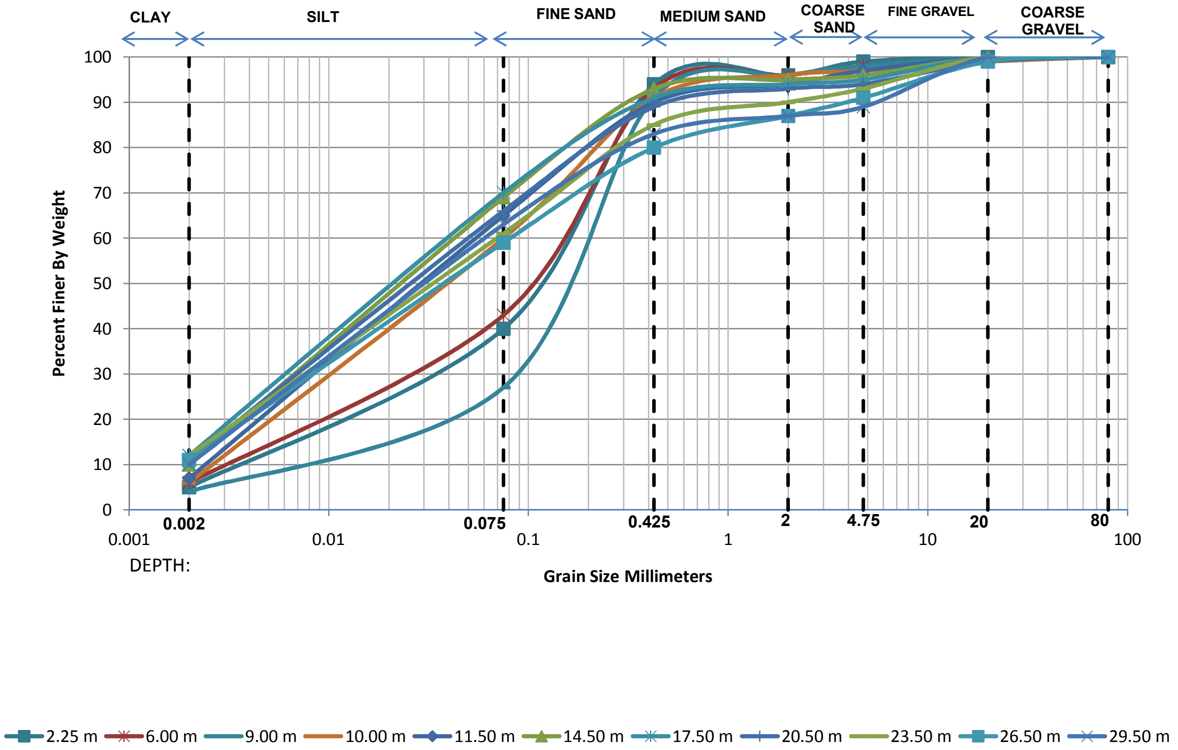
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

