

## Load Penetration Curve of Field C.B.R. Test

## Field CBR NO.-10 (Soaked)

## Test - 1

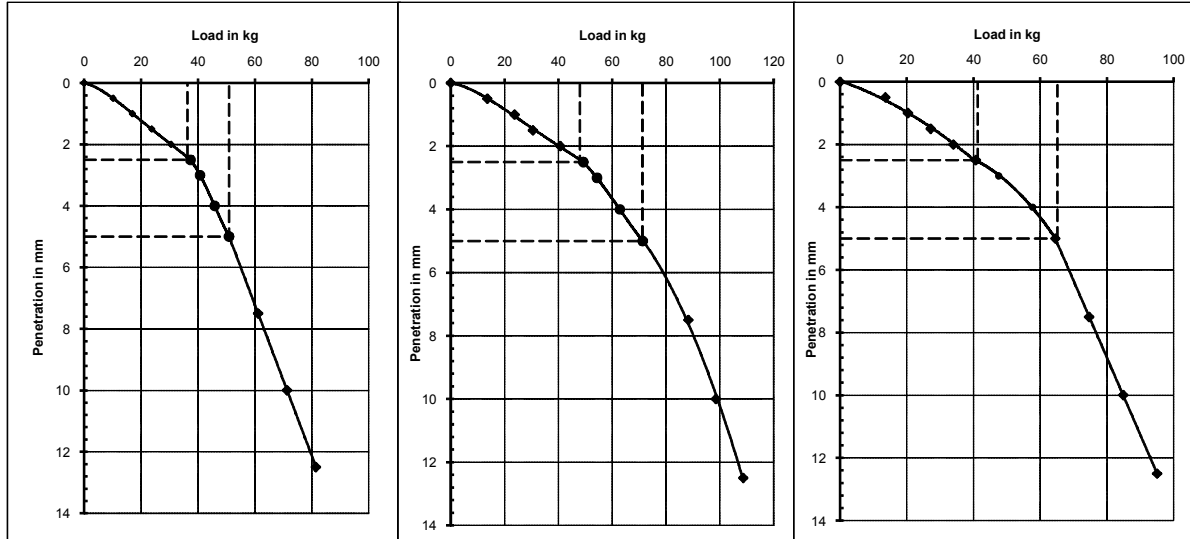
Penetration (mm)	CBR (%)
2.5	2.65
5.0	2.48

## Test - 2

Penetration (mm)	CBR (%)
2.5	3.51
5.0	3.46

## Test - 3

Penetration (mm)	CBR (%)
2.5	3.01
5.0	3.17



## Load Penetration Curve of Field C.B.R. Test

## Field CBR NO.-10 (Unsoaked)

## Test - 1

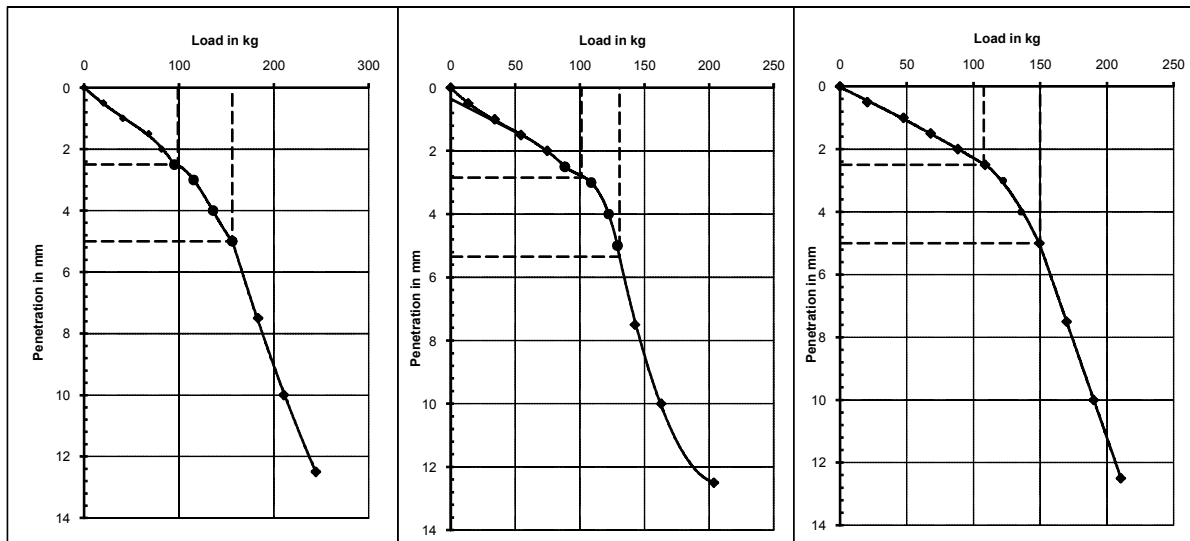
Penetration (mm)	CBR (%)
2.5	7.20
5.0	7.59

## Test - 2

Penetration (mm)	CBR (%)
2.5	7.38
5.0	6.35

## Test - 3

Penetration (mm)	CBR (%)
2.5	7.86
5.0	7.29



## **PART IV: SAMPLE CALCULATION**



**SAMPLE PILE CAPACITY CALCULATION**  
(Using Layer Stratification of BH-91)

Bottom depth of Pile = 31.00 m below FGL  
FGL = 904M, RL of BH = 903.400M. So, filling will be (904 - 903.40) = 0.60m  
Thickness of existing filled up soil = 10.55m  
Therefor overall filling depth = (0.60 + 10.55) = 11.15m from FGL.  
The effect of filled up soil towards pile capacity is neglected.  
Diameter of Pile = 750 mm  
FOS of Shaft Resistance = 2.50  
FOS for End Bearing = 2.50  
So, maximum Depth upto which pressure will increase = 11.25 m  
Critical depth 15.00 D  
Maximum OVP = 10.125 t/sqm

Layer No.	Top Depth (M)	Bottom Depth (M)	Eff. Depth (M)	Cohesion (kg/sqcm)	$\phi$ (Degree)	Adhesion Factor ( $\alpha$ )	$K_0$	Eff. Density (gm/cc)	Mean Pressure (t/sqm)
I	11.15	30.10	18.95	0.90	0	0.500	1.00	0.90	10.12
II	30.10	33.10	0.90	1.50	0	0.297	1.00	0.90	10.13

Layer No.	Eff. Depth (M)	Effective $\sigma_z$ (t/sqm)	$f_{s1} = \alpha C$	$f_{s2} = K_0 \sigma_z \tan \phi$	$f_s = f_{s1} + f_{s2}$ (t/sqm)	Ultimate Shaft Resistance (T)	Safe Shaft Resistance (T)
I	18.95	10.12	4.50	0.00	4.50	200.91	80.36
II	0.90	10.13	4.45	0.00	4.45	9.44	3.77
	19.85					210.34	84.14

**For End Bearing**

Cohesion C = 1.5 kg/sqcm  
Friction Angle = 0 °  
So,  $N_c$  = 9  
 $N_q$  = 1.00  
Eff. Ovp. Pressure =  $p(\text{tip})$   
 $q(\text{tip}) = C.N_c + p(\text{tip}).N_q$   
Ultimate End Bearing = 145.13 t/sqm  
Safe End Bearing = 64.11 T  
Safe Shaft Resistance = 25.65 T  
Safe Shaft Resistance = 84.14 T  
So, Total Pile Capacity = 109.78 T

**Uplift Pile Capacity: With factor of safety 2.50 & 2.50**

Uplift capacity =  $\frac{1}{3} \times [(\text{Shaft Resistance in Vertical Capacity}) + \text{self weight of pile (Buoyant)}]$   
=  $\frac{1}{3} \times [210.34 + (3.1415/4) \times (750/1000)^2 \times (31 - 11.15) \times (2.5 - 1)]$   
= 74.4996831

**So, Recommended Uplift Capacity = 74 T**

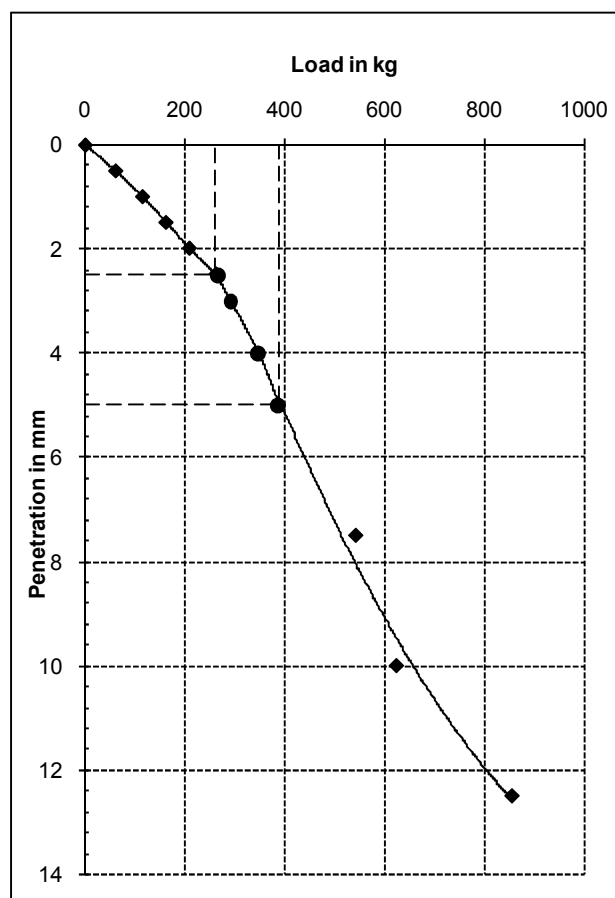
**So, Recommended Pile Capacity = 105T**

### SAMPLE FIELD CBR CALCULATION

Test No. FCBR-02  
 Depth: 0.50m  
 Description: Brownish grey silty clay with traces of fine sand. Obs. kankar.

#### Field CBR Test Results

CBR Type: <i>Soaked</i>		
Period of Soaking = 24 Hours		
Weight of Surcharge = 10 kg		
Proving Ring Constant = 6.79 kg/division		
Penetration (mm)	Proving Ring Reading	Load (in kg)
0	0.00	0.00
0.50	9.00	61.10
1.00	17.00	115.40
1.50	24.00	163.00
2.00	31.00	210.50
2.50	39.00	264.80
3.00	43.00	292.00
4.00	51.00	346.30
5.00	57.00	387.00
7.50	80.00	543.20
10.00	92.00	624.70
12.50	126.00	855.50



From graph,

Load for 2.50mm penetration = 258.50 kg  
 Hence CBR for 2.50mm penetration =  $(258.50 / 1370) \times 100 = 18.87\%$

Load for 5.00mm penetration = 387.90 kg  
 Hence CBR for 5.00mm penetration =  $(387.90 / 2055) \times 100 = 18.88\%$

**Bearing Capacity around BH-47, Depth of foundation = 6.00m below FGL (FGL = 931.100M)**

Place the foundation at 6.00m below FGL (FGL = 931.100M) i.e. about 1.0m inside rock layer (layer VI)

Bearing capacity is calculated based on following two approaches.

**i) Bearing Capacity Based on RMR Method:**

Calculated RMR = 33 as per IS: 13365(Part1)-1998, Annex B

- a) Unconfined Compressive Strength is taken as 248 kg/sqcm, corresponding rating = 2.
- b) Average RQD value = 35%, corresponding rating = 8.
- c) Spacing of discontinuity taken as close (i.e. 0.06m), corresponding rating = 8.
- d) Condition of discontinuity considered as Slightly rough and moderately to highly weathered wall rock surface, separation < 1mm, corresponding rating = 20.
- e) Ground water condition taken as Wet, corresponding rating = 7.
- f) Dip Angle Joint Orientation taken as favourable, corresponding rating = -2.

So,  $RMR = 2+8+8+20+7+(-)2 = 43$

So, from Table-3 of IS: 12070: 1987 (Amendment No. 1, 2008),  $q_{ns} = 155.63 \text{ t/sqm}$

**ii) Bearing Capacity Based on Uni-axial Compressive Strength Method:**

The safe bearing pressure,  $q_s = q_c N_j$

Where,  $q_s$  = Safe bearing pressure

$q_c$  = Average uniaxial compressive strength of rock core

$N_j$  = Empirical co-efficient depending on spacing of discontinuities

For spacing of discontinuity, 0.06m i.e. 6cm, corresponding  $N_j = 0.10$

$q_c = 248 \text{ kg/sqcm}$

So, safe bearing pressure,  $q_s = 248 \times 0.10 = 24.80 \text{ kg/sqcm} = 248 \text{ t/sqm}$

A factor of 3/4 is taken considering rock with discontinuous joints with opening less than 1mm wide.

Hence, safe bearing pressure,  $= 248 \times \frac{3}{4} = 186.00 \text{ t/sqm}$

**However, let us restrict the bearing capacity to 100t/sqm.**

**Bearing Capacity around Effluent Treatment Plant Area (BH-01), Size of foundation = 6m x 6m, Depth of foundation = 1.00m below FGL (FGL = 914.000M)**

The suggested founding level falls inside hard clay layer (i.e. layer II).

Average N in this layer = 64, corresponding cohesion from N value =  $2.37 \text{ kg/sqcm}^1$

In absence of any laboratory test results, let us restrict the C value to  $1.60 \text{ kg/sqcm}$  &  $\phi = 0^\circ$

### **Design Strength Parameters for Stratum – II:**

Total soil modulus,  $E_s = 4.4 \times N = 281.6 \text{ kg/sqcm}$

[Ref. to “History of Soil penetration testing” by B. B. Broms & N. Flodin in “Penetration Testing 1988”, ISPT-1: vol.1, p – 185]

Undrained Young’s modulus,  $E_u = K \times C = 500 \times 1.6 = 800 \text{ kg/sqcm}$

Again,  $1/E_s = 1/E_u + 1/E_d$  giving drained young's modulus,  $E_d = 434.57 \text{ kg/sqcm}$

Now, we have,  $E_d = E_u/3 = 266.67 \text{ kg/sqcm}$

[Refer to “Cone Penetration Testing” by A.C.Meigh, pp. No. – 53]

Considering the above, let us use  $E_d = 350 \text{ kg/sqcm}$

From  $E_d$ ,  $m_{vc} = 1/G.E_d = 0.0052 \text{ sqcm/kg}$  [Geological Factor,  $G = 0.55$  &  $\mu = 0.35$ ]

Again from SPT “N”,  $m_{vc} = 1/5N = 0.0031 \text{ sqcm/kg}$

[Refer to “Standard Penetration Test, State-of-the-art-Report” by Ivan K. Nixon in “Penetration testing 1” Edited by A.Verrujt, F.L.beringen & E.H.De Leeuw, pp. No. 11]

Thus average  $m_{vc} = [0.0052 + 0.0031]/2 = 0.0042 \text{ sqcm/kg}$

### **For Stratum –V & VI:**

From laboratory rock test results, it is seen that average Young’s modulus values for layer IV, V & VI =  $4204 \text{ kg/sqcm}$ ,  $42422 \text{ kg/sqcm}$  (based on 5nos. tests) &  $36763 \text{ kg/sqcm}$  (based on 54nos. tests) respectively. This is

### **1 Relation between SPT “N” and Shear Strength**

Widely used relationship is due to Terzaghi and Peck recommending  $C = N/16$

However, it has been seen over the years with stiffness in clay the shear strength does not increase as rapidly as proposed by Terzaghi.

Our experience also shows that for clays at medium to higher depth, the above relation does not hold good.

For Static Cone Penetration Tests, the recommendations for cone factor  $N_k$  generally are

$C = q_c/N_k$  where  $C$  = Cohesion in  $\text{kg/sqcm}$  and  $q_c$  = Cone resistance in Static Cone and

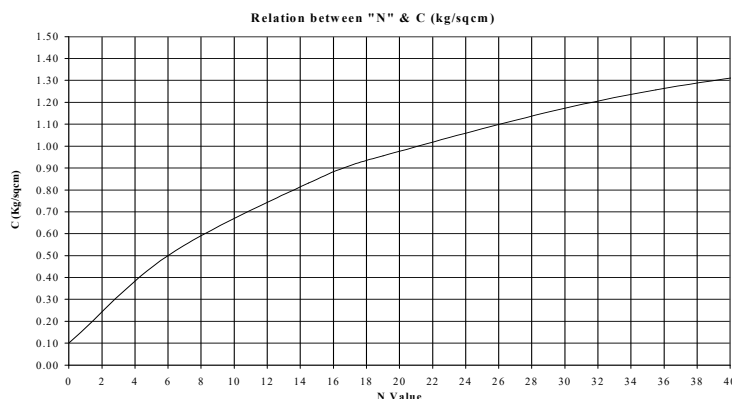
$N_k = 17, 21$  &  $27$  for normally consolidated clay, partly over consolidated clay and heavily over consolidated clay respectively

[Ref. Meigh, A.C (1987) : Cone Penetration Testing Methods and Interpretation, Butterworths, London, pp-43-47]

Taveres, A.X [Penetration Testing 1988, ISOPT-1, Volume-I, J.De Ruiter Editor, pp-375-379] has shown very clearly that a better correlation can be obtained with stiffness of the clay. From his experimental results he obtained,

Range of SPT ‘N’	$K = N/C$
$N < 10$	12.50
$10 < N < 20$	14.20
$20 < N < 30$	16.25
$30 < N < 40$	20.00

Over the years on the basis of the laboratory test results we have been using the following relations. However, for “N” value greater than 40, we use  $C = N/27$



for core samples and not truly representative of the entire layer. Considering the above and uncertain rock behaviour, we use Young's modulus for layer-V & VI = 5000 kg/sqcm & 10000 kg/sqcm respectively.

#### **Determination of Bearing Capacity:**

The Net Ultimate Bearing Capacity is given as:

$$q_{nu} = C.N_c.S_c.D_c + q.N_q.S_q.D_q + 0.5\gamma.B.N_\gamma.S_\gamma.D_\gamma - q$$

Where,

$N_c$ ,  $N_q$  and  $N_\gamma$  are bearing capacity factors,

$S_c$ ,  $S_q$  and  $S_\gamma$  are shape factors,

$D_c$ ,  $D_q$  and  $D_\gamma$  are depth factors,

And

$C$  = Cohesion

$q$  = Overburden pressure,

$B$  = Width of foundation,

$\gamma$  = Effective density below foundation.

Cohesion,  $C = 16.00$  t/sqm

Using  $\phi = 0$  degree, the bearing capacity factors are:

$$N_c = 5.14, N_q = 1.00 \text{ \& } N_\gamma = 0.00$$

Use,

Depth of Foundation =  $D_f = 1$  M (Below FGL)

Size of Foundation =  $B = 6$  M Square

Overburden Pressure =  $q = 1.000$  (Depth)  $\times 0.90$  (Submerged density) =  $0.90$  t/sqm (Assuming the ground water table is flushing with the ground level)

The Shape factors are [ IS:6403 - 1981 ]

$$S_c = 1.30 \quad S_q = 1.20 \quad S_\gamma = 0.80$$

The Depth factors are [ IS:6403 - 1981 ]

$$D_c = 1.03 \quad D_q = 1.00 \quad D_\gamma = 1.00$$

Computed Net Ultimate Bearing Capacity =  $110.74$  t/sqm

**Using a factor of safety of 2.5, Net Safe Bearing Capacity = 44.30 t/sqm**

The above bearing capacity should be checked against settlement criteria. This is shown below.

**Settlement Analysis****A) General Data:**

Width of foundation =	6.0	m
Length of foundation =	6.0	m
Depth of foundation =	1.00	m
Net Base Pressure =	2.8	kg/sqcm

**B) Subsoil Properties:****Layer - II**

Young's Modulus =	800	kg/sqcm
Poisson Ratio, $\mu$ =	0.35	
Top of Stratum =	1.00	m
End of Stratum =	8.877	m
Geological factor, G =	0.55	
$m_{vc}$ =	0.0042	sqcm/kg

**Layer - V**

Young's Modulus =	5000	kg/sqcm
Poisson Ratio, $\mu$ =	0.25	
Top of Stratum =	8.877	m
End of Stratum =	11.877	m
Geological factor, G =	1.00	
$m_{vc}$ =	0.0000	sqcm/kg

**Layer - VI**

Young's Modulus =	10000	kg/sqcm
Poisson Ratio, $\mu$ =	0.25	
Top of Stratum =	11.877	m
End of Stratum =	13	m
Geological factor, G =	1	
$m_{vc}$ =	0.0000	sqcm/kg

**C) Calculation of Immediate Settlement:****Settlement at center**

$M = L' / B' =$	1.000
$N = H / B' =$	2.626
$I_1 =$	0.339
$I_2 =$	0.053
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.364
Immediate settlement $S_i =$	1.340 cm
$[q_0 \times B \times (1-\mu^2) \times m \times I_s] / E_s$	

**Settlement at center**

$M = L' / B' =$	1.000
$N = H / B' =$	0.432
$I_1 =$	0.038
$I_2 =$	0.069
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.084
Immediate settlement $S_i =$	0.023 cm
$[q_0 \times B \times (1-\mu^2) \times m \times I_s] / E_s$	

**Settlement at center**

$M = L' / B' =$	1.000
$N = H / B' =$	0.133
$I_1 =$	0.004
$I_2 =$	0.029
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.023
Immediate settlement $S_i =$	0.003 cm
$[q_0 \times B \times (1-\mu^2) \times m \times I_s] / E_s$	

**Settlement at corner**

$M = L' / B' =$	1.00
$N = H / B' =$	1.313
$I_1 =$	0.195733
$I_2 =$	0.078556
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.232
Immediate settlement $S_i =$	0.427 cm

**Settlement at corner**

$M = L' / B' =$	1.00
$N = H / B' =$	0.216
$I_1 =$	0.010
$I_2 =$	0.044
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.039
Immediate settlement $S_i =$	0.005 cm

**Settlement at corner**

$M = L' / B' =$	1.000
$N = H / B' =$	0.067
$I_1 =$	0.001
$I_2 =$	0.016
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.011
Immediate settlement $S_i =$	0.001 cm

Average  $S_i$  for Stratum II= 8.84 mm

Total immediate settlement = 8.99 mm

Average  $S_i$  for Stratum V= 0.14 mm

(for all the three layers)

Average  $S_i$  for Stratum VI= 0.02 mm**D) Calculation of Consolidation Settlement:**

Strata	From (M)	To (M)	Thickness (M)	Mid depth (M)	$\Delta P$ (kg/sqcm)	$m_{vc}$ sqcm/kg	G	$S_c$ (cm)
Layer - II	1.00	4.94	3.94	1.97	1.59	0.0042	0.55	1.44
	4.94	8.88	3.94	5.91	0.71	0.0042	0.55	0.65

Hence, Total Consolidation Settlement = 20.91 mm

So, Total Settlement = 29.90 mm

Fox's Depth correction Factor = 0.96

Applying Rigidity correction Factor : 0.80

**Corrected total settlement = 23.04 mm < 25mm**

The calculated settlement is well within the permissible limit. So, use a net allowable bearing capacity of 28t/sqm for depth of foundation 1.00m below FGL.

**Bearing Capacity around Pipe Rack CISF Colony Area (BH-53), Size of foundation = 3m x 6m, Depth of foundation = 3.00m below FGL (FGL = EGL)**

The suggested founding level falls inside very dense sand layer (i.e. layer III).

Design field "N" = 100

After correction for Overburden Pressure and Dilatancy, Final Corrected N = 69, corresponding  $\phi = 44^\circ$

So, use  $C = 0$  kg/sqcm &  $\phi = 34^\circ$

**Design Strength Parameters for Stratum – III:**

Treating the sand to be over consolidated,  $E_s = 400 + 10.5N = 1124.50$  kg/sqcm

[Refer to "Foundation Analysis and Design", 5<sup>th</sup> Edition, by J.E.Bowles, pp. No. 316, Table:5-6]

However, let us restrict the  $E_s$  value to 750 kg/sqcm

**For Stratum – VI:**

Let us use Young's modulus for layer-VI = 10000 kg/sqcm (as discussed earlier)

**Considering general shear failure condition**

Cohesion,  $C = 0.00$  t/sqm

Using  $\phi = 36$  degree, the bearing capacity factors are:

$$N_c = 50.59$$

$$N_q = 37.75$$

$$N_\gamma = 56.31$$

Use,

Depth of Foundation =  $D_f = 3$  M (Below Existing Ground level)

Width of Foundation =  $B = 3$  M

Length of Foundation =  $L = 6$  M

Overburden Pressure =  $q = 3.000$  (Depth)  $\times$  0.90 (Submerged density) = 2.70 t/sqm (Assuming the ground water table is flushing with the ground level)

The Shape factors are [ IS:6403 - 1981 ]

$$S_c = 1.10 \quad S_q = 1.10 \quad S_\gamma = 0.80$$

The Depth factors are [ IS:6403 - 1981 ]

$$D_c = 1.39 \quad D_q = 1.20 \quad D_\gamma = 1.20$$

Computed Net Ultimate Bearing Capacity = 204.18 t/sqm

Using a factor of safety of 2.5, Net Safe Bearing Capacity = 81.67 t/sqm

**Considering local shear failure condition:**

$$\phi' = 19^\circ$$

Computed Net Ultimate Bearing Capacity = 22.50 t/sqm

Using a factor of safety of 2.5, Net Safe Bearing Capacity = 9.08 t/sqm

So, interpolated SBC for  $\phi$  of  $34^\circ = 9.08 + \{(81.67 - 9.08)/(36-28)\} \times (34-28) = 63.53$  t/sqm

Similarly, for 6m x 12m foundation, interpolated SBC = 78.85 t/sqm

The above bearing capacity should be checked against settlement criteria. This is shown below.

## Settlement Analysis

### A) General Data:

Width of foundation =	6.0	m
Length of foundation =	12.0	m
Depth of foundation =	3.0	m
Net Base Pressure =	6.3	kg/sqcm

### B) Subsoil Properties:

#### Layer - III

Young's Modulus =	750	kg/sqcm
Poisson Ratio, $\mu$ =	0.25	
Top of Stratum =	3.00	m
End of Stratum =	4.100	m
Geological factor, G =	1.00	
$m_{vc}$ =	0.0000	sqcm/kg

#### Layer - VI

Young's Modulus =	10000	kg/sqcm
Poisson Ratio, $\mu$ =	0.25	
Top of Stratum =	4.100	m
End of Stratum =	15.00	m
Geological factor, G =	1.00	
$m_{vc}$ =	0.0000	sqcm/kg

### C) Calculation of Immediate Settlement:

#### Settlement at center

$M = L' / B' =$	2.000	
$N = H / B' =$	0.367	
$I_1 =$	0.023	
$I_2 =$	0.069	
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.068	
Immediate settlement $S_i =$	0.646	cm
$[q_o \times B' \times (1 - \mu^2) \times m \times I_s] / E_s$		

#### Settlement at center

$M = L' / B' =$	1.845	
$N = H / B' =$	3.070	
$I_1 =$	0.406	
$I_2 =$	0.078	
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.458	
Immediate settlement $S_i =$	0.298	cm
$[q_o \times B' \times (1 - \mu^2) \times m \times I_s] / E_s$		

#### Settlement at corner

$M = L' / B' =$	2.00	
$N = H / B' =$	0.183	
$I_1 =$	0.005887	
$I_2 =$	0.039915	
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.032	
Immediate settlement $S_i =$	0.154	cm

#### Settlement at corner

$M = L' / B' =$	1.85	
$N = H / B' =$	1.535	
$I_1 =$	0.221	
$I_2 =$	0.106	
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.292	
Immediate settlement $S_i =$	0.095	cm

Average  $S_i$  for Stratum III = 4.00 mm

Total immediate settlement = 5.96 mm

So, Total Settlement = 5.96 mm

Fox's Depth correction Factor = 0.901

Applying Rigidity correction Factor : 0.80

**Corrected total settlement = 4.29 mm < 25mm**

Average  $S_i$  for Stratum VI = 1.96 mm

(for both the layer)

The calculated settlement is well within the permissible limit. However, let us restrict the bearing capacity to 40t/sqm for depth of foundation 3.00m below FGL.



## **PART V: PHOTOGRAPHS**



**Borehole**



**Borehole**



## Rock Core



## Rock Core





Field CBR



ERT



**Trial Pit**

**Job No: 4095**

**REPORT ON  
GEOTECHNICAL INVESTIGATION WORK FOR  
5<sup>th</sup> ALUMINA REFINERY AT DAMANJODI, ODISHA  
AND PORT FACILITIES AT VISAKHAPATNAM**

**2nd Phase**

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**January – 2019**

**LIST OF CONTENTS**

<b><u>SUBJECT</u></b>	<b><u>SHEET NUMBER</u></b>
<b>1. INTRODUCTION</b>	<b>2</b>
Field Test Location Map	3
<b>2. FIELD INVESTIGATIONS</b>	
General, Boring, Sampling, Standard Penetration Tests, Measurement of Water Table, Rotary Core Drilling, Trial Pits, Field CBR Tests, Cyclic Plate Load Tests, Electrical Resistivity Tests, Block Vibration Tests	<b>4</b>
<b>3. LABORATORY TESTING</b>	<b>9</b>
<b>4. SUB-SOIL CONDITIONS, STRATIFICATION &amp; PROPERTIES</b>	<b>10</b>
Sub-Soil Conditions	10
Sub-Soil Stratifications	10
Generalized Soil Profile	11
Graphical Presentation	27
<b>5. DISCUSSION</b>	<b>28</b>
Cyclic Plate Load Test	28
Details of Structures	29
Choice of Foundation and Founding Level	30
Bearing Capacity around Filtered Water Tank Area	30
Swelling Characteristics	39
Chemical Tests	39
Possibility of Subsoil Liquefaction Due To Earthquake	40
Suitability of Existing Soil For Filling and Back-filling	41
Dewatering	41
Excavation	41
Determination of Subgrade Modulus	42
<b>6. SUMMARY &amp; RECOMMENDATIONS</b>	<b>44</b>
<b>7. GEOLOGICAL LOGGING</b>	<b>46</b>

# REPORT ON GEOTECHNICAL INVESTIGATION WORK FOR 5<sup>th</sup> ALUMINA REFINERY AT DAMANJODI, ODISHA AND PORT FACILITIES AT VISAKHAPATNAM

## 1. INTRODUCTION

**M/s. National Aluminium Company Limited** has proposed the construction of 5<sup>th</sup> Alumina Refinery at Damanjodi, Odisha and Port facilities at Visakhapatnam. For designing foundation structures coming under this project, it was necessary to conduct a detailed Geotechnical Investigation Work to obtain engineering properties of the underlying soil and **M/s. National Aluminium Company Limited**, in turn, appointed **M/s. C. E. Testing Company Pvt. Ltd., Kolkata** as their Geotechnical Consultant.

The scope of the work comprised of sinking 70 nos. bore holes. The scope also includes, TP (Trial Pit – 5 Nos.), CPLT (Cyclic Plate Load Tests – 7 Nos.), ERT (Electrical Resistivity Tests – 1 No.), BVT (Block Vibration Test – 7 Nos.) and Field CBR Tests – 5 Nos.

This is a part of report and the scope included sinking 30 nos. Boreholes and 2 Nos. Trial Pits.

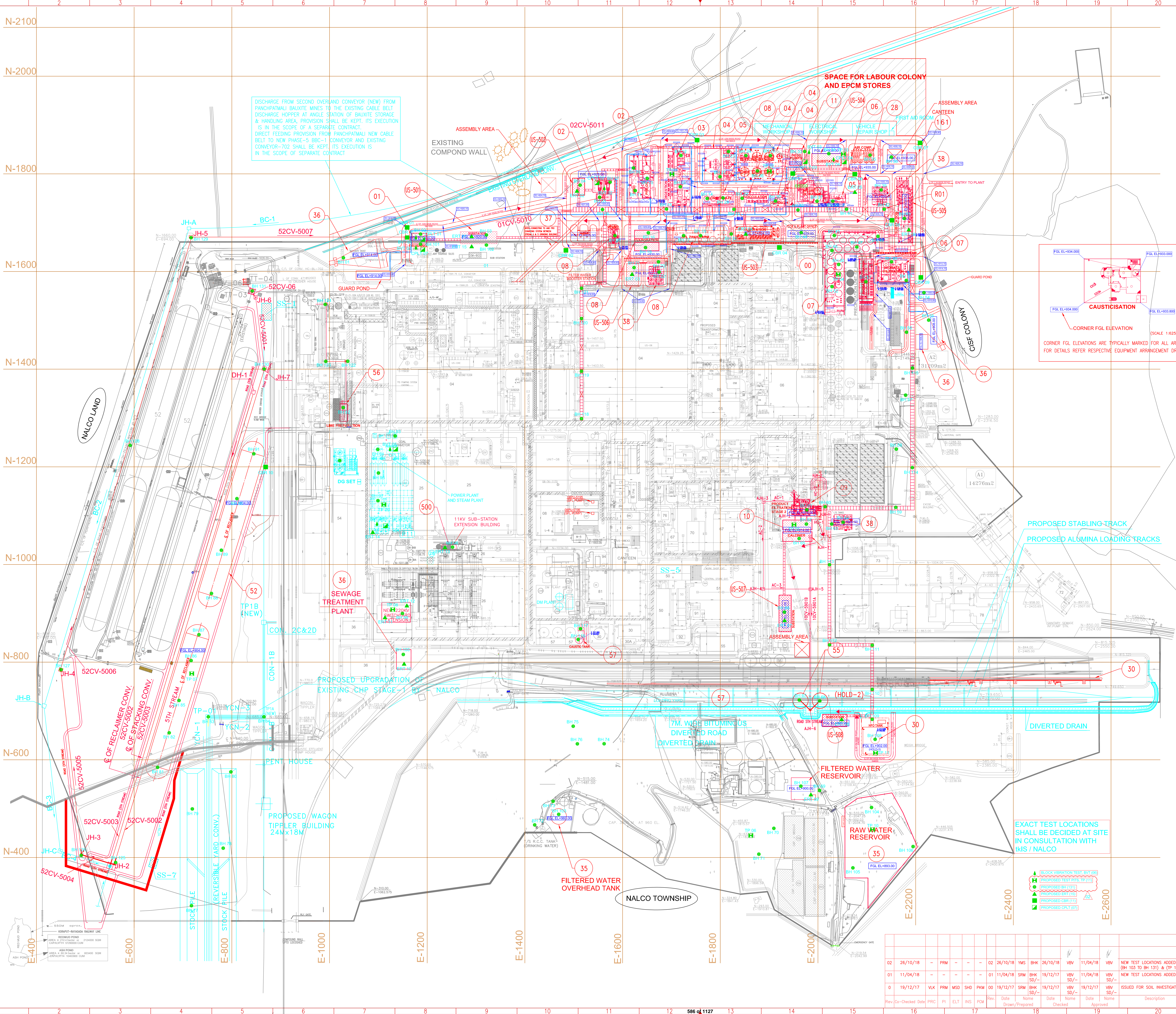
The boreholes of 150 mm diameter were advanced by Shell and Auger method in soil. In rock, rotary core drilling of “NX” size was adopted. The scope also included conducting Standard Penetration Tests, collecting disturbed samples at regular intervals for identification and logging purposes, collecting undisturbed tube samples at suitable intervals or at change of strata whichever is earlier and testing these in the laboratory.

Based on the above, this report presents the Bore Logs, Soil Profile, laboratory and field Test Results.

The subsoil is characterised by stiff to very stiff silty clay followed by hard silty clay. Below this dense to very dense silty sand with clay binder was observed. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes. However, around some borehole locations, soft to medium silty clay layer was observed.

Considering the nature of the subsoil as revealed from field tests and laboratory tests most suitable type of foundation is recommended. However, this is discussed in details later.





**GENERAL NOTES:-**

1. ALL CO-ORDINATES, DIMENSIONS & ELEVATIONS IN METER UNLESS OTHERWISE STATED.
2. ALL LEVELS ARE ABSOLUTE LEVELS W.R.T MEAN SEA LEVEL.
3. THIS LAYOUT IS TO BE REFERRED ONLY FOR CONCEPTUAL LOCATION OF THE UNITS.
4. THE LEVELS OF THE UNITS ARE PRESENTLY HOLD DUE TO NON-AVAILABILITY OF CONTOUR SURVEY. IT SHALL BE FINALIZED ONLY AFTER RECEIPT OF CONTOUR SURVEY.
5. THE UNIT SIZES AND CO-ORDINATES SHALL BE CONFIRMED AFTER RECEIPT OF UNIT PLOT PLANS FROM LICENSOR AND PRELIMINARY VENDOR DATA.
6. THE LOCATION OF NEW CAUSTIC AND FUEL OIL UNLOADING STATION IS UNDER HOLD. TO BE CONFIRMED DURING THE COURSE OF DETAILED ENGINEERING.
7. FEASIBILITY OF USAGE OF EXISTING PIPE RACKS FOR THE NEW PIPE LINES / CABLE TRAYS SHALL BE CONFIRMED ONLY AFTER SITE SURVEY. THE REQUIREMENT OF ADDITIONAL PIPE RACKS SHALL BE INDICATED BASED ON THE RESULTS OF THE SAME.
8. THE EXTENT OF RAW WATER RESERVOIR AND FILTERED WATER RESERVOIR IS UNDER HOLD. IT SHALL BE CONFIRMED DURING THE COURSE OF DETAILED ENGINEERING.
9. NO UNDERGROUND PIPING IS ENVISAGED IN THE NEW FACILITIES UNDER THIS SCOPE.
10. PREVAILING WIND DIRECTION MOVING FROM SW DIRECTION CONSIDERED FROM WIND ROSE.
11. PASSIVE FIRE PROTECTION (i.e. FIRE-PROOFING) IS NOT APPLICABLE.

**NEW UNITS / AREA SCHEDULE**

NALCO AREA NO.	UNITS / AREA DESCRIPTION
52	BAUXITE STORAGE AND HANDLING
01	SECONDARY CRUSHING
02	BAUXITE GRINDING
02	INDIRECT BAUXITE SLURRY HEATING(BSH) & PREDISULCATION
03	DIGESTION
08	ACID CLEANING PREPARATION
04	MUD SETTLING
05	TRI CALCIUM ALUMINATE (TCA) PREPARATION
04	MUD WASHING
04	FLOCCULENT PREPARATION
05	SECURITY FILTRATION
04	CAUSTICIZATION
06	HEAT INTERCHANGE
06	HYDRATE FILTRATION
07	PRECIPITATION
07	SEED GRINDING
07	CAUSTIC CLEANING PREPARATION (INCLUDED IN PRECIPITATION)
07	HYDRATE CLASSIFICATION
09	PRODUCT HYDRATE FILTRATION STAGE-1
09	PRODUCT HYDRATE FILTRATION STAGE-2
53	HYDRATE TRANSFER
10	CALCINATION
08	EVAPORATION
08	CONDENSATE TANK FARM
56	LIME PREPARATION (SLAKING)
11	RESIDUE PUMPING
08	TANK FARM FOR EVAPORATION
55	CAUSTIC SODA STORAGE AND HANDLING
36	EFFLUENT TREATMENT PLANT
36	SEWAGE TREATMENT PLANT
35	RAW WATER RESERVOIR
35	DRINKING WATER UNIT
38	COOLING TOWERS & COOLING WATER DISTRIBUTION
28	PLANT AIR AND INSTRUMENT AIR SYSTEM
37	FIRE WATER STORAGE
R01	MAIN PIPE RACK FOR MAIN PLANT
26-01 TO 08	SUBSTATION
00	CCR
30	FUEL OIL UNLOADING AND STORAGE

**REFERENCE DRAWINGS**

DRAWING Nos.	DESCRIPTION
11253-03-0001	PLAN GENERAL LAYOUT
202-000-1-GA-0001	PLOT PLAN PRELIMINARY
26328-03-02-ELE-0002	LAYOUT PLAN & SECTION FOR 220KV/132KV NALCO DAMANJODI SS(EXTN)
11253-B-02-0001	GENERAL LAYOUT NALCO DAMANJODI ALUMINA RETINERY. PLOT PLAN SUPERIMPOSED ON REVENUE MAP.

**LEGEND:**

COMPOUND WALL (EXISTING)	NEW FACILITIES IN THIS SCOPE
PIPERACK (EXISTING)	NEW FACILITIES BY OTHER
PIPERACK (EXISTING)	NEW PIPE RACK ROUTING
ROADS (EXISTING)	NEW CONVEYOR
EXTENSION OF EXISTING PIPERACK	NEW FENCING
PIPE RACK (EXISTING)	

**HOLD LIST**

1. FUEL OIL UNLOADING STATION.
2. CAUSTIC SODA UNLOADING STATION.
3. FILTERED WATER RESERVOIR.
4. RAW WATER RESERVOIR.

**Category Codes**

Category Codes	Volume	Area	Permit
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8

**Acceptance Codes**

Acceptance Codes	Volume	Area	Permit
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8

**Contract No.** 66-6695-700 **Document ID** 6695-CVC-G00-LA-0001 **Part** 02 **Rev.**

**Store Location:** Server/Share **BAR-Code**

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**Store Name** 6695-CVC-G00-LA-0001

**Pro. Unit** Con. Unit TON **Group** **Order No.** **Type of Document** Sheet 1/1

**नलको NALCO**  
National Aluminum Company Ltd.

**1.0 MTPA ALUMINA REFINERY STREAM-5 DAMANJODI, ODISHA**

**thysseknrupp**  
thyssenkrupp Industrial Solutions (India) Private Limited

Drawn	SRM	Name	Description
19/12/2017	SRM	SRM	SOIL INVESTIGATION - BORE HOLE & TEST LOCATION PLAN FOR DAMANJODI SITE
19/12/2017	SRM	SRM	
19/12/2017	SRM	SRM	

Rev.	Co-Checked	Date	PRC	PI	ELT	INS	PCM	Rev.	Date	Name	Drawn/Prepared	Checked	Approved	Description	Acc. Code	Scale	Cat. Code	Acc. Code	Status	IFC
02	26/10/18	-	PRM	-	-	-	-	02	26/10/18	YMS	BHK	26/10/18	VBV	11/04/18	VBV	NEW TEST LOCATIONS ADDED (BH 103 TO BH 131) & (TP 10 TO 11)				
01	11/04/18	-	-	-	-	-	-	01	11/04/18	SRM	BHK	19/12/17	VBV	SD/-	VBV	SD/-	NEW TEST LOCATIONS ADDED			
0	19/12/17	VLK	PRM	MSD	SHD	PKM	00	19/12/17	SRM	BHK	19/12/17	VBV	SD/-	VBV	SD/-	ISSUED FOR SOIL INVESTIGATION				

Page 3/58



## 2. FIELD INVESTIGATIONS

### 2.1. GENERAL:

In an attempt for finalisation in the design of foundation for these proposed structures to be constructed at this site, Geotechnical Investigation was envisaged. The entire Investigation programme had been divided mainly into two parts, I) Field works & II) Laboratory tests.

- I) Field works unfold the sub-surface deposit types and their characteristics and
- II) Laboratory tests part would help determining the relevant physical and geotechnical properties of the sub-surface deposits leading to finalisation of foundation depths of the structures and the bearing capacity with particular reference to the sub-surface types and their strength parameters and settlement potentials at the site.

A list of the bore holes with the reduced level and standing water level are presented in a tabular form below.

Structure Name	BH No.	Co-ordinate (M)			Terminating Depth (M)	SWL (M)	Top of rock below EGL (M)
		E	N	R.L.			
Crushing	BH-101	1186.379	1650.000	919.471	18.50	9.50	13.50
Substation-07	BH-102	1321.199	1648.217	915.810	19.00	5.20	12.00
Filtered Water Tank	BH-103	1469.207	488.317	960.179	10.00	8.90	1.00
Raw Water Reservoir (Area-3)	BH-104	2109.615	502.400	895.975	40.00	3.60	36.00
Raw Water Reservoir (Area-4)	BH-105	2071.500	378.731	896.081	37.50	4.10	10.50
Raw Water Reservoir (Area-5)	BH-106	2194.743	422.348	894.029	40.45	2.50	--
Filtered Water Reservoir	BH-107	1965.023	545.988	899.936	14.50	4.20	9.50
HFO Tank	BH-108	2117.000	641.999	902.281	31.50	11.20	27.50
Pipe Rack	BH-109	2111.023	683.026	905.140	32.00	11.70	29.00
Pipe Rack (Area-8)	BH-110	2111.119	744.174	902.810	21.50	8.00	16.50
	BH-111	2111.119	834.707	912.137	26.00	3.20	12.50
	BH-112	2023.707	835.477	912.300	12.00	1.80	3.00
Pipe Rack (Area-5)	BH-113	2023.596	999.498	925.139	11.50	4.70	3.50
Pipe Rack (Area-1)	BH-114	2193.188	1198.398	904.502	12.50	2.60	8.50
	BH-115	2193.454	1402.134	907.053	10.60	2.10	0.60
Caustic Storage	BH-116	1511.800	846.470	899.150	40.00	2.90	25.50
	BH-117	1513.792	868.338	898.570	40.00	3.20	27.00
Pipe Rack	BH-118	1515.874	1298.715	909.052	40.00	5.10	32.00
	BH-119	1515.874	1395.754	913.370	40.00	3.90	31.10
	BH-120	1515.874	1503.646	917.070	40.00	4.70	30.00
	BH-121	1515.874	1565.710	919.318	40.00	4.20	31.50

Structure Name	BH No.	Co-ordinate (M)			Terminating Depth (M)	SWL (M)	Top of rock below EGL (M)
		E	N	R.L.			
Lime Preparation - Conveyor	BH-122	1033.751	1416.709	901.030	12.00	3.10	3.00
	BH-123	992.260	1415.962	901.184	22.00	3.00	15.00
Lime Preparation - Crusher	BH-124	993.474	1533.989	900.310	12.50	3.10	4.50
Bauxite Handling- Conveyor	BH-125	562.083	389.723	898.290	40.00	6.80	15.50
	BH-126	491.678	404.511	<i>Not done as the location comes outside of boundary</i>			
	BH-127	450.301	784.537	903.984	40.00	11.70	35.00
	BH-128	591.895	1243.994	904.687	40.00	3.80	20.00
	BH-129	7121.701	1665.405	911.194	37.00	7.20	27.00
	BH-130	866.117	1400.462	902.464	40.00	6.90	19.00
	BH-131	841.806	1560.417	905.224	40.00	3.70	26.00

**2.2. BORING:**

Boring was carried out by Shell and Auger method to sink nominal 150mm diameter bore holes to depths envisaged by using a mechanical winch. Undisturbed soil samples were collected at suitable intervals or at change of strata whichever is earlier by open drive sampling method since it was intended to ascertain the sub-soil characteristics.