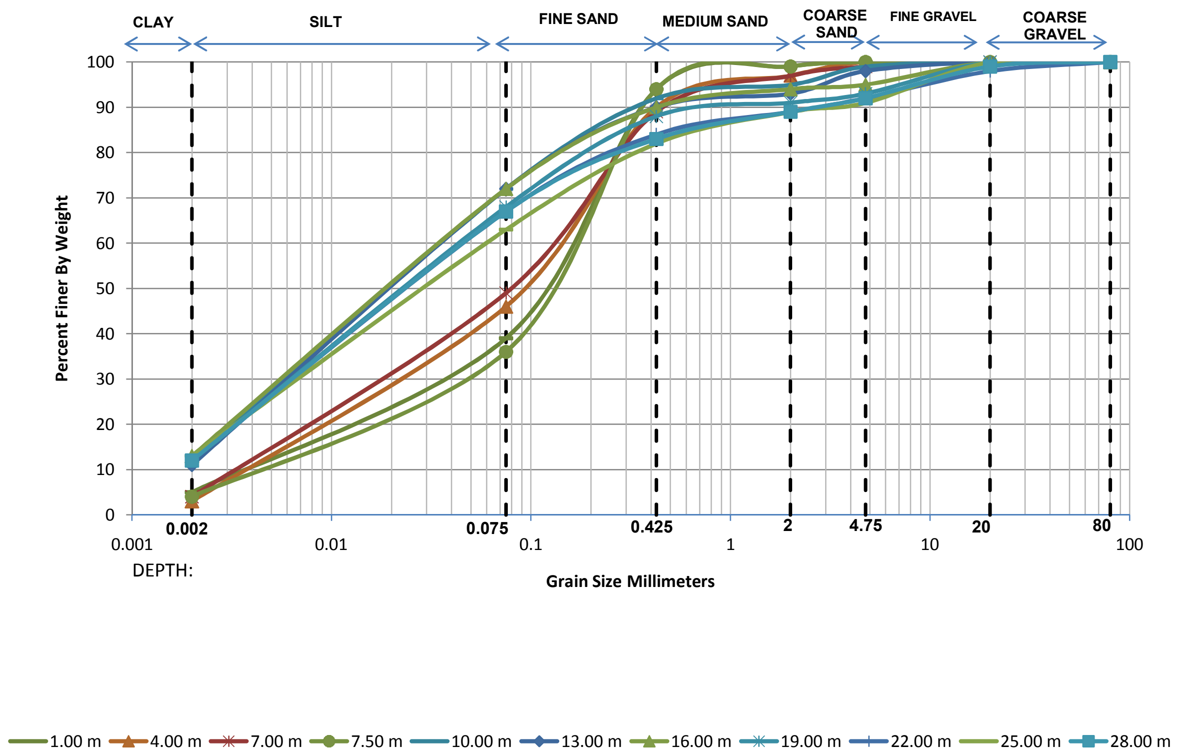
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

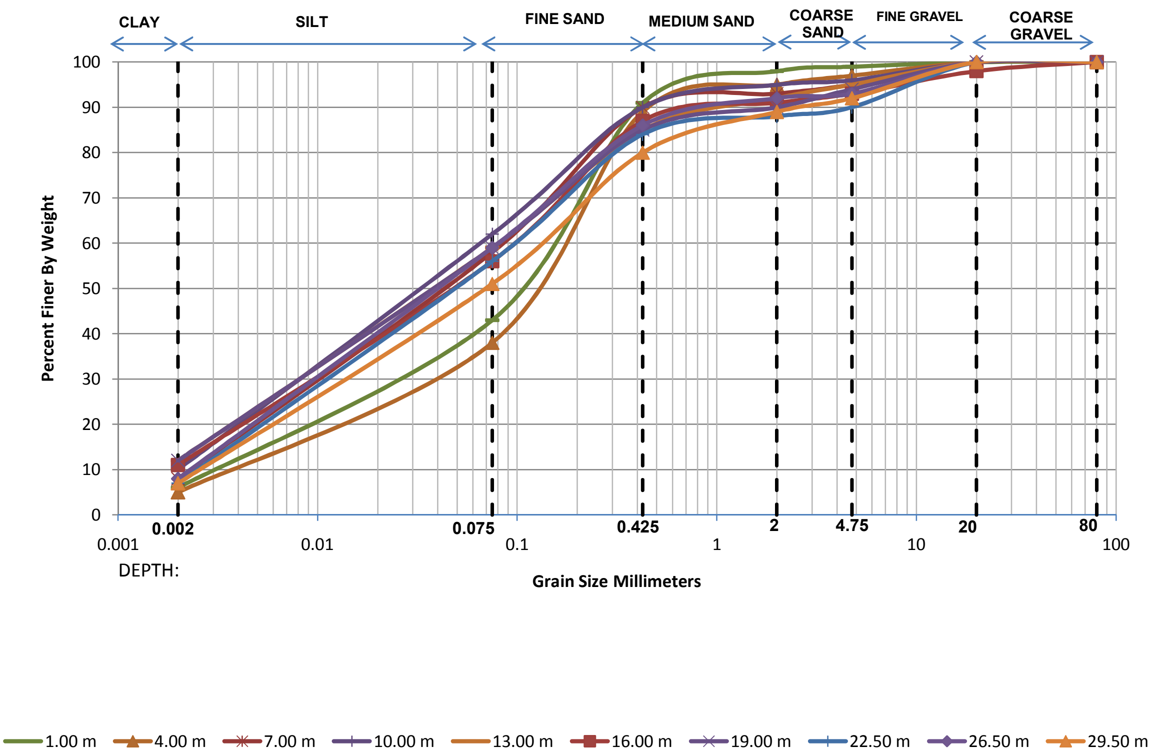
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