**2.3. SAMPLING:**

Nominal 100 mm diameter undisturbed samples were recovered. The sampling equipment used consists of a two-tier assembly of sample tubes 450 mm in length fitted at its lower end. The sampling assembly was driven by means of a jarring link to its full length or as far down as was found practicable. As the soil is very stiff to hard and contains sand mixtures / calcareous nodules, cutting shoe was used with a area ratio < 20%. After withdrawal the ends of the tubes were sealed with wax and capped before onward transmission to the laboratory. At close intervals in depth disturbed samples were collected for identification and logging purpose. These were tagged and packed in polythene packets and transported to the laboratory.

**2.4. STANDARD PENETRATION TESTS:**

Standard Penetration Tests were conducted in the bore holes at intervals of 1.5M to 3.0M depth or at change of strata whichever is earlier using a split spoon sampler. The split spoon sampler used is of a Standard design having an outer diameter of 50.8 mm and inner diameter of 35 mm, driven with a monkey weighing 63.5 kgs, falling freely through 75cms. A record of the number of blows required to penetrate every 15cms to a maximum depth of 45cms was

made. The first 15cm of drive are considered to be seating drive and are neglected. The total blows required for second & third 15cm of penetration is counted and termed as penetration resistance "N". On completion of a test, the split spoon sampler was opened and soil specimens were preserved in polythene bags for logging purpose.

All the boreholes were sunk with winch. However, raising of hammer for SP Tests were done manually. Hence there will not be any inertia loss and the efficiency of hammer blows should be considered as 100%.

## 2.5. MEASUREMENT OF WATER TABLE:

Standing water level after 24 hours of removal of casing was also noted and shown in the profile.

## 2.6. ROTARY CORE DRILLING:

This drilling technique is regarded as the most satisfactory method of assessing the character of rock formations, which lie at depth below the ground surface. Specimens of rock in the form of cylindrical cores are recovered from the drill holes by means of a core barrel. Double barrel technique is adopted according to field condition. The core barrel is provided at its lower end with a detachable shoe or core bit, which is of diamond. All rotary core bits were of NX (73mm) size.

## 2.7. TRIAL PITS:

Out of 5 nos. only 2 nos. Trial Pits were excavated for physical verification of subsoil with depth. The co-ordinates of the Trial Pit locations are presented below.

Trial Pit No.	Co-ordinate (M)			Depth (M)
	Easting	Northing	R.L.	
TP – 10	2111.748	457.187	893.199	3.50
TP – 11	2117.885	614.077	901.350	3.50

**2.8. FIELD C.B.R. TEST:**

The tests were carried out in accordance with IS 2720 (Part 31) : 1969 (and Amendment 1). Total 5nos. Field C.B.R. Tests (soaked) were conducted. The co-ordinates of the test location are presented below.

FCBR No.	Co-ordinate (M)			Depth (M)
	E	N	R.L.	
CBR - 1				
CBR - 2				
CBR - 3				
CBR - 4				
CBR - 5				

**Test not yet been conducted**

**2.9. CYCLIC PLATE LOAD TESTS:**

Total seven (7) sets of Plate Load Tests (Cyclic type) were conducted **using a 450mm square plate**. Test is continued upto a maximum desired loading intensity or specified plate settlement which ever is earlier. The load is applied through a hydraulic jack. The reaction for applying the load on the plate is obtained by a loading platform with sandbags. After applying the load increments, settlement records are made at intervals of 1, 2.25, 4, 6.25, 9, 16, 25, 60, 90 & 120 minutes and thereafter at an interval of an hour. When the rate of plate settlement reduced to 0.02 mm per minute, the final reading of the dial gauges is recorded. The applied load is then released and the plate allowed to rebound. When no further rebound occurs or the rate of rebound becomes negligible, the readings of the dial gauges are again noted. The load then is increased gradually till its magnitude acquires a value equal to the proposed next higher stage of loading which is to be maintained constantly and the final dial gauge readings are noted as earlier. The entire load is then reduced to zero and final dial gauge readings recorded when the rate of rebound becomes negligible. The coordinate of test locations are given below.

PLT No.	Type of Tests	Plate size (mm x mm)	Co-ordinates (M)		R. L. (M)	Depth (M)
			E	N		
CPLT-01	Cyclic Type	450 x 450				
CPLT-02	Cyclic Type	450 x 450				
CPLT-03	Cyclic Type	450 x 450				
CPLT-04	Cyclic Type	450 x 450				
CPLT-05	Cyclic Type	450 x 450				
CPLT-06	Cyclic Type	450 x 450				
CPLT-07	Cyclic Type	450 x 450				

**Test not yet been conducted**

**2.10. ELECTRICAL RESISTIVITY TESTS:**

Only one (1) no. Electrical Resistivity Tests were carried out at the following locations. The test procedure and results are presented under Section-8.

ERT	Co-ordinate (M)		R.L. (M)
	E	N	
ERT-1	Test not yet been conducted		

**2.11. BLOCK VIBRATION TESTS:**

Six (7) nos. Block Vibration Tests were carried out to determine the dynamic properties of the layer for the construction of machine foundations at the following locations.

BVT No.	Co-ordinates (M)		R. L. (M)
	Easting	Northing	
BVT-1			
BVT-2			
BVT-3			
BVT-4	Test not yet been conducted		
BVT-5			
BVT-6			
BVT-7			

### 3. LABORATORY TESTING

For proper identification and classification of the sub-soil deposits and for deriving adequate information regarding its relevant physical and geotechnical properties at the site under investigation, the following laboratory tests were conducted on the soil / rock samples collected from the exploratory bore holes:

#### On Soil Samples:

1. Grain size analysis (Sieve as well as Hydrometer).
2. Determination of Liquid Limit, Plastic Limit and Shrinkage Limit.
3. Determination of Natural Moisture Content.
4. Determination of Specific Gravity.
5. Determination of Bulk & Dry Unit Weight.
6. Strength determination by Triaxial Unconsolidated Undrained Test (UU).
7. Strength determination by Triaxial Consolidated Drained Test (CD).
8. Strength Determination of Unconfined Compression Test on "UDS" (UNCONFD).
9. Strength Determination of Unconfined Compression Test on REMOULDED samples.
10. Strength determination by Direct Shear Test.
11. One-dimensional Consolidation Test for determining settlement potentiality.
12. Determination of Free Swelling Index & Swelling Pressure.
13. Chemical tests on soil and water samples to determine pH value, Sulphate, Chloride & organic matter content etc.

#### On Rock Samples:

1. Determination of Bulk Density, Water Content, Specific Gravity & Porosity of Rock.
2. Determination of Unconfined Compressive Strength of Rock samples (Saturated & Dry State)
3. Determination of Point Load Strength Index.

Laboratory test results are presented in a tabular form in the Appendix. The results are self explanatory excepting that of consolidation tests. The compressibility for a pressure range has been separated into 2 components through the compression ratio. As a first step dial gauge reading is plotted against square root of time and by extrapolation dial reading at zero time, is obtained. The compression ratio is given as

$$r = (d_i - d_s) / (d_i - d_f), \text{ where}$$

$d_i$  = Initial reading of dial before load application

$d_s$  = Dial reading corresponding to theoretical zero time

$d_f$  = Final dial reading after 24 hrs.

Now we write  $m_{vc} = (1 - r) \times m_v$

All the tests were conducted as per relevant Indian Standard Specifications.

## 4. SUBSOIL CONDITION, STRATIFICATION AND PROPERTIES

### 4.1. SUB-SOIL CONDITIONS:

The boring records showing the various soils met with are enclosed in the Appendix. These are prepared from field logs after proper modifications in the light of the laboratory test results and observation of disturbed and penetrometer soil samples. The results of the Standard Penetration Tests are given as 'N' values in these boring records. The sub-soil profiles (as obtained from field and Laboratory test results) across the bore holes are shown under Figs. 2.01 to 2.14 giving description, consistency and colour of each strata. The "N" values are shown in the profiles as well as presented in the borelogs in the Appendix. The laboratory test results and the back up sheets are also presented there.

### 4.2. SUB-SOIL STRATIFICATIONS:

The subsoil is characterised by stiff to very stiff silty clay followed by hard silty clay. Below this dense to very dense silty sand with clay binder was observed. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes. However, around some borehole locations, soft to medium silty clay layer was observed. The description of each layer is presented below.

#### 4.2.1. STRATUM - IA:

This layer is present only around some borehole (BH-118, 124, 130 & 131) locations. The soil in this layer consists of soft to medium, reddish brown silty clay / clayey silt with sand mixture, moorum, boulder, gravel. The average properties of this layer are presented below, however these properties do not truly represents the properties of whole stratum.

Bulk Density, gms/cc	1.93	Specific gravity	2.76
Dry Density, gms/cc	1.51	Void Ratio	0.755
Natural Water Content %	28	Liquid limit %	38
<b>TRSH-UU:</b>		Plastic Limit %	23
Cohesion kg/sqcm	0.33	Shrinkage Limit %	21
Friction angle °	3°	<b>GRAIN SIZE</b>	
<b>Unconfined cohesion, kg/sqcm</b>	<b>0.38</b>	Sand %	43
<b>Remoulded cohesion, kg/sqcm</b>	<b>0.25</b>	Silt %	47
<b>Sensitivity, S<sub>t</sub></b>	<b>1.55</b>	Clay %	10

#### 4.2.2. STRATUM - I:

The soil in this layer consists of stiff to very stiff, reddish brown to brownish grey / whitish grey, silty clay / clayey silt with sand mixture, kankar, moorum. Grey spots & reddish spots have also been observed in this layer. The average properties of this layer are presented below.



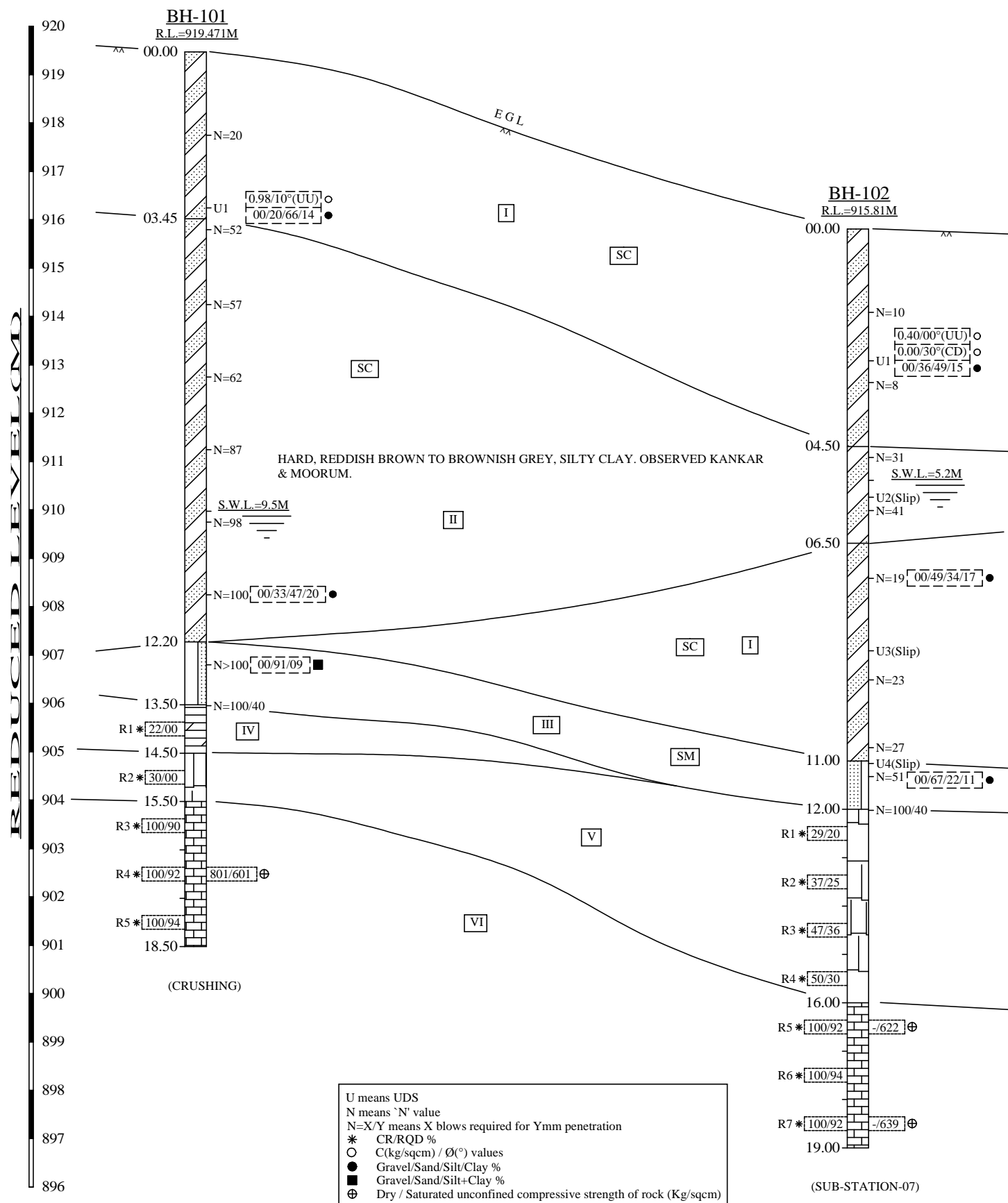


FIG. 2.01 : GENERALISED SOIL PROFILE



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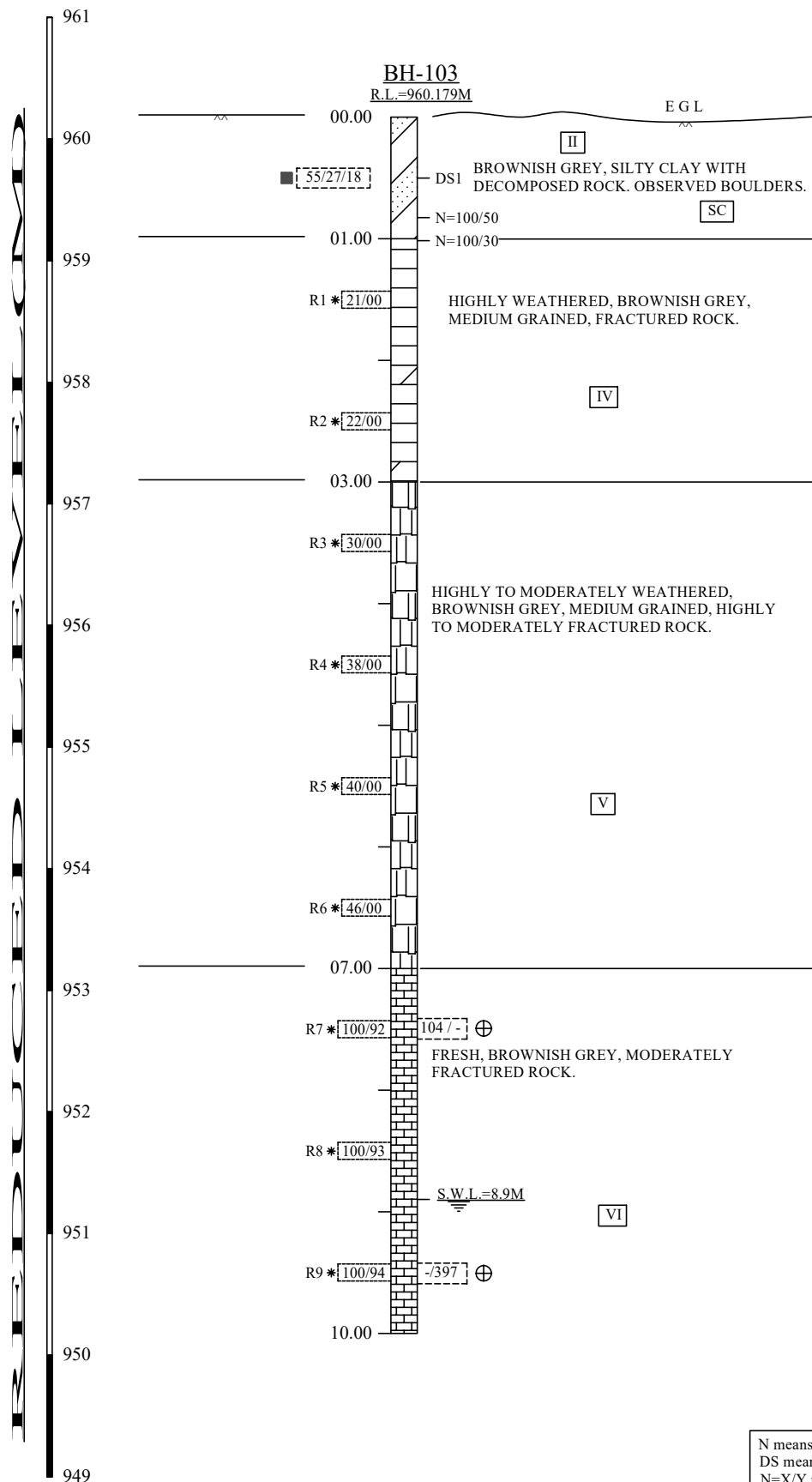
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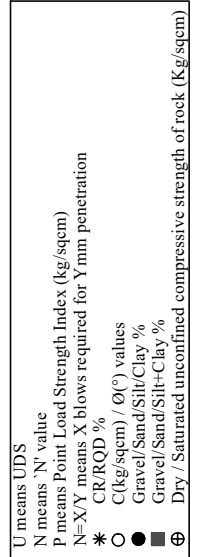


N means 'N' value  
DS means Disturbed Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (Kg/sqcm)

(Filtered Water Tank)

FIG. 2.02 : SUB-SOIL PROFILE

595 of 1127



(Raw Water Reservoir)

**FIG. 2.03 : GENERALISED SOIL PROFILE**

FIG. 2.03 : GENERALISED SOIL PROFILE



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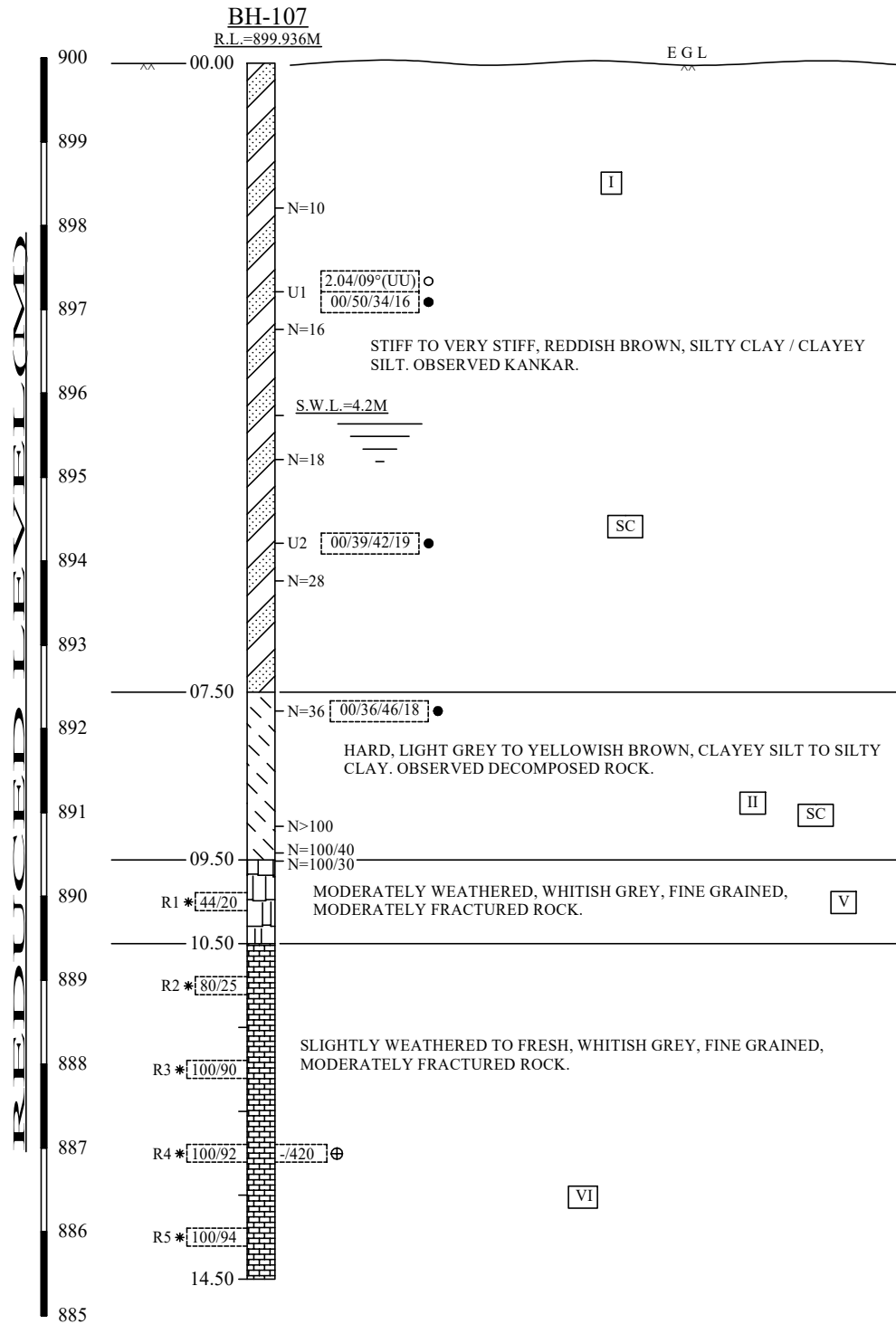
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U means UDS  
N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
○ C(kg/sqcm) / Ø(°) values  
● Gravel/Sand/Silt/Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (Kg/sqcm)

(Filtered Water Reservoir)

FIG. 2.04 : SUB-SOIL PROFILE

597 of 1127



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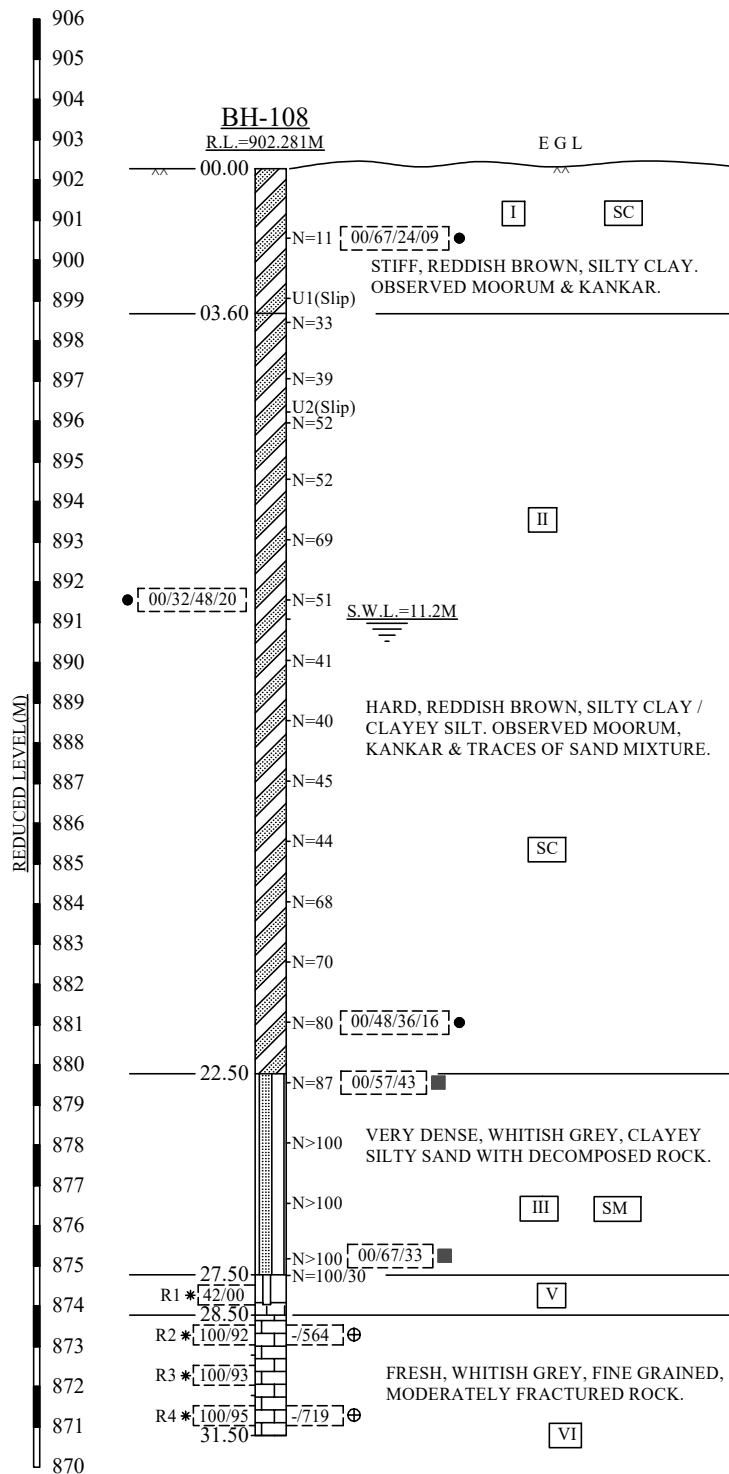
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V → MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

U means UDS  
N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
● Gravel/Sand/Silt/Clay %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (Kg/sqcm)

(HFO Tank)  
FIG. 2.05 : SUB-SOIL PROFILE

598 of 1127





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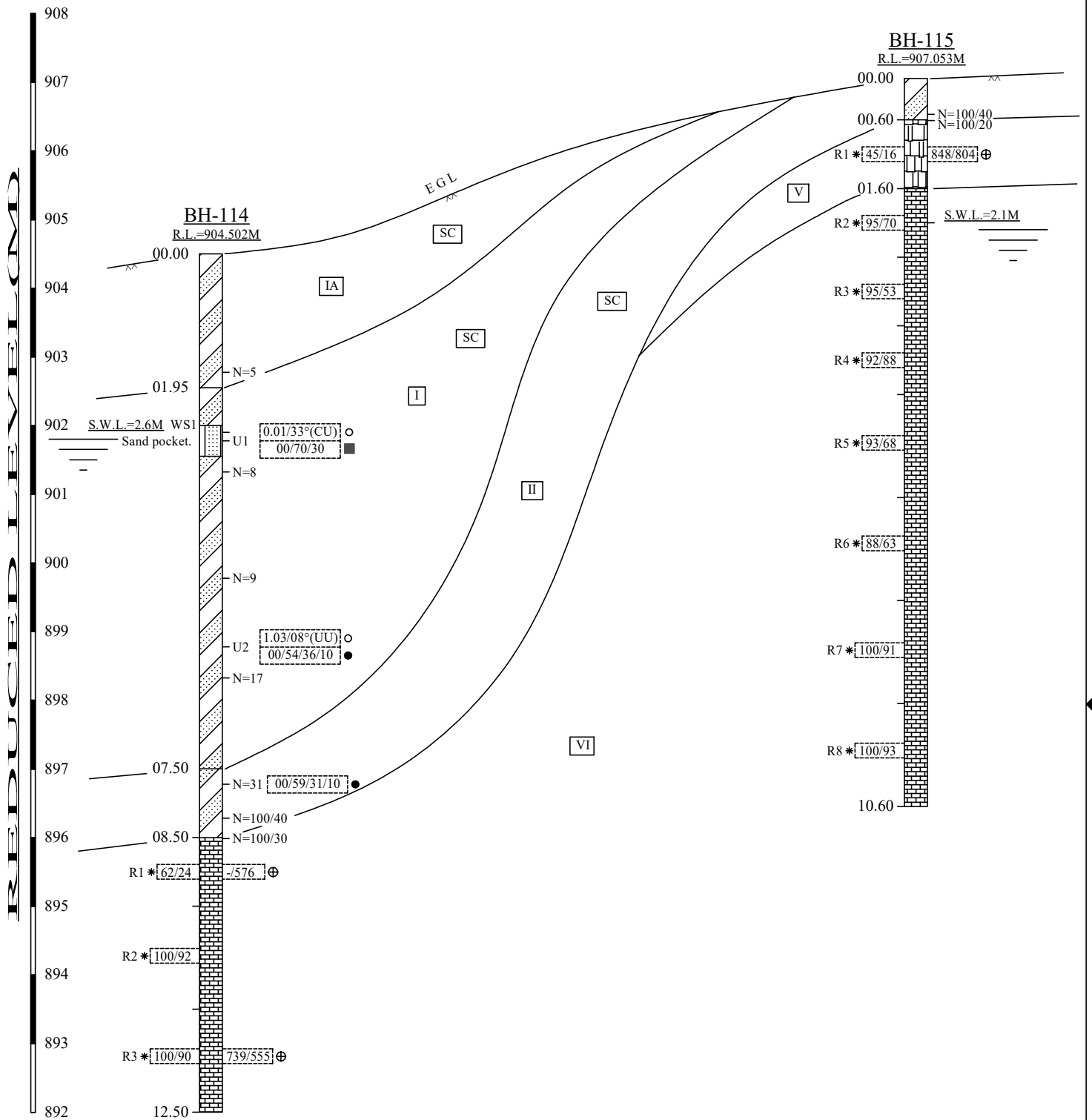
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IA → MEDIUM, REDDISH BROWN, SILTY CLAY / CLAYEY SILT. OBSERVED FINE SAND MIXTURE & KANKAR.

I → STIFF TO VERY STIFF, REDDISH BROWN, SILTY CLAY / CLAYEY SILT. OBSERVED SAND MIXTURE & KANKAR.

II → HARD, REDDISH BROWN, SILTY CLAY / CLAYEY SILT WITH SAND MIXTURE. OBSERVED DECOMPOSED ROCK.

V → MODERATELY WEATHERED, LIGHT GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → SLIGHTLY WEATHERED TO FRESH, LIGHT GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

U means UDS  
N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
○ C(kg/sqcm) / Ø(°) values  
● Gravel/Sand/Silt/Clay %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (Kg/sqcm)

(Pipe Rack)

FIG. 2.07 : GENERALISED SOIL PROFILE

600 of 1127



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

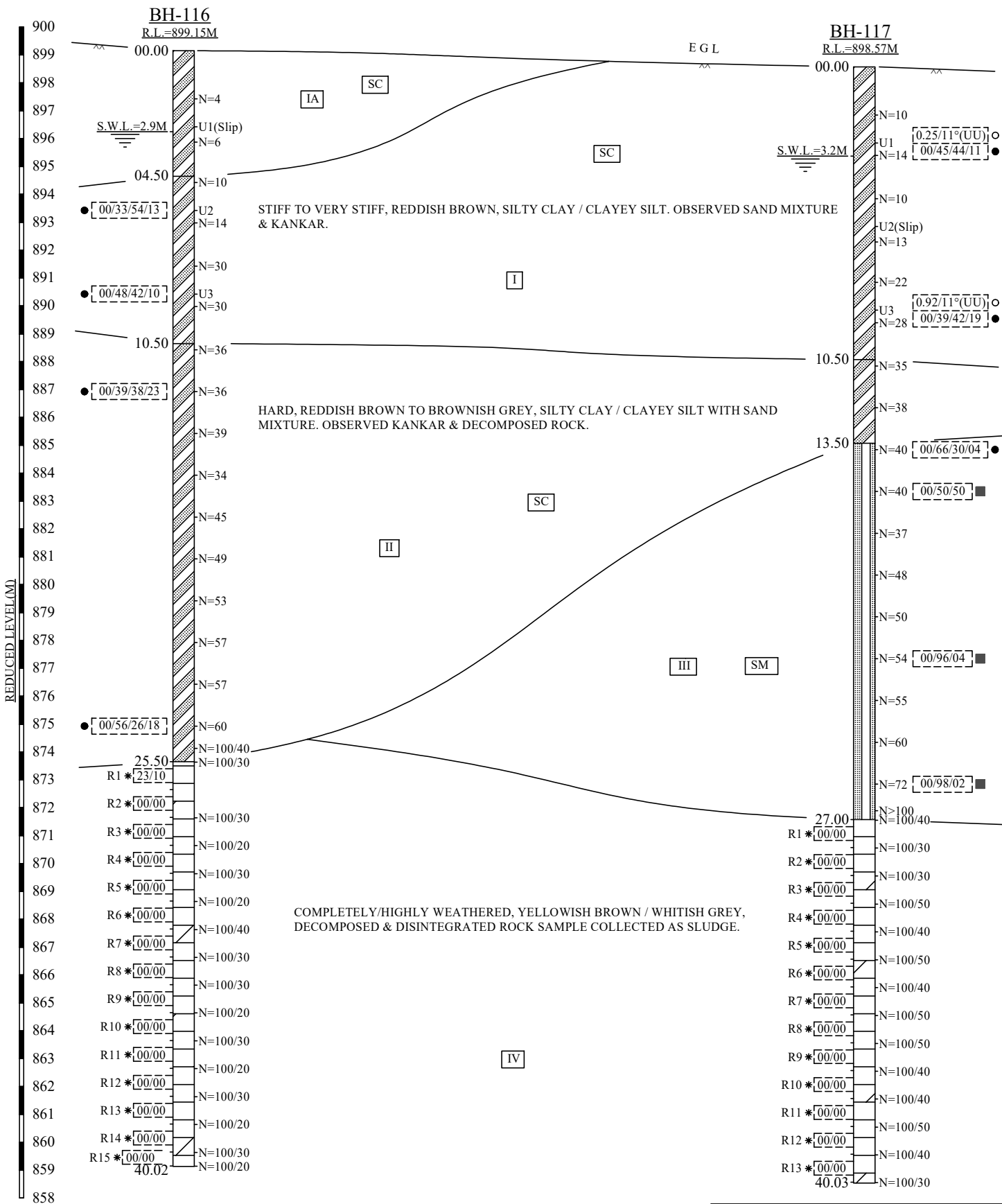
CETEST

Job No : 4095

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Created on : 03/01/2019

Sheet No:



IA → MEDIUM, REDDISH BROWN, SILTY CLAY / CLAYEY SILT. OBSERVED KANKAR.  
III → DENSE TO VERY DENSE, BROWNISH GREY TO YELLOWISH BROWN, SILTY SAND WITH DECOMPOSED ROCK. OBSERVED KANKAR.

U means UDS  
N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
○ C(kg/sqcm) / Ø(°) values  
● Gravel/Sand/Silt/Clay %  
■ Gravel/Sand/Silt+Clay %

(Caustic Storage)  
FIG. 2.08 : GENERALISED SOIL PROFILE



Job No : 4095

Created by : SKD

Created on : 31/12/2018

Sheet No:

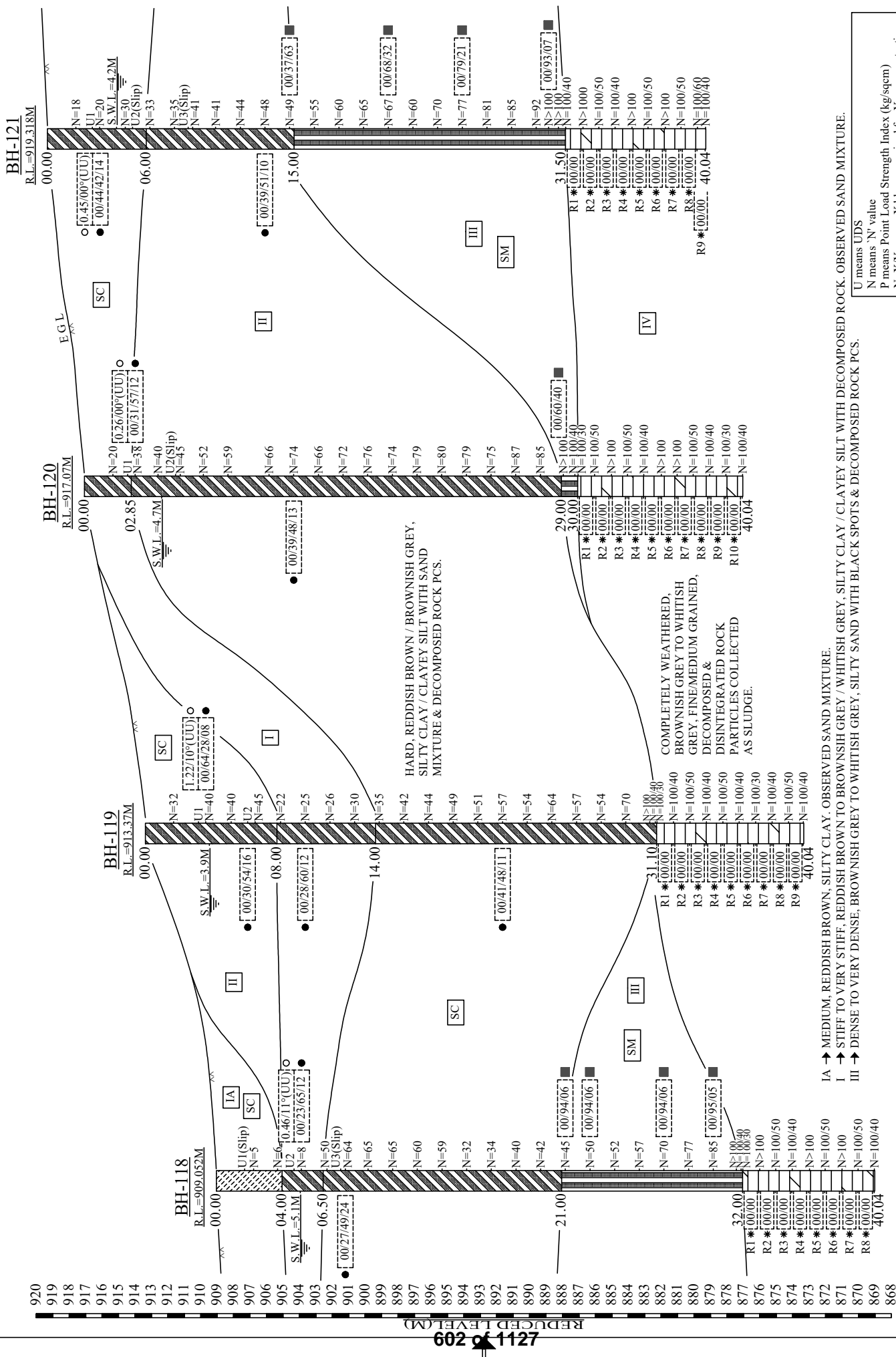


Fig. 2.09 : GENERALISED SOIL PROFILE

(Pipe Rack)



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

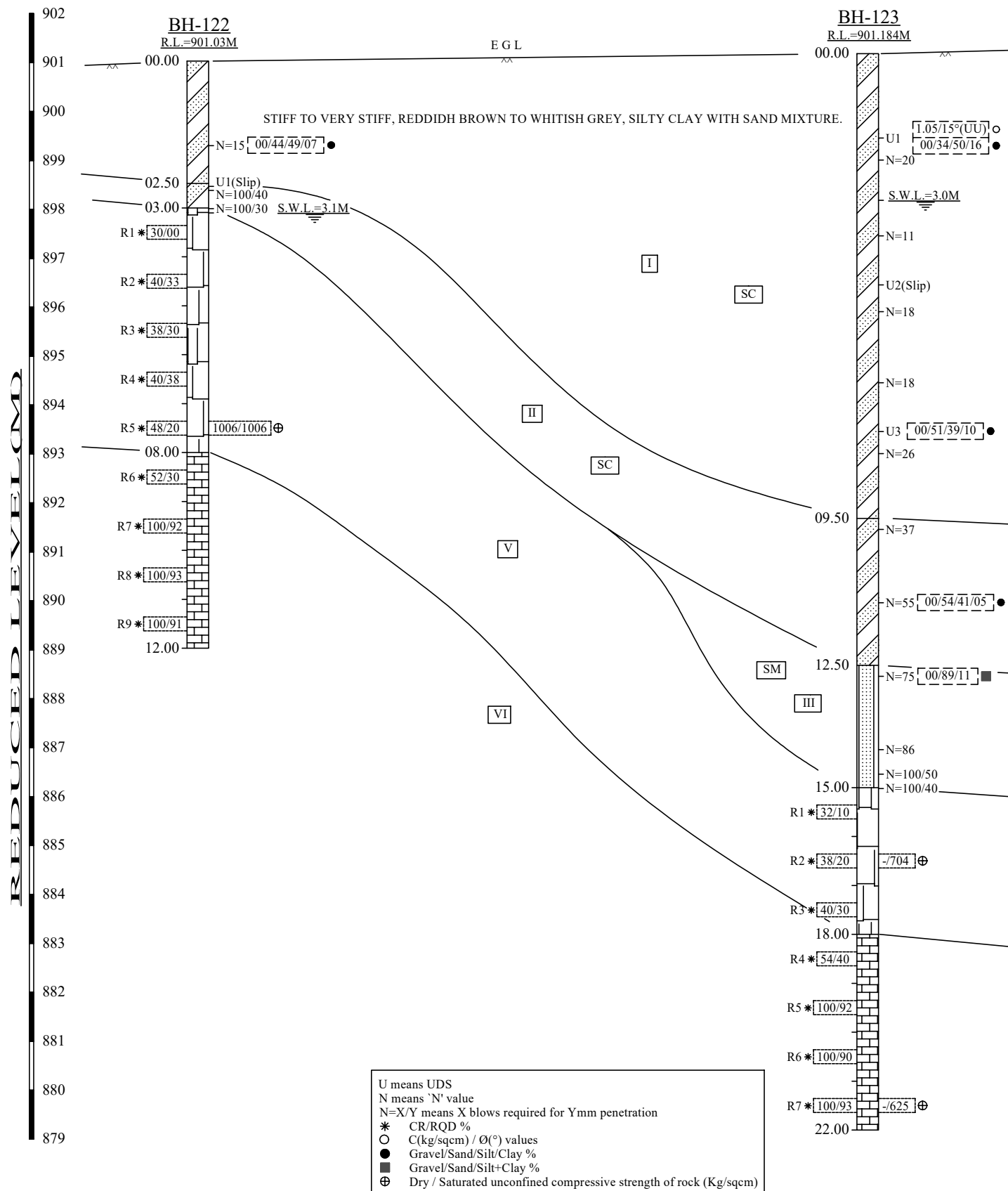
CETEST

Job No : 4095

Created by : SKD

Created on : 04/01/2019

Sheet No:



II → HARD, REDDISH BROWN / WHITISH GREY, SILTY CLAY. OBSERVED SAND MIXTURE & DECOMPOSED ROCK.

III → VERY DENSE, BROWNISH GREY, SILTY SAND WITH MICA. OBSERVED DECOMPOSED ROCK.

V → HIGHLY TO MODERATELY WEATHERED, BROWNISH GREY / WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY WEATHERED TO FRESH, BROWNISH GREY / WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

[Lime Preparation (Conveyor)]

FIG. 2.10 : GENERALISED SOIL PROFILE

603 of 1127



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

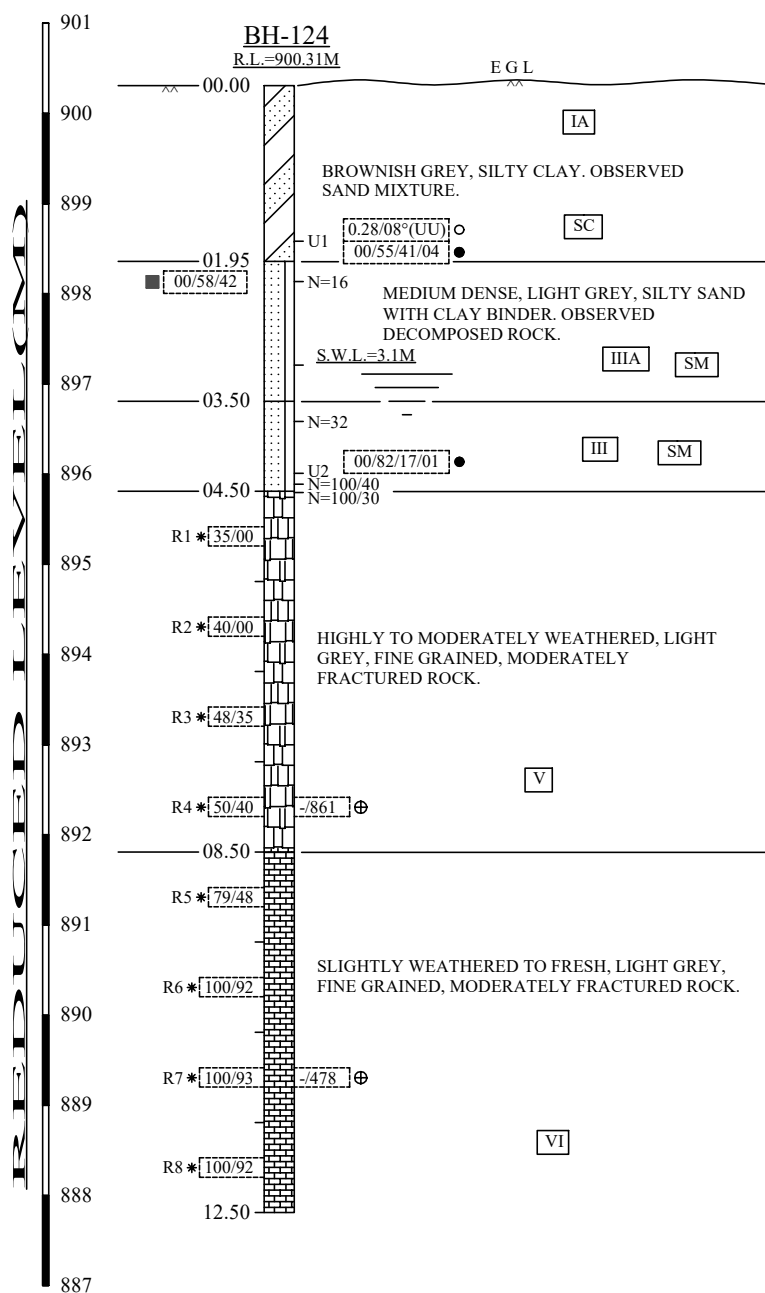
CETEST

Job No : 4095

Created by : SKD

Created on : 03/01/2019

Sheet No:



III → DENSE, LIGHT GREY, SILTY SAND WITH CLAY BINDER. OBSERVED DECOMPOSED ROCK.

U means UDS  
N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
○ C(kg/sqcm) / Ø(°) values  
● Gravel/Sand/Silt/Clay %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (Kg/sqcm)

(Lime Preparation - Crusher)  
FIG. 2.11 : SUB-SOIL PROFILE





Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

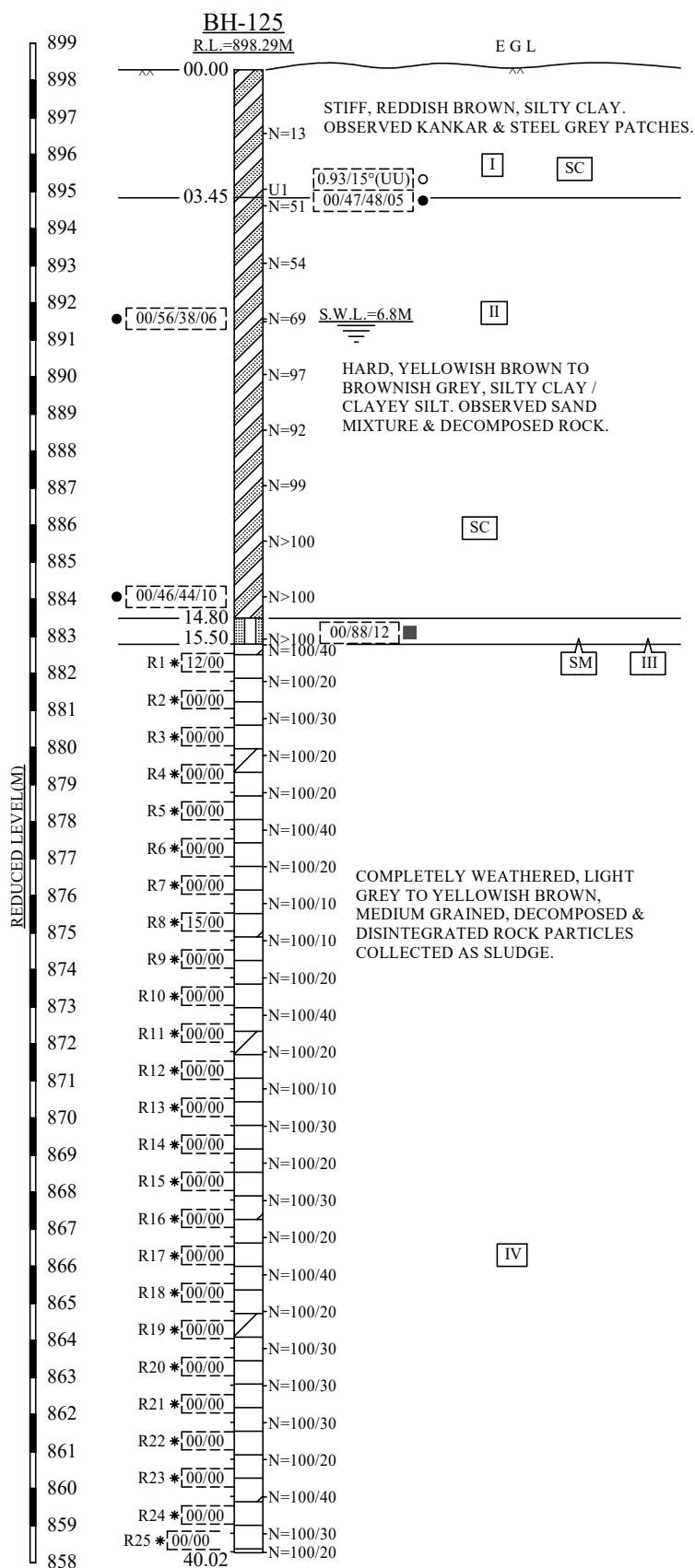
CETEST

Job No : 4095

Created by : SKD

Created on : 03/01/2019

Sheet No:



U means UDS  
N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
○ C(kg/sqcm) / Ø(°) values  
● Gravel/Sand/Silt/Clay %  
■ Gravel/Sand/Silt+Clay %

(Bauxite Handling)

FIG. 2.12 : SUB-SOIL PROFILE

605 of 1127

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

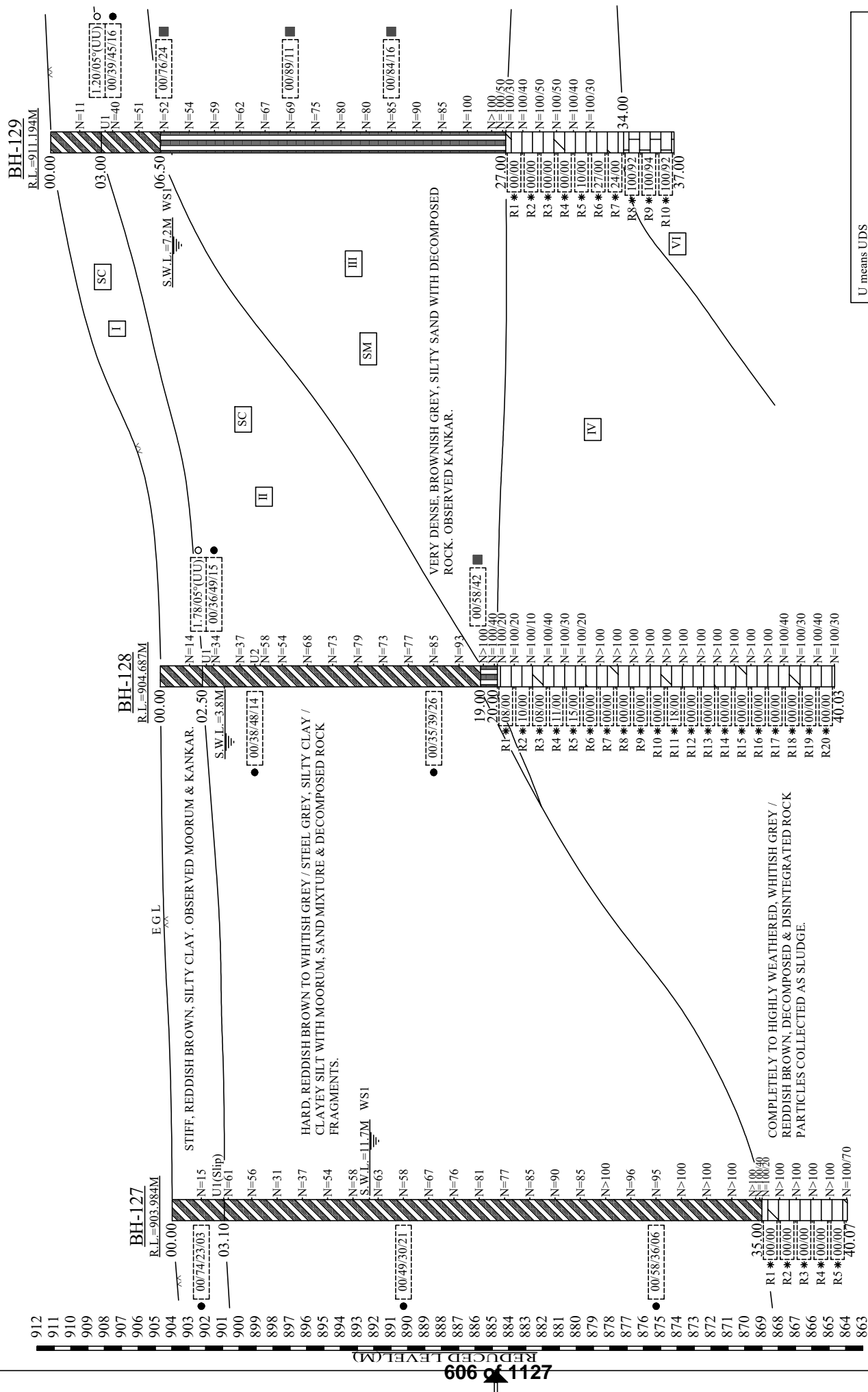
CETEST

Job No : 4095

Created by : SKD

Created on : 03/01/2019

Sheet No:



U means UDS  
N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
C(kg/sqcm) /  $\phi$ (°) values  
○ Gravel/Sand/Silt/Clay %  
● Gravel/Sand/Silt+Clay %

(Bauxite Handling - Conveyor)

FIG. 2.13 : GENERALISED SOIL PROFILE

VI → FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.



VI → MODERATELY TO SLIGHTLY WEATHERED, LIGHT GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

FIG. 2.14 : GENERALISED SOIL PROFILE

Bulk Density, gms/cc	1.95	Natural Water Content %	24
Dry Density, gms/cc	1.58	Specific gravity	2.73
<b>TRSH-UU:</b>		Void Ratio	0.717
Cohesion kg/sqcm	0.80	Liquid limit %	44
Friction angle °	8°	Plastic Limit %	26
<b>TRSH-CD:</b>		Shrinkage Limit %	20
Cohesion kg/sqcm	0.00		
Friction angle °	30°	<b>GRAIN SIZE</b>	
<b>Unconfined cohesion, kg/sqcm</b>	<b>0.81</b>	Sand %	40
<b>Remoulded cohesion, kg/sqcm</b>	<b>0.63</b>	Silt %	46
<b>SENSITIVITY, S<sub>t</sub></b>	<b>1.30</b>	Clay %	14

**4.2.3. STRATUM - II:**

The soil in this layer consists of hard reddish brown to brownish grey / whitish grey, silty clay / clayey silt with sand mixture, kankar, moorum, decomposed rock fragments. Grey spots & reddish spots have also been observed in this layer. The average properties of this layer are presented below.

Bulk Density, gms/cc	1.95	Specific gravity	2.73
Dry Density, gms/cc	1.60	Void Ratio	0.782
Natural Water Content %	22	Liquid limit %	46
<b>TRSH-UU:</b>		Plastic Limit %	27
Cohesion kg/sqcm	1.31	Shrinkage Limit %	22
Friction angle °	8°	<b>GRAIN SIZE</b>	
<b>Unconfined cohesion, kg/sqcm</b>	<b>0.95</b>	Sand %	42
<b>Remoulded cohesion, kg/sqcm</b>	<b>0.72</b>	Silt %	43
<b>SENSITIVITY, S<sub>t</sub></b>	<b>1.32</b>	Clay %	15

**4.2.4. STRATUM - IIIA:**

This layer is present only around BH-124 location and the soil in this layer consists of medium dense light grey silty sand with clay binder & decomposed rock fragments. The properties of this layer are presented below.

**GRAIN SIZE**

Gravel %	
Sand %	58
(Silt + Clay) %	42

**4.2.5. STRATUM - III:**

The soil in this layer consists of dense to very dense light brownish grey / yellowish brown to reddish brown silty sand with clay binder, mica, kankar, moorum, decomposed rock fragments. The average properties of this layer are presented below.

Specific gravity 2.75

**GRAIN SIZE**

Sand % 79

(Silt + Clay) % 21

**4.2.6. STRATUM - IV:**

This is rock layer and consists of completely to highly weathered, brownish grey to whitish grey / reddish brown, fine to medium grained, decomposed & disintegrated, highly fractured rock. The core recovery of this layer ranges from 0% to 22% with nil RQD.

Only one type of test was carried out on the rock samples viz.

## 1. Determination of Point Load Strength Index.

The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.683	Specific Gravity	2.731
Dry Density, gms/cc	2.650	Porosity %	3.295
Water Content %	1.245	Point Load Strength Index, kg/sqcm	56.32

**4.2.7. STRATUM - V:**

This is also rock layer and consists of highly to moderately weathered, brownish grey to whitish grey / whitish brown, fine to medium grained, highly to moderately fractured rock. Core recovery of this layer ranges from 29% to 50% and RQD varies from 0% to 40%.

The following tests were carried out on the rock samples viz.

1. Unconfined Compressive Strength determination of the rock samples as collected from the field (i.e. dry condition).
2. Unconfined Compressive Strength determination of the rock samples after 24 hours full submergence and thereafter air drying before testing (i.e. saturated condition).
3. Determination of Point Load Strength Index.

The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.783	UCS (dry), kg/sqcm	927
Dry Density, gms/cc	2.761	UCS (saturated), kg/sqcm	658
Water Content %	0.797	Co-efficient of Softening	0.71
Specific Gravity	2.794		
Porosity %	1.325	Point Load Strength Index, kg/sqcm	71.24



**4.2.8. STRATUM - VI:**

This is rock layer and consists of moderately to slightly weathered / fresh, whitish grey to light brownish grey / whitish brown, fine to medium grained, highly to moderately fractured rock. Core recovery of this layer ranges from 55% to 100% and RQD varies from 12% to 96%.

The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.821	UCS (dry), kg/sqcm	630
Dry Density, gms/cc	2.801	UCS (saturated), kg/sqcm	537
Water Content %	0.714	Co-efficient of Softening	0.853
Specific Gravity	2.839		
Porosity %	1.890	Point Load Strength Index, kg/sqcm	76.53

**4.3. GRAPHICAL PRESENTATION:**

The detailed Laboratory Test Results in tabular form are given in the Appendix. The back up sheets are also presented there as given in below:

1. *Strength envelopes from Triaxial Tests.*
2. *Normal Stress vs. Shear Stress from Direct Shear Tests.*
3. *e-log p curves from consolidation tests.*
4. *Grain size distribution curves for sieve and hydrometer tests.*

The consolidation test results are analysed by numerical methods and only the final output in a tabular form is given. The  $m_{vc}$  indicates the time dependent component of  $m_v$  and  $c_v$  is the co-efficient of consolidation.

## 5. DISCUSSION

### 5.1. CYCLIC PLATE LOAD TEST:

**Will be Incorporated Later**

**5.2. DETAILS OF STRUCTURES:**

The subsoil quality, thickness of each layer varies widely within the zone of investigation. Again, the type of structures to be constructed is different with different requirement. Considering all these aspect, the entire area is subdivided in to the following.

Sl. No.	Structure Name	Bore Hole Points	Reference Figure No.
1	Crushing & Substation-07	BH-101 & 102	2.01
2	Filtered Water Tank	BH-103	2.02
3	Raw Water Reservoir	BH-104, 105 & 106	2.03
4	Filtered Water Reservoir	BH-107	2.04
5	HFO Tank	BH-108	2.05
6	Pipe Rack	BH-109 to 113	2.06
7	Pipe Rack	BH-114 & 115	2.07
8	Caustic Storage	BH-116 & 117	2.08
9	Pipe Rack	BH-118 to 121	2.09
10	Lime Praparation - Conveyor	BH-122 & 123	2.10
11	Lime Praparation - Crusher	BH-124	2.11
12	Bauxite Handling- Conveyor	BH-125 & 126	2.12
13	Bauxite Handling- Conveyor	BH-127 to 129	2.13
14	Bauxite Handling- Conveyor	BH-130 & 131	2.14

**5.3. CHOICE OF FOUNDATION AND FOUNDING LEVEL:**

Considering the nature of the subsoil and the type of structures to be constructed at the present site, it is suggested to go for open foundation. Such foundation may be placed at a depth of 1.00m or more below FGL. The determination of bearing capacity is presented below.

**5.4. BEARING CAPACITY AROUND FILTERED WATER TANK AREA:****5.4.1. DETERMINATION OF BEARING CAPACITY:**

Let us consider BH-103.

Place the foundation at 2.00m below FGL. (FGL = 960.000M)

Founding level falls inside weathered rock layer.

**A) Bearing Capacity Based on RMR Method:**

Calculated RMR = 24 as per IS: 13365(Part1)-1998, Annex B

- a) Point Load Strength Index is taken as 0.95 kg/sqcm, corresponding rating = 1.
- b) RQD value, a minimum of 10% is considered as per codal provision (IS 13365, Part 1), corresponding rating = 3.
- c) Spacing of discontinuity taken as very close (i.e. 0.05m), corresponding rating = 5.
- d) Condition of discontinuity considered as Slickensided wall rock surface of 1-5mm thick gauge or 1-5mm wide opening, continuous discontinuity, corresponding rating = 10.
- e) Ground water condition taken as Wet, corresponding rating = 7.
- f) Dip Angle Joint Orientation taken as favourable, corresponding rating = -2.

So,  $RMR = 1+3+5+10+7+(-)2 = 24$

So, from Table-3 of IS: 12070: 1987 (Amendment No. 1, 2008),  $q_{ns} = 61.74 \text{ t/sqm}$

**B) Bearing Capacity Based on Uni-axial Compressive Strength Method:**

The safe bearing pressure,  $q_s = q_c N_j$

Where,  $q_s$  = Safe bearing pressure

$q_c$  = Average uni-axial compressive strength of rock core

$N_j$  = Empirical co-efficient depending on spacing of discontinuities

For spacing of discontinuity, 0.05m i.e. 5cm, corresponding  $N_j = 0.10$

$q_c = 165 \text{ kg/sqcm}$  (minimum value of layer IV)

So, safe bearing pressure,  $q_s = 165 \times 0.10 = 16.50 \text{ kg/sqcm} = 165 \text{ t/sqm}$

A factor of 3/4 is taken considering rock with discontinuous joints with opening less than 1mm wide.

Hence, safe bearing pressure,  $= 226 \times \frac{3}{4} = 123.75 \text{ t/sqm}$

Based on above two approaches, let us restrict the bearing capacity to 50t/sqm.

**5.4.2. RECOMMENDATION:**

With reference to the above and considering the subsoil condition around each bore hole, the following bearing capacity values may be used.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Crushing	BH-101 (FGL = EGL)	1.00	1<B≤3	1.0	27.18	--	22	27
				1.5	23.68	--	20	23
				2.0	22.97	--	18	22
			3 <B ≤6	1.0	26.33	--	16	25
				1.5	22.94	--	14	22
				2.0	22.26	--	14	22
			B> 6	1.0	25.99	--	13	20
				1.5	22.65	--	12	19
				2.0	21.97	--	11	17
		2.00	1<B≤3	1.0	28.94	--	28	28
				1.5	25.20	--	25	25
				2.0	24.44	--	24	24
			3 <B ≤6	1.0	27.25	--	20	27
				1.5	23.73	--	18	23
				2.0	23.01	--	17	23
			B> 6	1.0	26.57	--	15	24
				1.5	23.14	--	14	22
				2.0	22.44	--	14	22
		3.00	1<B≤3	1.0	30.71	--	30	30
				1.5	26.73	--	26	26
				2.0	25.91	--	25	25
			3 <B ≤6	1.0	28.17	--	28	28
				1.5	24.51	--	24	24
				2.0	23.76	--	22	23
			B> 6	1.0	27.15	--	20	27
				1.5	23.63	--	18	23
				2.0	22.90	--	17	22
Substation-07	BH-102 (FGL = EGL)	1.00	1<B≤3	1.0	14.34	--	8	12
				1.5	12.49	--	7	11
				2.0	12.11	--	6	9
			3 <B ≤6	1.0	13.89	--	6	9
				1.5	12.10	--	5	8
				2.0	11.73	--	5	8
			B> 6	1.0	13.72	--	4	6
				1.5	11.94	--	4	6
				2.0	11.58	--	4	6
		2.00	1<B≤3	1.0	15.30	--	10	15
				1.5	13.31	--	9	13
				2.0	12.90	--	8	12
			3 <B ≤6	1.0	14.41	--	7	11
				1.5	12.53	--	6	9
				2.0	12.14	--	6	9
			B> 6	1.0	14.05	--	6	9
				1.5	12.22	--	5	8
				2.0	11.84	--	5	8
		3.00	1<B≤3	1.0	16.27	--	13	16
				1.5	14.14	--	12	14
				2.0	13.69	--	11	13
			3 <B ≤6	1.0	14.93	--	10	14
				1.5	12.97	--	9	12
				2.0	12.56	--	8	12
			B> 6	1.0	14.39	--	7	11
				1.5	12.51	--	7	11
				2.0	12.11	--	6	9
		5.00	1<B≤3	1.0	43.16	--	28	40
				1.5	37.55	--	24	36
				2.0	36.40	--	21	32
			3 <B ≤6	1.0	37.81	--	19	30
				1.5	32.89	--	16	25
				2.0	31.87	--	15	24

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Substation-07	BH-102 (FGL = EGL)	5.00	B> 6	1.0	35.67	--	13	20
				1.5	31.02	--	12	18
				2.0	30.06	--	11	17
Filtered Water Tank	BH-103 (FGL = 960.000M)	2.00 - 3.00	1 - 6	1.00 - 2.00	61.74	50	--	--
			≥ 6	1.00 - 2.00	61.74	50	--	--
Raw Water Reservoir	BH-104 to 106 (FGL = 893.000M)	1.00	1<B≤3	1.0	28.60	--	23	28
				1.5	24.92	--	20	24
				2.0	24.18	--	19	24
			3 <B ≤6	1.0	27.71	--	15	24
				1.5	24.15	--	13	20
				2.0	23.42	--	12	19
			B> 6	1.0	27.36	--	9	14
				1.5	23.83	--	8	12
				2.0	23.12	--	8	12
		2.00	1<B≤3	1.0	30.46	--	30	30
				1.5	26.53	--	25	26
				2.0	25.72	--	23	25
			3 <B ≤6	1.0	28.68	--	17	27
				1.5	24.97	--	15	24
				2.0	24.22	--	14	22
			B> 6	1.0	27.96	--	10	16
				1.5	24.35	--	9	14
				2.0	23.61	--	8	12
		3.00	1<B≤3	1.0	45.16	--	38	40
				1.5	39.32	--	32	39
				2.0	38.13	--	28	38
			3 <B ≤6	1.0	41.41	--	20	32
				1.5	36.06	--	17	27
				2.0	34.97	--	15	24
			B> 6	1.0	39.91	--	11	17
				1.5	34.75	--	10	16
				2.0	33.70	--	9	14
Filtered Water Reservoir	BH-107 (FGL = 900.000M)	1.00	1<B≤3	1.0	25.75	--	11	17
				1.5	22.44	--	10	16
				2.0	21.76	--	9	14
			3 <B ≤6	1.0	24.95	--	8	12
				1.5	21.74	--	7	11
				2.0	21.09	--	6	9
			B> 6	1.0	24.63	--	6	9
				1.5	21.46	--	5	8
				2.0	20.81	--	5	8
		2.00	1<B≤3	1.0	27.43	--	13	20
				1.5	23.88	--	11	17
				2.0	23.16	--	10	16
			3 <B ≤6	1.0	25.82	--	9	14
				1.5	22.48	--	8	12
				2.0	21.80	--	7	11
			B> 6	1.0	25.18	--	7	11
				1.5	21.92	--	6	9
				2.0	21.26	--	6	9
		3.00	1<B≤3	1.0	29.11	--	15	24
				1.5	25.33	--	12	19
				2.0	24.55	--	11	17
			3 <B ≤6	1.0	26.70	--	10	16
				1.5	23.23	--	9	14
				2.0	22.52	--	9	14
			B> 6	1.0	25.74	--	8	12
				1.5	22.39	--	7	11
				2.0	21.70	--	7	11
HFO Tank	BH-108 (FGL = 902.000M)	1.00	1<B≤3	1.0	20.04	--	10	16
				1.5	17.46	--	9	14
				2.0	16.94	--	9	14
			3<B≤6	1.0	19.42	--	8	12
				1.5	16.92	--	8	12
				2.0	16.41	--	7	11

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
HFO Tank	BH-108 (FGL = 902.000M)	1.00	B> 6	1.0	19.17	--	6	9
				1.5	16.70	--	5	8
				2.0	16.20	--	5	8
		2.00	1<B≤3	1.0	21.37	--	15	21
				1.5	18.60	--	13	18
				2.0	18.03	--	12	18
			3<B≤6	1.0	20.12	--	11	17
				1.5	17.51	--	10	16
				2.0	16.97	--	9	14
			B> 6	1.0	19.62	--	8	12
				1.5	17.07	--	7	11
				2.0	16.55	--	6	9
		3.00	1<B≤3	1.0	22.69	--	22	22
				1.5	19.73	--	19	19
				2.0	19.12	--	19	19
			3<B ≤6	1.0	20.81	--	17	20
				1.5	18.10	--	15	18
				2.0	17.54	--	14	17
			B> 6	1.0	20.07	--	11	17
				1.5	17.45	--	9	14
				2.0	16.90	--	9	14
Pipe Rack	BH-109 to 111 (FGL = EGL)	1.00	1<B≤3	1.0	27.18	--	19	27
				1.5	23.68	--	16	23
				2.0	22.97	--	15	22
			3<B≤6	1.0	26.33	--	12	19
				1.5	22.94	--	11	17
				2.0	22.26	--	10	16
			B> 6	1.0	25.99	--	7	11
				1.5	22.65	--	7	11
				2.0	21.97	--	6	9
		2.00	1<B≤3	1.0	28.94	--	22	28
				1.5	25.20	--	19	25
				2.0	24.44	--	17	24
			3<B≤6	1.0	27.25	--	13	20
				1.5	23.73	--	12	19
				2.0	23.01	--	11	17
			B> 6	1.0	26.57	--	8	12
				1.5	23.14	--	7	11
				2.0	22.44	--	7	11
		3.00	1<B≤3	1.0	30.71	--	26	30
				1.5	26.73	--	22	26
				2.0	25.91	--	20	25
			3 <B ≤6	1.0	28.17	--	15	24
				1.5	24.51	--	13	20
				2.0	23.76	--	12	19
			B> 6	1.0	27.15	--	9	14
				1.5	23.63	--	8	12
				2.0	22.90	--	7	11
Pipe Rack	BH-112 & 113 (FGL = EGL)	1.00	1<B≤3	1.0	21.47	--	21	21
				1.5	18.70	--	18	18
				2.0	18.14	--	18	18
			3<B≤6	1.0	20.80	--	20	20
				1.5	18.12	--	18	18
				2.0	17.58	--	17	17
			B> 6	1.0	20.54	--	19	20
				1.5	17.89	--	17	17
				2.0	17.35	--	17	17
		2.00	1<B≤3	1.0	22.88	--	22	22
				1.5	19.92	--	19	19
				2.0	19.31	--	19	19
			3<B≤6	1.0	21.54	--	21	21
				1.5	18.75	--	18	18
				2.0	18.18	--	18	21
			B> 6	1.0	21.01	--	21	21
				1.5	18.29	--	18	18
				2.0	17.73	--	17	17

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Pipe Rack	BH-112 & 113 (FGL = EGL)	3.00	1<B≤3	1.0	64.41	--	40	40
				1.5	56.11	--	40	40
				2.0	54.43	--	40	40
			3<B≤6	1.0	59.06	--	40	40
				1.5	51.45	--	40	40
				2.0	49.90	--	40	40
			B> 6	1.0	56.92	--	40	40
				1.5	49.58	--	40	40
				2.0	48.09	--	40	40
Pipe Rack	BH-114 (FGL = EGL)	2.00	1<B≤3	1.0	21.37	--	11	17
				1.5	18.60	--	9	14
				2.0	18.03	--	8	12
			3<B≤6	1.0	20.12	--	8	12
				1.5	17.51	--	7	11
				2.0	16.97	--	7	11
			B> 6	1.0	19.62	--	6	9
				1.5	17.07	--	5	8
				2.0	16.55	--	5	8
		3.00	1<B≤3	1.0	22.69	--	13	20
				1.5	19.73	--	11	17
				2.0	19.12	--	10	16
			3<B≤6	1.0	20.81	--	9	14
				1.5	18.10	--	8	12
				2.0	17.54	--	8	12
			B> 6	1.0	20.07	--	7	11
				1.5	17.45	--	7	11
				2.0	16.90	--	6	9
Pipe Rack	BH-115 (FGL = EGL)	1.50	1 - 6	1.00 - 2.00	80.05	80	--	--
			≥ 6	1.00 - 2.00	80.05	80	--	--
		2.00 - 3.00	1 - 6	1.00 - 2.00	169.50	100	--	--
			≥ 6	1.00 - 2.00	169.50	100	--	--
Caustic Storage	BH-116 & 117 (FGL = 895.000M)	1.00	1<B≤3	1.0	31.46	--	21	30
				1.5	27.41	--	18	27
				2.0	26.59	--	16	25
			3<B≤6	1.0	30.48	--	13	20.8
				1.5	26.55	--	12	19.2
				2.0	25.76	--	11	17.6
			B> 6	1.0	30.08	--	8	12.8
				1.5	26.21	--	8	12.8
				2.0	25.43	--	7	11.2
		2.00	1<B≤3	1.0	33.49	--	23	33
				1.5	29.17	--	20	29
				2.0	28.29	--	18	28
			3<B≤6	1.0	31.53	--	14	22
				1.5	27.46	--	13	20
				2.0	26.63	--	12	19
			B> 6	1.0	30.75	--	9	14
				1.5	26.77	--	8	12
				2.0	25.97	--	7	11
		3.00	1<B≤3	1.0	35.53	--	26	35
				1.5	30.93	--	23	30
				2.0	29.99	--	21	28
			3<B≤6	1.0	32.58	--	16	25.6
				1.5	28.36	--	14	22.4
				2.0	27.50	--	13	20.8
			B> 6	1.0	31.41	--	9	14
				1.5	27.34	--	9	14
				2.0	26.50	--	8	12
Pipe Rack	BH-118 (FGL = EGL)	4.50	1≤ B <3	1.0	22.93	--	17	22
				1.5	19.92	--	15	19
				2.0	19.29	--	14	19
			3≤ B <6	1.0	20.32	--	12	19
				1.5	17.65	--	11	17
				2.0	17.08	--	10	16



Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Pipe Rack	BH-118 (FGL = EGL)	4.50	$B \geq 6$	1.0	19.28	--	4	6
				1.5	16.74	--	3	4
				2.0	16.20	--	3	4
		5.50	$1 \leq B < 3$	1.0	24.16	--	24	24
				1.5	20.98	--	20	20
				2.0	20.31	--	20	20
			$3 \leq B < 6$	1.0	20.97	--	17	20
				1.5	18.20	--	15	18
				2.0	17.61	--	14	17
			$B \geq 6$	1.0	19.70	--	4	6
				1.5	17.09	--	3	4
				2.0	16.53	--	3	4
Pipe Rack	BH-119 (FGL = EGL)	1.00	$1 \leq B < 3$	1.0	41.44	--	34	40
				1.5	36.12	--	28	36
				2.0	35.04	--	26	35
			$3 \leq B < 6$	1.0	40.15	--	17	27
				1.5	34.99	--	15	24
				2.0	33.95	--	14	22
			$B \geq 6$	1.0	39.63	--	10	16
				1.5	34.54	--	9	14
				2.0	33.51	--	8	12
		2.00	$1 \leq B < 3$	1.0	44.10	--	36	40
				1.5	38.42	--	32	38
				2.0	37.27	--	29	37
			$3 \leq B < 6$	1.0	41.52	--	17	27
				1.5	36.16	--	15	24
				2.0	35.08	--	14	22
			$B \geq 6$	1.0	40.48	--	10	16
				1.5	35.26	--	9	14
				2.0	34.20	--	8	12
		3.00	$1 \leq B < 3$	1.0	46.76	--	40	40
				1.5	40.72	--	34	40
				2.0	39.49	--	30	38
			$3 \leq B < 6$	1.0	42.88	--	15	24
				1.5	37.34	--	15	24
				2.0	36.21	--	14	22
			$B \geq 6$	1.0	41.33	--	10	16
				1.5	35.99	--	9	14
				2.0	34.90	--	8	12
Pipe Rack	BH-120 & 121 (FGL = EGL)	1.00	$1 \leq B < 3$	1.0	21.47	--	11	17
				1.5	18.70	--	10	16
				2.0	18.14	--	9	14
			$3 \leq B < 6$	1.0	20.80	--	8	12
				1.5	18.12	--	8	12
				2.0	17.58	--	7	11
			$B \geq 6$	1.0	20.54	--	7	11
				1.5	17.89	--	6	9
				2.0	17.35	--	5	8
		2.00	$1 \leq B < 3$	1.0	22.88	--	15	22
				1.5	19.92	--	13	19
				2.0	19.31	--	12	19
			$3 \leq B < 6$	1.0	21.54	--	11	17
				1.5	18.75	--	10	16
				2.0	18.18	--	9	14
			$B \geq 6$	1.0	21.01	--	8	12
				1.5	18.29	--	7	11
				2.0	17.73	--	7	11
		3.00	$1 \leq B < 3$	1.0	24.29	--	24	24
				1.5	21.13	--	20	21
				2.0	20.48	--	20	20
			$3 \leq B < 6$	1.0	22.29	--	16	22
				1.5	19.38	--	14	19
				2.0	18.78	--	13	18
			$B \geq 6$	1.0	21.48	--	10	16
				1.5	18.68	--	9	14
				2.0	18.10	--	9	14

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Lime Praparation - Conveyor	BH-122 & 123 (FGL = 900.400M)	1.00	1<B≤3	1.0	28.60	--	20	28
				1.5	24.92	--	18	24
				2.0	24.18	--	16	24
			3 <B ≤6	1.0	27.71	--	12	19
				1.5	24.15	--	11	17
				2.0	23.42	--	10	16
			B> 6	1.0	27.36	--	9	14
				1.5	23.83	--	8	12
				2.0	23.12	--	7	11
		2.00	1<B≤3	1.0	30.46	--	22	30
				1.5	26.53	--	20	26
				2.0	25.72	--	18	25
			3 <B ≤6	1.0	28.68	--	14	22
				1.5	24.97	--	12	19
				2.0	24.22	--	11	17
			B> 6	1.0	27.96	--	9	14
				1.5	24.35	--	8	12
				2.0	23.61	--	8	12
		3.00	1<B≤3	1.0	32.32	--	25	32
				1.5	28.13	--	21	28
				2.0	27.27	--	19	27
			3 <B ≤6	1.0	29.64	--	15	24
				1.5	25.80	--	13	20
				2.0	25.01	--	12	19
			B> 6	1.0	28.57	--	10	16
				1.5	24.86	--	9	14
				2.0	24.10	--	9	14
Lime Praparation - Crusher	BH-124 (FGL = 900.200M)	2.00	1<B≤3	1.0	18.92	--	18	18
				1.5	17.73	--	17	17
				2.0	17.57	--	17	17
			3 <B ≤6	1.0	21.15	--	21	21
				1.5	19.69	--	19	19
				2.0	20.03	--	20	20
			B> 6	1.0	37.88	--	36	37
				1.5	35.01	--	35	35
				2.0	36.85	--	36	36
		3.00	1<B≤3	1.0	28.04	--	28	28
				1.5	26.25	--	26	26
				2.0	27.06	--	27	27
			3 <B ≤6	1.0	30.72	--	30	30
				1.5	28.63	--	28	28
				2.0	29.03	--	29	29
			B> 6	1.0	44.48	--	40	64
				1.5	41.20	--	40	40
				2.0	42.91	--	40	40
		4.00	1<B≤3	1.0	62.21	--	40	40
				1.5	58.21	--	40	40
				2.0	58.28	--	40	40
			3 <B ≤6	1.0	64.26	--	40	40
				1.5	60.00	--	40	40
				2.0	60.50	--	40	40
			B> 6	1.0	86.32	--	40	40
				1.5	80.13	--	40	40
				2.0	82.94	--	40	40
Bauxite Handling- Conveyor	BH-125 (FGL = EGL)	1.00	1≤ B <3	1.0	22.90	--	14	22
				1.5	19.95	--	12	19
				2.0	19.35	--	12	19
			3≤ B <6	1.0	22.18	--	11	17
				1.5	19.33	--	10	16
				2.0	18.75	--	10	16
			B ≥ 6	1.0	21.90	--	9	14
				1.5	19.08	--	8	12
				2.0	18.51	--	8	12

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Bauxite Handling-Conveyor	BH-125 (FGL = EGL)	2.00	$1 \leq B < 3$	1.0	24.40	--	20	24
				1.5	21.24	--	18	21
				2.0	20.59	--	16	20
			$3 \leq B < 6$	1.0	22.97	--	15	22
				1.5	20.00	--	14	20
				2.0	19.39	--	13	19
			$B \geq 6$	1.0	22.40	--	11	17
				1.5	19.50	--	11	17
				2.0	18.90	--	10	16
		3.00	$1 \leq B < 3$	1.0	25.90	--	25	25
				1.5	22.53	--	22	22
				2.0	21.84	--	21	21
			$3 \leq B < 6$	1.0	23.76	--	23	23
				1.5	20.67	--	20	20
				2.0	20.03	--	20	20
			$B \geq 6$	1.0	22.90	--	18	22
				1.5	19.92	--	16	19
				2.0	19.30	--	15	19
Bauxite Handling-Conveyor	BH-127 to 129 (FGL = EGL)	1.00	$1 < B \leq 3$	1.0	21.47	--	15	21
				1.5	18.70	--	13	18
				2.0	18.14	--	12	18
			$3 < B \leq 6$	1.0	20.80	--	12	19
				1.5	18.12	--	11	18
				2.0	17.58	--	10	16
			$B > 6$	1.0	20.54	--	9	14
				1.5	17.89	--	8	12
				2.0	17.35	--	8	12
		2.00	$1 < B \leq 3$	1.0	22.88	--	22	22
				1.5	19.92	--	19	19
				2.0	19.31	--	19	19
			$3 < B \leq 6$	1.0	21.54	--	17	21
				1.5	18.75	--	15	18
				2.0	18.18	--	14	18
			$B > 6$	1.0	21.01	--	12	19
				1.5	18.29	--	10	16
				2.0	17.73	--	10	16
		3.00	$1 < B \leq 3$	1.0	24.29	--	24	24
				1.5	21.13	--	21	21
				2.0	20.48	--	20	20
			$3 < B \leq 6$	1.0	22.29	--	22	22
				1.5	19.38	--	19	19
				2.0	18.78	--	18	18
			$B > 6$	1.0	21.48	--	17	21
				1.5	18.68	--	16	18
				2.0	18.10	--	15	18
Bauxite Handling-Conveyor	BH-130 (FGL = EGL)	4.00	$1 < B \leq 3$	1.0	32.48	--	26	32
				1.5	28.26	--	23	28
				2.0	27.38	--	20	27
			$3 < B \leq 6$	1.0	29.09	--	17	27
				1.5	25.30	--	14	22
				2.0	24.51	--	13	20
			$B > 6$	1.0	27.73	--	9	14
				1.5	24.12	--	8	12
				2.0	23.37	--	8	12
		6.00	$1 < B \leq 3$	1.0	36.01	--	30	36
				1.5	31.31	--	26	31
				2.0	30.32	--	24	30
			$3 < B \leq 6$	1.0	30.93	--	20	30
				1.5	26.88	--	17	26
				2.0	26.02	--	15	24
			$B > 6$	1.0	28.90	--	13	20
				1.5	25.10	--	11	17
				2.0	24.30	--	11	17

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Bauxite Handling-Conveyor	BH-130 (FGL = EGL)	7.00	1<B≤3	1.0	37.78	--	36	36
				1.5	32.83	--	32	32
				2.0	31.79	--	31	31
			3<B≤6	1.0	31.85	--	25	31
				1.5	27.66	--	21	27
				2.0	26.77	--	19	26
			B> 6	1.0	29.48	--	16	29
				1.5	25.59	--	14	25
				2.0	24.77	--	13	24
Bauxite Handling-Conveyor	BH-131 (FGL = EGL)	6.00	1<B≤3	1.0	36.01	--	30	36
				1.5	31.31	--	26	31
				2.0	30.32	--	24	30
			3<B≤6	1.0	30.93	--	20	30
				1.5	26.88	--	17	26
				2.0	26.02	--	15	24
			B> 6	1.0	28.90	--	13	20
				1.5	25.10	--	11	17
				2.0	24.30	--	11	17
		7.00	1<B≤3	1.0	37.78	--	36	36
				1.5	32.83	--	32	32
				2.0	31.79	--	31	31
			3<B≤6	1.0	31.85	--	25	31
				1.5	27.66	--	21	27
				2.0	26.77	--	19	26
			B> 6	1.0	29.48	--	16	29
				1.5	25.59	--	14	25
				2.0	24.77	--	13	24

**Note:**

1. NSBC = Net Safe Bearing Capacity, NABC = Net Allowable Bearing Capacity, EGL = Existing Ground Level
2. S = Limiting Settlement.
3. However for foundation placed inside rock, permissible settlement is considered as 12mm irrespective of type of foundation.
4. In case any loose pocket is observed at the founding level, then the same should be excavated out and the same shall be filled up with PCC.

**5.5. SWELLING CHARACTERISTICS:**

The swelling pressure and Free Swell Index tests were performed on few samples and the test results are presented in the Appendix. The average swelling pressure and free swell index are 0.041kg/sqcm & 6.82% respectively. Thus, the subsoil has low swelling characteristics. So, no problem with respect to the swelling of the subsoil is anticipated.

**5.6. CHEMICAL TESTS:**

Chemical tests were performed on few soil and water samples for determining the pH value, Sulphate, Chloride content etc. The results are given in a tabular form below:

**CHEMICAL TEST RESULTS ON SOIL SAMPLES:**

BH/Sample No.	Depth (m)	pH value	Sulphate as SO <sub>3</sub> (%)	Chloride as Cl (%)	Organic matter (%)
BH101/ UDS01	3.00	5.69	BDL	0.0060	0.5874
BH102 / UDS01	2.50	4.85	BDL	0.0060	0.5185
BH104 / UDS01	3.00	6.38	BDL	0.0060	0.2603
BH105 / UDS01	2.50	5.83	0.060	0.0060	0.4959
BH106 / UDS01	2.50	5.13	BDL	0.0070	0.4477
BH107 / UDS01	2.50	4.89	BDL	0.0070	0.3299
BH108 / SPT03	5.00	6.13	BDL	0.0050	0.4129
BH109 / SPT02	3.15	5.41	BDL	0.0050	0.3067
BH110 / UDS01	2.50	4.91	BDL	0.0060	0.36456
BH111 / UDS02	5.50	6.30	0.060	0.0050	0.4228
BH113 / UDS01	2.50	4.79	BDL	0.0070	0.2469
BH114 / UDS02	5.50	6.02	BDL	0.0060	0.2357
BH116 / UDS02	5.50	6.00	BDL	0.0060	1.0570
BH117 / UDS03	8.50	5.58	BDL	0.0060	0.1177
BH118 / UDS02	4.50	9.89	BDL	0.0060	0.2369
BH119 / UDS01	3.00	7.61	BDL	0.0060	0.2589
BH120 / UDS01	2.00	5.92	BDL	0.0070	0.1884
BH121 / UDS01	2.50	5.39	BDL	0.0060	0.3778
BH123 / UDS03	7.50	5.63	BDL	0.0080	0.2833
BH124 / UDS02	4.20	6.41	BDL	0.0050	0.1891
BH125 / UDS01	3.00	6.60	BDL	0.0050	0.2007
BH127 / SPT02	3.10	9.53	BDL	0.0050	0.3775
BH128 / UDS01	2.50	5.36	BDL	0.0050	0.16449
BH129 / UDS01	3.00	5.43	BDL	0.0060	0.40105
BH130 / UDS01	2.50	6.48	BDL	0.0050	0.4023
BH131 / UDS01	2.50	6.41	BDL	0.0070	0.9536

**CHEMICAL TEST RESULTS ON WATER SAMPLES:**

BH/Sample No.	Depth (M)	pH value	Sulphate as (mg/litre)	Chloride as (mg/litre)
BH-114	2.60	9.19	BDL	12
BH-127	11.70	9.31	BDL	11
BH-129	7.20	9.27	BDL	12

**B.D.L:** Below Detection Limit (<0.05%).

It is seen that the values are on a safe side and so no precaution will be required for foundation concrete. **Either Ordinary Portland cement or Portland slag cement or Portland Pozzolana cement can be used for the purpose.**

**5.7. POSSIBILITY OF SUBSOIL LIQUEFACTION DUE TO EARTHQUAKE:**

Seed et al. (1983) stated that based on both laboratory testing and field performance, the great majority of cohesive soils will not liquefy during earthquakes. Using criteria originally stated by Seed and Idriss (1982) and subsequently confirmed by Youd and Gilstrap (1999), in order for a cohesive soil to liquefy, it must meet all the following three criteria:

- The soil must have less than 15 percent of the particles, based on dry weight, that are finer than 0.005 mm (i.e., percent finer at 0.005 mm < 15 percent).
- The soil must have a liquid limit (LL) that is less than 35 (that is, LL < 35).
- The water content  $w$  of the soil must be greater than 0.9 of the liquid limit [that is,  $w > 0.9 (LL)$ ].