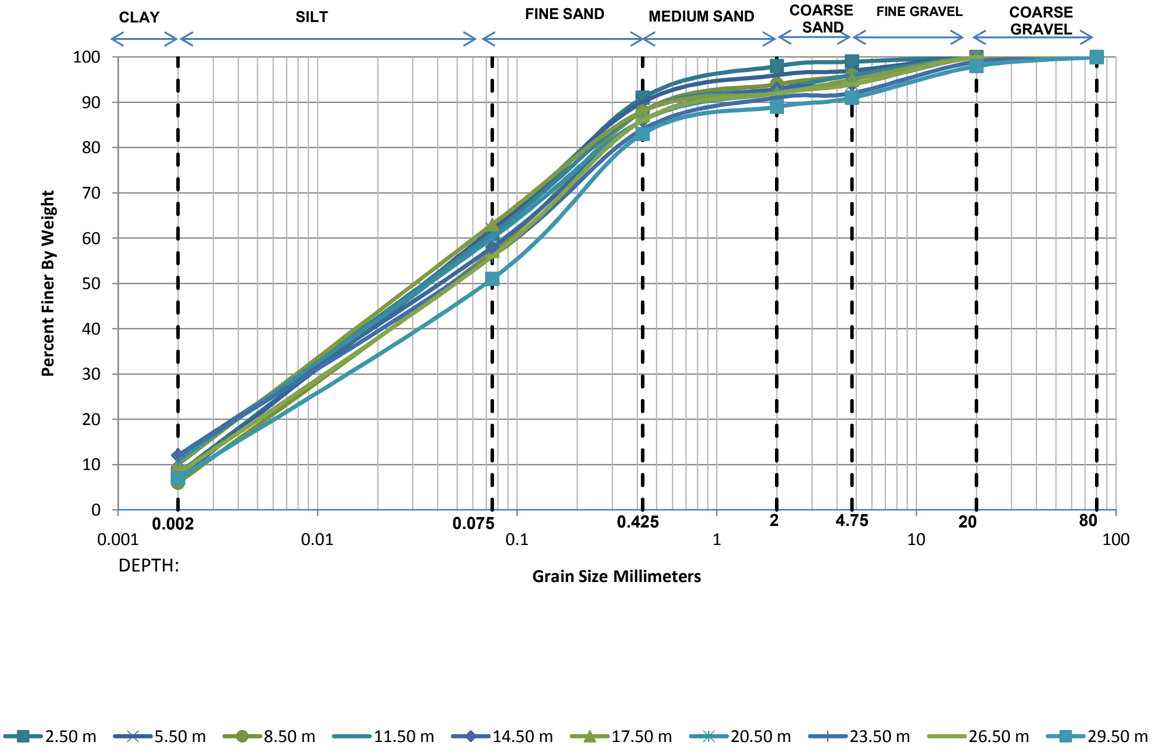
| | |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing IR 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