If the cohesive soil does not meet all three criteria, then it is generally considered to be not susceptible to liquefaction. In our present case, we have

- The average clay % fraction of layer- II IS 19% i.e. more than the critical value of 15% ----- safe
- The average Liquid Limit layer- I, IA & II are 44%, 38% and 46% respectively i.e. more than the critical value of LL<35% ----- safe.
- The average moisture content of layer- I, IA & II are 24%, 28% and 22% respectively which is less than 90% of LL of a certain layer ----- safe.

From the above discussion, it can be seen that all the three clauses (a to c) are against the possibility of liquefaction of the subsoil.

At lower reaches, we have dense to very dense silty sand layer. Liquefaction of this layer is also not expected.

However around BH-124 location medium dense sand layer appears. So, the subsoil may have some possibility to liquefy under earthquake.

The liquefaction potential of subsoil is evaluated as per provision laid down in “*Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils*” by Dr. Gonzalo Castro et al. published in “*Journal of Geotechnical and Geoenvironmental Engineering*”, October’ 2001.

The ratio of  $CRR/CSR \leq 1.0$  indicates that the soil is prone to liquefaction whereas  $CRR/CSR > 1.0$  or corrected  $N_1 > 30$  indicates the soil is non liquefiable.

Based on the SPT values in boreholes, the liquefaction resistance of all the boreholes were evaluated for zone – II as per IS:1893 Part I and presented in a separate sheet.

Bore Hole No.	Avg Depth	Field N	Total OVP (t/sqm)	Effective OVP (t/sqm)	CN	CE	CB	CS	CR	(N1)	FC	$\alpha$	$\beta$	Corr. (N1)	$r_d$	CSR	CRR <sub>7.5</sub>	FOS	
BH-124	2.18	16	4.17	1.99	1.70	1.00	1.05	1.10	0.75	23.6	42	5.00	1.20	33.3					
															Non liquefiable				
1) $C_N$ = Correction for Overburden pressure limited to 1.70										Fine content means particles smaller than 75 micron									
$C_N = \sqrt{\frac{P_o}{\sigma}}$										For Fine Content $\leq 5$ , $\alpha = 0$ and $\beta = 1$									
$P_o = 1$ Atmospheric pressure = 10t/sqm										For(Fine Content $> 5$ AND $< 35$ ), $\alpha = \text{EXP}((1.76 - (190/FC^2)))$ and $\beta = (0.99 + (FC^{-1.7}/1000))$									
$\sigma$ = Vertical effective stress at the depth of SPT										For Fine Content $> 35$ , $\alpha = 5$ and $\beta = 1.20$									
2) $C_E$ = Correction for Level of energy delivered by SPT hammer = 1.00.										Corrected (N1) = $\alpha + \beta \cdot (N1)$									
3) $C_B$ = Correction for Borehole Diameter = 1.05 for 150mm borehole dia.										$r_d = (1 - 0.4113 \cdot d^{0.5} - 0.04052 \cdot d + 0.001753 \cdot d^{1.5}) \cdot (1 - 0.4177 \cdot d^{0.5} + 0.05729 \cdot d - 0.006205 \cdot d^{1.5} + 0.00121 \cdot d^2)$									
4) $C_S$ = Correction for SPT sampler use = 1.10 for sampler without liner.										CSR = $0.65 \cdot (a_{max}/g) \cdot (\text{Total Overburden pressure}) \cdot r_d / (\text{Effective Overburden pressure})$									
5) $C_R$ = Correction for short length of drill rod.										$CRR_{7.5} = 1 / (34 \cdot \text{Final}(N1)_{log} + \text{Final}(N1)_{log} / 135 + 50 / (10 \cdot \text{Final}(N1)_{log} + 45)) \cdot 1/200$									
Rod length(m)		$C_R$		Rod length(m)		$C_R$		FOS against Liquefaction = $(CRR_{7.5} / CSR) \cdot MSF$											
<3		0.75		6-<10		0.95		For calculation of CSR & CRR, water level is considered at ground level.											
3-<4		0.80		10-30		1.00													
4-<6		0.85																	
(N1) = $N \cdot C_N \cdot C_E \cdot C_B \cdot C_S \cdot C_R$																			

## 5.8. SUITABILITY OF EXISTING SOIL FOR FILLING AND BACK-FILLING:

**Recommendation for Filling At foundation locations & Backfilling Purposes:** The subsoil at the site consists of silty clay with decomposed rock fragments, moorum & fine sand mixtures having low swelling properties. So, the soil can be used for filling and backfilling purposes with necessary compaction as required.

## 5.9. DEWATERING:

The standing water level was found from 1.80m to a maximum depth of 11.70m during the time of investigation. So, construction of open foundation, placed at a depth of 1.00m or more, may create a problem. The subsoil being predominantly clayey in nature, seepage is expected to be less. So, ordinary surface operated pump will be able to tackle the situation for dewatering. For excavation more than 4m proper shoring arrangement may be required to protect the side slope.

## 5.10. EXCAVATION:

For excavation in virgin soil, a slope of 1(H):2(V) may be used for layer I, IA & II. For layer III, (cohesion less soil) a reduced slope of 2(H):1(V) may be used. For excavation in stratum-IV, V & VI (i.e. rock layer), vertical or almost vertical slope may be used. However,

to be in the safer side, a nominal side slope of 0.5(H):1(V) for stratum-IV & V and 0.25(H):1(V) for stratum-VI should be provided.

It is also suggested to provide a Berm of at least 1m wide after each 3m to 4m of excavation. Excavation in stratum-I, IA, II & III can be made with shovels and pick-axe. At lower reaches, pneumatic / jack hammer will be more efficient. Alternatively controlled blasting may be required.

### 5.11. DETERMINATION OF SUBGRADE MODULUS:

Refer to "Handbook of Machine Foundations" by P. Srinivasulu & C. V. Vaidyanathan, 2<sup>nd</sup> Reprint, 1978, pp-39

$$\text{Co-efficient of uniform compression, } C_z = \frac{\alpha \cdot E}{(1 - \mu^2)} \cdot \frac{1}{\sqrt{B \cdot L}}$$

$$\text{Similarly, under static condition, Subgrade Modulus can be expressed, } K = \frac{\alpha \cdot E}{(1 - \mu^2)} \cdot \frac{1}{\sqrt{B \cdot L}}$$

Where,

K = Subgrade Modulus, kg/cucm

$\alpha$  = Constant = 1.06, 1.07 & 1.09 for L/B = 1.00, 1.50 & 2.0 respectively.

E = Young's Modulus, kg/sqcm

$\mu$  = Poisson's Ratio

B, L = Width & Length of the foundation (cm)

Now, the Subgrade Modulus remains constant modulus for foundation area more than 10sqm.

Assume B.L = 10 sqm. Using L/B ratio as 2.00,  $\alpha$  = 1.09

Using the above values and soil properties of each layer, the Subgrade Modulus is calculated for a foundation area of 10 sqm and is presented below.

Layer No.	Young's Modulus (Kg/sqcm)		Poisson's Ratio (m)	Subgrade Modulus (kg/cucm)	
	$E_u$	$E_s$		Short Term	Long Term
Layer – IA	105	22	0.35	0.41	0.09
Layer – I	320	66	0.35	1.26	0.26
Layer – II	750	228.80	0.35	2.95	0.90
Layer – IIIA	115	115	0.25	0.42	0.42
Layer – III	485	485	0.25	1.78	1.78
Layer – IV	2500	2500	0.25	9.19	9.19
Layer – V	5000	5000	0.25	18.38	18.38
Layer – VI	10000	10000	0.25	36.77	36.77

The above values of Subgrade Modulus can be used for different foundation sizes having area equal to 10sqm or more.

For lesser foundation area (say for 5sqm area), the following Subgrade Modulus values can



be used.

Layer No.	Young's Modulus (Kg/sqcm)		Poisson's Ratio (m)	Subgrade Modulus (kg/cucm)	
	E <sub>u</sub>	E <sub>s</sub>		Short Term	Long Term
Layer – IA	105	22	0.35	0.58	0.12
Layer – I	320	66	0.35	1.78	0.37
Layer – II	750	228.80	0.35	4.17	1.27
Layer – IIIA	115	115	0.25	0.60	0.60
Layer – III	485	485	0.25	2.52	2.52
Layer – IV	2500	2500	0.25	13.00	13.00
Layer – V	5000	5000	0.25	26.00	26.00
Layer – VI	10000	10000	0.25	52.00	52.00

The above values of Subgrade Modulus can be used for different foundation sizes having area less than 10sqm. However, for more accurate result, the values may be recalculated using the formula as illustrated above.

#### **Stratum IA**

Average N = 5, corresponding cohesion from N value = 0.45 kg/sqcm

From laboratory test results, average C = 0.33 kg/sqcm &  $\phi = 3^\circ$

Use C = 0.35 kg/sqcm &  $\phi = 0^\circ$

$E_s = 4.4N = 22 \text{ kg/sqcm}$

$E_u = 300 \times 0.35 = 105 \text{ kg/sqcm}$

#### **Stratum I**

Average N = 15, corresponding cohesion from N value = 0.85 kg/sqcm

From laboratory test results, average C = 0.80 kg/sqcm &  $\phi = 8^\circ$

Use C = 0.80 kg/sqcm &  $\phi = 0^\circ$

$E_s = 4.4N = 66 \text{ kg/sqcm}$

$E_u = 400 \times 0.80 = 320 \text{ kg/sqcm}$

#### **Stratum II**

Average N = 52, corresponding cohesion from N value = 1.93 kg/sqcm

From laboratory test results, average C = 1.31 kg/sqcm &  $\phi = 8^\circ$

Use C = 1.50 kg/sqcm &  $\phi = 0^\circ$

$E_s = 4.4N = 228.80 \text{ kg/sqcm}$

$E_u = 500 \times 1.50 = 750 \text{ kg/sqcm}$

#### **Stratum IIIA**

Average corrected N = 18

Treating the sand to be silty sand,  $E_s = 3(N+6) = 72 \text{ kg/sqcm}$

Treating the sand to be normally consolidated sand,  $E_s = 5(N+15) = 165 \text{ kg/sqcm}$

Thus average  $E_s = 118.50 \text{ kg/sqcm}$

Use  $E_s = 115 \text{ kg/sqcm}$

#### **Stratum III**

Average corrected N = 32

Treating the sand to be normally consolidated sand,  $E_s = 5(N+15) = 235 \text{ kg/sqcm}$

Treating the sand to be over consolidated sand,  $E_s = 400 + 10.5N = 736 \text{ kg/sqcm}$

Thus average  $E_s = 486 \text{ kg/sqcm}$

Use  $E_s = 485 \text{ kg/sqcm}$

#### **Stratum IV, V & VI**

Use  $E_s$  for layer IV, V & VI = 2500 kg/sqcm, 5000 kg/sqcm & 10000 kg/sqcm respectively

## 6. SUMMARY & RECOMMENDATIONS

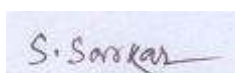
Based on the field and laboratory tests and the foregoing discussion the following are summarised.

1. The subsoil is characterised by stiff to very stiff silty clay followed by hard silty clay. Below this dense to very dense silty sand with clay binder was observed. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes. However, around some borehole locations, soft to medium silty clay layer was observed.
2. The standing water level was struck at an average depth of about 5.20m below existing ground level. So, construction of open foundation placed at a depth of 1.00m or more may not create any problem. However, if required ordinary surface operated pump will be able to tackle the situation for dewatering.
3. Considering the subsoil condition and the proposed structure to be constructed at the present site, it is suggested to go for open foundation. The foundation may be placed at 1.00m or more below FGL.
4. The recommended bearing capacity values with various depth of foundation are presented in Section 5.4.2.
5. The discussion on swelling characteristics is given in Section 5.5.
6. Chemical tests were carried out on few soil and water samples so as to detect the **pH value, Sulphate, Chloride etc.** It is seen that the values are on a safe side. So, any cement can be used for foundation concrete. **Either Ordinary Portland cement or Portland slag cement or Portland Pozzolana cement can be used for the purpose.**
7. The possibility of subsoil liquefaction due to earthquake is given in Section 5.7.
8. The suitability of existing soil for filling and back-filling is given in Section 5.8.
9. Dewatering Scheme is discussed in Section 5.9.
10. Excavation Scheme is discussed in Section 5.10.

11. Geological Logging for the zone of investigation is presented in Section -7.

For C. E. Testing Company Private Limited,

Prepared By



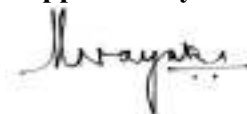
( S. SARKAR )

Checked By



( S. NATH )

Approved By



( DR. M. NAYAK )

## 7. GEOLOGICAL LOGGING

**BH No. 101**

(00.00 – 13.50)m:

Overburden.

(13.50 – 18.50)m:

**Rock Description:** Highly (up to 15.50m), then abruptly changed to fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 15.50m) to very hard and strong rock.

**Structural Condition:** Very closely spaced (>15 nos./m up to 15.50m) followed by widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to fresh.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 15.50m depth. Followed by mostly 100-300mm lengths.

**Rock Mass Structure:** The rock mass is of very poor (up to 15.50m) to excellent quality.

High drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh. As a result high amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result high to no core loss occurred.

**BH No. 102**

(00.00 – 12.00)m:

Overburden.

(12.00 – 19.00)m:

**Rock Description:** High (up to 14.00m) to moderately (up to 16.00m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 16.00m) to very hard and strong rock.

**Structural Condition:** Closely spaced (15-8 nos/m up to 16.00m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of fair to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh. As a result high amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result high to no core loss occurred.

**BH No. 103**

(00.00 – 01.00)m:

Overburden.

(01.00 – 10.00)m:

**Rock Description:** High (up to 05.00m) to moderately (up to 07.00m) weathered, followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted

**Khondalite.**

**Rock Properties:** Hard and moderately strong (up to 07.00m) to hard and strong rock.

**Structural Condition:** Closely spaced (>15 nos/m up to 07.00m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 07.00m, followed by mostly 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of very poor (up to 07.00m) to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh. As a result high amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result high to no core loss occurred.

**BH No. 104**

(00.00 – 36.00)m:

Overburden.

(36.00 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 105**

(00.00 – 10.50)m:

Overburden.

(10.50 – 31.50)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments.

(31.50 – 37.50)m:

**Rock Description:** Moderately (up to 33.50m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 32.50m) to very hard and strong rock.

**Structural Condition:** Closely spaced (15-8 nos/m up to 33.50m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of fair to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is completely weathered to fresh. As a result huge amount of core loss and ultimate core recovery both cases are

observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to no core loss occurred.

**BH No. 107**

(00.00 – 09.50)m:

Overburden.

(09.50 – 14.50)m:

**Rock Description:** Moderately (up to 10.50m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 10.50m) to very hard and strong rock.

**Structural Condition:** Closely spaced (15-8 nos/m up to 11.50m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of fair to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh. As a result modest amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to no core loss occurred.

**BH No. 108**

(00.00 – 27.50)m:

Overburden.

(27.50 – 31.50)m:

**Rock Description:** Moderately (up to 28.50m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 28.50m) to very hard and strong rock.

**Structural Condition:** Very closely spaced (>15 nos/m up to 22.50m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 22.50m, followed by 100-300mm and >300mm pieces.

**Rock Mass Structure:** The rock mass is of poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh. As a result modest amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to no core loss occurred.

**BH No. 109**

(00.00 – 29.00)m:

Overburden.

(29.00 – 32.00)m:

**Rock Description:** Fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and strong rock.

**Structural Condition:** Widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm pieces.

**Rock Mass Structure:** The rock mass is good to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is fresh. As a result no core loss observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result no core loss occurred.

**BH No. 110**

(00.00 – 16.50)m:

Overburden.

(16.50 – 21.50)m:

**Rock Description:** Moderately (up to 18.50m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 18.50m) to very hard and strong rock.

**Structural Condition:** Very closely spaced (>15 nos/m up to 18.50m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 18.50m, followed by 100-300mm and >300mm pieces.

**Rock Mass Structure:** The rock mass is of poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh. As a result modest amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to no core loss occurred.

**BH No. 111**

(00.00 – 12.50)m:

Overburden.

(12.50 – 20.50)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments.

(20.50 – 26.50)m:

**Rock Description:** Highly (up to 22.50m) to moderately (up to 23.50m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 22.50m) to very



hard and strong rock.

**Structural Condition:** Closely spaced (15-8 nos/m up to 23.50m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 22.50m, followed by mostly 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is completely weathered to fresh. As a result huge amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to no core loss occurred.

#### **BH No. 112**

(00.00 – 03.00)m:

Overburden.

(03.00 – 12.00)m:

**Rock Description:** High (up to 07.00m) to moderately (up to 09.00m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 09.00m) to very hard and strong rock.

**Structural Condition:** Closely spaced (15-8 nos/m up to 09.00m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 5.00m, followed by 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh. As a result high amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result high to no core loss occurred.

#### **BH No. 113**

(00.00 – 03.50)m:

Overburden.

(03.50 – 11.50)m:

**Rock Description:** High (up to 07.00m) to moderately (up to 09.00m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 09.00m) to very hard and strong rock.

**Structural Condition:** Closely spaced (15-8 nos/m up to 09.00m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to

slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 5.00m, followed by 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh. As a result high amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result high to no core loss occurred.

#### **BH No. 114**

(00.00 – 08.50)m:

Overburden.

(08.50 – 12.50)m:

**Rock Description:** Moderately (up to 09.50m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and strong rock.

**Structural Condition:** Closely spaced (15-8 nos/m up to 09.50m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 09.50m, followed by 100-300mm and >300mm pieces.

**Rock Mass Structure:** The rock mass is of poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh. As a result modest amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to no core loss occurred.

#### **BH No. 115**

(00.00 – 00.60)m:

Overburden.

(00.60 – 10.60)m:

**Rock Description:** Moderately (up to 01.60m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and strong rock.

**Structural Condition:** Very closely spaced (>15 nos/m up to 01.60m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 01.60m, followed by 100-300mm and >300mm pieces.

**Rock Mass Structure:** The rock mass is of very poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh. As a result modest amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to no core loss occurred.

**BH No. 116**

(00.00 – 25.50)m:

Overburden.

(25.50 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred. Remnants of highly weathered rock pieces at 25.50-26.50m depth.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 117**

(00.00 – 27.00)m:

Overburden.

(27.00 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 118**

(00.00 – 32.00)m:

Overburden.

(32.00 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 119**

(00.00 – 31.10)m:

Overburden.

(31.10 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 120**

(00.00 – 30.00)m:

Overburden.

(30.00 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 121**

(00.00 – 31.50)m:

Overburden.

(31.50 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 122**

(00.00 – 03.00)m:

Overburden.

(03.00 – 12.00)m:

**Rock Description:** High (up to 07.00m) to moderately (up to 09.00m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 07.00m) to very hard and strong rock.

**Structural Condition:** Closely spaced (15-8 nos/m up to 09.00m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 5.00m, followed by 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of poor (up to 09.00m) to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh. As a result high amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result high to no core loss occurred.

**BH No. 123**

(00.00 – 15.00)m:

Overburden.

(15.00 – 22.00)m:

**Rock Description:** High (up to 18.00m) to moderately (up to 19.00m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (55°-60°), coarse grains are tightly compacted

**Khondalite.**

**Rock Properties:** Hard and moderately strong (up to 18.00m) to very hard and strong rock.

**Structural Condition:** Closely spaced (>15 to 15-8 nos/m up to 19.00m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 17.00m, followed by 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of poor (up to 19.00m) to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh. As a result high amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result high to no core loss occurred.

**BH No. 124**

(00.00 – 04.50)m:

Overburden.

(04.50 – 12.50)m:

**Rock Description:** Moderately weathered (up to 08.50m), followed by almost fresh to fresh, whitish grey with dark brownish bands and red spots, foliated (55°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 08.50m) to very hard and strong rock.

**Structural Condition:** Closely spaced (>15 to 15-8 nos/m up to 09.50m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 06.50m, followed by 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of poor (up to 09.50m) to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh. As a result modest amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to no core loss occurred.

**BH No. 125**

(00.00 – 15.50)m:

Overburden.

(15.50 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 127**

(00.00 – 35.00)m:

Overburden.

(35.00 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 128**

(00.00 – 20.00)m:

Overburden.

(20.00 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred. Remnants of highly weathered, medium grained, light grey rock pieces at places.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 129**

(00.00 – 27.00)m:

Overburden.

(27.00 – 31.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments.

(31.00 – 37.00)m:

**Rock Description:** Highly (up to 34.00m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 34.00m) to hard and strong rock.

**Structural Condition:** Closely spaced (>15 nos/m up to 34.00m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 34.00m, followed by 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of very poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is completely weathered to fresh. As a result huge amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to



no core loss occurred.

**BH No. 130**

(00.00 – 19.00)m:

Overburden.

(19.00 – 40.00)m:

Completely weathered, decomposed and disintegrated, brownish grey, medium to coarse grains, loosely compacted **Khondalite**, recovered as rock fragments. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete core loss occurred.

**Rock Mass Structure:** The rock mass is of very poor quality.

Partial drill water loss has been noticed for the entire depth.

**BH No. 131**

(00.00 – 28.00)m:

Overburden.

(28.00 – 40.00)m:

**Rock Description:** Highly (up to 33.00m), followed by fresh, whitish grey with dark brownish bands and red spots, foliated (50°-60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard and moderately strong (up to 33.00m) to hard and strong rock.

**Structural Condition:** Closely spaced (>15 nos/m up to 33.00m) to widely spaced (5-1 nos./m) fractures. Dominantly horizontal fractures. Open horizontal fracture surfaces non-planar, rough, and altered to slightly altered.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm up to 34.00m, followed by 100-300mm and >300mm.

**Rock Mass Structure:** The rock mass is of very poor to excellent quality.

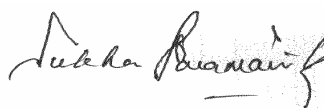
Partial drill water loss has been noticed for the entire depth.

The formation rock is completely weathered to fresh. As a result huge amount of core loss and ultimate core recovery both cases are observed. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to no core loss occurred.

For C. E. Testing Company private Limited,



(M. Dey, Geologist)



(S. Paramanik, Geologist)

## **APPENDIX**

### **SUBJECT**

### **SHEET NUMBER**

**PART I: ALL FIELD TESTS RESULTS**

Bore Log Data Sheet  
Pit Log of TP  
Field Density Test Results

**A1**

A2 – A51  
A52 – A53  
A54

**PART II: LABORATORY TEST RESULTS**

Laboratory Soil Test Results  
Laboratory Rock Test Results  
Swelling Test Results

**A55**

A57 – A73  
A74 – A76  
A77 – A78

**PART III: CHARTS & GRAPHS**

Strength Curves  
e – Logp Curves  
Grain Size Distribution Curves

**A79**

A80 – A87  
A88 – A114  
A115 – A140

**PART IV: SAMPLE CALCULATION****A141****PART V: PHOTOGRAPHS****A147**



**PART I: ALL FIELD TESTS RESULTS**

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.101

Co-ordinates E=1186.379  
N=1650.000

Field Test	Nos	Samples	Nos	Commencement Date : 11/12/2018
Penetrometer (SPT)	9	Undisturbed (UDS)	1	Completion Date : 13/12/2018
Cone (Pc)		Penetrometer (SPT)	9	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	9	Level Of Ground : 919.471 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 9.5 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
Very stiff, reddish brown, silty clay.		6	9	11				DS-2	1.00
								SPT-1	1.50-1.95
								DS-3	2.50
								UDS-1	3.00-3.45
3.45m		12	20	32				SPT-2	3.45-3.90
Hard, reddish brown, silty clay.		14	23	34				DS-4	4.50
								SPT-3	5.00-5.45
								DS-5	6.00
								SPT-4	6.50-6.95
6.20m		20	25	37				DS-6	7.50
Hard, brownish grey, silty clay. Observed moorum.		24	38	49				SPT-5	8.00-8.45
								DS-7	9.00
								SPT-6	9.50-9.95
								DS-8	10.50
		32	52	72				SPT-7	11.00-11.45
								DS-9	12.00
								SPT-8	12.50-12.85
								*SPT-9	13.50-13.54
12.20m		44	69	100				R1	13.50
Very dense, light brownish grey, silty sand with decomposed rock.									
13.50m		100							
Highly weathered, light brownish grey, fine grained, highly fractured rock.									
14.50m		4.0							
Highly weathered, light brownish grey, fine grained, highly to moderately fractured rock.									
15.50m									
Fresh, light brownish grey, fine grained, highly to moderately fractured rock.								R2	14.50
								R3	15.50
								R4	16.50
								R5	17.50
18.50m									18.50
N.B. - '*' means sample could not be recovered.									

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.102

Co-ordinates E=1321.199  
N=1648.217

Field Test	Nos	Samples	Nos	Commencement Date : 10/12/2018
Penetrometer (SPT)	9	Undisturbed (UDS)	4	Completion Date : 12/12/2018
Cone (Pc)		Penetrometer (SPT)	9	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	6	Level Of Ground : 915.81 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 5.2 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
								DS-2	1.00
								SPT-1	1.50-1.95
Medium/stiff, reddish brown, silty clay. Observed kankar & moorum.		3	4	6				UDS-1	2.50-2.95
								SPT-2	2.95-3.40
		3	4	4				DS-3	4.00
								SPT-3	4.50-4.95
4.50m		7	12	19				*UDS-2	5.50-5.60
Hard, reddish brown, silty clay. Observed kankar & moorum.								SPT-4	5.60-6.05
		9	15	26				DS-4	6.50
								SPT-5	7.00-7.45
6.50m		6	8	11				DS-5	8.00
Very stiff, reddish brown, silty clay. Observed traces of sand mixture & kankar.								*UDS-3	8.50-8.95
		6	7	16				SPT-6	9.10-9.55
								DS-6	10.20
		7	9	18				SPT-7	10.50-10.95
11.00m		16	23	28				*UDS-4	11.00-11.10
Very dense, yellowish brown, clayey silty sand with moorum & decomposed rock.								SPT-8	11.10-11.55
12.00m		100						*SPT-9	12.00-12.04
		4.0 cm						R1	CR=29% RQD=20%
								R2	CR=37% RQD=25%
Highly to moderately weathered, whitish grey, fine grained, moderately fractured rock.								R3	CR=47% RQD=36%
								R4	CR=50% RQD=30%
16.00m								R5	CR=100% RQD=92%
								R6	CR=100% RQD=94%
								R7	CR=100% RQD=92%
19.00m									19.00
Fresh, whitish grey, fine grained, moderately fractured rock.									
N.B. - '*' means sample could not be recovered.									

Job No : 4095

Created by : SKD

Created on : 29/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.103

Co-ordinates E=1469.207  
N=488.317

Field Test	Nos	Samples	Nos	Commencement Date : 24/12/2018
Penetrometer (SPT)	2	Undisturbed (UDS)	0	Completion Date : 26/12/2018
Cone (Pc)		Penetrometer (SPT)	2	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	1	Level Of Ground : 960.179 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 8.90 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
Brownish grey, sitly clay. Observed boulders.		100	5.0 cm	Refusal		DS-1 *SPT-1	0.00m
Brownish grey, silty clay with decomposed rock.		100	3.0 cm	Pentn.		*SPT-2	0.50 0.80-0.85 1.00-1.03
Highly weathered, brownish grey, medium grained, highly fractured rock.		NX rotary drilling from 1.00m to 10.00m				R1	1.00
						R2	2.00
						R3	3.00
						R4	4.00
						R5	5.00
						R6	6.00
						R7	7.00
						R8	8.00
						R9	9.00
							10.00

N.B. - '\*' means sample could not be recovered.

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 26/12/2018

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.104**Co-ordinates E=2109.616  
N=502.401

Field Test	Nos	Samples	Nos	Commencement Date : 14/12/2018
Penetrometer (SPT)	29	Undisturbed (UDS)	6	Completion Date : 19/12/2018
Cone (Pc)		Penetrometer (SPT)	29	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	23	Level Of Ground : 895.975 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.6 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m										
Stiff, reddish brown, silty clay. Observed moorum & kankar.		3	4	6				10	DS-1	0.50
									DS-2	1.00
									SPT-1	1.50-1.95
									DS-3	2.50
2.80m								21	UDS-1	3.00-3.45
Very stiff, reddish brown, silty clay. Observed kankar.		6	8	13					SPT-2	3.45-3.90
									DS-4	4.50
5.00m								51	SPT-3	5.00-5.45
		10	18	33					DS-5	6.00
Hard, reddish brown, silty clay. Observed kankar.								57	SPT-4	6.50-6.95
		13	22	35					DS-6	7.50
8.00m								53	SPT-5	8.00-8.45
		12	23	30					DS-7	9.00
								30	SPT-6	9.50-9.95
		10	12	18					DS-8	10.50
								28	SPT-7	11.00-11.45
		8	11	17					*UDS-2	12.00-12.45
								28	SPT-8	12.55-13.00
		7	13	15					DS-9	13.50
Hard, reddish brown, silty clay. Observed grey patches & traces of sand mixture.								37	SPT-9	14.00-14.45
		9	16	21					*UDS-3	15.00-15.45
								30	SPT-10	15.60-16.05
		10	11	19					DS-10	16.50
								37	SPT-11	17.00-17.45
		8	14	23					*UDS-4	18.00-18.45
								45	SPT-12	18.60-19.05
		12	18	27					DS-11	19.50
19.50m										
20.10m										

646 of 1127

BH-104/Sheet-1

Job No : 4095

Created by : SKD

Created on : 26/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.104

Co-ordinates E=2109.616  
N=502.401

Field Test	Nos	Samples	Nos	Commencement Date : 14/12/2018
Penetrometer (SPT)	29	Undisturbed (UDS)	6	Completion Date : 19/12/2018
Cone (Pc)		Penetrometer (SPT)	29	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	23	Level Of Ground : 895.975 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.6 m.

DESCRIPTION	SYMBOL	N-VALUE			SAMPLES	
		EACH	DIVN.	15cm	Ref. No	Depth (m)
20.10m Hard, whitish grey, silty clay. Observed kankar & sand mixture.		10	16	20	SPT-13	20.00-20.45
				36	*UDS-5	21.00-21.45
		11	15	19	SPT-14	21.60-22.05
				34	DS-12	22.50
		8	12	21	SPT-15	23.00-23.45
25.00m Very dense, brownish grey, silty sand.		10	14	37	*UDS-6	24.00-24.10
				51	SPT-16	24.10-24.55
				53	DS-13	25.00
		16	23	30	SPT-17	25.50-25.95
				72	DS-14	26.50
28.00m Hard, whitish grey, silty clay with decomposed rock.		20	32	40	SPT-18	27.00-27.45
				73	DS-15	28.00
		22	35	38	SPT-19	28.50-28.95
				85	DS-16	29.50
		20	40	45	SPT-20	30.00-30.45
				92	DS-17	31.00
		23	43	49	SPT-21	31.50-31.95
				>100	DS-18	32.50
		37	54	76	SPT-22	33.00-33.45
				>100	DS-19	34.00
36.00m Completely weathered, brownish grey, medium grained, decomposed & disintegrated rock particles collected as sludge.  N.B. - '*' means sample could not be recovered.		65	100		SPT-23	34.50-34.75
				10.0 cm Pentn.		
		100	4.0 cm Pentn.	Refusal	*SPT-24	35.50-35.54
		100	2.0 cm Pentn.	Refusal	*SPT-25	36.00-36.02
				NX rotary drilling from 36.00m to 40.00m	R1	CR=Nil
		100	Refusal		DS-20	RQD=Nil
				4.0 cm Pentn.	*SPT-26	37.00-37.04
		100	Refusal		R2	CR=Nil
				2.0 cm Pentn.	DS-26	RQD=Nil
		100	Refusal		*SPT-27	38.00-38.02
40.00m				4.0 cm Pentn.	R3	CR=Nil
				Refusal	DS-22	RQD=Nil
				4.0 cm Pentn.	*SPT-28	39.00-39.04
				Refusal	R4	CR=Nil
				3.0 cm Pentn.	DS-23	RQD=Nil
					*SPT-29	40.00-40.03

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.105

Co-ordinates E=2071.500  
N=378.732

Field Test	Nos	Samples	Nos	Commencement Date : 07/11/2018
Penetrometer (SPT)	29	Undisturbed (UDS)	2	Completion Date : 13/11/2018
Cone (Pc)		Penetrometer (SPT)	29	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	28	Level Of Ground : 896.081 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 4.10 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m							DS-1	0.50
							DS-2	1.00
					11		SPT-1	1.50-1.95
Stiff to very stiff, reddish brown, silty clay / clayey silt.					13		UDS-1	2.50-2.95
							SPT-2	2.95-3.40
					25		DS-3	4.00
							SPT-3	4.50-4.95
					42		UDS-2	5.50-5.95
5.95m							SPT-4	5.95-6.40
Very dense, reddish brown, clayey silty sand with decomposed rock dust & rock pcs.					≥100		DS-4	7.00
							SPT-5	7.20-7.57
					≥100		DS-5	8.00
8.50m							SPT-6	8.50-8.85
Hard, reddish brown, silty clay with decomposed rock.					5.0 cm Pentn.		DS-6	9.50
					≥100		SPT-7	10.00-10.18
10.50m					3.0 cm Pentn.		*SPT-8	10.50-10.53 10.50
					Refusa.		R1	CR=Nil
					3.0 cm Pentn.		DS-7	RQD=Nil
					Refusa.		*SPT-9	11.50-11.53 11.50
					3.0 cm Pentn.		R2	CR=Nil
Completely weathered, reddish brown, decomposed & disintegrated rock particles collected as sludge.					NX rotary drilling from 10.50m to 37.50m		DS-8	RQD=Nil
					Refusa.		*SPT-10	12.50-12.52 12.50
					2.0 cm Pentn.		R3	CR=Nil
					Refusa.		DS-9	RQD=Nil
					3.0 cm Pentn.		*SPT-11	13.50-13.53 13.50
					Refusa.		R4	CR=Nil
14.50m					3.0 cm Pentn.		DS-10	RQD=Nil
					Refusa.		*SPT-12	14.50-14.54 14.50
					4.0 cm Pentn.		R5	CR=Nil
					Refusa.		DS-11	RQD=Nil
					2.0 cm Pentn.		*SPT-13	15.50-15.52 15.50
					Refusa.		R6	CR=Nil
					3.0 cm Pentn.		DS-12	RQD=Nil
					Refusa.		*SPT-14	16.50-16.53 16.50
Completely weathered, reddish brown, decomposed & disintegrated rock particles collected as sludge.					3.0 cm Pentn.		R7	CR=Nil
					Refusa.		DS-13	RQD=Nil
					2.0 cm Pentn.		*SPT-15	17.50-17.52 17.50
					Refusa.		R8	CR=Nil
					3.0 cm Pentn.		DS-14	RQD=Nil
					Refusa.		*SPT-16	18.50-18.53 18.50
					2.0 cm Pentn.		R9	CR=Nil
					Refusa.		DS-15	RQD=Nil
					2.0 cm Pentn.		*SPT-17	19.50-19.52 19.50
					Refusa.		R10	CR=Nil
20.10m					2.0 cm Pentn.		DS-16	RQD=Nil

648 of 1127

BH-105/Sheet-1

## BORE LOG DATA SHEET

## BORE HOLE NO.105

Co-ordinates	E=2071.500 N=378.732
--------------	-------------------------

Field Test	Nos	Samples	Nos	Commencement Date :	07/11/2018
Penetrometer (SPT)	29	Undisturbed (UDS)	2	Completion Date :	13/11/2018
Cone (Pc)		Penetrometer (SPT)	29	Bore Hole Diameter :	150mm / NX.
		Disturbed (DS)	28	Level Of Ground :	896.081 m.
Vane (V)		Water Sample (WS)	0	Water Struck At :	
				Standing Water Level :	4.10 m.

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Job No : 4095

Created by : SKD

Created on : 29/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.106

Co-ordinates E=2194.744  
N=422.348

Field Test	Nos	Samples	Nos	Commencement Date : 20/12/2018
Penetrometer (SPT)	27	Undisturbed (UDS)	2	Completion Date : 25/12/2018
Cone (Pc)		Penetrometer (SPT)	27	Bore Hole Diameter : 150 mm.
Vane (V)		Disturbed (DS)	26	Level Of Ground : 894.029 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 2.5 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
Very stiff, reddish brown, silty clay. Observed grey spots, traces of sand mixture & kankar.								DS-2	1.00
		5	8	8			16	SPT-1	1.50-1.95
								UDS-1	2.50-2.95
							35	SPT-2	2.95-3.40
2.95m		7	15	20				DS-3	4.00
Hard, reddish brown, silty clay. Observed grey spots & traces of sand mixture & kankar.								SPT-3	4.50-4.95
		10	21	25			46	*UDS-2	5.50-5.60
		11	14	17			31	SPT-4	5.60-6.05
								DS-4	6.50
		13	20	31			51	SPT-5	7.00-7.45
								DS-5	8.00
		0	16	26			42	SPT-6	8.50-8.95
								DS-6	9.50
		12	18	32			50	SPT-7	10.00-10.45
								DS-7	11.00
		14	20	34			54	SPT-8	11.50-11.95
								DS-8	12.50
14.20m		13	23	30			53	SPT-9	13.00-13.45
								DS-9	14.00
		15	25	32			57	SPT-10	14.50-14.95
								DS-10	15.50
		17	28	35			63	SPT-11	16.00-16.45
								DS-11	17.00
		14	30	32			62	SPT-12	17.50-17.95
20.30m								DS-12	18.50
		18	33	34			67	SPT-13	19.00-19.45
								DS-13	20.00

650 of 1127

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095

Created by : SKD

Created on : 29/12/2018

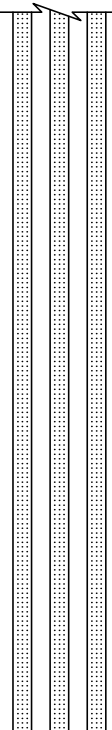

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.106

Co-ordinates E=2194.744  
N=422.348

Field Test	Nos	Samples	Nos	Commencement Date : 20/12/2018
Penetrometer (SPT)	27	Undisturbed (UDS)	2	Completion Date : 25/12/2018
Cone (Pc)		Penetrometer (SPT)	27	Bore Hole Diameter : 150 mm.
Vane (V)		Disturbed (DS)	26	Level Of Ground : 894.029 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 2.5 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
Very dense, brownish grey to whitish grey, clayey silty sand / clayey sandy silt.		20	35	37	72			SPT-14	20.50-20.95
					68			DS-14	21.50
		20	38	30				SPT-15	22.00-22.45
					73			DS-15	23.00
		20	35	38				SPT-16	23.50-23.95
					66			DS-16	24.50
		23	32	34				SPT-17	25.00-25.45
					73			DS-17	26.00
		27	34	39				SPT-18	26.50-26.95
					71			DS-18	27.50
Hard, brownish grey, clayey silt / silty clay with sand mixture.		24	35	36				SPT-19	28.00-28.45
					63			DS-19	29.00
		25	30	33				SPT-20	29.50-29.95
					58			DS-20	30.50
		18	28	30				SPT-21	31.00-31.45
					52			DS-21	32.00
		12	17	35				SPT-22	32.50-32.95
					54			DS-22	33.50
		11	20	34				SPT-23	34.00-34.45
					61			DS-23	35.00
N.B. - '*' means sample could not be recovered.		14	25	36				SPT-24	35.50-35.95
					60			DS-24	36.50
		13	22	38				SPT-25	37.00-37.45
					63			DS-25	38.00
		15	27	36				SPT-26	38.50-38.95
					72			DS-26	39.50
		18	30	42				SPT-27	40.00-40.45

651 of 1127

BH-106/Sheet-2

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.107

Co-ordinates E=1965.024  
N=545.988

Field Test	Nos	Samples	Nos	Commencement Date : 14/11/2018
Penetrometer (SPT)	8	Undisturbed (UDS)	2	Completion Date : 17/11/2018
Cone (Pc)		Penetrometer (SPT)	8	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	5	Level Of Ground : 899.936 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 4.2 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
								DS-2	1.00
		3	5	5				SPT-1	1.50-1.95
								UDS-1	2.50-2.95
		4	7	9				SPT-2	2.95-3.40
								DS-3	4.00
		5	8	10				SPT-3	4.50-4.95
								UDS-2	5.50-5.95
		7	10	18				SPT-4	5.95-6.40
								DS-4	7.00
		9	16	20				SPT-5	7.50-7.95
		24	60					DS-5	8.50
		100	5.0 cm	Pentn.				SPT-6	9.00-9.20
		100	4.0 cm	Pentn. Refusal				*SPT-7	9.40-9.44
		100		Refusal				*SPT-8	9.50-9.53
		100	3.0 cm	Pentn.				R1	CR=44% RQD=20%
		NX	rotary drilling from 9.50m to 14.50m					R2	CR=80% RQD=25%
								R3	CR=100% RQD=90%
								R4	CR=100% RQD=92%
								R5	CR=100% RQD=94%

N.B. - '\*' means sample could not be recovered.

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095

Created by : SKD

Created on : 26/12/2018

Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO.108

Co-ordinates E=2117.000  
N=642.000

Field Test	Nos	Samples	Nos	Commencement Date : 18/12/2018
Penetrometer (SPT)	19	Undisturbed (UDS)	2	Completion Date : 22/12/2018
Cone (Pc)		Penetrometer (SPT)	19	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	18	Level Of Ground : 902.281 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 11.2 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Stiff, reddish brown, silty clay. Observed moorum & kankar.								DS-1	0.50
								DS-2	1.00
							11	SPT-1	1.50-1.95
		4	5	6				DS-3	2.50
3.60m								*UDS-1	3.00-3.45
							33	SPT-2	3.60-4.05
		9	13	20				DS-4	4.50
							39	SPT-3	5.00-5.45
		8	15	24				*UDS-2	6.00-6.10
							52	SPT-4	6.10-6.55
		7	17	35				DS-5	7.00
							52	SPT-5	7.50-7.95
		10	20	32				DS-6	8.50
							69	SPT-6	9.00-9.45
12.00m		25	30	39				DS-7	10.00
							51	SPT-7	10.50-10.95
		20	26	25				DS-8	11.50
							41	SPT-8	12.00-12.45
		14	17	24				DS-9	13.00
							40	SPT-9	13.50-13.95
		16	18	22				DS-10	14.50
							45	SPT-10	15.00-15.45
		13	15	30				DS-11	16.00
							44	SPT-11	16.50-16.95
20.10m		15	14	30				DS-12	17.50
							68	SPT-12	18.00-18.45
		22	30	38				DS-13	19.00
							70	SPT-13	19.50-19.95
		20	27	43					

653 of 1127

BH-108/Sheet-1

Job No : 4095

Created by : SKD

Created on : 26/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.108

Co-ordinates E=2117.000  
N=642.000

Field Test	Nos	Samples	Nos	Commencement Date : 18/12/2018
Penetrometer (SPT)	19	Undisturbed (UDS)	2	Completion Date : 22/12/2018
Cone (Pc)		Penetrometer (SPT)	19	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	18	Level Of Ground : 902.281 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 11.2 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
20.10m Hard, reddish brown, silty clay / clayey silt. Observed traces of sand mixture & kankar.		27	35	45	80		DS-14	20.50
							SPT-14	21.00-21.45
22.50m		18	40	47	87		DS-15	22.00
							SPT-15	22.50-22.95
					>100		DS-16	23.50
		22	48	54			SPT-16	24.00-24.45
					>100		DS-17	25.00
		30	57	72			SPT-17	25.50-25.95
					>100		DS-18	26.50
		65	100				SPT-18	27.00-27.20
27.50m Moderately weathered, whitish grey, fine grained, moderately fractured rock.					5.0 cm Pentn. Refusal		*SPT-19	27.50-27.53 27.50
28.50m					3.0 cm Pentn.		R1	CR=42% RQD=Nil
					NX rotary drilling from 27.50m to 31.50m			28.50
							R2	CR=100% RQD=92%
							R3	CR=100% RQD=93%
							R4	CR=100% RQD=95%
31.50m Fresh, whitish grey, fine grained, moderately fractured rock.								29.50
								30.50
								31.50

N.B. - '\*' means sample could not be recovered.

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

Job No : 4095

Created by : SKD

Created on : 29/12/2018

Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.109

Co-ordinates E=2111.023  
N=683.026

Field Test	Nos	Samples	Nos	Commencement Date : 12/12/2018
Penetrometer (SPT)	20	Undisturbed (UDS)	2	Completion Date : 15/12/2018
Cone (Pc)		Penetrometer (SPT)	20	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	19	Level Of Ground : 905.14 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 11.7 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
Very stiff, brownish grey, silty clay with moorum. Observed sand mixture.								DS-2	1.00
		7	12	15			27	SPT-1	1.50-1.95
								DS-3	2.50
							40	*UDS-1	3.00-3.12
3.15m		12	18	22			SPT-2	3.15-3.60	
Hard, brownish grey, silty clay with moorum. Observed sand mixture.							44	DS-4	4.00
		10	20	24			SPT-3	4.50-4.95	
								DS-5	5.50
							51	*UDS-2	6.00-6.10
	14	18	33			SPT-4	6.10-6.55		
						55	DS-6	7.00	
	16	20	35			SPT-5	7.50-7.95		
						55	DS-7	8.50	
	19	24	31			SPT-6	9.00-9.45		
						65	DS-8	10.00	
	22	30	35			SPT-7	10.50-10.95		
					70	DS-9	11.50		
	20	32	38			SPT-8	12.00-12.45		
					68	DS-10	13.00		
	21	30	38			SPT-9	13.50-13.95		
					71	DS-11	14.50		
16.10m	22	32	39			SPT-10	15.50-15.95		

655 of 1127

BH-109/Sheet-1

Job No : 4095

Created by : SKD

Created on : 29/12/2018

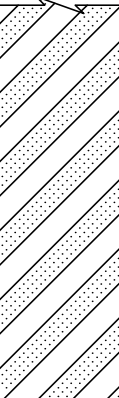
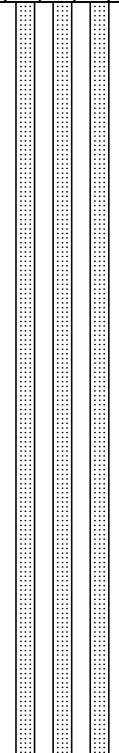
Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.109

Co-ordinates E=2111.023  
N=683.026

Field Test	Nos	Samples	Nos	Commencement Date : 12/12/2018
Penetrometer (SPT)	20	Undisturbed (UDS)	2	Completion Date : 15/12/2018
Cone (Pc)		Penetrometer (SPT)	20	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	19	Level Of Ground : 905.14 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 11.7 m.

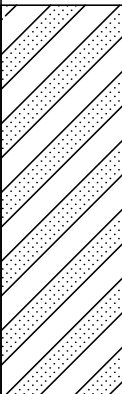
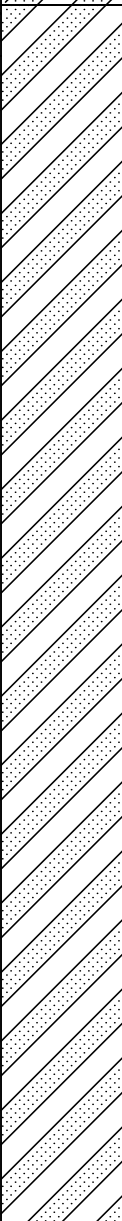
DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
16.10m Hard, brownish grey, silty clay with moorum. Observed sand mixture.		25	30	35	65			DS-12	16.50
								SPT-11	17.00-17.45
		26	32	40	72			DS-13	18.00
								SPT-12	18.50-18.95
								DS-14	19.50
20.00m		27	30	40	70			SPT-13	20.00-20.45
								DS-15	21.00
		29	35	40	75			SPT-14	21.50-21.95
								DS-16	22.50
		30	38	42	80			SPT-15	23.00-23.45
Very dense, brownish grey, silty sand. Observed kankar.								DS-17	24.00
		35	40	50	90			SPT-16	24.50-24.95
								DS-18	25.50
		32	39	52	91			SPT-17	26.00-26.45
								DS-19	27.00
27.50m		43	69	100	>100			SPT-18	27.50-27.85
Very dense, brownish grey, silty sand with decomposed rock.		100			Refusal			*SPT-19	28.50-28.54
		4.0			Pentn.			*SPT-20	29.00-29.03 29.00
29.00m		100			Refusal			R1	CR=100% RQD=93%
		3.0			Pentn.			R2	CR=100% RQD=92%
Fresh, brownish grey, fine grained, moderately fractured rock.					NX rotary drilling from 29.00m to 32.00m			R3	CR=100% RQD=94%
N.B. - '*' means sample could not be recovered.									30.00
32.00m									31.00
									32.00

## BORE LOG DATA SHEET

## BORE HOLE NO.110

Co-ordinates	E=2111.119 N=744.174
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Field Test	Nos	Samples	Nos	Commencement Date :	14/12/2018
Penetrometer (SPT) Cone (Pc) Vane (V)	12	Undisturbed (UDS)	1	Completion Date :	18/12/2018
		Penetrometer (SPT)	12	Bore Hole Diameter :	150mm / NX.
		Disturbed (DS)	15	Level Of Ground :	902.81 m.
		Water Sample (WS)	0	Water Struck At :	
				Standing Water Level :	8.0 m.

DESCRIPTION	SYMBOL	N-VALUE								SAMPLES	
		EACH	DIVN. = 15cm						Ref. No	Depth (m)	
0.00m										DS-1	0.50
Very stiff, reddish brown, silty clay. Observed moorum, kankar & traces of sand mixture.										DS-2	1.00
		5	7	14					21	SPT-1	1.50-1.95
2.50m									UDS-1	2.50-2.95	
Hard, reddish brown, silty clay. Observed moorum, kankar & traces of sand mixture.		24	35	47					82	SPT-2	2.95-3.40
										DS-3	4.00
		22	31	43					74	SPT-3	4.50-4.95
										DS-4	5.50
		25	34	45					79	SPT-4	6.00-6.45
										DS-5	7.00
			20	37	40					77	SPT-5
								DS-6	8.50		
								74	SPT-6	9.00-9.45	
	17	32	42								
									DS-7	10.00	
								91	SPT-7	10.50-10.95	
10.80m		18	38	53							

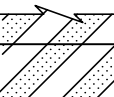
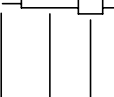


## BORE LOG DATA SHEET

## BORE HOLE NO.110

Co-ordinates	E=2111.119 N=744.174
--------------	-------------------------

Field Test	Nos	Samples	Nos	Commencement Date :	14/12/2018
Penetrometer (SPT)	12	Undisturbed (UDS)	1	Completion Date :	18/12/2018
Cone (Pc)		Penetrometer (SPT)	12	Bore Hole Diameter :	150mm / NX.
		Disturbed (DS)	15	Level Of Ground :	902.81 m.
Vane (V)		Water Sample (WS)	0	Water Struck At :	
				Standing Water Level :	8.0 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
Hard, reddish brown, silty clay. Observed moorum, kankar & traces of sand mixture.									
								DS-8	11.50
		15	40	65	$\geq 00\%$			SPT-8	12.00-12.45
								DS-9	13.00
		19	45	72	$\geq 100$			SPT-9	13.50-13.95
								DS-10	14.50
		32	54	77	$\geq 100$			SPT-10	15.00-15.45
		65	100	$\geq 100$				SPT-11	16.00-16.25
		10.0 cm	Pentn.	Refusal				*SPT-12	16.50-16.54 16.50
		100	4.0 cm	Pentn.				R1	CR=40% RQD=Nil ↓
Highly to moderately weathered, brownish grey, fine grained, moderately fractured rock.		NX rotary drilling from 16.50m to 21.50m							17.50
								R2	CR=45% RQD=Nil ↓
									18.50
								R3	CR=100% RQD=90% ↓
									19.50
								R4	CR=100% RQD=92% ↓
									20.50
								R5	CR=100% RQD=94% ↓
									21.50
N.B. - '*' means sample could not be recovered.									

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.111

Co-ordinates E=2111.119  
N=834.707

Field Test	Nos	Samples	Nos	Commencement Date : 05/11/2018
Penetrometer (SPT)	17	Undisturbed (UDS)	3	Completion Date : 13/11/2018
Cone (Pc)		Penetrometer (SPT)	17	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	14	Level Of Ground : 912.137 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.20 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m							DS-1	0.50
							DS-2	1.00
						20	SPT-1	1.50-1.95
Very stiff, reddish brown, silty clay with moorum. Observed kankar.		5	9	11			UDS-1	2.50-2.95
						23	SPT-2	2.95-3.40
		9	11	12			DS-3	4.00
						39	SPT-3	4.50-4.95
4.50m		12	16	23			UDS-2	5.50-5.95
						49	SPT-4	5.95-6.40
		16	22	27			DS-4	7.00
Hard, reddish brown, silty clay with moorum. Observed kankar.						38	SPT-5	7.50-7.95
		11	16	22			UDS-3	8.50-8.95
						44	SPT-6	8.95-9.40
		14	19	25			DS-5	10.00
						51	SPT-7	10.50-10.95
10.50m		16	23	28			DS-6	11.50
Very dense, reddish brown / whitish grey, silty sand with decomposed rock pcs.		20	39	50		>100	SPT-8	12.00-12.37
					7.0 cm Pentn.		*SPT-9	12.50-12.52 12.50
12.50m		52			Refusa.		R1	CR=Nil
					2.0 cm Pentn.		DS-7	RQD=Nil
		57			Refusa.		*SPT-10	13.50-13.52 13.50
					2.0 cm Pentn.		R2	CR=Nil
		54			Refusa.		DS-8	RQD=Nil
					4.0 cm Pentn.		*SPT-11	14.50-14.54 14.50
					NX rotary drilling from 12.50m to 26.00m		R3	CR=Nil
		53			Refusa.		DS-9	RQD=Nil
Completely weathered, whitish grey, decomposed & disintegrated rock particles collected as sludge.					2.0 cm Pentn.		*SPT-12	15.50-15.52 15.50
							R4	CR=Nil
		52			Refusa.		DS-10	RQD=Nil
					3.0 cm Pentn.		*SPT-13	16.50-16.53 16.50
							R5	CR=Nil
		53			Refusa.		DS-11	RQD=Nil
					3.0 cm Pentn.		*SPT-14	17.50-17.53 17.50
							R6	CR=Nil
		52			Refusa.		DS-12	RQD=Nil
					2.0 cm Pentn.		*SPT-15	18.50-18.52 18.50
							R7	CR=Nil
		54			Refusa.		DS-13	RQD=Nil
					3.0 cm Pentn.		*SPT-16	19.50-19.53 19.50
							R8	CR=Nil
20.10m							DS-14	RQD=Nil

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.111**Co-ordinates E=2111.119  
N=834.707

Field Test	Nos	Samples	Nos	Commencement Date : 05/11/2018
Penetrometer (SPT)	17	Undisturbed (UDS)	3	Completion Date : 13/11/2018
Cone (Pc)		Penetrometer (SPT)	17	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	14	Level Of Ground : 912.137 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 3.20 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
20.10m Completely weathered, whitish decomposed & disintegrated rock particles collected as sludge.		52					*SPT-17 R9	20.50-20.52 CR=28% RQD=Nil
20.50m Highly weathered, whitish brown, fine grained rock.							R10	21.50 CR=36% RQD=10%
22.50m							R11	22.50 CR=68% RQD=30%
23.50m Slightly weathered to fresh, whitish brown, fine grained rock.							R12	23.50 CR=100% RQD=95%
24.50m							R13	24.50 CR=100% RQD=97%
26.00m								26.00
N.B. - '*' means sample could not be recovered.								

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.112

Co-ordinates E=2023.707  
N=835.477

Field Test	Nos	Samples	Nos	Commencement Date : 21/11/2018
Penetrometer (SPT)	3	Undisturbed (UDS)	1	Completion Date : 23/11/2018
Cone (Pc)		Penetrometer (SPT)	3	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	2	Level Of Ground : 912.300 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.8 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m								
Stiff, reddish brown, silty clay / clayey silt. Observed kankar.							DS-1	0.50
							DS-2	1.00
							UDS-1	1.50-1.95
							SPT-1	1.95-2.40
2.80m								
Reddish brown, silty clay with decomposed rock.							*SPT-2	2.80-2.84
							*SPT-3	3.00-3.03
3.00m							R1	CR=40% RQD=Nil
Moderately weathered, light grey, fine grained, moderately fractured rock.							R2	CR=42% RQD=13%
							R3	CR=44% RQD=32%
							R4	CR=45% RQD=35%
							R5	CR=48% RQD=42%
							R6	CR=49% RQD=40%
							R7	CR=100% RQD=91%
							R8	CR=100% RQD=92%
							R9	CR=100% RQD=94%
9.00m								
Fresh, light grey, fine grained, moderately fractured rock.								
12.00m								

N.B. - '\*' means sample could not be recovered.

661 of 1127

## BORE HOLE NO. 113

Co-ordinates	E=2023.597 N=999.438
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N.B. – '\*' means sample could not be recovered.

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO.114

Co-ordinates E=2193.188  
N=1198.398

Field Test	Nos	Samples	Nos	Commencement Date : 07/11/2018
Penetrometer (SPT)	7	Undisturbed (UDS)	2	Completion Date : 16/11/2018
Cone (Pc)		Penetrometer (SPT)	7	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	4	Level Of Ground : 904.502 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 2.6 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m Medium, reddish brown, silty clay / clayey silt. Observed fine sand mixture & kankar.								DS-1	0.50
								DS-2	1.00
		2	3	2				SPT-1	1.50-1.95
1.95m								UDS-1	2.50-2.95
		2	3	5				WS-1	2.60
								SPT-2	2.95-3.40
Stiff to very stiff, reddish brown, silty clay / clayey silt. Observed fine sand mixture & kankar. Also observed sand pocket in UDS-01.								DS-3	4.00
		3	4	5				SPT-3	4.50-4.95
								UDS-2	5.50-5.95
		8	7	10				SPT-4	5.95-6.40
								DS-4	7.00
7.50m								SPT-5	7.50-7.95
Hard, reddish brown, silty clay / clayey silt. Observed decomposed rock.		7	10	21				*SPT-6	8.20-8.24
8.50m		100	4.0	cm	Pentn. Refusal			*SPT-7	8.50-8.53
					Refusal			R1	CR=62% RQD=24%
		100	3.0	cm	Pentn.				9.50
								R2	CR=100% RQD=92%
Slightly weathered to fresh, light grey, fine grained, moderately fractured rock.									11.00
								R3	CR=100% RQD=90%
									12.50
12.50m									

N.B. - '\*' means sample could not be recovered.

663 of 1127

Job No : 4095

Created by : SKD

Created on : 29/11/2018



Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.115

Co-ordinates E=2193.454  
N=1402.134

Field Test	Nos	Samples	Nos	Commencement Date : 02/11/2018
Penetrometer (SPT)	2	Undisturbed (UDS)	0	Completion Date : 06/11/2018
Cone (Pc)		Penetrometer (SPT)	2	Bore Hole Diameter : NX.
Vane (V)		Disturbed (DS)	1	Level Of Ground : 907.053 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 2.1 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
0.00m Reddish brown, silty clay / clayey silt with sand. Observed decomposed rock.		100	Refusal			DS-1	0.40
		4.0 cm	Penth.			*SPT-1	0.50-0.54
0.60m Moderately weathered, light grey, fine grained, moderately fractured rock.		100	Refusal			*SPT-2	0.60-0.62
		2.0 cm	Penth.			R1	CR=45% RQD=16%
		NX rotary drilling from 0.60m to 10.60m				R2	CR=95% RQD=70%
						R3	CR=95% RQD=53%
						R4	CR=92% RQD=88%
						R5	CR=93% RQD=86%
							6.10
						R6	CR=88% RQD=63%
							7.60
						R7	CR=100% RQD=91%
							9.10
						R8	CR=100% RQD=93%
							10.60
10.60m							

N.B. - '\*' means sample could not be recovered.

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO.116

Co-ordinates E=1511.800  
N=846.470

Field Test	Nos	Samples	Nos	Commencement Date : 14/11/2018
Penetrometer (SPT)	32	Undisturbed (UDS)	3	Completion Date : 18/11/2018
Cone (Pc)		Penetrometer (SPT)	32	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	29	Level Of Ground : 899.15 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 2.90 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
								DS-2	1.00
		1	2	2			4	SPT-1	1.50-1.95
Medium, reddish brown, silty clay / clayey silt. Observed kankar.							6	*UDS-1	2.50-2.95
		2	3	3				SPT-2	3.05-3.50
							10	DS-3	4.00
4.50m		3	4	6				SPT-3	4.50-4.95
							14	UDS-2	5.50-5.95
		3	7	7				SPT-4	5.95-6.40
Stiff to very stiff, reddish brown, silty clay / clayey silt. Observed kankar.							30	DS-4	7.00
		6	12	18				SPT-5	7.50-7.95
							30	UDS-3	8.50-8.95
		8	13	17				SPT-6	8.95-9.40
							36	DS-5	10.00
10.50m		8	14	22				SPT-7	10.50-10.95
							36	DS-6	11.50
Hard, reddish brown, silty clay / clayey silt. Observed kankar.		9	16	20				SPT-8	12.00-12.45
							39	DS-7	13.00
		11	18	21				SPT-9	13.50-13.95
14.50m							34	DS-8	14.50
		10	15	19				SPT-10	15.00-15.45
							45	DS-9	16.00
Hard, brownish grey, silty clay / clayey silt with sand mixture.		10	18	27				SPT-11	16.50-16.95
							49	DS-10	17.50
		12	20	29				SPT-12	18.00-18.45
							53	DS-11	19.00
20.10m		12	22	31				SPT-13	19.50-19.95

665 of 1127

BH-116/Sheet-1





Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO.117

Co-ordinates E=1513.792  
N=868.338

Field Test	Nos	Samples	Nos	Commencement Date : 19/11/2018
Penetrometer (SPT)	32	Undisturbed (UDS)	3	Completion Date : 22/11/2018
Cone (Pc)		Penetrometer (SPT)	32	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	28	Level Of Ground : 898.57 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 3.2 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Stiff, reddish brown, silty clay / clayey silt. Observed kankar.								DS-1	0.50
								DS-2	1.00
		3	4	6			10	SPT-1	1.50-1.95
							14	UDS-1	2.50-2.95
2.95m		4	6	8				SPT-2	2.95-3.40
Stiff to very stiff, reddish brown, silty clay. Observed sand mixture.								DS-3	4.00
							10	SPT-3	4.50-4.95
		4	4	6				*UDS-2	5.50-5.95
							13	SPT-4	6.05-6.50
		4	5	8				DS-4	7.00
							22	SPT-5	7.50-7.95
		5	3	19				UDS-3	8.50-8.95
							28	SPT-6	8.95-9.40
10.50m		8	11	17				DS-5	10.00
Hard, reddish brown, silty clay. Observed sand mixture.							35	SPT-7	10.50-10.95
		10	15	20				DS-6	11.50
							38	SPT-8	12.00-12.45
		12	17	21				DS-7	13.00
13.50m							40	SPT-9	13.50-13.95
Dense to very dense, brownish grey, silty sand. Observed kankar.		13	18	22				DS-8	14.50
							40	SPT-10	15.00-15.45
		14	20	20				DS-9	16.00
							37	SPT-11	16.50-16.95
		15	17	20				DS-10	17.50
							48	SPT-12	18.00-18.45
		17	25	23				DS-11	19.00
							50	SPT-13	19.50-19.95
20.10m		15	24	26					

667 of 1127

BH-117/Sheet-1

Job No : 4095

Created by : SKD

Created on : 29/11/2018

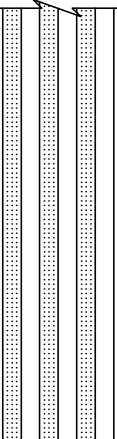
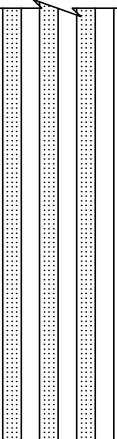
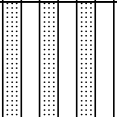
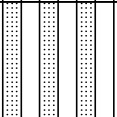


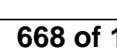
Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.117

Co-ordinates E=1513.792  
N=868.338

Field Test	Nos	Samples	Nos	Commencement Date : 19/11/2018
Penetrometer (SPT)	32	Undisturbed (UDS)	3	Completion Date : 22/11/2018
Cone (Pc)		Penetrometer (SPT)	32	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	28	Level Of Ground : 898.57 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.2 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES		
		EACH DIVN. = 15cm				Ref. No	Depth (m)	
20.10m						DS-12	20.50	
Dense to very dense, brownish grey, silty sand. Observed kankar.		18	27	27	54	SPT-14	21.00-21.45	
		17	23	32	55	DS-13	22.00	
					SPT-15	22.50-22.95		
					DS-14	23.50		
					SPT-16	24.00-24.45		
		20	28	32	60	DS-15	25.00	
25.50m		21	30	42	72	SPT-17	25.50-25.95	
Very dense, yellowish brown, silty sand with decomposed rock.		24	38	52	>100	SPT-18	26.50-26.85	
		100			5.0 cm Pentn.	*SPT-19	27.00-27.04 27.00	
27.00m			4.0	cm	Pentn.	R1	CR=Nil	
Completely weathered, whitish grey, fine grained, decomposed rock pcs. collected as sludge.		100			Refusal	DS-16	RQD=Nil	
		*SPT-20	28.00-28.03 28.00					
		100			3.0 cm	Pentn.	R2	CR=Nil
		100			Refusal	DS-17	RQD=Nil	
		*SPT-21	29.00-29.03 29.00					
		100			3.0 cm	Pentn.	R3	CR=Nil
		DS-18	RQD=Nil					
		*SPT-22	30.00-30.05 30.00					
		100			5.0 cm	Pentn.	R4	CR=Nil
		DS-19	RQD=Nil					
		*SPT-23	31.00-31.04 31.00					
		100			4.0 cm	Pentn.	R5	CR=Nil
		DS-20	RQD=Nil					
		*SPT-24	32.00-32.05 32.00					
		100			5.0 cm	Pentn.	R6	CR=Nil
		DS-21	RQD=Nil					
		*SPT-25	33.00-33.04 33.00					
		100			4.0 cm	Pentn.	R7	CR=Nil
		DS-22	RQD=Nil					
		*SPT-26	34.00-34.05 34.00					
		100			5.0 cm	Pentn.	R8	CR=Nil
		DS-23	RQD=Nil					
		*SPT-27	35.00-35.05 35.00					
		100			5.0 cm	Pentn.	R9	CR=Nil
DS-24	RQD=Nil							
*SPT-28	36.00-36.04 36.00							
100			4.0 cm	Pentn.	R10	CR=Nil		
DS-25	RQD=Nil							
*SPT-29	37.00-37.04 37.00							
100			4.0 cm	Pentn.	R11	CR=Nil		
DS-26	RQD=Nil							
*SPT-30	38.00-38.05 38.00							
100			5.0 cm	Pentn.	R12	CR=Nil		
DS-27	RQD=Nil							
*SPT-31	39.00-39.04 39.00							
100			4.0 cm	Pentn.	R13	CR=Nil		
DS-28	RQD=Nil							
*SPT-32	40.00-40.03 40.00							
N.B. - '*' means sample could not be recovered.		100			Refusal			
40.00m								

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.118

Co-ordinates E=1515.874  
N=1298.715

Field Test	Nos	Samples	Nos	Commencement Date : 08/12/2018
Penetrometer (SPT)	31	Undisturbed (UDS)	3	Completion Date : 11/12/2018
Cone (Pc)		Penetrometer (SPT)	31	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	28	Level Of Ground : 909.052 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 5.1 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
								DS-2	1.00
Medium, reddish brown, silty clay. Observed sand mixture.		2	2	3				*UDS-1	1.50-1.95
								SPT-1	2.05-2.50
								DS-3	3.00
		2	3	3				SPT-2	3.50-3.95
6.50m								UDS-2	4.50-4.95
Medium/stiff, reddish brown, silty clay.		3	4	4				SPT-3	4.95-5.40
								DS-4	6.00
6.50m		12	25	25				SPT-4	6.50-6.95
								*UDS-3	7.50-7.62
		16	28	36				SPT-5	7.62-8.07
								DS-5	8.60
		16	30	35				SPT-6	9.00-9.45
								DS-6	10.00
Hard, reddish brown, silty clay with sand mixture.		18	28	37				SPT-7	10.50-10.95
								DS-7	11.50
		15	25	35				SPT-8	12.00-12.45
								DS-8	13.00
		16	24	35				SPT-9	13.50-13.95
								DS-9	14.50
15.00m		10	12	20				SPT-10	15.00-15.45
								DS-10	16.00
		8	12	22				SPT-11	16.50-16.95
Hard, reddish brown, silty clay. Observed kankar.								DS-11	17.50
		9	15	25				SPT-12	18.00-18.45
								DS-12	19.00
		10	16	26				SPT-13	19.50-19.95
20.10m									

Job No : 4095

Created by : SKD

Created on : 17/12/2018

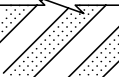
Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.118

Co-ordinates E=1515.874  
N=1298.715

Field Test	Nos	Samples	Nos	Commencement Date : 08/12/2018
Penetrometer (SPT)	31	Undisturbed (UDS)	3	Completion Date : 11/12/2018
Cone (Pc)		Penetrometer (SPT)	31	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	28	Level Of Ground : 909.052 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 5.1 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
Hard, reddish brown, silty clay. Observed kankar.							DS-13	20.50
		11	18	27		45	SPT-14	21.00-21.45
						50	DS-14	22.00
		12	20	30			SPT-15	22.50-22.95
						52	DS-15	23.50
		14	22	30			SPT-16	24.00-24.45
						57	DS-16	25.00
		17	25	32			SPT-17	25.50-25.95
						70	DS-17	26.50
		25	30	40			SPT-18	27.00-27.45
						77	DS-18	28.00
		27	35	42			SPT-19	28.50-28.95
						85	DS-19	29.50
		35	40	45			SPT-20	30.00-30.45
						>100	DS-20	31.00
		45	100				SPT-21	31.50-31.75
		100	4.0 cm	Pentn.			*SPT-22	31.90-31.94
		100	3.0 cm	Pentn. Refusal			*SPT-23	32.00-32.03
		NX rotary drilling from 32.00m to 40.00m					R1	CR=Nil
							DS-21	RQD=Nil
		100					SPT-24	33.00-33.09
		9.0 cm	Pentn.				R2	CR=Nil
							DS-22	RQD=Nil
		100					*SPT-25	34.00-34.05
		5.0 cm	Pentn.				R3	CR=Nil
							DS-23	RQD=Nil
		100					*SPT-26	35.00-35.04
		4.0 cm	Pentn.				R4	CR=Nil
							DS-24	RQD=Nil
		100					SPT-27	36.00-36.15
							R5	CR=Nil
		100					DS-25	RQD=Nil
							*SPT-28	37.00-37.05
		5.0 cm	Pentn.				R6	CR=Nil
							DS-26	RQD=Nil
		100					SPT-29	38.00-38.10
		10.0 cm	Pentn.				R7	CR=Nil
							DS-27	RQD=Nil
		100					*SPT-30	39.00-39.05
		5.0 cm	Pentn.				R8	CR=Nil
							DS-28	RQD=Nil
		100					*SPT-31	40.00-40.04
		1.0 cm	Pentn.					

N.B. - '\*' means sample could not be recovered.

670 of 1127

BH-118/Sheet-2

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO.119

Co-ordinates E=1515.874  
N=1395.754

Field Test	Nos	Samples	Nos	Commencement Date : 02/12/2018
Penetrometer (SPT)	31	Undisturbed (UDS)	2	Completion Date : 07/12/2018
Cone (Pc)		Penetrometer (SPT)	31	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	29	Level Of Ground : 913.37 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.9 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
								DS-2	1.00
								SPT-1	1.50-1.95
Hard, reddish brown, silty clay with moorum & kankar.								DS-3	2.50
								UDS-1	3.00-3.45
								SPT-2	3.45-3.90
								DS-4	4.40
5.00m								SPT-3	5.00-5.45
Hard, reddish brown, silty clay with kankar.								UDS-2	6.00-6.45
								SPT-4	6.45-6.90
								DS-5	7.50
8.00m								SPT-5	8.00-8.45
								DS-6	9.00
								SPT-6	9.50-9.95
Very stiff, reddish brown, silty clay. Observed sand mixture.								DS-7	10.50
								SPT-7	11.00-11.45
								DS-8	12.00
								SPT-8	12.50-12.95
								DS-9	13.50
14.00m								SPT-9	14.00-14.45
								DS-10	15.00
								SPT-10	15.50-15.95
								DS-11	16.50
Hard, reddish brown, silty clay. Observed sand mixture.								SPT-11	17.00-17.45
								DS-12	18.00
								SPT-12	18.50-18.95
								DS-13	19.50
20.10m									

671 of 1127

BH-119/Sheet-1

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.119

Co-ordinates E=1515.874  
N=1395.754

Field Test	Nos	Samples	Nos	Commencement Date : 02/12/2018
Penetrometer (SPT)	31	Undisturbed (UDS)	2	Completion Date : 07/12/2018
Cone (Pc)		Penetrometer (SPT)	31	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	29	Level Of Ground : 913.37 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.9 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH	DIVN.	= 15cm			Ref. No	Depth (m)
20.10m Hard, reddish brown, silty clay. Observed sand mixture.		12	20	31	51		SPT-13	20.00-20.45
21.00m					57		DS-14	21.00
		13	22	35			SPT-14	21.50-21.95
					54		DS-15	22.50
		13	19	35			SPT-15	23.00-23.45
					64		DS-16	24.00
		16	24	40			SPT-16	24.50-24.95
Hard, brownish grey, silty clay. Observed sand mixture.					57		DS-17	25.50
		19	25	32			SPT-17	26.00-26.45
					54		DS-18	27.00
		20	22	32			SPT-18	27.50-27.95
					70		DS-19	28.50
		24	30	40			SPT-19	29.00-29.45
					>100		DS-20	30.00
30.00m Hard, brownish grey, silty clay with decomposed rock.		30	35	50	5.0 cm Pentn. Refusal		SPT-20	30.50-30.85
31.10m		100	4.0 cm		Pentn. Refusal		*SPT-21	31.00-31.04
		100	3.0 cm		Pentn. Refusal		*SPT-22	31.10-31.13
		NX rotary drilling from 31.10m to 40.00m					R1	CR=Nil
		100			Refusal		DS-21	RQD=Nil
		100	4.0 cm		Pentn. Refusal		*SPT-23	32.10-32.14
					Refusal		R2	CR=Nil
		100			Refusal		DS-22	RQD=Nil
					Refusal		*SPT-24	33.10-33.15
					Refusal		R3	CR=Nil
		100	5.0 cm		Pentn. Refusal		DS-23	RQD=Nil
					Refusal		*SPT-25	34.10-34.14
					Refusal		R4	CR=Nil
		100	4.0 cm		Pentn. Refusal		DS-24	RQD=Nil
					Refusal		*SPT-26	35.10-35.15
					Refusal		R5	CR=Nil
		100	5.0 cm		Pentn. Refusal		DS-25	RQD=Nil
					Refusal		*SPT-27	36.10-36.14
					Refusal		R6	CR=Nil
		100	4.0 cm		Pentn. Refusal		DS-26	RQD=Nil
					Refusal		*SPT-28	37.10-37.13
					Refusal		R7	CR=Nil
		100	3.0 cm		Pentn. Refusal		DS-27	RQD=Nil
					Refusal		*SPT-29	38.10-38.14
					Refusal		R8	CR=Nil
		100	4.0 cm		Pentn. Refusal		DS-28	RQD=Nil
					Refusal		*SPT-30	39.10-39.15
					Refusal		R9	CR=Nil
		100	5.0 cm		Pentn. Refusal		DS-29	RQD=Nil
					Refusal		*SPT-31	40.00-40.04
		100	4.0 cm		Pentn.			40.00

N.B. - '\*' means sample could not be recovered.

672 of 1127

Job No : 4095

Created by : SKD

Created on : 29/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.120

Co-ordinates E=1515.874  
N=1503.647

Field Test	Nos	Samples	Nos	Commencement Date : 29/11/2018
Penetrometer (SPT)	31	Undisturbed (UDS)	2	Completion Date : 04/12/2018
Cone (Pc)		Penetrometer (SPT)	31	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	29	Level Of Ground : 917.07 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 4.7 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m Reddish brown, silty clay / clayey silt.									DS-1	0.50
									DS-2	1.00
1.50m Very stiff, brownish grey, silty clay. Observed sand mixture.		7	9	11					SPT-1	1.50-1.95
									UDS-1	2.40-2.85
2.85m		11	16	22					SPT-2	2.85-3.30
									DS-3	3.80
		10	16	24					SPT-3	4.25-4.70
									DS-4	5.00
		11	19	26					*UDS-2	5.50-5.58
									SPT-4	5.60-6.05
									DS-5	6.50
		13	22	30					SPT-5	7.00-7.45
									DS-6	8.00
		15	26	33					SPT-6	8.50-8.95
9.50m									DS-7	9.50
		18	29	37					SPT-7	11.00-11.45
									DS-8	12.00
		21	35	39					SPT-8	12.50-12.95
									DS-9	13.50
		19	27	39					SPT-9	14.00-14.45
									DS-10	15.00
		20	30	42					SPT-10	15.50-15.95
									DS-11	16.50
		22	32	44					SPT-11	17.00-17.45
									DS-12	18.00
		20	30	44					SPT-12	18.50-18.95
									DS-13	19.50
20.30m									SPT-13	20.00-20.45



Job No : 4095

Created by : SKD

Created on : 29/12/2018

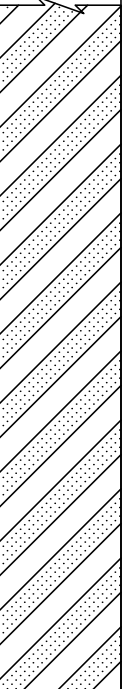
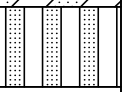
Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.120

Co-ordinates E=1515.874  
N=1503.647

Field Test	Nos	Samples	Nos	Commencement Date : 29/11/2018
Penetrometer (SPT)	31	Undisturbed (UDS)	2	Completion Date : 04/12/2018
Cone (Pc)		Penetrometer (SPT)	31	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	29	Level Of Ground : 917.07 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 4.7 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
20.30m		25	35	45	80	DS-14	21.00
						SPT-14	21.50-21.95
		25	34	45	79	DS-15	22.50
						SPT-15	23.00-23.45
		24	30	45	75	DS-16	24.00
						SPT-16	24.50-24.95
		22	37	50	87	DS-17	25.50
						SPT-17	26.00-26.45
		25	40	45	85	DS-18	27.00
						SPT-18	27.50-27.95
		40	100		>100	DS-19	28.50
						SPT-19	29.00-29.25
Very dense, brownish grey, silty sand / sandy silt. Observed decomposed rock.		100	4.0	cm	Pentn. Refusal	*SPT-20	29.80-29.84
30.00m		100	3.0	cm	Pentn. Refusal	*SPT-21	30.00-30.03 30.00
		100			Refusal	R1	CR=Nil
		100	5.0	cm	Pentn. >100	DS-20	RQD=Nil
		100	10.0	cm	Pentn.	*SPT-22	31.00-31.05 31.00
		100			Refusal	R2	CR=Nil
		100	4.0	cm	Pentn.	DS-21	RQD=Nil
		100	5.0	cm	Pentn.	SPT-23	32.00-32.10 32.00
		100	4.0	cm	Pentn.	R3	CR=Nil
		100			Refusal	DS-22	RQD=Nil
		100	5.0	cm	Pentn.	*SPT-24	33.00-33.05 33.00
		100	4.0	cm	Pentn.	R4	CR=Nil
		100			Refusal	DS-23	RQD=Nil
		100	5.0	cm	Pentn.	*SPT-25	34.00-34.04 34.00
		100			Refusal	R5	CR=Nil
		100	5.0	cm	Pentn.	DS-24	RQD=Nil
		100			Refusal	SPT-26	35.00-35.15 35.00
		100	9.0	cm	Pentn.	R6	CR=Nil
		100			Refusal	DS-25	RQD=Nil
		100	5.0	cm	Pentn.	*SPT-27	36.00-36.09 36.00
		100			Refusal	R7	CR=Nil
		100	5.0	cm	Pentn.	DS-26	RQD=Nil
		100			Refusal	*SPT-28	37.00-37.05 37.00
		100	4.0	cm	Pentn.	R8	CR=Nil
		100			Refusal	DS-27	RQD=Nil
		100	3.0	cm	Pentn.	*SPT-29	38.00-38.04 38.00
		100			Refusal	R9	CR=Nil
		100	4.0	cm	Pentn.	DS-28	RQD=Nil
		100			Refusal	*SPT-30	39.00-39.03 39.00
		100	4.0	cm	Pentn.	R10	CR=Nil
		100			Refusal	DS-29	RQD=Nil
		100	4.0	cm	Pentn.	*SPT-31	40.00-40.04 40.00

N.B. - '\*' means sample could not be recovered.

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.121

Co-ordinates E=1515.874  
N=1565.710

Field Test	Nos	Samples	Nos	Commencement Date : 06/12/2018
Penetrometer (SPT)	32	Undisturbed (UDS)	3	Completion Date : 08/12/2018
Cone (Pc)		Penetrometer (SPT)	32	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	27	Level Of Ground : 919.318 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 4.2 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m Reddish brown, silty clay. Observed sand mixture.								DS-1	0.50
								DS-2	1.00
1.50m		6	9	9				SPT-1	1.50-1.95
								UDS-1	2.50-2.95
		7	10	10				SPT-2	2.95-3.40
								DS-3	4.00
		10	11	19				SPT-3	4.50-4.95
								*UDS-2	4.95-5.40
6.00m		10	12	21				SPT-4	6.00-6.45
								DS-4	7.00
		11	15	20				SPT-5	7.50-7.95
		13	17	24				*UDS-3	8.50-8.60
								SPT-6	8.60-9.05
		14	19	22				DS-5	9.50
		15	20	24				SPT-7	10.00-10.45
								DS-6	11.00
		15	22	26				SPT-8	11.50-11.95
								DS-7	12.50
		16	24	25				SPT-9	13.00-13.45
								DS-8	14.00
15.00m								SPT-10	14.50-14.95
								DS-9	15.50
		18	26	29				SPT-11	16.00-16.45
								DS-10	17.00
		20	28	32				SPT-12	17.50-17.95
								DS-11	18.50
		22	30	35				SPT-13	19.00-19.45
20.10m								DS-12	20.00

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.121

Co-ordinates E=1515.874  
N=1565.710

Field Test	Nos	Samples	Nos	Commencement Date : 06/12/2018
Penetrometer (SPT)	32	Undisturbed (UDS)	3	Completion Date : 08/12/2018
Cone (Pc)		Penetrometer (SPT)	32	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	27	Level Of Ground : 919.318 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 4.2 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
20.10m		22	32	35	67	SPT-14	20.50-20.95
					60	DS-13	21.50
		20	25	35		SPT-15	22.00-22.45
					70	DS-14	23.00
		24	30	40		SPT-16	23.50-23.95
					77	DS-15	24.50
		25	32	45		SPT-17	25.00-25.45
					81	DS-16	26.00
		25	34	47		SPT-18	26.50-26.95
					85	DS-17	27.50
		28	35	50		SPT-19	28.00-28.45
					92	DS-18	29.00
29.50m		30	40	52		SPT-20	29.50-29.95
		40	45	50	>100	SPT-21	30.30-30.65
				5.0 cm Pentn.	>100	SPT-22	31.00-31.15
31.50m		100					
		100	4.0 cm Pentn.	Refusal		*SPT-23	31.50-31.54 31.50
						R1	CR=Nil
		100			>100	DS-19	RQD=Nil
		100	14.0 cm Pentn.			SPT-24	32.50-32.64 32.50
						R2	CR=Nil
		100			Refusal	DS-20	RQD=Nil
			5.0 cm Pentn.			*SPT-25	33.50-33.55 33.50
						R3	CR=Nil
		100			Refusal	DS-21	RQD=Nil
			4.0 cm Pentn.			*SPT-26	34.50-34.54 34.50
						R4	CR=Nil
		100			>100	DS-22	RQD=Nil
			10.0 cm Pentn.			SPT-27	35.50-35.60 35.50
						R5	CR=Nil
		100			Refusal	DS-23	RQD=Nil
			5.0 cm Pentn.			*SPT-28	36.50-36.55 36.50
						R6	CR=Nil
		100			>100	DS-24	RQD=Nil
			NX rotary drilling from			SPT-29	37.50-37.65 37.50
			31.50m to 40.00m			R7	CR=Nil
		100			Refusal	DS-25	RQD=Nil
			5.0 cm Pentn.			*SPT-30	38.50-38.55 38.50
						R8	CR=Nil
		100			Refusal	DS-26	RQD=Nil
			6.0 cm Pentn.			*SPT-31	39.50-39.56 39.50
						R9/DS-27	CR=0/RQD=0
		100	4.0 cm Pentn.		Refusal	*SPT-32	40.00-40.04 40.00

N.B. - '\*' means sample could not be recovered.

676 of 1127

## BORE LOG DATA SHEET

## BORE HOLE NO.122

Co-ordinates	E=1033.751 N=1416.709
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Field Test	Nos	Samples	Nos	Commencement Date :	24/11/2018
Penetrometer (SPT)	3	Undisturbed (UDS)	1	Completion Date :	27/11/2018
Cone (Pc)		Penetrometer (SPT)	3	Bore Hole Diameter :	150mm / NX.
		Disturbed (DS)	2	Level Of Ground :	901.03 m.
Vane (V)		Water Sample (WS)	0	Water Struck At :	
				Standing Water Level :	3.10 m.

[illegible]

Job No : 4095

Created by : SKD

Created on : 03/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.123

Co-ordinates E=992.260  
N=1415.962

Field Test	Nos	Samples	Nos	Commencement Date : 25/11/2018
Penetrometer (SPT)	11	Undisturbed (UDS)	3	Completion Date : 27/11/2018
Cone (Pc)		Penetrometer (SPT)	11	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	15	Level Of Ground : 901.184 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.00 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Stiff / very stiff, reddish brown, silty clay. Observed kankar.								DS-1	0.50
								DS-2	1.00
								UDS-1	1.50-1.95
		7	9	11			20	SPT-1	1.95-2.40
								DS-3	3.00
		4	6	5			11	SPT-2	3.50-3.95
								*UDS-2	4.50-4.95
		5	8	10			18	SPT-3	5.05-5.50
								DS-4	6.00
		4	7	11			18	SPT-4	6.50-6.95
Very stiff, brownish grey to whitish grey, silty clay. Observed sand mixture.								UDS-3	7.50-7.95
		7	12	14			26	SPT-5	7.95-8.40
								DS-5	9.00
9.50m		6	19	18			37	SPT-6	9.50-9.95
								DS-6	10.50
		9	20	35			55	SPT-7	11.00-11.45
								DS-7	12.00
12.10m									

678 of 1127

Job No : 4095

Created by : SKD

Created on : 03/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.123

Co-ordinates E=992.260  
N=1415.962

Field Test	Nos	Samples	Nos	Commencement Date : 25/11/2018
Penetrometer (SPT)	11	Undisturbed (UDS)	3	Completion Date : 27/11/2018
Cone (Pc)		Penetrometer (SPT)	11	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	15	Level Of Ground : 901.184 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 3.00 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
Hard, brownish grey to whitish grey, silty clay. Observed sand mixture. 12.10m to 12.50m		17	35	40	75			SPT-8	12.50-12.95
Very dense, brownish grey, silty sand with mica. Observed decomposed rock.		19	38	48	86			DS-8	13.50
		100			Refusal			SPT-9	14.00-14.45
		5.0 cm			Pentn.			*SPT-10	14.70-14.75
		100			Refusal			*SPT-11	15.00-15.04 15.00
		4.0 cm			Pentn.			R1	CR=32% RQD=10% ↓
		NX rotary drilling from 15.00m to 22.00m							16.00
Highly weathered, whitish grey, fine grained, moderately fractured rock.								R2	CR=38% RQD=20% ↓
									17.00
								R3	CR=40% RQD=30% ↓
									18.00
								R4	CR=54% RQD=40% ↓
									19.00
								R5	CR=100% RQD=92% ↓
									20.00
								R6	CR=100% RQD=90% ↓
									21.00
								R7	CR=100% RQD=93% ↓
									22.00

N.B. - '\*' means sample could not be recovered.