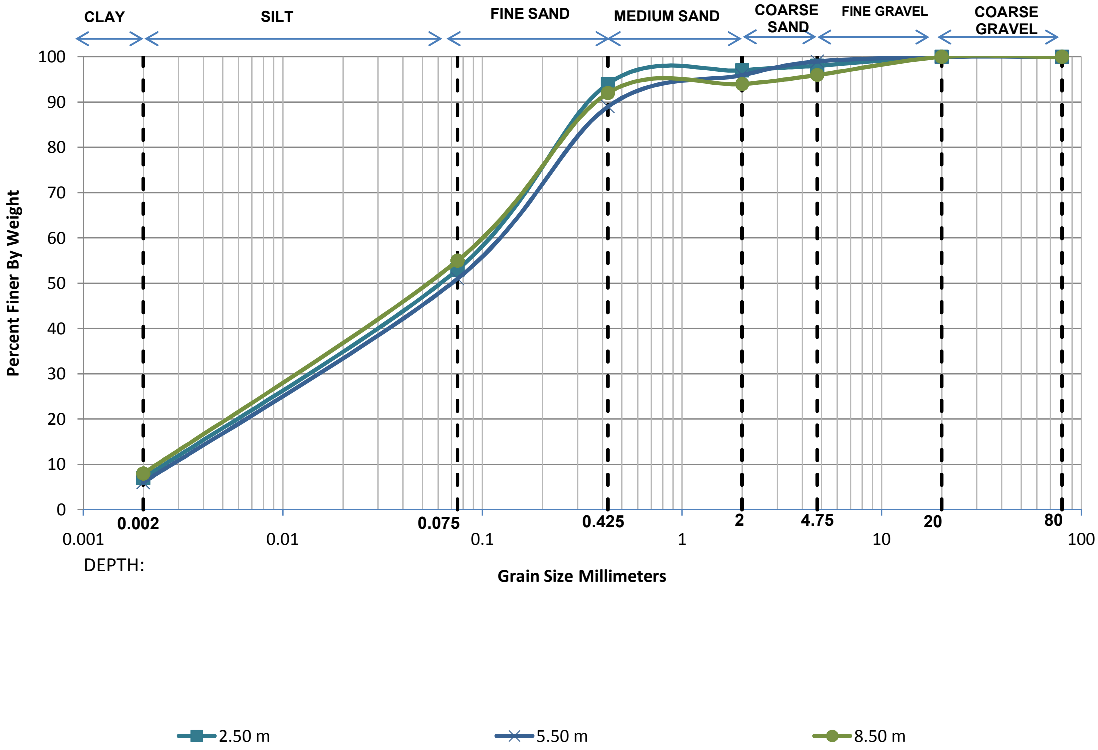
|  |  |
|---|---|
| **Project Name** | Conducting geotechnical investigation, preparation of geotechnical report for designing of bridges and for embankment in connection with construction of Haryana Orbital Rail Corridor (HORC) project from Palwal to Harsana Kalan including connectivity to existing 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 ($\sigma_o$), t/m$^2$ | Effective Overburden ($\sigma'_o$), 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 ($\phi$ °) | 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 (°) | 0.00 |
| Density of foundation soil (t/m$^3$) $\gamma_{bulk}$ | 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)

$N_\phi = \tan^2(\pi/4 + \phi/2)$

$\phi'$ 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)**

| | | | |
|---|---|---|---|
| $\phi$ | 31.00 | $\phi'$ | 21.93 |
| $N_c$ | 32.67 | $N'_c$ | 16.80 |
| $N_q$ | 20.63 | $N'_q$ | 7.76 |
| $N_\gamma$ | 25.99 | $N'_\gamma$ | 7.06 |

**Shape factors : (from IS 6403 : 1981, page No. 8, Table No. 2)**

| S.no. | Width(m) | $S_c$ | $S_q$ | $S_\gamma$ |
|---|---|---|---|---|
| 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 | $d_q$ | $d_\gamma$ |
|---|---|---|---|---|---|
| 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 | 1.00 | 6.55 | 5.55 | 1.44 | 3.70 | 3.70 | 5.55 | 3.70 | 3.700 | 1.437 | 30 | 0.50 | 0.9400 | 9.35 | 26.86 | 26.86 | 0.93 | 1.00 | 25.00 |
| | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | |
| Layer 1 | 1.50 | 1.50 | 7.05 | 5.55 | 1.51 | 3.70 | 3.70 | 5.55 | 3.70 | 3.700 | 1.512 | 30 | 0.50 | 0.9400 | 9.35 | 28.27 | 28.27 | 0.88 | 1.00 | 25.00 |
| | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | |
| Layer 1 | 2.00 | 2.00 | 7.55 | 5.55 | 1.60 | 3.70 | 3.70 | 5.55 | 3.70 | 3.700 | 1.595 | 30 | 0.50 | 0.9400 | 9.35 | 29.83 | 29.83 | 0.84 | 1.00 | 25.00 |
| | | | | | | | | | | | | | | | | | | | | |
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## 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

Qa,comp.= (366.67 + 90.54) / 2.5

Qa,comp.= 182.88 T

Say **Qa,comp.= 182.00 T**

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 366.67 / 3 + 43.2

Qa,uplift = 165.42 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

Qa,comp.= (403.21 + 90.54) / 2.5

Qa,comp.= 197.50 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 403.21 / 3 + 47.12

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

Qa,comp.= (439.77 + 117.21) / 2.5

Qa,comp.= 222.79 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 439.77 / 3 + 51.05

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

Qa,comp.= (479.5 + 117.21) / 2.5

Qa,comp.= 238.69 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 479.5 / 3 + 54.98