Job No : 4095

Created by : SKD

Created on : 29/12/2018


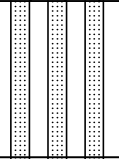
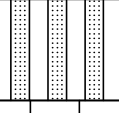
Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.124

Co-ordinates E=993.474  
N=1533.989

Field Test	Nos	Samples	Nos	Commencement Date : 28/11/2018
Penetrometer (SPT)	4	Undisturbed (UDS)	2	Completion Date : 30/11/2018
Cone (Pc)		Penetrometer (SPT)	4	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	3	Level Of Ground : 900.31 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.1 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m Brownish grey, silty clay. Observed sand mixture.								DS-1	0.50
								DS-2	1.00
1.95m Medium dense, light grey, silty sand with clay binder. Observed decomposed rock.		4	7	9		16		UDS-1	1.50-1.95
								SPT-1	1.95-2.40
3.50m Dense, light grey, silty sand with clay binder. Observed decomposed rock.						32		DS-3	3.00
		13	14	18				SPT-2	3.50-3.95
4.50m		100				Refusal		UDS-2	4.20-4.40
		4.0 cm				Pentn.		*SPT-3	4.40-4.44
						Refusal		*SPT-4	4.50-4.53
		100							4.50
		3.0 cm				Pentn.		R1	CR=35% RQD=Nil
									↓
									5.50
								R2	CR=40% RQD=Nil
									↓
									6.50
								R3	CR=48% RQD=35%
									↓
									7.50
								R4	CR=50% RQD=40%
									↓
									8.50
8.50m								R5	CR=79% RQD=48%
									↓
									9.50
								R6	CR=100% RQD=92%
									↓
									10.50
								R7	CR=100% RQD=93%
									↓
									11.50
								R8	CR=100% RQD=92%
									↓
									12.50
12.50m									

N.B. - '\*' means sample could not be recovered.

680 of 1127

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.125

Co-ordinates E=562.083  
N=389.723

Field Test	Nos	Samples	Nos	Commencement Date : 08/12/2018
Penetrometer (SPT)	36	Undisturbed (UDS)	1	Completion Date : 10/12/2018
Cone (Pc)		Penetrometer (SPT)	36	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	34	Level Of Ground : 898.29 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 6.8 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m							DS-1	0.50
Stiff, reddish brown, silty clay. Observed kankar & steel grey patches.		4	6	7	13		DS-2	1.00
							SPT-1	1.50-1.95
							DS-3	2.50
							UDS-1	3.00-3.45
3.45m		14	23	28	51		SPT-2	3.45-3.90
Hard, yellowish brown, silty clay / clayey silt. Observed sand mixture.		12	25	29	54		DS-4	4.50
							SPT-3	5.00-5.45
							DS-5	6.00
							SPT-4	6.50-6.95
6.00m		18	30	39	69		DS-6	7.50
Hard, brownish grey, clayey silt / silty clay. Observed decomposed rock.		31	42	55	97		SPT-5	8.00-8.45
							DS-7	9.00
							SPT-6	9.50-9.95
							DS-8	10.50
							SPT-7	11.00-11.45
							DS-9	12.00
							SPT-8	12.50-12.95
							DS-10	13.50
							SPT-9	14.00-14.45
							DS-11	15.00
14.80m		100	12.0	cm	Pentn.		SPT-10	15.30-15.42
Very dense, light grey, silty sand with decomposed rock.		100	4.0	cm	Pentn. Refusal		*SPT-11	15.50-15.54 15.50
15.50m		NX rotary drilling from 15.50m to 40.00m					R1	CR=12% RQD=Nil
		100	2.0	cm	Pentn. Refusal		*SPT-12	16.50-16.52 16.50
							R2	CR=Nil
							DS-12	RQD=Nil
							*SPT-13	17.50-17.53 17.50
							R3	CR=Nil
							DS-13	RQD=Nil
							*SPT-14	18.50-18.52 18.50
							R4	CR=Nil
							DS-14	RQD=Nil
							*SPT-15	19.50-19.52 19.50
		100	2.0	cm	Pentn.		R5	CR=Nil
							DS-15	RQD=Nil
20.10m								



Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.125

Co-ordinates E=562.083  
N=389.723

Field Test	Nos	Samples	Nos	Commencement Date : 08/12/2018
Penetrometer (SPT)	36	Undisturbed (UDS)	1	Completion Date : 10/12/2018
Cone (Pc)		Penetrometer (SPT)	36	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	34	Level Of Ground : 898.29 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 6.8 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
20.10m  Completely weathered, light grey to yellowish brown, medium grained, decomposed & disintegrated rock particles collected as sludge. N.B. - '*' means sample could not be recovered. 40.00m		100	Refusa.			*SPT-16	20.50-20.54 20.50
		4.0	cm Pentn.			R6	CR=Nil
						DS-16	RQD=Nil
		100	Refusa.			*SPT-17	21.50-21.52 21.50
		2.0	cm Pentn.			R7	CR=Nil
						DS-17	RQD=Nil
		100	Refusa.			*SPT-18	22.50-22.51 22.50
		1.0	cm Pentn.			R8	CR=15%
						DS-18	RQD=Nil
		100	Refusa.			*SPT-19	23.50-23.51 23.50
		1.0	cm Pentn.			R9	CR=Nil
						DS-19	RQD=Nil
		100	Refusa.			*SPT-20	24.50-24.52 24.50
		2.0	cm Pentn.			R10	CR=Nil
						DS-20	RQD=Nil
		100	Refusa.			*SPT-21	25.50-25.54 25.50
		4.0	cm Pentn.			R11	CR=Nil
						DS-21	RQD=Nil
		100	Refusa.			*SPT-22	26.50-26.52 26.50
		2.0	cm Pentn.			R12	CR=Nil
						DS-22	RQD=Nil
		100	Refusa.			*SPT-23	27.50-27.51 27.50
		1.0	cm Pentn.			R13	CR=Nil
						DS-23	RQD=Nil
		100	Refusa.			*SPT-24	28.50-28.53 28.50
		3.0	cm Pentn.			R14	CR=Nil
						DS-24	RQD=Nil
		100	Refusa.			*SPT-25	29.50-29.52 29.50
		2.0	cm Pentn.			R15	CR=Nil
						DS-25	RQD=Nil
		100	Refusa.			*SPT-26	30.50-30.53 30.50
		3.0	cm Pentn.			R16	CR=Nil
						DS-26	RQD=Nil
		100	Refusa.			*SPT-27	31.50-31.52 31.50
		2.0	cm Pentn.			R17	CR=Nil
						DS-27	RQD=Nil
		100	Refusa.			*SPT-28	32.50-32.54 32.50
		4.0	cm Pentn.			R18	CR=Nil
						DS-28	RQD=Nil
		100	Refusa.			*SPT-29	33.50-33.52 33.50
		2.0	cm Pentn.			R19	CR=Nil
						DS-29	RQD=Nil
		100	Refusa.			*SPT-30	34.50-34.53 34.50
		3.0	cm Pentn.			R20	CR=Nil
						DS-30	RQD=Nil
		100	Refusa.			*SPT-31	35.50-35.53 35.50
		3.0	cm Pentn.			R21	CR=Nil
						DS-31	RQD=Nil
		100	Refusa.			*SPT-32	36.50-36.53 36.50
		3.0	cm Pentn.			R22	CR=Nil
						DS-32	RQD=Nil
		100	Refusa.			*SPT-33	37.50-37.52 37.50
		2.0	cm Pentn.			R23	CR=Nil
						DS-33	RQD=Nil
		100	Refusa.			*SPT-34	38.50-38.54 38.50
		4.0	cm Pentn.			R24	CR=Nil
						DS-34	RQD=Nil
		100	Refusa.			*SPT-35	39.50-39.53 39.50
		3.0	cm Pentn.			R25/DS-34	CR=0/RQD=0
		100	Refusa.			*SPT-36	40.00-40.02 40.00

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.127

Co-ordinates E=450.301  
N=784.538

Field Test	Nos	Samples	Nos	Commencement Date : 03/12/2018
Penetrometer (SPT)	30	Undisturbed (UDS)	1	Completion Date : 07/12/2018
Cone (Pc)		Penetrometer (SPT)	30	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	29	Level Of Ground : 903.984 m.
		Water Sample (WS)	1	Water Struck At : Standing Water Level : 11.7 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
Stiff, reddish brown, silty clay. Observed moorum.		4	7	8				DS-2	1.00
								SPT-1	1.50-1.95
								DS-3	2.50
3.10m		12	30	31				*UDS-1	3.00-3.10
Hard, reddish brown, silty clay. Observed moorum.		14	22	34				SPT-2	3.10-3.55
								DS-4	4.00
								SPT-3	4.50-4.95
6.00m		10	13	18				DS-5	5.50
Hard, reddish brown, silty clay.		13	17	20				SPT-4	6.00-6.45
								DS-6	7.00
								SPT-5	7.50-7.95
9.00m		18	21	33				DS-7	8.50
Hard, reddish brown, silty clay. Observed moorum & sand mixture.		16	23	35				SPT-6	9.00-9.45
								DS-8	10.00
								SPT-7	10.50-10.95
		14	25	38				DS-9	11.50
		17	23	35				WS-1	11.70
								SPT-8	12.00-12.45
								DS-10	13.00
		23	28	39				SPT-9	13.50-13.95
		27	32	44				DS-11	14.50
								SPT-10	15.00-15.45
								DS-12	16.00
		30	35	46				SPT-11	16.50-16.95
		23	37	40				DS-13	17.50
								SPT-12	18.00-18.45
								DS-14	19.00
20.10m		23	37	40				SPT-13	19.50-19.95

Job No : 4095

Created by : SKD

Created on : 17/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.127

Co-ordinates E=450.301  
N=784.538

Field Test	Nos	Samples	Nos	Commencement Date : 03/12/2018
Penetrometer (SPT)	30	Undisturbed (UDS)	1	Completion Date : 07/12/2018
Cone (Pc)		Penetrometer (SPT)	30	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	29	Level Of Ground : 903.984 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 11.7 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
20.10m						DS-15	20.50
		25	40	45	85	SPT-14	21.00-21.45
						DS-16	22.00
		28	43	47	90	SPT-15	22.50-22.95
Hard, reddish brown, silty clay. Observed moorum & sand mixture.						DS-17	23.50
		30	40	45	85	SPT-16	24.00-24.45
						DS-18	25.00
		34	47	59	>100	SPT-17	25.50-25.95
26.50m						DS-19	26.50
		28	42	54	96	SPT-18	27.00-27.45
Hard, steel grey, silty clay with sand mixture. Observed moorum & kankar.						DS-20	28.00
		25	37	58	95	SPT-19	28.50-28.95
						DS-21	29.50
30.00m						SPT-20	30.00-30.45
		39	42	63	>100	DS-22	31.00
Hard, yellowish brown, silty clay / clayey silt with decomposed rock.						SPT-21	31.50-31.95
		42	45	65	>100	DS-23	32.50
						SPT-22	33.00-33.45
33.50m		35	42	60	>100	DS-24	34.00
Hard, whitish grey, silty clay / clayey silt with decomposed rock.		58	100		>100	SPT-23	34.50-34.75
		100	10.0 cm	Pentn.		*SPT-24	34.85-34.89
35.00m		100	4.0 cm	Pentn. Refusal		*SPT-25	35.00-35.02 35.00
		100	2.0 cm	Pentn. Refusal		R1	CR=Nil
						DS-25	RQD=Nil
						SPT-26	36.00-36.10 36.00
		100	10.0 cm	Pentn.		R2	CR=Nil
		100	10.0 cm	Pentn.		DS-26	RQD=Nil
		100	8.0 cm	Pentn.		SPT-27	37.00-37.08 37.00
Completely weathered, whitish grey, medium grained, decomposed & disintegrated rock particles collected as sludge.		100	10.0 cm	Pentn.		R3	CR=Nil
		100	10.0 cm	Pentn.		DS-27	RQD=Nil
		100	10.0 cm	Pentn.		SPT-28	38.00-38.10 38.00
		100	8.0 cm	Pentn.		R4	CR=Nil
		100	10.0 cm	Pentn.		DS-28	RQD=Nil
		100	8.0 cm	Pentn.		SPT-29	39.00-39.08 39.00
		100	10.0 cm	Pentn.		R5	CR=Nil
N.B. - '*' means sample could not be recovered.						DS-29	RQD=Nil
40.00m						SPT-30	40.00-40.07 40.00

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 29/12/2018

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.128**Co-ordinates E=591.896  
N=1243.994

Field Test	Nos	Samples	Nos	Commencement Date : 26/11/2018
Penetrometer (SPT)	35	Undisturbed (UDS)	2	Completion Date : 30/11/2018
Cone (Pc)		Penetrometer (SPT)	35	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	27	Level Of Ground : 904.687 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.80 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Stiff, reddish brown, silty clay. Observed kankar.								DS-1	0.50
								DS-2	1.00
		3	5	9			14	SPT-1	1.50-1.95
2.50m									
								UDS-1	2.50-2.95
		10	14	20			34	SPT-2	2.95-3.40
Hard, reddish brown, silty clay. Observed moorum mixture.								DS-3	4.00
		8	15	22			37	SPT-3	4.50-4.95
5.70m									
		17	23	35			58	UDS-2	5.50-5.70
								SPT-4	5.70-6.15
								DS-4	6.80
		15	26	28			54	SPT-5	7.00-7.45
Hard, reddish brown, silty clay. Observed moorum, kankar & light grey spots.								DS-5	8.00
		18	30	38			68	SPT-6	8.50-8.95
								DS-6	9.50
		18	33	40			73	SPT-7	10.00-10.45
11.00m								DS-7	11.00
		20	37	42			79	SPT-8	11.50-11.95
								DS-8	12.50
		18	35	38			73	SPT-9	13.00-13.45
								DS-9	14.00
		21	37	40			77	SPT-10	14.50-14.95
Hard, brownish grey to whitish grey, silty clay. Observed traces of sand mixture.								DS-10	15.50
		23	42	43			85	SPT-11	16.00-16.45
								DS-11	17.00
		29	45	48			93	SPT-12	17.50-17.95
								DS-12	18.50
		37	62	100			>100		
19.00m								SPT-13	19.00-19.35
Very dense, brownish grey, silty sand with decomposed rock.								*SPT-14	19.80-19.84
20.00m		100	4.0	cm	Pentn.	Refusal		*SPT-15	20.00-20.02
20.10m		100	2.0	cm	Pentn.	Refusal			20.00

Job No : 4095

Created by : SKD

Created on : 29/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.128

Co-ordinates E=591.896  
N=1243.994

Field Test	Nos	Samples	Nos	Commencement Date : 26/11/2018
Penetrometer (SPT)	35	Undisturbed (UDS)	2	Completion Date : 30/11/2018
Cone (Pc)		Penetrometer (SPT)	35	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	27	Level Of Ground : 904.687 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.80 m.

DESCRIPTION	SYMBOL	N-VALUE		SAMPLES	
		EACH DIVN. = 15cm		Ref. No	Depth (m)
20.10m  Completely weathered, reddish brown, medium grained, highly fractured rock.		NX rotary drilling from 20.00m to 40.00m		R1	CR=8% RQD=Nil
		100 Refusa.		*SPT-16	21.00-21.02 21.00
		2.0 cm Pentn.		R2	CR=10% RQD=Nil
		100 Refusa.		*SPT-17	22.00-22.01 22.00
		1.0 cm Pentn.		R3	CR=8% RQD=Nil
		100 Refusa.		*SPT-18	23.00-23.04 23.00
		4.0 cm Pentn.		R4	CR=11% RQD=Nil
		100 Refusa.		*SPT-19	24.00-24.03 24.00
		3.0 cm Pentn.		R5	CR=15% RQD=Nil
		100 Refusa.		*SPT-20	25.00-25.02 25.00
25.00m  Completely weathered, reddish brown, medium grained, decomposed & disintegrated rock particles collected as sludge.		2.0 cm Pentn.		R6	CR=Nil RQD=Nil
		43100 >100		DS-13	RQD=Nil
		5.0 cm Pentn.		SPT-21	26.00-26.20 26.00
		57100 >100		R7	CR=Nil RQD=Nil
		8.0 cm Pentn.		DS-14	RQD=Nil
		49100 >100		SPT-22	27.00-27.23 27.00
		5.0 cm Pentn.		R8	CR=Nil RQD=Nil
		100 >100		DS-15	RQD=Nil
		14.0 cm Pentn.		SPT-23	28.00-28.20 28.00
		100 >100		R9	CR=Nil RQD=Nil
		12.0 cm Pentn.		DS-16	RQD=Nil
		100 >100		SPT-24	29.00-29.14 29.00
		10.0 cm Pentn.		DS-17	RQD=Nil
		62100 >100		SPT-25	30.00-30.12 30.00
		4.0 cm Pentn.		R11	CR=18% RQD=Nil
		100 >100		DS-18	RQD=Nil
		12.0 cm Pentn.		SPT-26	31.00-31.10 31.00
		100 >100		R12	CR=Nil RQD=Nil
		14.0 cm Pentn.		DS-19	RQD=Nil
		100 >100		SPT-27	32.00-32.19 32.00
		10.0 cm Pentn.		R13	CR=Nil RQD=Nil
		100 >100		DS-20	RQD=Nil
		13.0 cm Pentn.		SPT-28	33.00-33.12 33.00
		100 Refusa.		R14	CR=Nil RQD=Nil
		4.0 cm Pentn.		DS-21	RQD=Nil
		100 Refusa.		SPT-29	34.00-34.14 34.00
		3.0 cm Pentn.		R15	CR=Nil RQD=Nil
		100 Refusa.		DS-22	RQD=Nil
		4.0 cm Pentn.		SPT-30	35.00-35.10 35.00
		100 Refusa.		R16	CR=Nil RQD=Nil
		3.0 cm Pentn.		DS-23	RQD=Nil
		100 Refusa.		SPT-31	36.00-36.13 36.00
		4.0 cm Pentn.		R17	CR=Nil RQD=Nil
		100 Refusa.		DS-24	RQD=Nil
		3.0 cm Pentn.		*SPT-32	37.00-37.04 37.00
		100 Refusa.		R18	CR=Nil RQD=Nil
		4.0 cm Pentn.		DS-25	RQD=Nil
		100 Refusa.		*SPT-33	38.00-38.03 38.00
		3.0 cm Pentn.		R19	CR=Nil RQD=Nil
		100 Refusa.		DS-26	RQD=Nil
		4.0 cm Pentn.		*SPT-34	39.00-39.04 39.00
		100 Refusa.		R20	CR=Nil RQD=Nil
		3.0 cm Pentn.		DS-27	RQD=Nil
		100 Refusa.		*SPT-35	40.00-40.03 40.00

N.B. - '\*' means sample could not be recovered.

686 of 1127

BH-128/Sheet-2

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 26/12/2018

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.129**Co-ordinates E=7121.701  
N=1665.405

Field Test	Nos	Samples	Nos	Commencement Date : 19/12/2018
Penetrometer (SPT)	24	Undisturbed (UDS)	1	Completion Date : 22/12/2018
Cone (Pc)		Penetrometer (SPT)	24	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	22	Level Of Ground : 911.194 m.
		Water Sample (WS)	1	Water Struck At : Standing Water Level : 7.2 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m										
Stiff, reddish brown, silty clay. Observed moorum & kankar.									DS-1	0.50
									DS-2	1.00
		4	5	6			11		SPT-1	1.50-1.95
									DS-3	2.50
3.00m										
Hard, reddish brown, silty clay. Observed moorum & kankar.									UDS-1	3.00-3.45
		12	19	21			40		SPT-2	3.45-3.90
									DS-4	4.50
		10	22	29			51		SPT-3	5.00-5.45
6.50m										
Very dense, brownish grey, silty sand. Observed clay binder.									DS-5	6.00
		11	22	30			52		SPT-4	6.50-6.95
									WS-1	7.20
									DS-6	7.50
11.00m										
Very dense, brownish grey, silty sand. Observed kankar.										
		12	21	33			54		SPT-5	8.00-8.45
									DS-7	9.00
18.60m										
		13	24	35			59		SPT-6	9.50-9.95
									DS-8	10.50
		14	25	37			62		SPT-7	11.00-11.45
									DS-9	12.00
		16	27	40			67		SPT-8	12.50-12.95
									DS-10	13.50
		18	30	39			69		SPT-9	14.00-14.45
									DS-11	15.00
		20	33	42			75		SPT-10	15.50-15.95
									DS-12	16.50
		25	35	45			80		SPT-11	17.00-17.45
									DS-13	18.00
18.60m										

687 of 1127

BH-129/Sheet-1

Job No : 4095

Created by : SKD

Created on : 26/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.129

Co-ordinates E=7121.701  
N=1665.405

Field Test	Nos	Samples	Nos	Commencement Date : 19/12/2018
Penetrometer (SPT)	24	Undisturbed (UDS)	1	Completion Date : 22/12/2018
Cone (Pc)		Penetrometer (SPT)	24	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	22	Level Of Ground : 911.194 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 7.2 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
18.60m		28	35	45	80	SPT-12	18.50-18.95
					85	DS-14	19.50
		25	37	48	85	SPT-13	20.00-20.45
					90	DS-15	21.00
		27	40	50	90	SPT-14	21.50-21.95
Very dense, brownish grey, silty sand. Observed kankar.					85	DS-16	22.50
		29	35	50	85	SPT-15	23.00-23.45
					100	DS-17	24.00
		35	40	60	100	SPT-16	24.50-24.95
					≥100	DS-18	25.50
26.00m		40	55	100	5.0 cm Pentn.	SPT-17	26.00-26.35
Very dense, brownish grey, silty sand with decomposed rock.		100	5.0 cm Pentn.	Refusal		*SPT-18	26.80-26.85
27.00m		100	3.0 cm Pentn.	Refusal		*SPT-19	27.00-27.03 27.00
						R1	CR=Nil
						DS-19	RQD=Nil
		100			Refusal	*SPT-20	28.00-28.04 28.00
Completely weathered, light to yellowish grey, medium grained, decomposed & disintegrated rock particles collected as sludge.			4.0 cm Pentn.			R2	CR=Nil
		100			Refusal	DS-20	RQD=Nil
			5.0 cm Pentn.			*SPT-21	29.00-29.05 29.00
						R3	CR=Nil
		100			Refusal	DS-21	RQD=Nil
			5.0 cm Pentn.			*SPT-22	30.00-30.05 30.00
						R4	CR=Nil
						DS-22	RQD=Nil
31.00m		100			Refusal	*SPT-23	31.00-31.04 31.00
			4.0 cm Pentn.			R5	CR=10%
							RQD=Nil
Completely to highly weathered, whitish grey, fine grained, highly fractured rock.		100			Refusal	*SPT-24	32.00-32.03 32.00
			3.0 cm Pentn.			R6	CR=27%
							RQD=Nil
			NX rotary drilling from 27.00m to 37.00m				33.00
						R7	CR=24%
							RQD=Nil
34.00m						R8	CR=100%
							RQD=92%
						R9	CR=100%
							RQD=94%
Fresh, whitish grey, fine grained, moderately fractured rock.						R10	CR=100%
							RQD=92%
N.B. - '*' means sample could not be recovered.							36.00
37.00m							37.00

Job No : 4095

Created by : SKD

Created on : 29/11/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.130

Co-ordinates E=866.118  
N=1400.462

Field Test	Nos	Samples	Nos	Commencement Date : 18/11/2018
Penetrometer (SPT)	36	Undisturbed (UDS)	2	Completion Date : 21/11/2018
Cone (Pc)		Penetrometer (SPT)	36	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	32	Level Of Ground : 902.464 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 6.9 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m Medium, reddish brown, silty clay. Observed gravel & boulders.								DS-1 DS-2 SPT-1	0.50 1.00 1.50-1.95
2.95m Very stiff, brownish grey, silty clay. Observed kankar & calcareous nodules.								UDS-1 SPT-2	2.50-2.95 2.95-3.40
5.50m Very dense, stone chips & concrete.								DS-3 SPT-3	4.00 4.50-4.95
5.65m								*UDS-2 *SPT-4	5.50-5.60 5.60-5.64
7.60m Very stiff, dark grey, silty clay.								DS-4 SPT-5	6.50 7.00-7.45
10.80m Hard, yellowish brown, silty clay. Observed kankar.								DS-5 SPT-6	8.00 8.50-8.95
12.90m								DS-6 SPT-7	9.50 10.00-10.45
19.00m Hard, reddish brown, silty clay. Observed kankar.								DS-7 SPT-8	11.00 11.50-11.95
20.10m Hard, brownish grey, silty clay. Observed traces of sand mixture & white spots.								DS-8 SPT-9	12.50 13.00-13.45
								DS-9 SPT-10	14.00 14.50-14.95
								DS-10 SPT-11	15.50 16.00-16.45
								DS-11 SPT-12	17.00 17.50-17.95
								DS-12 SPT-13	18.30 18.50-18.70
								*SPT-14 *SPT-15	18.90-18.94 19.00-19.02
								R1 DS-13	CR=Nil RQD=Nil
								*SPT-16	20.00-20.04



Job No : 4095

Created by : SKD

Created on : 29/11/2018


Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.130

Co-ordinates E=866.118  
N=1400.462

Field Test	Nos	Samples	Nos	Commencement Date : 18/11/2018
Penetrometer (SPT)	36	Undisturbed (UDS)	2	Completion Date : 21/11/2018
Cone (Pc)		Penetrometer (SPT)	36	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	32	Level Of Ground : 902.464 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 6.9 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
20.10m						R2	CR=Nil
						DS-14	RQD=Nil
		100	Refusa.			*SPT-17	21.00-21.02 21.00
		2.0	cm Pentn.			R3	CR=Nil
						DS-15	RQD=Nil
		100	Refusa.			*SPT-18	22.00-22.03 22.00
		3.0	cm Pentn.			R4	CR=Nil
						DS-16	RQD=Nil
		100	Refusa.			*SPT-19	23.00-23.02 23.00
		2.0	cm Pentn.			R5	CR=Nil
						DS-17	RQD=Nil
		100	Refusa.			*SPT-20	24.00-24.04 24.00
		4.0	cm Pentn.			R6	CR=Nil
						DS-18	RQD=Nil
		100	Refusa.			*SPT-21	25.00-25.03 25.00
		3.0	cm Pentn.			R7	CR=Nil
						DS-19	RQD=Nil
		100	Refusa.			*SPT-22	26.00-26.04 26.00
		4.0	cm Pentn.			R8	CR=Nil
						DS-20	RQD=Nil
		100	Refusa.			*SPT-23	27.00-27.02 27.00
		2.0	cm Pentn.			R9	CR=Nil
						DS-21	RQD=Nil
		100	Refusa.			*SPT-24	28.00-28.03 28.00
		3.0	cm Pentn.			R10	CR=Nil
						DS-22	RQD=Nil
		100	Refusa.			*SPT-25	29.00-29.02 29.00
		2.0	cm Pentn.			R11	CR=18%
						DS-23	RQD=Nil
		100	Refusa.			*SPT-26	30.00-30.01 30.00
		1.0	cm Pentn.			R12	CR=Nil
						DS-24	RQD=Nil
		100	Refusa.			*SPT-27	31.00-31.02 31.00
		2.0	cm Pentn.			R13	CR=Nil
						DS-25	RQD=Nil
		100	Refusa.			*SPT-28	32.00-32.04 32.00
		4.0	cm Pentn.			R14	CR=Nil
						DS-26	RQD=Nil
		100	Refusa.			*SPT-29	33.00-33.02 33.00
		2.0	cm Pentn.			R15	CR=Nil
						DS-27	RQD=Nil
		100	Refusa.			*SPT-30	34.00-34.03 34.00
		3.0	cm Pentn.			R16	CR=Nil
						DS-28	RQD=Nil
		100	Refusa.			*SPT-31	35.00-35.02 35.00
		2.0	cm Pentn.			R17	CR=Nil
						DS-29	RQD=Nil
		100	Refusa.			*SPT-32	36.00-36.04 36.00
		4.0	cm Pentn.			R18	CR=Nil
						DS-30	RQD=Nil
		100	Refusa.			*SPT-33	37.00-37.02 37.00
		2.0	cm Pentn.			R19	CR=Nil
						DS-31	RQD=Nil
		100	Refusa.			*SPT-34	38.00-38.03 38.00
		3.0	cm Pentn.			R20	CR=Nil
						DS-32	RQD=Nil
		100	Refusa.			*SPT-35	39.00-39.02 39.00
		2.0	cm Pentn.			R21	CR=Nil
						DS-33	RQD=Nil
		100	Refusa.			*SPT-36	40.00-40.02 40.00
		2.0	cm Pentn.				

Completely weathered, reddish brown to brownish grey, medium grained, decomposed & disintegrated rock particles collected as sludge.

N.B. - '\*' means sample could not be recovered.

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095

Created by : SKD

Created on : 29/12/2018

Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO.131

Co-ordinates E=8410.417  
N=1560.417

Field Test	Nos	Samples	Nos	Commencement Date : 22/11/2018
Penetrometer (SPT)	20	Undisturbed (UDS)	3	Completion Date : 24/11/2018
Cone (Pc)		Penetrometer (SPT)	20	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	28	Level Of Ground : 905.224 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.70 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m										
Soft to medium, reddish brown, silty clay. Observed kankar.									DS-1	0.50
									DS-2	1.00
									SPT-1	1.50-1.95
									UDS-1	2.50-2.95
									SPT-2	2.95-3.40
									DS-3	4.00
									SPT-3	4.50-4.95
5.50m										
Very stiff, brownish grey, silty clay. Observed kankar & sand mixture.									UDS-2	5.50-5.95
									SPT-4	5.95-6.40
7.50m										
Hard, brownish grey, silty clay. Observed kankar & sand mixture.									DS-4	7.00
									SPT-5	7.50-7.95
8.50m										
Hard, reddish brown, silty clay. Observed kankar & sand mixture.									UDS-3	8.50-8.80
									SPT-6	8.80-9.25
									DS-5	9.70
11.20m										
Very dense, whitish grey, clayey silty sand.									SPT-7	10.00-10.45
12.00m									DS-6	11.00
Very dense, brownish grey, silty sand.									SPT-8	11.50-11.95
									DS-7	12.50
									SPT-9	13.00-13.45
									DS-8	14.00
									SPT-10	14.50-14.95
									DS-9	15.50
									SPT-11	16.00-16.45
20.10m										
									DS-10	17.00
									SPT-12	17.50-17.95
									DS-11	18.50
									SPT-13	19.00-19.45
									DS-12	20.00

Job No : 4095

Created by : SKD

Created on : 29/12/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.131

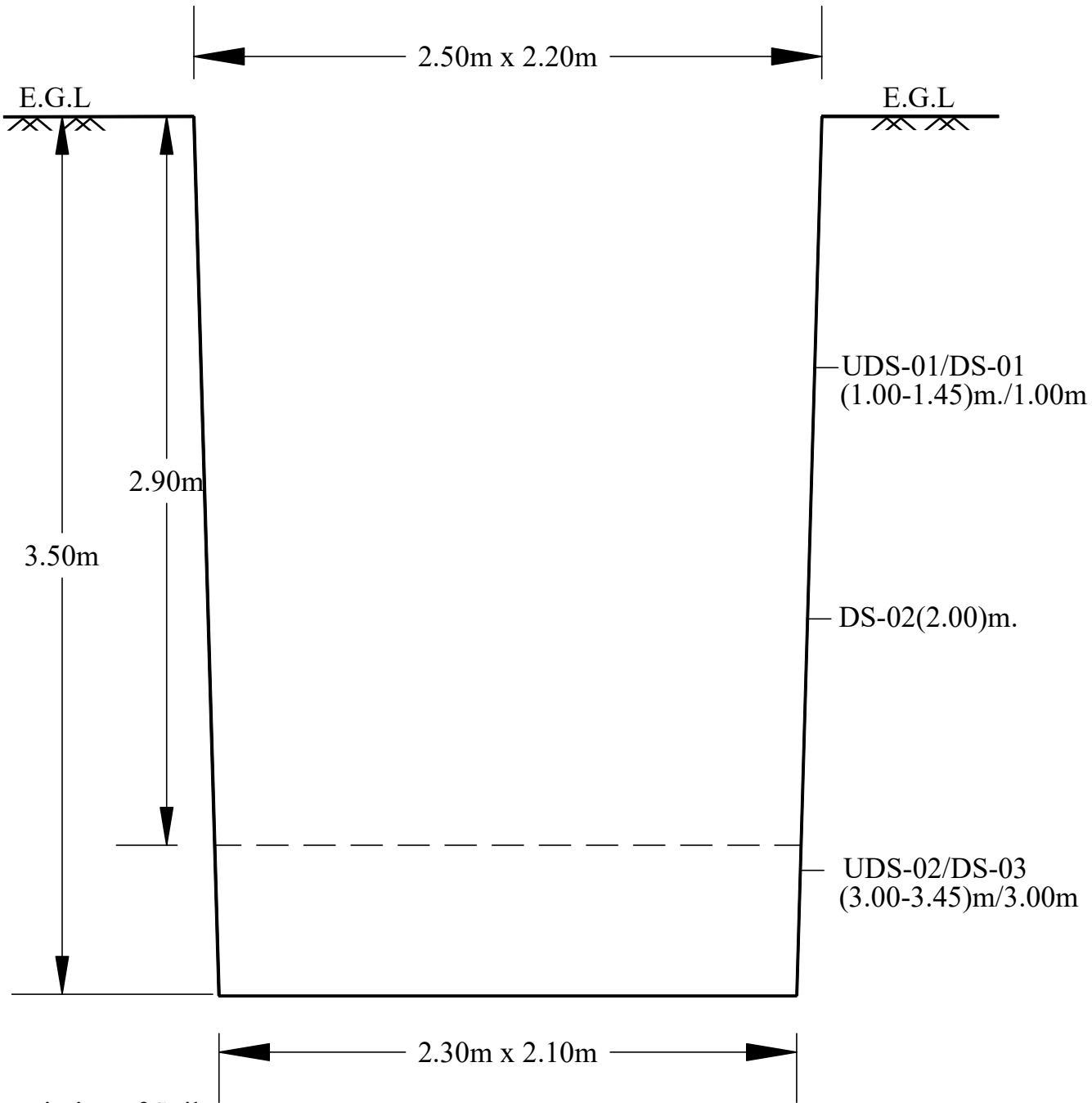
Co-ordinates E=8410.417  
N=1560.417

Field Test	Nos	Samples	Nos	Commencement Date : 22/11/2018
Penetrometer (SPT)	20	Undisturbed (UDS)	3	Completion Date : 24/11/2018
Cone (Pc)		Penetrometer (SPT)	20	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	28	Level Of Ground : 905.224 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 3.70 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
20.10m		19	33	48	81		SPT-14	20.50-20.95
Very dense, brownish grey, silty sand.		23	38	47	85		DS-13	21.50
		30	42	49	91		SPT-15	22.00-22.45
		39	100		>100		DS-14	23.00
		100	12.0	cm Pentn.	>100		SPT-16	23.50-23.95
25.00m		100	12.0	cm Pentn.	>100		DS-15	24.50
Very dense, whitish grey, silty sand with decomposed rock.		100	2.0	cm Pentn.	Refusal		SPT-17	25.00-25.25
		100	2.0	cm Pentn.	Refusal		SPT-18	25.50-25.62
26.00m		100	2.0	cm Pentn.	Refusal		*SPT-19	25.80-25.84
Highly to moderately weathered, whitish grey, medium grained, fractured rock.		100	2.0	cm Pentn.	Refusal		*SPT-20	26.00-26.02
							R1	CR=28% RQD=12%
							R2	CR=30% RQD=Nil
							R3	CR=32% RQD=Nil
							R4	CR=39% RQD=Nil
							R5	CR=43% RQD=20%
							R6	CR=46% RQD=20%
							R7	CR=42% RQD=Nil
							R8	CR=54% RQD=30%
							R9	CR=69% RQD=53%
							R10	CR=48% RQD=30%
							R11	CR=49% RQD=40%
							R12	CR=50% RQD=40%
33.00m							R13	CR=65% RQD=62%
Moderately weathered, light grey, fine grained, moderately fractured rock.								
34.00m								
Slightly weathered, light grey, fine grained, moderately fractured rock.								
35.50m								
Moderately weathered, light grey, fine grained, moderately fractured rock.								
39.00m								
Slightly weathered, light grey, fine grained, moderately fractured rock.								
40.00m								



Co-ordinates:  
E = 2111.748M.  
N = 457.187M.  
RL = 893.199M.



Description of Soil:-

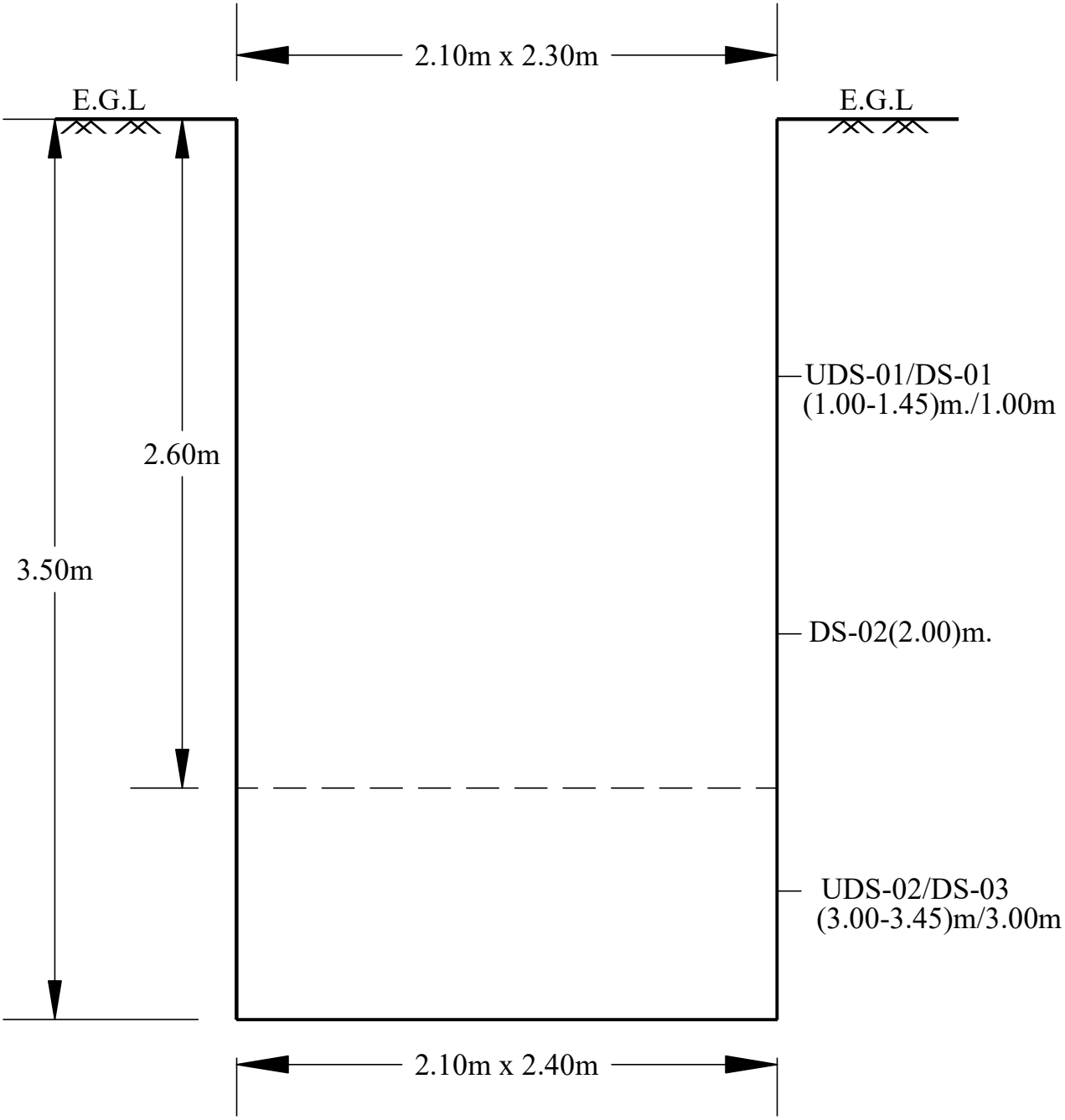
(EGL - 2.90)m:- Brownish grey silty clay. Obs. kankar.  
(2.90 - 3.50)m:- Brownish grey silty clay. Obs. sand mixture.

PIT LOG OF TP - 10





Co-ordinates:  
E = 2117.885M.  
N = 614.077M.  
RL = 901.350M.



Description of Soil:-

(EGL - 2.60)m:- Reddish brown silty clay. Obs. moorum & kankar.  
(2.60 - 3.50)m:- Reddish brown silty clay / clayey silt. Obs. traces of sand mixture & kankar.

PIT LOG OF TP - 11



**Summarised Field Density Test Results**

Test Location	Depth of Test (M)	Avg. Field Bulk Density (gm/cc)	Avg. Field Dry Density (gm/cc)	Moisture Content (%)
TP-10	1.00	1.550	1.310	18
	3.00	1.650	1.560	6
TP-11	1.00	1.870	1.650	13
	3.00	1.630	1.540	6

**PART II: LABORATORY TEST RESULTS**

Format No: CET/FM/42

## TEST REPORT

TEST REPORT NO : 4095 DATE: 21/01/2019

ULR: TC684019000000043P  
Name and Address of Customer: M/s. National Aluminium Company Limited  
Nalco Bhawan, Nayapalli  
Bhubaneswar – 751 013

Customer Reference No : 4095

Customer Reference Date : 22/12/2018

Date of Sample Received at Lab : 27/12/2018

Date of Starting of Test : 27/12/2018

Date of Completion of Test : 11/01/2019

Sample ID Nos : 4095/BH-101/UDS-01 to 4095/BH-130/UDS-01

Please refer the page no. A57 of A150 to A78 of A150 of the Report for the following:

1. Sample Description
2. Test methods used
3. Test results

Further to note that the test parameters are mentioned at the header of test result table.

- \* The report related to the particular sample(s) tested under stated condition.
- \* All tests are based as per IS/ASTM specifications
- \* Any discrepancy in this report should be brought to the notice within 15 (fifteen) days from the date of certificate
- \* Full/Partial use of this test results could not be done without the written permission of authorized signatory.



Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
BH101	UDS01	3.00	Reddish brown silty clay / clayey silt.	1.98	1.57	2.77	26 S	0.788	TRSH-UU	0.98	10	50	28	19	CH		20	66	14	* See the Note	
							26 T		3.0	1.798											
							26 C		2.0	1.588											
									1.0	1.378											
									UNCONF	1.49	0										
									0.0	1.513											
									0.0	1.480											
									0.0	1.477											
									REMOULD	1.09	0										
									0.0	1.113											
									0.0	1.087											
									0.0	1.070											
BH101	SPT04	6.50	Reddish brown clayey silt.									57	26		CH					Do	
BH101	SPT07	11.00	Yellowish grey clayey silt with sand mixture.			2.82									SC*		33	47	20	Do	
BH101	SPT08	12.50	Brownish grey silty sand.												SM-SP		91	9 (Silt+Clay)		Do	
BH102	UDS01	2.50	Reddish brown clayey silt with traces of kankar.	1.83	1.42	2.67	26 S	0.662	TRSH-UU	0.40	0	45	26	20	CI		36	49	15	Do	
							29 T		3.0	0.432											
							27 C		2.0	0.408											
									1.0	0.362											
									UNCONF	0.37	0										
									0.0	0.393											
									0.0	0.384											
									0.0	0.333											
									REMOULD	0.31	0										
									0.0	0.328											
									0.0	0.320											
									0.0	0.282											
									TRSH-CD	0.00	30										
									2.91	2.905											
									1.96	2.013											
									1.00	1.102											
BH102	SPT05	7.00	Reddish brown clayey silt with sand mixture & decomposed rock fragments.			2.78									SC*		49	34	17	Do	

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results					Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/sqcm kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %		Sand %	Silt %	Clay %		
BH102	SPT07	10.50	Reddish brown clayey silt with traces of sand mixture.										45	22	20	CI					Do	
BH102	SPT08	11.10	Brownish grey clayey silty sand with decomposed rock.			2.76										SM		67	22	11	Do	
BH103	DS01	0.50	Reddish brown silty clay with decomposed rock, boulder & sand mixture.													SC*	55**	27	18 (Silt+Clay)		Do	
BH104	UDS01	3.00	Reddish grey clayey silt / silty clay with traces of kankar.	1.90	1.47	2.69	30 S 30 T 21 C	0.564	TRSH-UU	0.84			44	27	18	MI		27	52	21	Do	
									3.0 2.0 1.0	1.283 1.166 1.050												
									UNCONF	0.52	0											
									0.0	0.564												
									0.0	0.483												
									0.0	0.515												
									REMOULD	0.36	0											
									0.0	0.382												
									0.0	0.327												
									0.0	0.362												
BH104	SPT03	5.00	Reddish brown clayey silt with sand & decomposed rock dust.			2.74										SC*		37	46	17	Do	
BH104	SPT06	9.50	Reddish brown clayey silt.										55	31	22	MH					Do	
BH104	SPT10	15.60	Reddish brown clayey silt with sand mixture			2.75										SC*		35	42	23	Do	
BH104	SPT15	23.00	Brownish grey clayey silt.										43	31	24	MI					Do	
BH104	SPT17	25.50	Brownish grey silty sand.													SM-SP		93	7 (Silt+Clay)		Do	
BH104	SPT19	28.50	Light grey clayey silt with sand & traces of rock dust.													SC*		45	55 (Silt+Clay)		Do	

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
BH104	SPT23	34.50	Brownish grey clayey silt.										48	35	33	MI					Do
BH105	UDS01	2.50	Reddish brown clayey silt / silty clay	1.94	1.58	2.70	25 S 23 T 27 C	0.812	UNCONFED		0.97	0	44	25	20	CI		32	51	17	Do
									0.0	0.910											
									0.0	0.990											
									0.0	0.996											
									REMOULD		0.68	0									
									0.0	0.635											
									0.0	0.699											
									0.0	0.695											
BH105	UDS02	5.50	Reddish brown clayey silt with decomposed rock dust.	1.98	1.46		36 S		UNCONFED		0.17	0				SC*					Do
							36 T		0.0	0.156											
									0.0	0.168											
									0.0	0.185											
									REMOULD		0.11	0									
									0.0	0.133											
									0.0	0.130											
									0.0	0.067											
BH105	SPT05	7.20	Reddish brown clayey silty sand with decomposed rock dust & rock pieces.			2.89										SM	9	63	17	11	Do
BH105	SPT07	10.00	Reddish brown clayey silt with traces of sand mixture.										46	24		CI					Do
BH106	UDS01	2.50	Reddish brown clayey silt / silty clay with traces of decomposed rock pieces.	1.94	1.57	2.73	25 S 23 T		TRSH-UU		0.68	15	47	28	21	MI		34	50	16	Do
									3.0	1.943											
									2.0	1.515											
									1.0	1.257											
									UNCONFED		0.90	0									
									0.0	1.093											
									0.0	0.952											
									0.0	0.648											
									REMOULD		0.71	0									
									0.0	0.894											
									0.0	0.760											
									0.0	0.487											
BH106	SPT05	7.00	Reddish brown clayey silt with traces of decomposed rock pieces.										47	28	21	MI					Do

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results					Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %		Sand %	Silt %	Clay %		
BH106	SPT09	13.00	Reddish brown clayey silt with traces of decomposed rock pieces.			2.78											SC*		30	51	19	Do
BH106	SPT10	14.50	Brownish grey silty sand with traces of clay binders & kankar.														SM		69	31 (Silt+Clay)		Do
BH106	SPT14	20.50	Brownish grey clayey silty sand with decomposed rock pieces.														SM		56	44 (Silt+Clay)		Do
BH106	SPT20	29.50	Brownish grey clayey silt with sand mixture & decomposed rock pieces.														SC*		22	78 (Silt+Clay)		Do
BH106	SPT27	40.00	Brownish grey clayey silt with sand mixture & decomposed rock pieces.														SC*		40	60 (Silt+Clay)		Do
BH107	UDS01	2.50	Reddish brown clayey silt with traces of moorum, sand & rock dust.	1.98	1.68	2.76	21 S 18 T 21 C	0.751	TRSH-UU 3.0 2.0 1.0 UNCONF 0.0 0.0 0.0 REMOULD 0.0 0.0 0.0	2.04	9	48	29	22	SC*	50**		34	16		Do	
BH107	UDS02	5.50	Reddish brown clayey silt with traces of decomposed rock fragments.			2.68	31 S 32 C	0.810					52	29	17	MH		39	42	19	Do	
BH107	SPT05	7.50	Reddish brown clayey silt with sand mixture.			2.72											SC*		36	46	18	Do
BH107	SPT06	9.00	Reddish brown clayey silt with traces of sand mixture.									37	23		CI						Do	

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
				Dens. gms/cc						Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
BH108	SPT01	1.50	Reddish brown silty clay with moorum & decomposed rock fragments.				2.78										SC*	67**		24	9	Do
BH108	SPT04	6.10	Reddish brown clayey silt.											57	28		CH					Do
BH108	SPT07	10.50	Reddish brown clayey silt with sand mixture.				2.73										SC*		32	48	20	Do
BH108	SPT11	16.50	Reddish brown clayey silt.											56	29		CH					Do
BH108	SPT14	21.00	Reddish brown clayey silt with sand mixture & kankar.				2.77										SC*		48	36	16	Do
BH108	SPT15	22.50	Brownish grey clayey silty sand with decomposed rock fragments														SM		57	43 (Silt+Clay)		Do
BH108	SPT18	27.00	Brownish grey clayey silty sand with decomposed rock fragments.														SM		67	33 (Silt+Clay)		Do
BH109	SPT01	1.50	Reddish brown clayey silt with sand mixture & decomposed rock fragments.				2.76										SC*	51**		35	14	Do
BH109	SPT04	6.10	Reddish brown clayey silt.											57	29		CH					Do
BH109	SPT09	13.50	Reddish brown clayey sandy silt with traces of kankar.				2.71										SC*		50	38	12	Do
BH109	SPT12	18.50	Reddish brown clayey silt with sand mixture.											30	20		CL					Do

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits				IS Classification	Grain Size				Test Method
										Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %			Gravl %	Sand %	Silt %	Clay %	
BH109	SPT13	20.00	Brownish grey clayey silty sand with decomposed rock fragments.															SM	57	43 (Silt+Clay)			Do
BH109	SPT15	23.00	Brownish grey clayey silty sand.															SM	82	18 (Silt+Clay)			Do
BH109	SPT18	27.50	Brownish grey clayey silty sand.															SM	87	13 (Silt+Clay)			Do
BH110	UDS01	2.50	Reddish brown clayey silt / silty clay with traces ofkankar. sand mixture.	1.96		1.71	2.73	20 S	0.670	TRSH-UU	1.57		9	49	27	22		CI	43	41	15		Do
								15 T		3.0	2.395												
								20 C		2.0	2.209												
										1.0	2.024												
										UNCONF	1.61		0										
										0.0	1.633												
										0.0	1.603												
										0.0	1.594												
										REMOULD	1.06		0										
										0.0	1.083												
										0.0	1.057												
										0.0	1.040												
BH110	SPT05	7.50	Reddish brown clayey silt with traces of sand mixture.											49	26			CI					Do
BH110	SPT09	13.50	Reddish brown clayey silt with traces of sand mixture.											41	23			CI					Do
BH111	UDS01	2.50	Reddish brown clayey silt / silty clay with traces of kankar & sand mixture.	1.99		1.65	2.69	21 S	0.591	UNCONF	1.09		0	50	30	20		MH	33	49	18		Do
								21 T		0.0	1.113												
								19 C		0.0	1.087												
										0.0	1.070												
										REMOULD	1.03		0										
										0.0	1.053												
										0.0	1.028												
										0.0	1.009												
BH111	UDS02	5.50	Reddish brown clayey silt / silty clay.	1.92		1.59	2.71	25 S	1.107	TRSH-UU	0.95		9	44	26	20		CI	32	52	16		Do
								21 T		3.0	1.669												
								23 C		2.0	1.483												
										1.0	1.298												

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
									UNCONFD	0.75	0										
									0.0	0.722											
									0.0	0.785											
									0.0	0.736											
									REMOULD	0.50	0										
									0.0	0.478											
									0.0	0.519											
									0.0	0.510											
BH111	UDS03	8.50	Reddish brown clayey silt / silty clay.	1.95	1.60	2.70	24 S 22 T		UNCONFD	0.75	0	42	24	18	CI		30	48	22	Do	
									0.0	0.722											
									0.0	0.785											
									0.0	0.736											
									REMOULD	0.50	0										
									0.0	0.478											
									0.0	0.519											
									0.0	0.510											
BH111	SPT07	10.50	Brownish grey silty sand with clay binder.												SM		63	37 (Silt+Clay)		Do	
BH112	UDS01	1.50	Reddish brown clayey silt / silty clay with traces of rock dust, sand mixture.	2.00	1.70	2.68	18 S 18 T 17 C	0.610	UNCONFD	0.86	0	55	28	20	CH		41	42	17	Do	
									0.0	0.878											
									0.0	0.857											
									0.0	0.845											
									REMOULD	0.46	0										
									0.0	0.478											
									0.0	0.466											
									0.0	0.436											
BH113	UDS01	2.50	Brownish grey clayey silt with decomposed rock dust.	2.05	1.72	2.66	16 S 19 T 17 C	0.599	UNCONFD	0.67	0	41	25	18	SC		53**	34	13	Do	
									0.0	0.830											
									0.0	0.547											
									0.0	0.619											
									REMOULD	0.51	0										
									0.0	0.528											
									0.0	0.515											
									0.0	0.487											
BH113	SPT02	2.95	Yellowish brown clayey silt.									31	20		CL					Do	
BH114	UDS01	2.50	Light grey silty sand with traces of clay binder.	1.73	1.49		16 S 16DR		DRSH-CU	0.01	33				SM		70	30 (Silt+Clay)		Do	
									0.5	0.359											
									1.0	0.636											
									2.0	1.335											

Bore Hole	Sample Number	Depth	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size			Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	
BH114	UDS02	5.50	Reddish brown clayey silt with decomposed rock dust.	2.02	1.72	2.68	17 S	0.707	TRSH-UU	1.03	8	40	22	18	SC	54**	36	10	Do	
							17 T		3.0	1.706										
							25 C		2.0	1.514										
									1.0	1.366										
									UNCONF	0.83	0									
									0.0	1.007										
									0.0	0.769										
									0.0	0.707										
									REMOULD	0.63	0									
									0.0	0.792										
									0.0	0.576										
									0.0	0.508										
BH114	SPT05	7.50	Reddish brown clayey silt with sand mixture.			2.71								SC*	59**	31	10	Do		
BH116	UDS02	5.50	Reddish brown clayey silt with sand mixture & kankar.			2.73	9 S					44	23	20	CI	33	54	13	Do	
BH116	UDS03	8.50	Reddish brown clayey silt / silty clay with traces of rock dust, kankar & sand mixture.			2.70	25 S					40	23	18	CI	48	42	10	Do	
BH116	SPT08	12.00	Reddish brown clayey silt with sand mixture.			2.76									SC*	39	38	23	Do	
BH116	SPT13	19.50	Light grey clayey silt with decomposed rock.									34	21		CL				Do	
BH116	SPT16	24.00	Light grey clayey silt with sand mixture & decomposed rock fragments.			2.67									SC*	56**	26	18	Do	
BH117	UDS01	2.50	Reddish brown clayey silt with sand mixture, rock dust.	1.95	1.58	2.70	23 S	0.577	TRSH-UU	0.25	11	43	28	24	MI	45	44	11	Do	
							23 T		3.0	1.049										
							22 C		2.0	0.777										
									1.0	0.562										
BH117	UDS03	8.50	Brownish grey silty clay with sand mixture, red spots & kankar.	2.03	1.80	2.71	15 S	0.440	TRSH-UU	0.92	11	28	13	11	CL	39	42	19	Do	
							13 T		3.0	1.823										
							15 C		2.0	1.588										
									1.0	1.352										



Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
									UNCONFD	0.74	0										
									0.0	0.773											
									0.0	0.711											
									0.0	0.737											
									REMOULD	0.51	0										
									0.0	0.535											
									0.0	0.486											
									0.0	0.510											
BH117	SPT09	13.50	Light grey clayey silty sand with decomposed fragments.			2.67									SM		66	30	4	Do	
BH117	SPT10	15.00	Brownish grey clayey silty sand.												SM		50	50 (Silt+Clay)		Do	
BH117	SPT14	21.00	Brownish grey silty sand.												SP		96	4 (Silt+Clay)		Do	
BH117	SPT17	25.50	Brownish grey silty sand.												SP		98	2 (Silt+Clay)		Do	
BH118	SPT01	2.00	Reddish brown clayey silt with sand mixture & moorum.										30	21	CL					Do	
BH118	UDS02	4.50	Reddish brown clayey silt / silty clay with traces of kankar & sand mixture.	2.00	1.62	2.85	23 S 23 T 23 C	0.778	TRSH-UU	0.46	11		30	20	17	CL	23	65	12	Do	
									3.0	1.265											
									2.0	1.030											
									1.0	0.794											
									UNCONFD	0.69	0										
									0.0	0.708											
									0.0	0.691											
									0.0	0.671											
									REMOULD	0.58	0										
									0.0	0.598											
									0.0	0.583											
									0.0	0.559											
BH118	SPT05	7.62	Reddish brown clayey silt with sand mixture.			2.82									SC*		27	49	24	Do	
BH118	SPT09	13.50	Brownish grey clayey silt.										50	30	MH					Do	

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits				IS Classification	Grain Size				Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %		Sand %	Silt %	Clay %		
BH118	SPT14	21.00	Brownish grey silty sand.														SM-SP		94	6	(Silt+Clay)	Do
BH118	SPT15	22.50	Brownish grey silty sand.														SM-SP		94	6	(Silt+Clay)	Do
BH118	SPT18	27.00	Brownish grey silty sand..														SM-SP		94	6	(Silt+Clay)	Do
BH118	SPT20	30.00	Brownish grey silty sand..														SM-SP		95	5	(Silt+Clay)	Do
BH119	UDS01	3.00	Reddish brown clayey silt with decomposed rock fragments.	1.98	1.62	2.87	21 S 22 T 20 C	0.638	TRSH-UU 3.0 2.092 2.0 1.888 1.0 1.665 UNCONF 1.10 0 0.0 1.457 0.0 1.015 0.0 0.839 REMOULD 0 0.0 1.188 0.0 0.771 0.0 0.937	1.22	10	45	25	20	SC	64**	28	8	Do			
BH119	SPT06	9.50	Brownish grey clayey silt with sand mixture.			2.69										SC*	28	60	12	Do		
BH119	SPT10	15.50	Light brownish grey clayey silt.										45	26	CI					Do		

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/sqcm kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
BH119	SPT14	21.50	Brownish grey clayey silt with sand mixture, traces of kankar.			2.68									SC*		41	48	11	Do	
BH119	SPT19	29.00	Light grey clayey silt with decomposed rock fragments.									45	31		MI					Do	
BH120	DS02	1.00	Reddish brown clayey silt.									55	33	28	MH					Do	
BH120	UDS01	2.40	Reddish brown clayey silt with traces of decomposed rock fragments.	1.78	1.27	2.68	39 S 40 T 38 C	1.031	TRSH-UU 3.0 0.288 2.0 0.288 1.0 0.195 UNCONF 0.0 0.149 0.0 0.188 0.0 0.217 REMOULD 0.0 0.100 0.0 0.110 0.0 0.131	0.26	0	47	31	26	MI	31	57	12	Do		
BH120	SPT04	5.60	Greyish brown clayey silt.									44	28	25	MI					Do	
BH120	SPT08	12.50	Reddish grey clayey silt with sand mixture			2.68									SC*	39	48	13	Do		
BH120	SPT13	20.00	Greyish brown clayey silt.									44	28	24	MI					Do	
BH120	SPT19	29.00	Brownish grey silty sand.												SM	60	40 (Silt+Clay)			Do	
BH121	UDS01	2.50	Reddish brown clayey silt with decomposed rock fragments.	1.95	1.54	2.68	31 S 27 T 28 C	0.662	TRSH-UU 3.0 0.468 2.0 0.457 1.0 0.425 UNCONF 0.0 0.126 0.0 0.274 0.0 0.245	0.45	0	44	25	20	CI	44	42	14	Do		

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results					Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %		Sand %	Silt %	Clay %		
									REMOULD	0.14	0											
									0.0	0.077												
									0.0	0.178												
									0.0	0.164												
BH121	SPT05	7.50	Yellowish brown clayey silt with traces of sand mixture.									46	31		MI					Do		
BH121	SPT09	13.00	Light grey clayey silt with sand mixture.			2.70									SC*		39	51	10	Do		
BH121	SPT10	14.50	Brownish grey clayey silt with sand mixture.												SC*		37	63 (Silt+Clay)		Do		
BH121	SPT14	20.50	Brownish grey clayey silty sand.												SM		68	32 (Silt+Clay)		Do		
BH121	SPT17	25.00	Brownish grey clayey silty sand.												SM		79	21 (Silt+Clay)		Do		
BH121	SPT21	30.30	Brownish grey silty sand.												SM-SP		93	7 (Silt+Clay)		Do		
BH122	DS01	0.50	Reddish brown clayey silt with traces of sand mixture.									50	26		CH					Do		
BH122	SPT01	1.50	Reddish brown clayey silt with sand mixture.			2.78									SC*		44	49	7	Do		
BH123	UDS01	1.50	Reddish brown clayey silt with decomposed rock fragments.	1.94	1.55	2.74	25 S	0.825	TRSH-UU	1.05	15	42	24	21	CI		34	50	16	Do		
							25 T		3.0	2.416												
							25 C		2.0	2.067												
									1.0	1.718												
									UNCONF	0.86	0											
									0.0	0.878												
									0.0	0.857												
									0.0	0.845												
									REMOULD	0.76	0											
									0.0	0.778												
									0.0	0.759												
									0.0	0.743												

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
BH123	UDS03	7.50	Brownish grey clayey silt with decomposed rock fragments.	2.00	1.47	2.75	27 S	0.863	UNCONFD	0.75	0	36	23	22	SC	51**	39	10	Do		
					0.0	0.768															
					0.0	0.749															
					0.0	0.733															
					REMOULD	0.55	0														
BH123				0.0	0.568																
				0.0	0.554																
				0.0	0.528																
	SPT07	11.00	Light grey clayey silt with sand mixture.			2.68								SC*	54**	41	5	Do			
BH123	SPT08	12.50	Brownish grey silty sand.											SM-SP	89	11 (Silt+Clay)		Do			
BH124	UDS01	1.50	Brownish grey clayey silt with decomposed rock fragments.	1.87	1.41	2.73	30 S	0.917	TRSH-UU	0.28	8	45	29	26	SC*	55**	41	4	Do		
							33 T			3.0	0.781										
							31 C			2.0	0.722										
										1.0	0.455										
										UNCONFD	0.49	0									
									0.0	0.471											
									0.0	0.523											
									0.0	0.489											
									REMOULD	0.33	0										
									0.0	0.321											
									0.0	0.340											
									0.0	0.329											
	SPT01	1.95	Brownish grey silty sand with decomposed rock fragments.												SM	58	42 (Silt+Clay)	Do			
BH124	UDS02	4.20	Brownish grey silty sand with decomposed rock fragments.			2.67								SM	82	17	1	Do			
BH125	UDS01	3.00	Reddish brown clayey silt with sand mixture.	1.91	1.63	2.78	17 S		TRSH-UU	0.93	15	30	24	24	ML	47	48	5	Do		
							17 T			3.0	2.260										
										2.0	1.910										
										1.0	1.561										
BH125	SPT04	6.50	Brownish grey clayey silt with sand mixture.			2.69								SC*	56**	38	6	Do			

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
				Dens. gms/cc	Dens. gms/cc					Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
BH125	SPT07	11.00	Brownish grey clayey silt with decomposed rock fragments.											30	16		CL					Do
BH125	SPT09	14.00	Brownish grey clayey silt with sand mixture & decomposed rock fragments.				2.69										SC*	46	44	10		Do
BH125	SPT10	15.30	Brownish grey silty sand with decomposed rock fragments.														SM-SP	88	12 (Silt+Clay)			Do
BH127	SPT01	1.50	Reddish brown clayey silt with moorum & decomposed rock fragments.				2.69										SC*	74**	23	3		Do
BH127	SPT05	7.50	Reddish brown clayey silt.											55	31	22	MH					Do
BH127	SPT09	13.50	Reddish brown clayey silt with sand mixture & traces of kankar.				2.85										SC*	49	30	21		Do
BH127	SPT15	22.50	Reddish brown clayey silt.											55	31	22	MH					Do
BH127	SPT19	28.50	Brownish grey clayey silt with moorum & decomposed rock fragments.				2.67										SC*	58**	36	6		Do
BH127	SPT22	33.00	Yellowish grey clayey silt.											37	25	24	MI					Do
BH128	SPT07	0.00	Reddish brown clayey silt with traces of sand mixture											49	26		CI					Do
BH128	UDS01	2.50	Reddish brown clayey silt with traces of moorum & sand mixture.		1.87	1.46	2.73	26 S 28 T 29 C	0.939	TRSH-UU 3.0 2.0 1.0	2.291 2.155 2.080	1.78	5	51	27	23	CH	36	49	15		Do

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results					Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/sqcm kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %		Sand %	Silt %	Clay %		
									UNCONFD	1.04	0											
									0.0	1.087												
									0.0	1.006												
									0.0	1.035												
									REMOULD	0.81	0											
									0.0	0.846												
									0.0	0.784												
									0.0	0.803												
BH128	UDS02	5.50	Reddish brown clayey silt with ecomposed rock fragments.	1.76	1.43	2.78	24 S	0.871	UNCONFD	0.85	0		50	31	20	MH		38	48	14	Do	
							23 T		0.0	0.852												
							23 C		0.0	0.852												
									0.0	0.852												
									REMOULD	0.62	0											
									0.0	0.623												
									0.0	0.623												
									0.0	0.623												
BH128	SPT11	16.00	Reddish brown clayey silt with sand mixture.			2.81										SC*		35	39	26	Do	
BH128	SPT13	19.00	Brownish grey clayey silty sand.													SM		58	42 (Silt+Clay)		Do	
BH129	UDS01	3.00	Reddish brown clayey silt / silty clay with traces of kankar, rock dust.	2.08	1.75	2.72	18 S	0.603	TRSH-UU	1.20	5		46	26	20	CI		39	45	16	Do	
							18 T		3.0	1.596												
							20 C		2.0	1.501												
									1.0	1.405												
									UNCONFD	1.07	0											
									0.0	1.088												
									0.0	1.062												
									0.0	1.060												
									REMOULD	0.97	0											
									0.0	0.988												
									0.0	0.964												
									0.0	0.958												
BH129	SPT04	6.50	Brownish grey silty sand with clay binder.													SM		76	24 (Silt+Clay)		Do	
BH129	SPT09	14.00	Brownish grey silty sand with clay binder.													SM-SP		89	11 (Silt+Clay)		Do	

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %	
BH129	SPT13	20.00	Brownish grey silty sand with clay binder.												SM		84	16 (Silt+Clay)	Do		
BH130	UDS01	2.50	Reddish brown clayey silt / silty clay with traces of kankar.	1.95	1.51	2.79	28 S 29 T 28 C	0.653	TRSH-UU 3.0 2.0 1.0 UNCONFD	0.333 0.296 0.274	0.30	0	39	21	16	CI	33	52	15	Do	
									0.0 0.0 0.0	0.274 0.265											
									0.0 REMOULD	0.265	0.16	0									
									0.0	0.162											
									0.0	0.159											
									0.0	0.164											
BH130	SPT05	7.00	Brownish grey clayey silt / silty clay with traces of sand mixture.										55	24		CH			Do		
BH130	SPT09	13.00	Brownish grey clayey silt with sand mixture & decomposed rock fragments.			2.72										SC*	45	43	12	Do	
BH130	SPT13	18.50	Light grey clayey silt with decomposed rock fragments.										45	29		MI			Do		
BH131	UDS01	2.50	Reddish brown clayey silt with traces of kankar, sand mixture.	1.98	1.58	2.75	24 S 26 T 26 C	0.694	TRSH-UU 3.0 2.0 1.0	0.491 0.375 0.358	0.41	0	39	22	21	CI	41	49	10	Do	
BH131	UDS02	5.50	Reddish brown clayey silt with sand mixture.	1.99	1.60	2.73	24 S 24 T		TRSH-UU 3.0 2.0 1.0	0.986 0.979 0.877	0.95	0	42	24	20	CI	38	43	19	Do	
BH131	UDS03	8.50	Reddish brown clayey silt with decomposed rock fragments.	1.99	1.67	2.70	18 S 19 T		TRSH-UU 3.0 2.0 1.0	2.182 1.944 1.672	1.16	12	39	21	19	SC	50	37	13	Do	
BH131	SPT08	11.50	Whitish grey clayey silty sand.													SM	87	13 (Silt+Clay)	Do		



Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS Classification	Grain Size				Test Method			
				Dens. gms/cc						Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %		Gravl %	Sand %	Silt %	Clay %				
BH131	SPT12	17.50	Brownish grey silty sand.													SM-SP		92	8	(Silt+Clay)	Do				
BH131	SPT16	23.50	Brownish grey silty sand.													SM-SP		94	6	(Silt+Clay)	Do				
** - The apparent high percentage of sand & gravel content is mainly due to presence of decomposed rock fragments, kankar, moorum etc.																									

## LABORATORY ROCK TEST RESULTS

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive Strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Young's Modulus, kg/sqcm	Test Method
				Bulk	Dry				Dry	Saturated				
101	4	16.50 - 17.50	Fresh, light brownish grey, fine grained, highly fractured rock.	2.747	2.740	0.248	0.945	2.766	801	601	0.75	--	63357	* See the Note
102	1	12.00 - 13.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.900	2.896	0.152	0.609	2.914	--	--	--	29.88	--	Do
102	5	16.00 - 17.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.799	2.794	0.176	0.639	2.812	--	622	--	81.29	30053	Do
102	7	18.00 - 19.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.834	2.830	0.157	0.605	2.847	--	639	--	--	41026	Do
103	4	4.00 - 5.00	Highly weathered, brownish grey, medium grained, highly to moderately fractured rock.	2.171	1.918	13.171	8.744	2.102	--	--	--	--	--	Do
103	7	7.00 - 8.00	Fresh, brownish grey, moderately fractured rock.	2.683	2.421	10.812	23.074	2.752	104	--	--	--	15688	Do
103	9	9.00 - 10.00	Fresh, brownish grey, moderately fractured rock.	2.791	2.746	1.637	2.264	2.810	--	397	--	--	45835	Do
105	22	31.50 - 32.50	Moderately weathered, whitish brown, fine grained, fractured rock.	2.755	2.749	0.234	0.968	2.776	--	507	--	--	27210	Do
105	25	34.50 - 36.00	Fresh, whitish brown, fine grained, fractured rock.	2.771	2.765	0.206	0.927	2.791	--	613	--	57.63	31411	Do
107	1	9.50 - 10.50	Moderately weathered, whitish grey, fine grained, moderately fractured rock.	2.692	2.686	0.251	0.854	2.709	--	--	--	73.64	--	Do
107	4	12.50 - 13.50	Fresh, whitish grey, fine grained, moderately fractured rock.	2.775	2.772	0.129	0.654	2.790	--	420	--	69.74	18760	Do
108	2	28.50 - 29.50	Fresh, whitish grey, fine grained, moderately fractured rock.	2.769	2.763	0.214	0.807	2.785	--	564	--	--	33540	Do
108	4	30.50 - 31.50	Fresh, whitish grey, fine grained, moderately fractured rock.	2.810	2.807	0.102	0.752	2.828	--	719	--	80.04	69886	Do
109	1	29.00 - 30.00	Fresh, brownish grey, fine grained, moderately fractured rock.	3.011	3.002	0.300	0.874	3.028	--	598	--	--	29767	Do
109	3	31.00 - 32.00	Fresh, brownish grey, fine grained, moderately fractured rock.	2.909	2.904	0.162	0.495	2.919	--	505	--	112.93	25377	Do

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive Strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Young's Modulus, kg/sqcm	Test Method
				Bulk	Dry				Dry	Saturated				
110	1	16.50 - 17.50	Highly weathered, brownish grey, fine grained, moderately fractured rock.	2.765	2.758	0.242	0.737	2.779	--	--	--	36.34	--	Do
110	4	19.50 - 20.50	Fresh, brownish grey, fine grained, moderately fractured rock.	2.730	2.725	0.203	0.885	2.749	802	323	0.40	--	16918	Do
111	12	23.50 - 24.00	Fresh, whitish brown, fine grained, rock.	3.015	3.011	0.130	0.709	3.032	533	419	0.79	--	44718	Do
112	1	3.00 - 4.00	Moderately weathered, light grey, fine grained, moderately fractured rock.	2.667	2.662	0.202	0.866	2.685	--	--	--	90.35	--	Do
112	4	6.00 - 7.00	Moderately weathered, light grey, fine grained, moderately fractured rock.	2.791	2.788	0.133	0.628	2.805	--	560	--	--	49553	Do
112	8	10.00 - 11.00	Fresh, light grey, fine grained, moderately fractured rock.	2.769	2.764	0.176	0.766	2.786	704	363	0.52	--	34325	Do
113	2	4.50 - 5.50	Highly weathered, light grey, fine grained, moderately fractured rock.	2.782	2.773	0.301	1.202	2.807	--	--	--	12.97	--	Do
113	5	7.50 - 8.50	Moderately weathered, light grey, fine grained, moderately fractured rock.	2.811	2.804	0.244	1.009	2.833	724	516	0.71	--	16688	Do
114	1	8.50 - 9.50	Slightly weathered, light grey, fine grained, moderately fractured rock.	2.774	2.767	0.237	0.823	2.790	--	576	--	--	38456	Do
114	3	11.00 - 12.50	Fresh, light grey, fine grained, moderately fractured rock.	2.815	2.812	0.117	0.592	2.828	739	555	0.75	--	27035	Do
115	1	0.60 - 1.60	Moderately weathered, light grey, fine grained, moderately fractured rock.	2.984	2.981	0.114	0.447	2.994	848	804	0.95	--	38439	Do
115	5	4.60 - 5.60	Fresh, light grey, fine grained, moderately fractured rock.	2.947	2.944	0.115	0.509	2.959	--	--	--	75.47	--	Do
116	1	25.50 - 26.50	Highly weathered, yellowish brown, medium grained, fractured rock.	2.501	2.411	3.733	8.420	2.612	--	--	--	12.72	--	Do
122	2	4.00 - 5.00	Highly weathered, brownish grey, fine grained, moderately fractured rock.	2.985	2.983	0.079	0.286	2.992	--	--	--	152.64	--	Do
122	5	8.00 - 9.00	Moderately weathered, brownish grey, fine grained, moderately fractured rock.	3.047	3.045	0.065	0.236	3.052	1006	1006	1.00	--	55068	Do
123	2	16.00 - 17.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.730	2.723	0.257	0.893	2.747	--	704	--	96.05	49695	Do
123	7	21.00 - 22.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.787	2.769	0.650	1.167	2.801	--	625	--	--	32790	Do

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive Strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Young's Modulus, kg/sqcm	Test Method
				Bulk	Dry				Dry	Saturated				
124	2	5.50 - 6.50	Highly weathered, light grey, fine grained, moderately fractured rock.	2.891	2.884	0.253	0.925	2.911	--	--	--	78.05	--	Do
124	4	7.50 - 8.50	Moderately weathered, light grey, fine grained, moderately fractured rock.	2.921	2.918	0.094	0.307	2.927	--	861	--	--	56709	Do
124	7	10.50 - 11.50	Fresh, light grey, fine grained, moderately fractured rock.	2.856	2.851	0.183	0.786	2.873	--	478	--	--	50389	Do
129	5	31.00 - 32.00	Completely weathered, whitish grey, fine grained, highly fractured rock.	2.784	2.780	0.140	0.648	2.798	--	--	--	84.33	--	Do
129	7	33.00 - 34.00	Completely weathered, whitish grey, fine grained, highly fractured rock.	2.764	2.759	0.186	0.818	2.782	--	--	--	71.92	--	Do
131	6	31.00 - 32.00	Moderately weathered, whitish grey, medium grained, fractured rock.	2.670	2.656	0.521	2.174	2.715	--	165	--	--	14329	Do
131	9	34.00 - 35.00	Slightly weathered, light grey, fine grained, fractured rock.	2.760	2.754	0.218	0.651	2.772	--	671	--	58.64	28179	Do

**SWELLING TEST RESULTS**

Bore Hole No.	Sample No.	Depth (M)	Description	Free Swell Index, (%)	Swelling Pressure, (kg/sqcm)	PI (%)	Test Method
BH-101	UDS01	3.00	Reddish brown clayey silt with traces of sand mixture.	9.09	0.020	22	* See the Note
BH-102	UDS01	2.50	Reddish brown silty clay.	8.33	0.055	19	Do
BH-104	UDS01	3.00	Reddish silty clay with kankar & sand mixture.	4.00	0.073	17	Do
BH-106	UDS01	2.50	Reddish brown clayey silt with sand mixture.	9.09	0.025	19	Do
BH-107	UDS01	2.50	Reddish brown clayey silt / silty clay with kankar & sand mixture.	4.35	0.016	19	Do
BH-108	SPT04	6.10	Reddish brown clayey silt.	8.33	--	29	Do
BH-109	SPT01	1.50	Reddish brown clayey silt with sand mixture & decomposed rock fragments.	9.09	--	--	Do
BH-110	UDS01	2.50	Reddish brown clayey silt with sand mixture.	4.35	0.130	22	Do
BH-111	UDS01	2.50	Reddish brown clayey silt / silty clay with traces of kankar & sand mixture.	8.33	0.022	20	Do
BH-112	UDS01	1.50	Reddish brown clayey silt with sand mixture.	8.33	0.042	27	Do
BH-113	UDS-01	2.50	Reddish brown clayey silt with sand mixture.	8.70	0.021	16	Do
BH-114	UDS01	2.50	Light grey silty sand with traces of clay binder.	0.00	0.010	NP	Do
BH-116	UDS02	5.50	Reddish brown clayey silt with sand mixture & kankar.	9.09	0.031	21	Do
BH-117	UDS01	2.50	Reddish brown clayey silt with sand mixture & rock pieces.	2.17	0.027	15	Do
BH-118	UDS02	4.50	Reddish brown clayey silt with sand mixture.	9.09	0.026	10	Do
BH-119	UDS02	6.00	Reddish brown silty clay with traces of kankar & sand mixture.	1.82	0.124	18	Do
BH-120	UDS01	2.40	Reddish brown clayey silt.	10.00	0.036	16	Do
BH-121	UDS01	2.50	Reddish brown silty clay with kankar & sand mixture.	4.55	0.012	19	Do

**SWELLING TEST RESULTS**

Bore Hole No.	Sample No.	Depth (M)	Description	Free Swell Index, (%)	Swelling Pressure, (kg/sqcm)	PI (%)	Test Method
BH-123	UDS03	7.50	Yellowish grey clayey silt with sand mixture.	4.17	0.013	13	Do
BH-128	UDS01	2.50	Reddish brown clayey silt with sand mixture.	3.85	0.100	24	Do
BH-129	UDS01	3.00	Reddish brown clayey silt with sand mixture.	9.09	0.022	20	Do
BH-130	UDS01	2.50	Reddish silty clay with rock pieces, kankar & sand mixture.	14.29	0.016	18	Do

**\*Note: Test Methods**

Bulk Density &amp; Dry Density: Ref. CET/SOP/01, Issue No. 01-(Page 27 &amp; 39 of 40)

Natural Moisture Content: IS 2720 (Part 2)

Specific Gravity: IS 2720 (Part 3).

Grain size analysis: IS 2720 (Part 4)

Liquid Limit &amp; Plastic Limit: IS 2720 (Part 5)

Shrinkage Limit: IS 2720 (Part 6)

Unconfined Compressive Strength Test: IS 2720 (Part 10)

Triaxial Test (TRSH-UU): IS 2720 (Part 11)

Triaxial Test (TRSH-CD): IS 2720 (Part 12)

Direct Shear Test (DRSH-CU): IS 2720 (Part 13)

Consolidation Properties (Void Ratio): IS 2720 (Part 15)

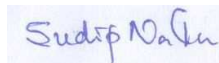
Free Swell Index: IS 2720 (Part 40)

Swelling Pressure: IS 2720 (Part 41)

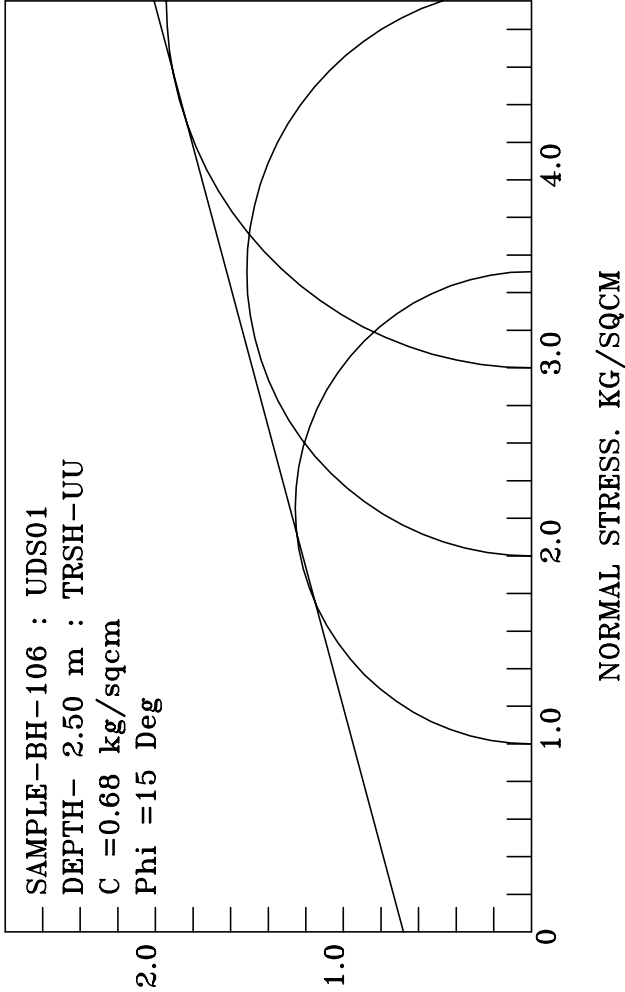
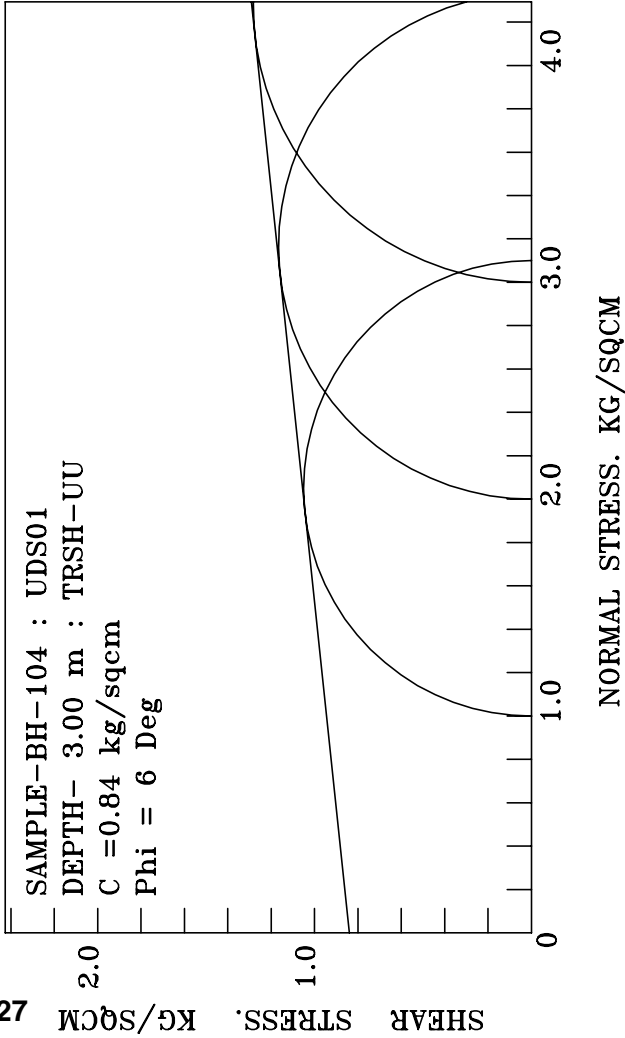
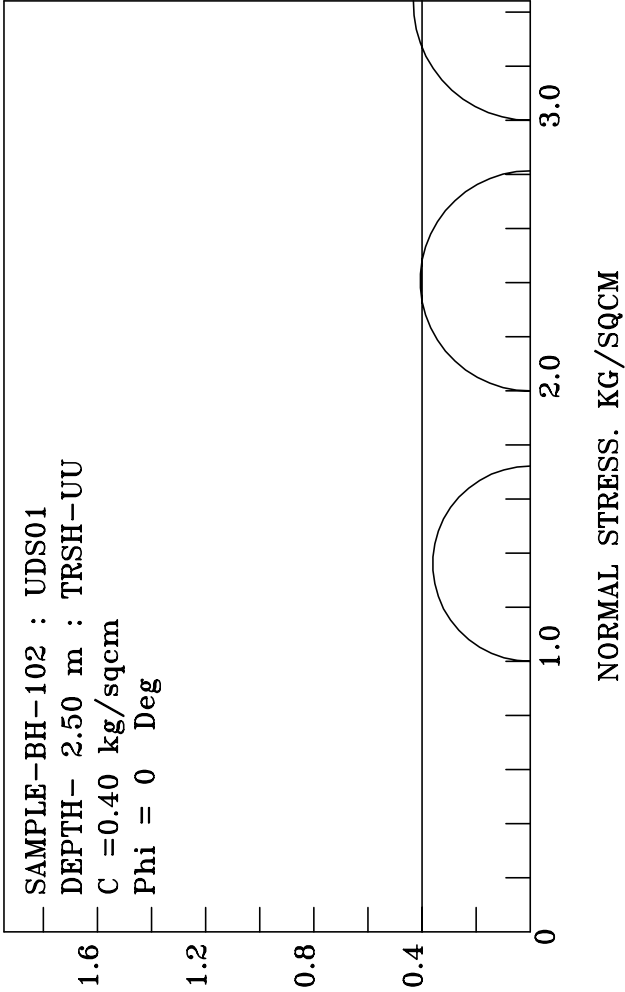
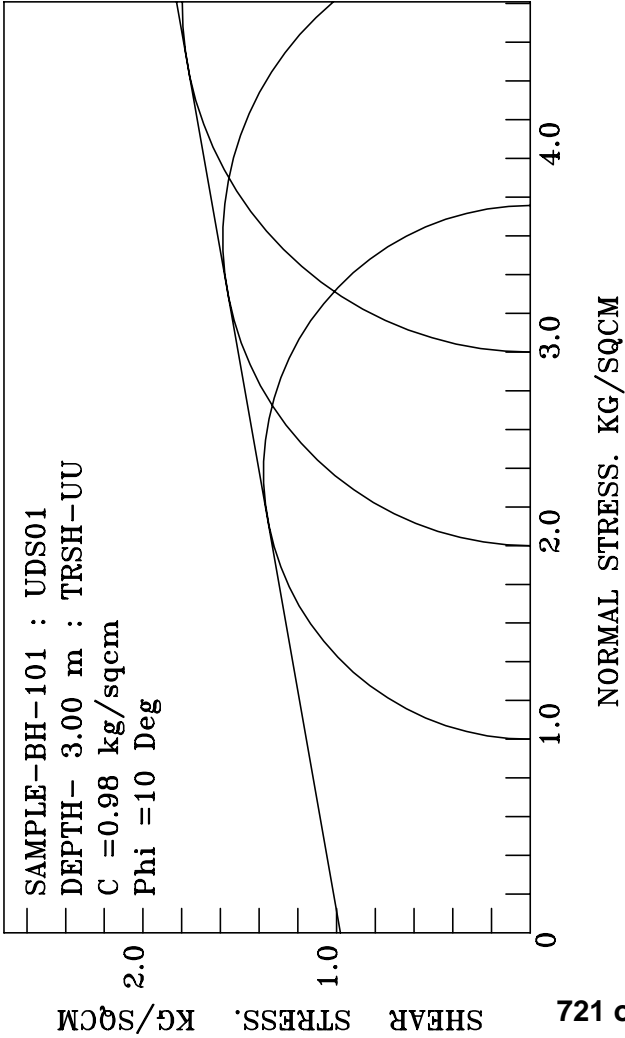
Point Load Index: IS 8764.

Water Content, Bulk &amp; Dry Density and Porosity: IS 13030

Unconfined Compressive Strength: IS 9143.