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

Qa,comp.= (528.76 + 197.83) / 2.5

Qa,comp.= 290.64 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 528.76 / 3 + 58.9

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

Qa,comp.= (402.59 + 136.16) / 2.5

Qa,comp.= 215.50 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 402.59 / 3 + 56.55

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

Qa,comp.= (448.76 + 136.16) / 2.5

Qa,comp.= 233.97 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 448.76 / 3 + 62.2

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

Qa,comp.= (494.85 + 136.16) / 2.5

Qa,comp.= 252.40 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 494.85 / 3 + 67.86

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

Qa,comp.= (540.66 + 174.06) / 2.5

Qa,comp.= 285.89 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 540.66 / 3 + 73.51

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

Qa,comp.= (590.28 + 174.06) / 2.5

Qa,comp.= 305.74 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 590.28 / 3 + 79.17

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

Qa,comp.= (651.34 + 290.15) / 2.5

Qa,comp.= 376.60 T

Qu,uplift = Safe Frictional Resistance + Weight of Pile

Qa,uplift = 651.34 / 3 + 84.82

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$^2$) = $\pi x D^4/64$ = 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 = = $k_1$x0.3/(1.5xB) = 0.497 kg/cm$^3$

R, Relative stiffness factor in Preloaded Clay R = $\sqrt[4]{\frac{EI}{KD}}$ = **413.5** cm

**For Long Pile If $L_e$ > 3.5R**

L1 = = **0.000** cm

$\frac{L_1}{R}$ = 0.00

**For Fixed Head Pile**

$\frac{L_f}{R}$ = **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$^2$) = $\pi x D^4/64$ = 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 = = $k_1$x0.3/(1.5xB) = 0.414 kg/cm$^3$

R, Relative stiffness factor in Preloaded Clay R = $\sqrt[4]{\frac{EI}{KD}}$ = **496.2** cm

**For Long Pile If $L_e$ > 3.5R**

L1 = = **0.000** cm

$\frac{L_1}{R}$ = 0.00

**For Fixed Head Pile**

$\frac{L_f}{R}$ = **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

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 HRIDC.

The list of approved makes for products and materials is given below. No Further approval is required to be taken for usage of these makes.

| **S. No.** | **Details of Materials/ Products** | | **Manufacturer’s Name** |
|---|---|---|---|
| 1. | Cement | OPC | ACC, Ultratech, Ambuja, JK Lakshmi, JSW, Orient Cement , JK Cement ,Lafrage ,Wonder |
| | | PSC | DALMIA, JSW |
| 2. | Reinforcement Bars | | Prequlified Manufacturers as per RDSO’s latest approved list with proper approval of HRIDC |
| 3. | ***** Epoxy | | FOSROC, SIKA QUALCRETE, BASF, CHRYSO, Vista, CICO, Pinnacle, MYK Schomburg, Thermax, Kunal Conchem, Sunanda, Fairmate,Berger, MC–Bauchemie, Fibrex, MAPEI, Ultracon, ECMAS, Durabuild |
| 4(a). | ***** Expansion Joints for Viaduct | | Prequlified Manufacturers as per RDSO’s latest approved list with proper approval of HRIDC. |
| 4(b). | ***** Expansion Joints for buildings | | MYK Schomburg, Migua, CS, Sanfield, Inpro, 3R Joints & Seals, VR Engineers, Greensboro Polychem, Maruti, MC-Bauchemie, Asian Paints, ECMAS ,Z Tech |
| 5. | ***** Admixtures | | Buildtech, FOSROC, SIKA, MBT, MC-Bauchemie, Pidilite, CHRYSO, MYK Schomburg, BASF, MAPEI, Kunal Conchem, UNIROCK , CICO, ECMAS, CAC, Fairmate, Vista, Thermax, TP Buildtech, Sunanda, Molecules Conchem, Pinnacle, Durabuild, Ultracon, Ado additives, Asian, Greensboro Polychem, STP, Berger, Fibrex |
| 6. | Pile Integrity Testing | | CIMEC, Spectro, ADS Labstech, ATL, Avantech, Geodynamics, AIMIL, Cengers, CBRI, EMC India, Pile Dynamic, Composites Combine Technocrats, CEG test House **(PLEASE NOTE THAT NABL ACCREDITION IS MANDATORY)** |

| | | |
|---|---|---|
| | | |
| 7. | * Anchor Fastener | HILTI, FISCHER,BIT, TRUTEK, FOSROC, Mungo, Minova, UIP, Wuerth **(Please note that ETA Certification is mandatory for using/supplying fasteners for load bearing structural members)** |
| 8. | Structural Steel | TATA, SAIL, ESSAR, Maharashtra Pipes, Jindal Steel & Power Ltd., K.L. Steel, Steel Works & Power Engineers, SKS Ispat & Power, Shamli Steel, Topworth, Goodluck India, Rimjhim |
| 9. | * Pre- stressing Strand (LRPC) | TATA SSL Ltd, USHA Martin, DP Wires, Miki Steel, Kataria Group |
| 10. | * Pot/Elastomeric /Spherical Bearings | Prequalified Manufactures as per RDSO's latest approved list with proper approval of HRIDC |
| 11. | * Horizontal Tie Bars/Shear Bars | Dextra, BB Bars System, BBV Systems, Minova, Euroalloy |
| 12. | * HDPE Sheathing | Rex, Gwalior Polypipes Ltd, Kataria Sheathing, Tirupati, Dynamic Prestress, JK Prestressing |
| 13. | Formwork Release Agent | FOSROC, MC Bauchemie, CICO, CHRYSO, Fibrex, BASF, Sunanda, Pinnacle, Fairmate, Durabuild, CAC, Adoadditives, MYK Schomburg, Greensboro Polychem, Thermax, STP, MAPEI, Asian Labs, ECMAS ,Ultracon, Buildtech. |
| 14. | * Prestressing System | Freyssinet, BBR, VSL, Dynamic, Kellick Nixon, Tensacciai (India Ltd.), JK Prestressing, Usha Martin, VSIL |
| 15. | * Reinforcement Couplers (cold forged paralled threads type only) | Dextra, Halfen Moment, Sanfield, Kridhan , JB Engg |
| 16. | Hollow Sections, Pipes | Surya Pipes, Hi-Tech Pipes, JSW, Jindal Steel and Power ltd., Garg Ispat Udyog, Navratan, VMC Steel, APL Appolo, DADU Pipes Goodluck India, Sarvari Steel |
| 17. | * Drainage Pipes | Tirupati Plastomatics, Duraline, REX, STIPL, Kriti, Vishal, Eonn, Giga Pipes. |

| | | |
|---|---|---|
| 18. | Acrylic Textured Coatings | Spectrum, Surfa Nova, Sunanda, Jotun, Asian Paints, Berger, Hempel, DULUX, STP, Godavari Paints, MC-Bauchemie, MAPEI |
| 19. | * Non Shrink Grout | FOSROC, SIKA, BASF, MBT, CHRYSO, Fairmate, CICO, MYK Schomburg, Pinnacle, |
| | | ECMAS, Minova, Durabuild, CAC, Asian Paints, STP, BERGER, Fibrex, Ado Additives, Thermax, CICO, Greensboro Polychem, Ultracon, Kunal Conchem, MC-Bauchemie, Asian Labs, MAPEI, Buildtech |
| 20. | Bonding Coat | CICO, FOSROC, Sunanda, BASF, CHRYSO, MYK Schomburg, Minova, Fairmate, STP, SIKA, BERGER, Greensboro Polychem, Thermax, Ultracon, ECMAS, Asian Paints, Fibrex, Asian Labs, Ado Additives, MAPEI, MC-Bauchemie, Durabuild |
| 21. | * Polysuphide Sealant | CICO, Pidilite, BASF, FOSROC, CHRYSO, STP, SIKA, Sunanda, Fairmate, Kunal Conchem, Durabuild, Asian Paints, MYK Schomburg, Greensboro Polychem, Ultracon, ECMAS, Fibrex, MC-Bauchemie, Buildtech |
| 22. | * Steel Structural Fasteners | Sundram Fasteners, Pioneer Nuts & Bolts, Unbrako, Nelson, Panchsheel, LPSEJOT, UIP, Canon, Trutek, Kwality Forge, Atul Fasteners, Imperial Bolts, Pooja Forge **(Please note that ETA Certification is mandatory for using/supplying fasteners for load bearing structural members)** |
| 23. | * Corrosion Protection Paints | Berger, Johnson Nicholson, Nerolac, Asian Paints, Akzo Nobel, Jotun, Shalimar, 3M Fosroc, Hempel, Universal Paint, Sunanda, Kunal Conchem, STP, INM Nuvent Paints, CICO, CHRYSO, Greensboro Polychem |
| 24. | Micro Silica | Thermal Plants, Sika Elkem, FOSROC, MAPEI, Corniche, Star Silica, CICO, Rockfit, Jaycee Build Corp LLP, Vista, Kunal Conchem, CAC, BASF, Buildtech, Ashtech, Ultracon, Alccofine |
| 25. | * Fire Resistant Paint | Akzo Nobel, PPG, Jotun, Sunanda, Berger Paints |
| 26. | * Integral Crystalline Waterproofing Method | Penetron, XYPEX, SIKA |
| 27. | * Water stopper/ Bar | Kanta Rubber, Greenstreak, Duron, Sunanda, Wall Grip, Asian Paints, FOSROC, Maruti, CHRYSO |

| | | |
|---|---|---|
| 28. | * Liquid Polymer membrane waterproofing | BASF, MAPEI , NINA, CICO, Kunal Conchem, MYK Schomburg, Sunanda, ECMAS, Durabuild, Asian Paints, STP, BERGER, FOSROC, Greensboro Polychem, Ado Additives, MC-Bauchemie, Thermax, Asian Labs, CHRYSO, Ultracon, Buildtech |
| 29. | * Curing Compound | Clean Tech Concure, Vista, FOSROC, STP, Kunal Conchem, CHRYSO, CICO, Pinnacle, Durabuild, BERGER, Fibrex, Greensboro Polychem, UNICRETE, Ado Additives, UNIROCK, SIKA, Fairmate, MYK Schomburg, Ultracon, ECMAS, Asian Labs, Asian Paints, Molecules Conchem, MC-Bauchemie, MAPEI, Thermax, Buildtech, CAC |
| 30. | * Polycarbonate Sheets | Gallina Acroplus, Coxwell, Poly U, Fabic, Lexan, (SABIC Innovative Plastics), DANPALON, GE Plastics, VMI Plastics, Power Chem Plast, Super Disco Ispat |
| 31. | Fly Ash | Thermal Plants, Ashcrete, Ultra Pozz, Star Pozz, Ashtech, Jaycee Build Corp LLP, SUPERPOZZ P500 |
| 32. | * Pre-Coated Profiled Metal Sheethings | TATA Blue Scope, Multicolor, Kamdhenu, Essar Steel, Bhushan Steel, Ispat Profile India, Super Disco Ispat, Aditya Profiles |
| 33. | Sodium Silicate for Grouting purposes during TBM operations | BASF, Kunal Conchem, SIKA, CHRYSO, Subham Mineral, Minova, Sunanda, Greensboro Polychem, Ado Additives, FOSROC, Ultracon, Asian Labs, Fibrex, Buildtech |
| 34. | * Fly Ash Block/ AAC Block | Siporex, Ascolite, J.K. Laxmi, Ashtech, UNICRETE |
| 35. | * Tunnel Segment EPDM | FIP, Datwyler, E.S. Rubber, Haida Rubber |
| 36. | * Rock Bolts/Swellex Bolts | Geo Constech, DSI, Atlas Copco, FIREP International, Minova |
| 37. | * Softeye GFRP | Dextra, FIREP International, Minova, Hughes Brother, Geo Constech |
| 38. | Material Testing | ADS Labstech, Anshu Tech, Arihant, SHREE BALAJI Test House, Beauru Veritas, ShriRam, National Test House, Spectro, Indian Institute of Technology, Pioneer, Secon, Delta, CEG Test House |
| 39. | Geotechnical Investigation | Cengers, CEG Testhouse, Delhi Test House, SHREE BALAJI Test House, Techpro, Arun Soil Labs, Indian Geotechnical, Raicon, Composite Combine Technocrats, Secon, Sai Geotech |

| | | |
|---|---|---|
| 40. | ***** Polymer | WALLGRIP, TRISHUL, Shubham Minerals, Goldy Minerals, GeoPolymer |

**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:** |
| **Category 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 HRIDC.

| | | |
|---|---|---|
| **(Stamp and Signature)** | **(Stamp and Signature)** | **(Stamp and Signature)** |
| **Manufacturer Representative** | **Executing agency Representative** | **Contractor Representative** |