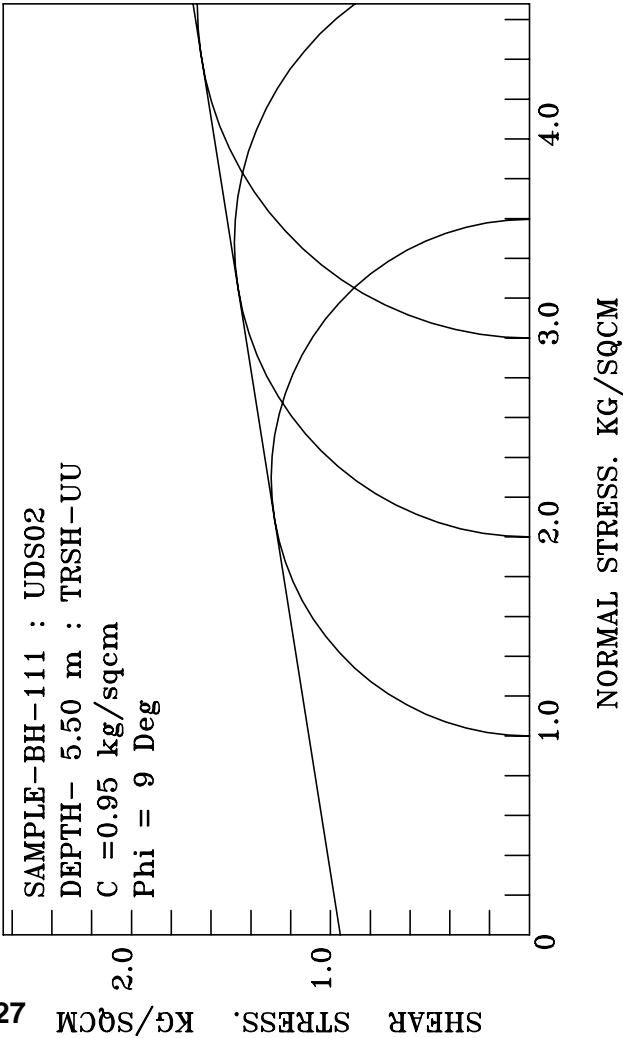
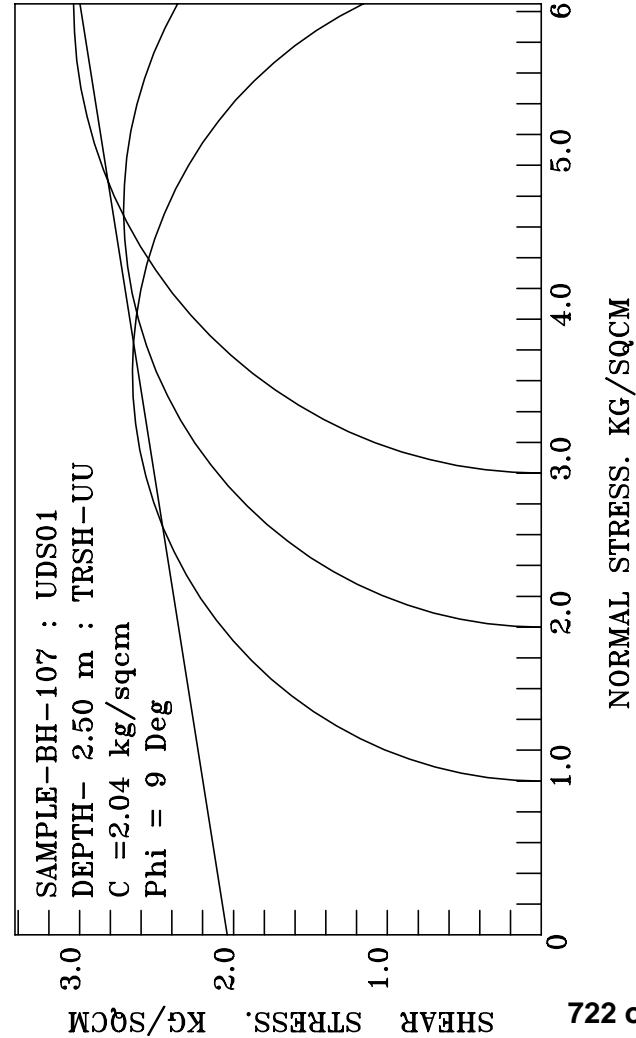
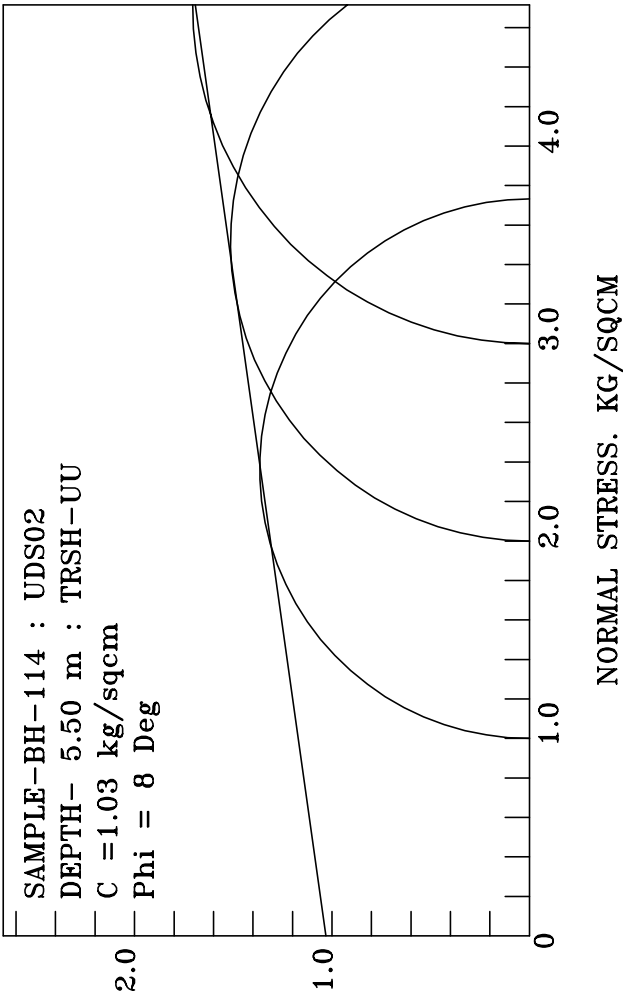
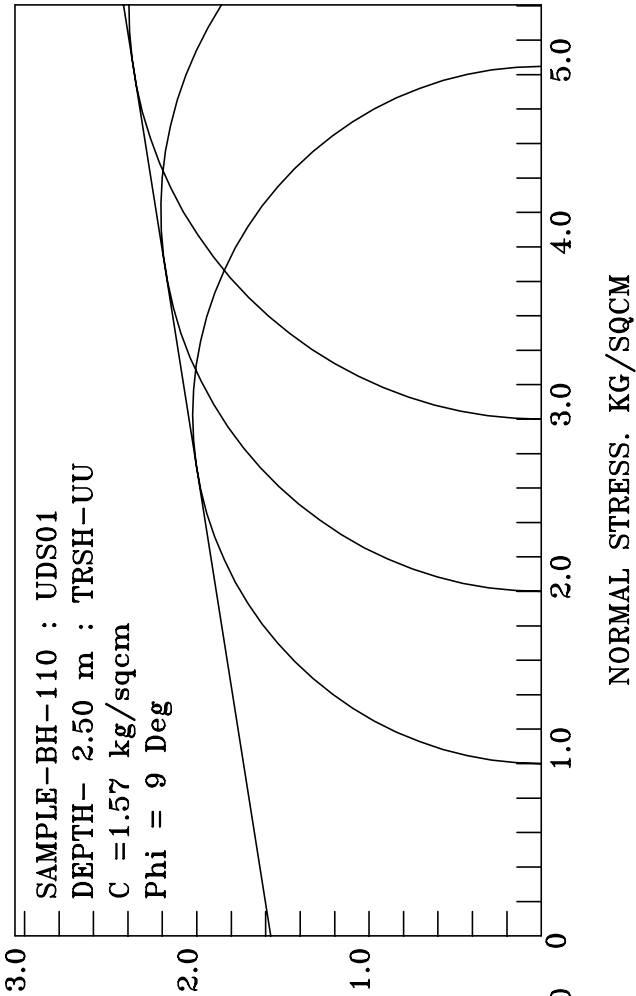
**C.E. Testing Company Pvt. Ltd.****Prepared By****(I. Chowdhury)  
Deputy Technical Manager****Checked & Approved By****Sudip Nath  
Technical Manager****\*\*End of Report\*\***

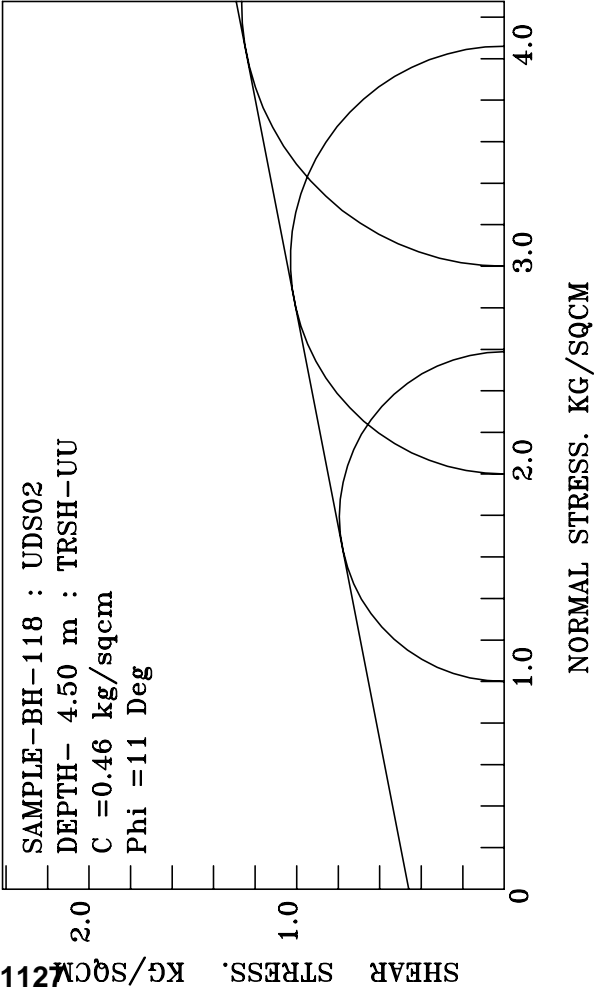
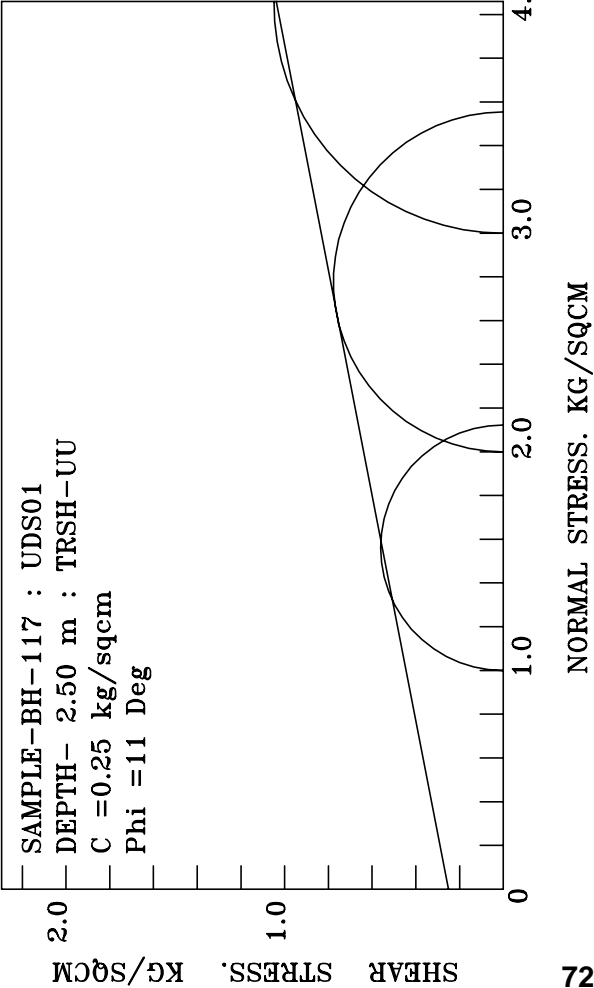
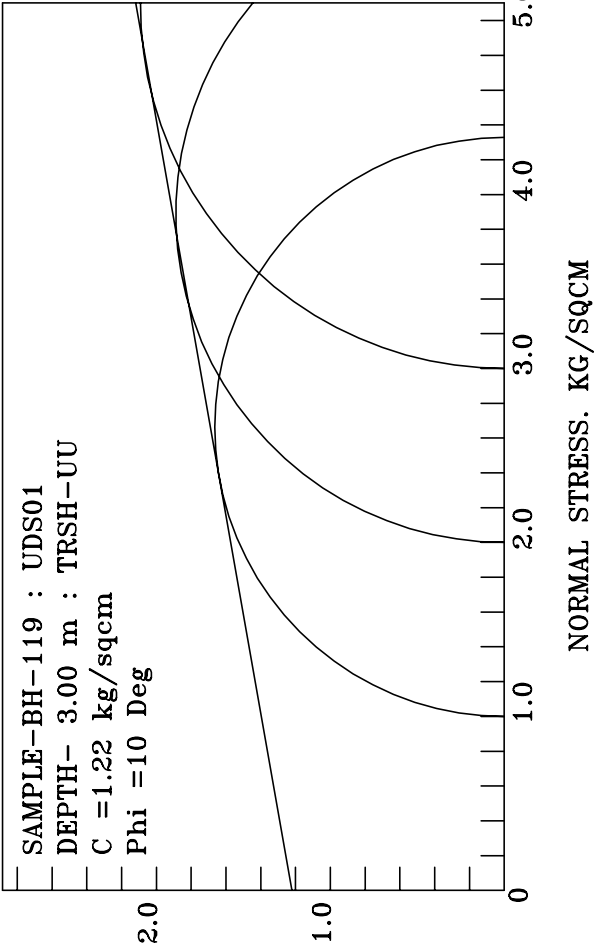
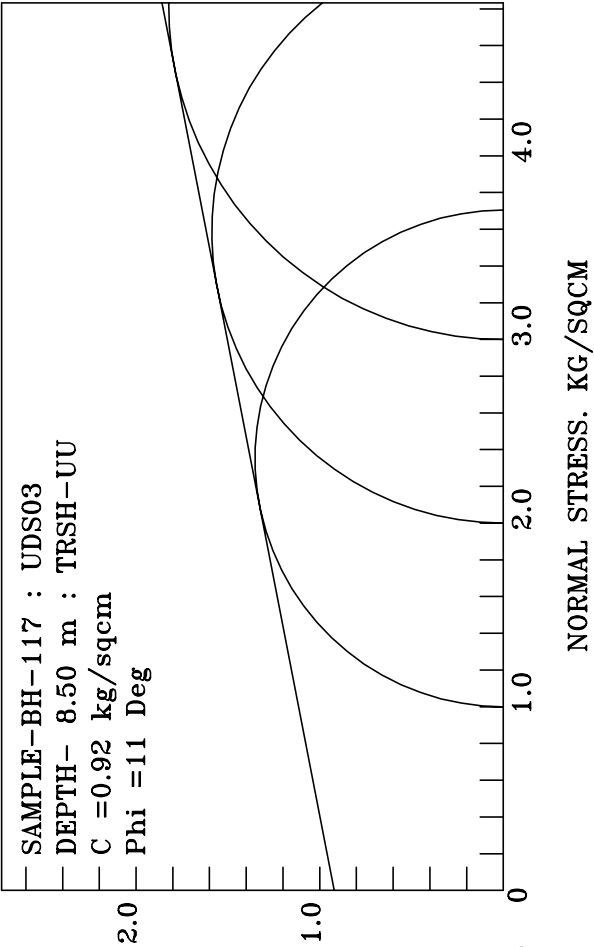
### **PART III: CHARTS & GRAPHS**





Job No :4095	Created by : Srabanti	Created on :	Sheet No:
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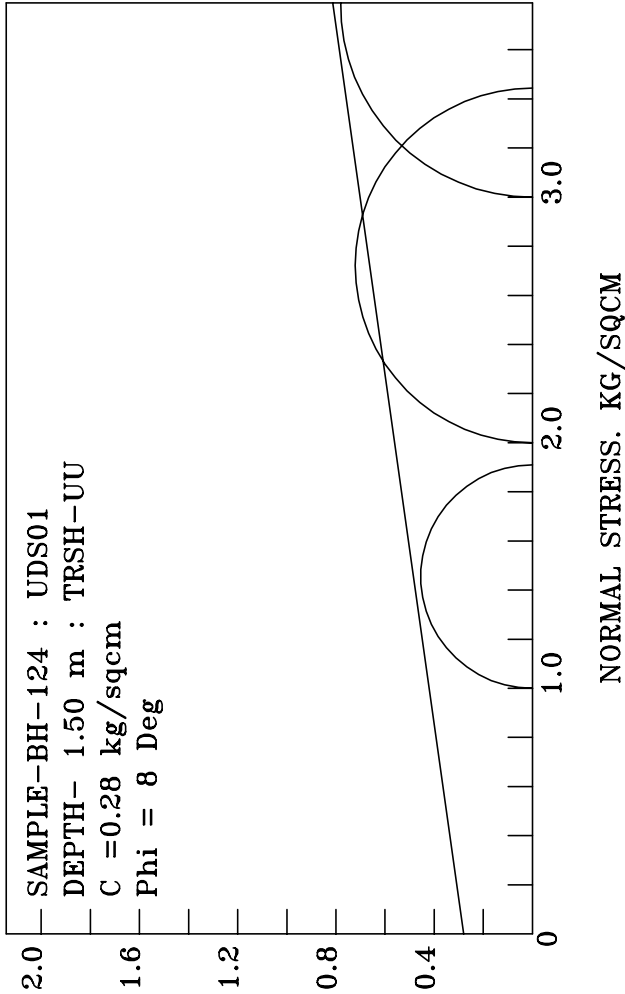
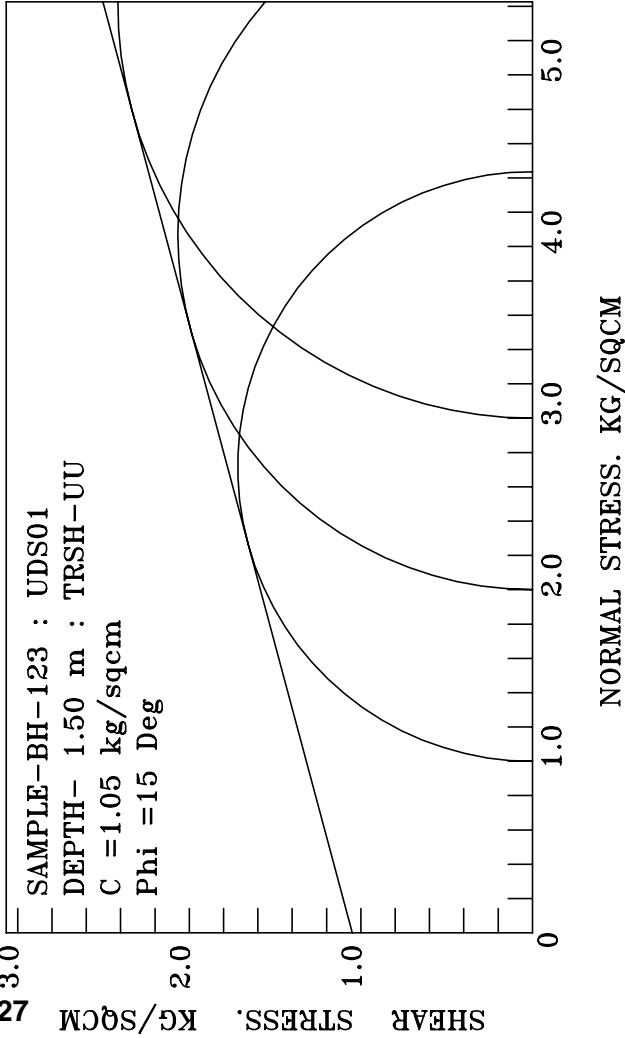
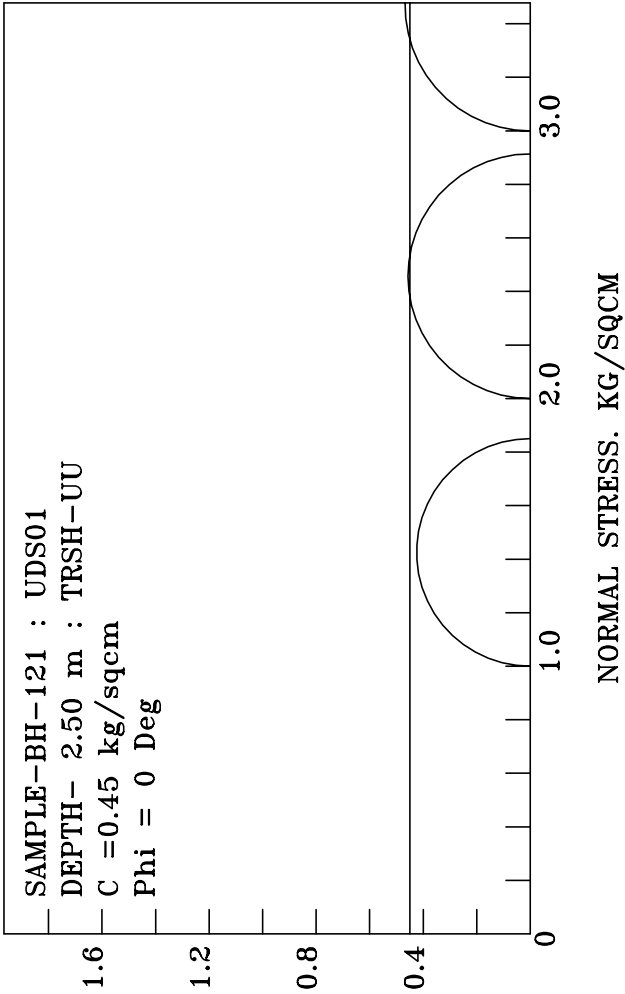
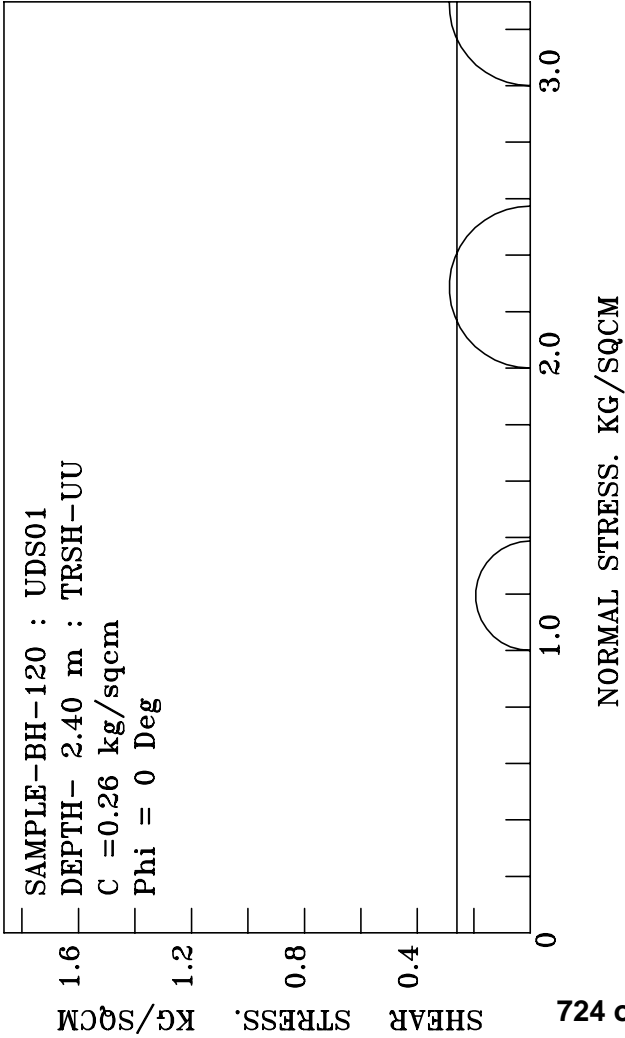


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Created by : Srabanti

Created on :

Sheet No:

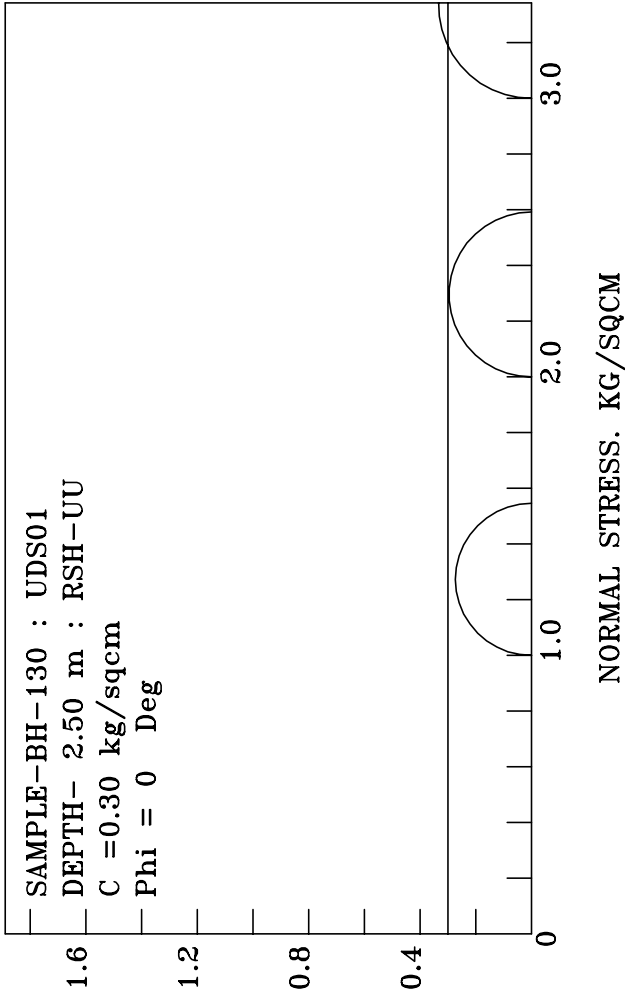
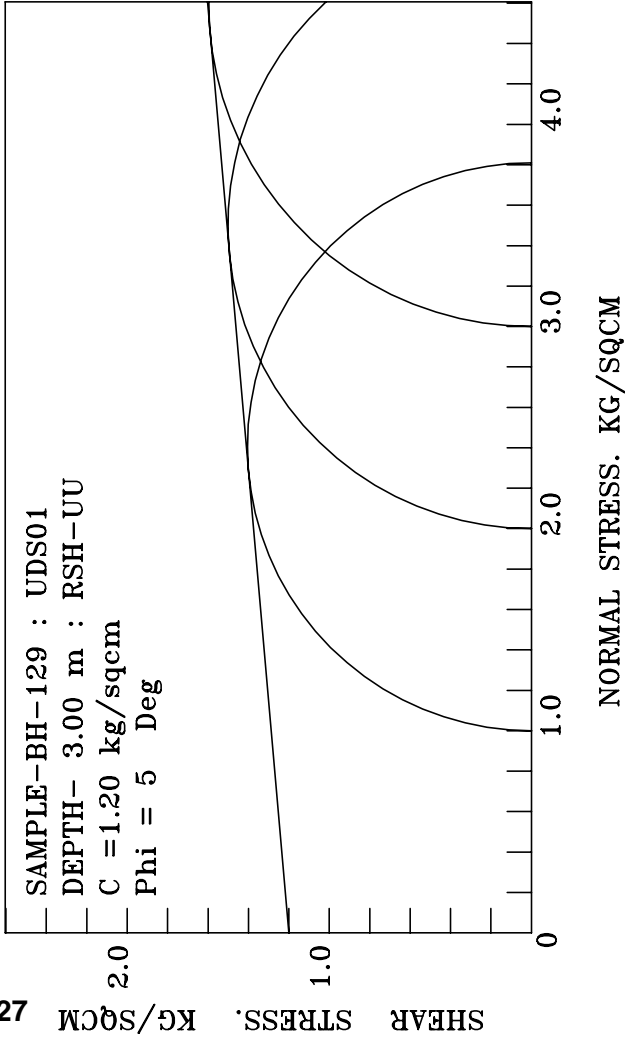
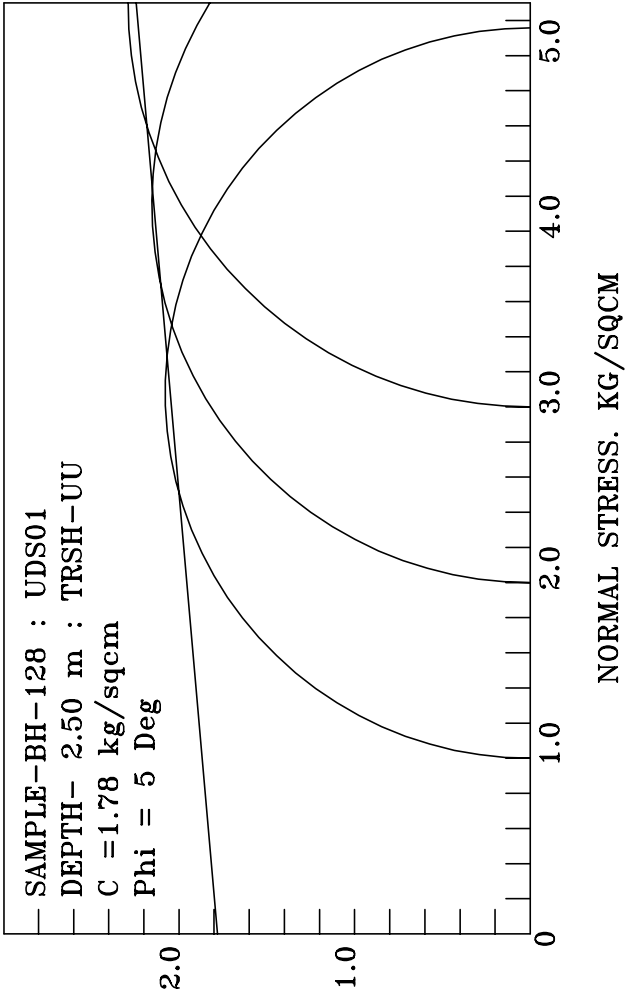
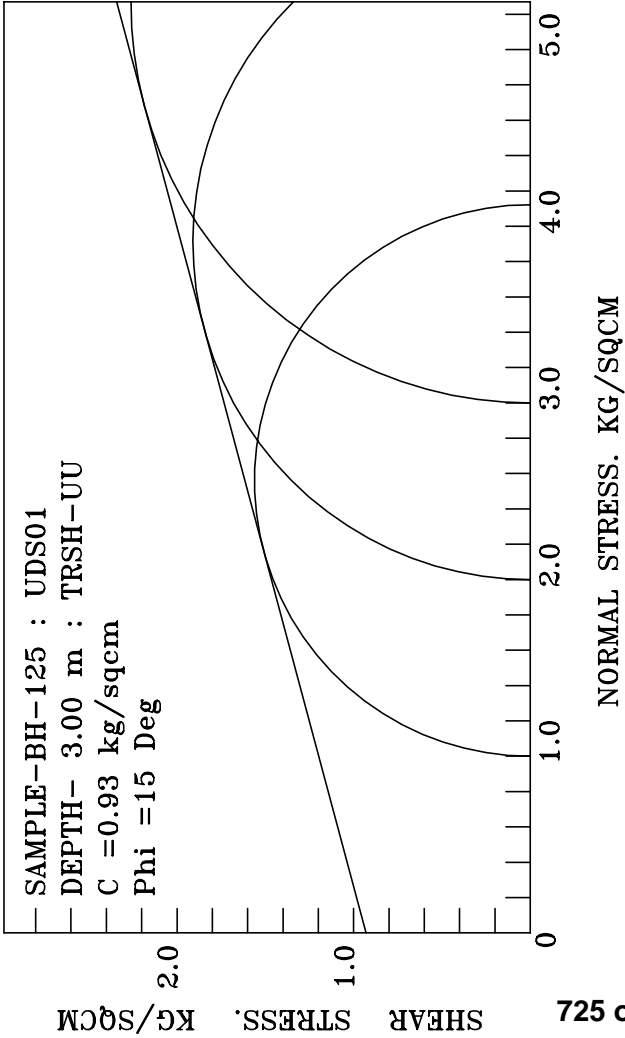


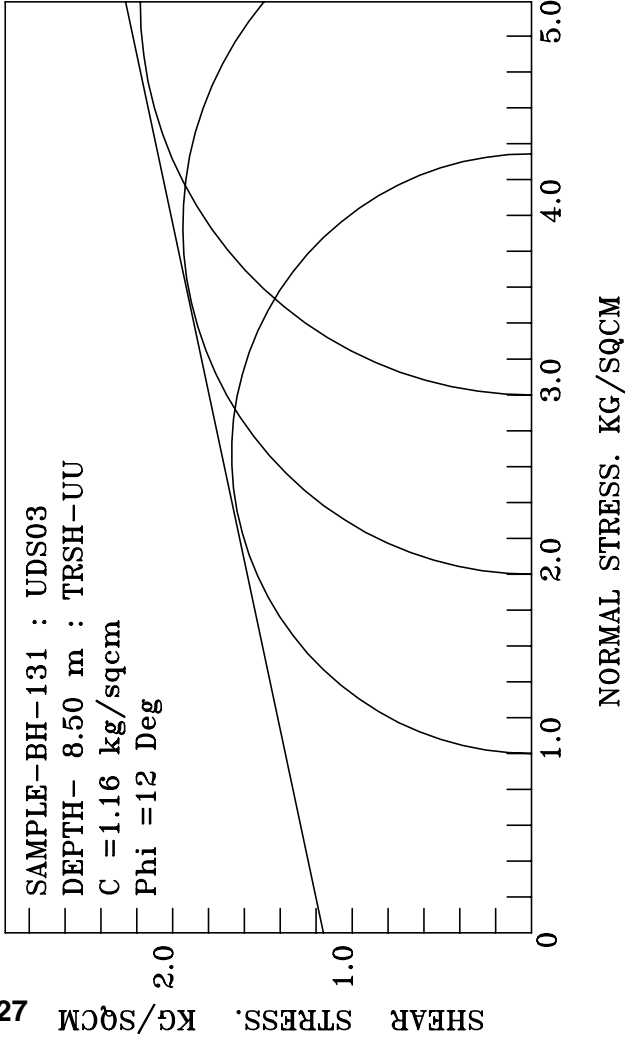
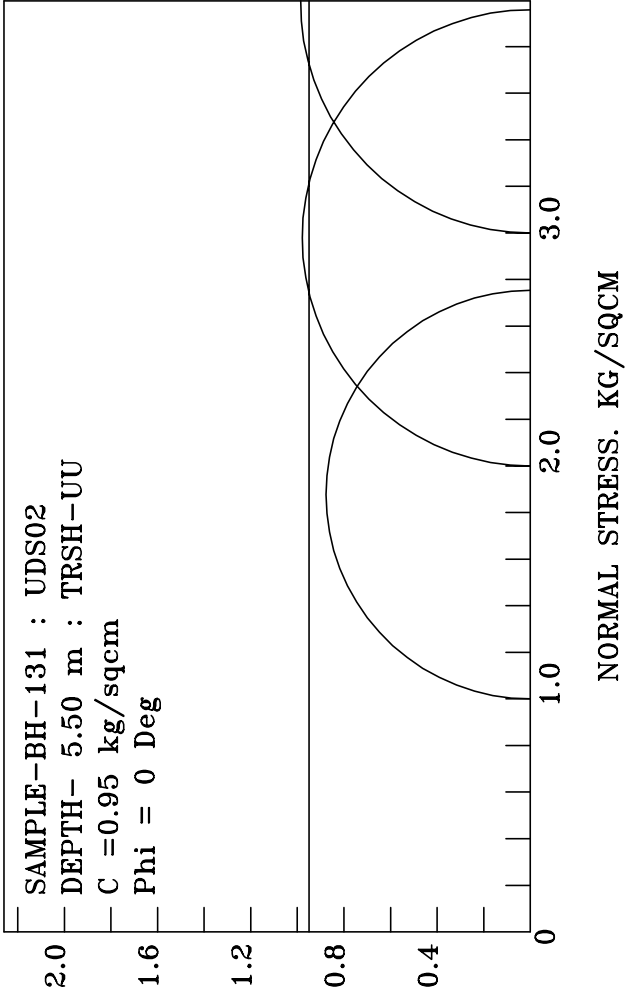
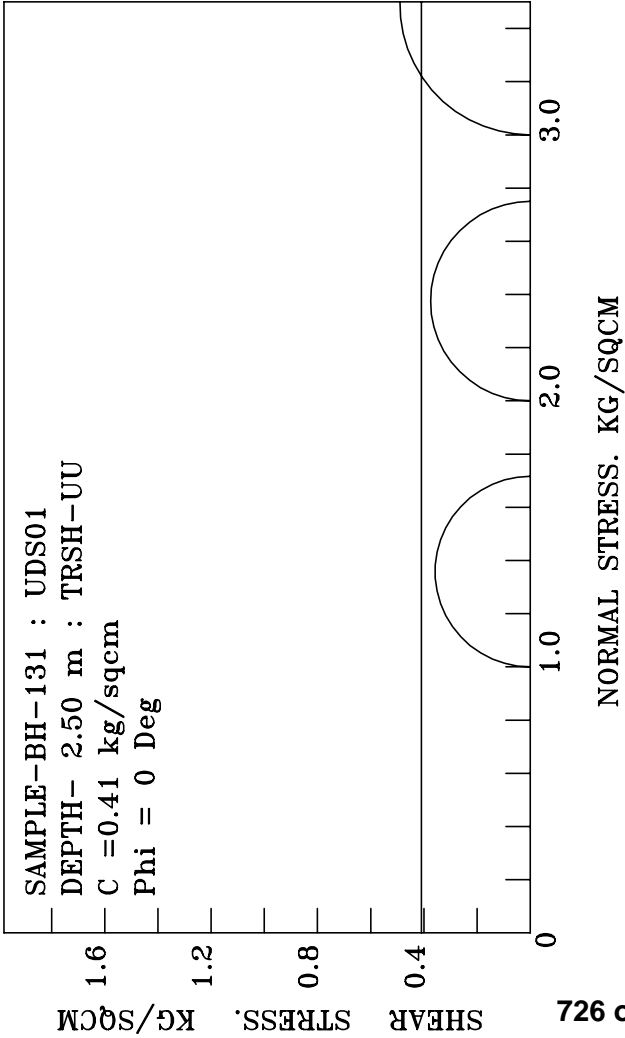
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Created by : Srabanti

Created on :

Sheet No:





**Triaxial Consolidated Drained Test With Pore Water Pressure Measurements**

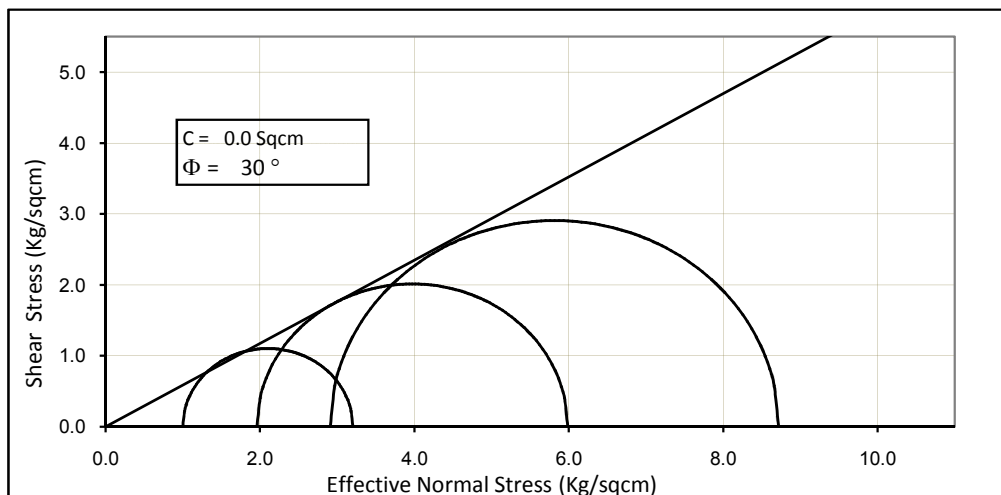
Job No. - 4095

Borehole No : 102

Sample No: UDS-01

Depth: 2.50-2.95m

Used Back Pressure = 5 Kg/sqcm

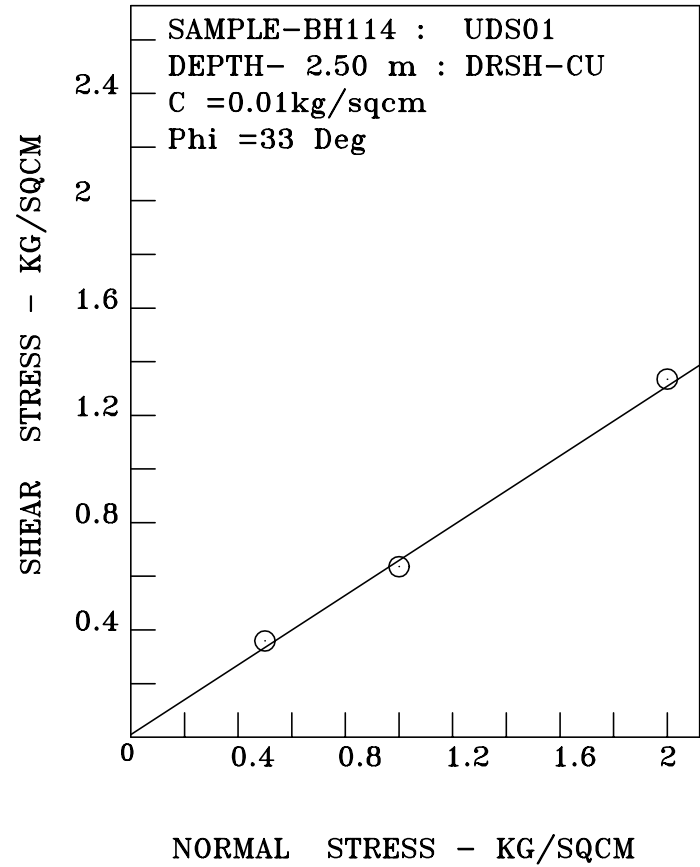


Job No :4095

Created by : Srabanti

Created on :

Sheet No:



Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

Sample Number: BH--101/UDS-01

Depth : 3-3.45 meters

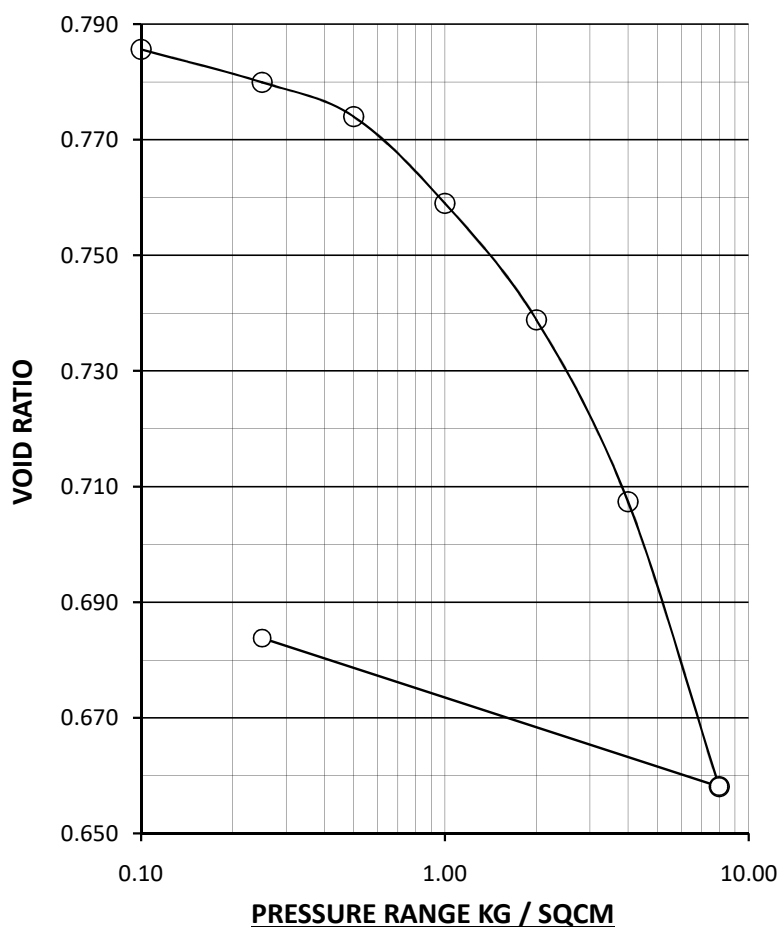
Description : Reddish brown clayey silt with traces of sand mixture.

Water content: Initial=26%

Final =25.6%

Initial Void Ratio =0.788

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	13	0.786	0.0130				
0.10 - 0.25	32	0.780	0.0213	56.25	0.0093	121.0	6.939
0.25 - 0.50	33	0.774	0.0132	45.45	0.0072	223.5	3.708
0.50 - 1.00	84	0.759	0.0169	59.52	0.0068	104.5	7.739
1.00 - 2.00	113	0.739	0.0115	61.06	0.0045	109.4	7.104
2.00 - 4.00	176	0.707	0.0090	73.86	0.0024	142.3	5.134
4.00 - 8.00	276	0.658	0.0072	69.93	0.0022	80.7	8.189
8.00 - 0.25	144	0.684	0.0020				

**e-logp Curve**



Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

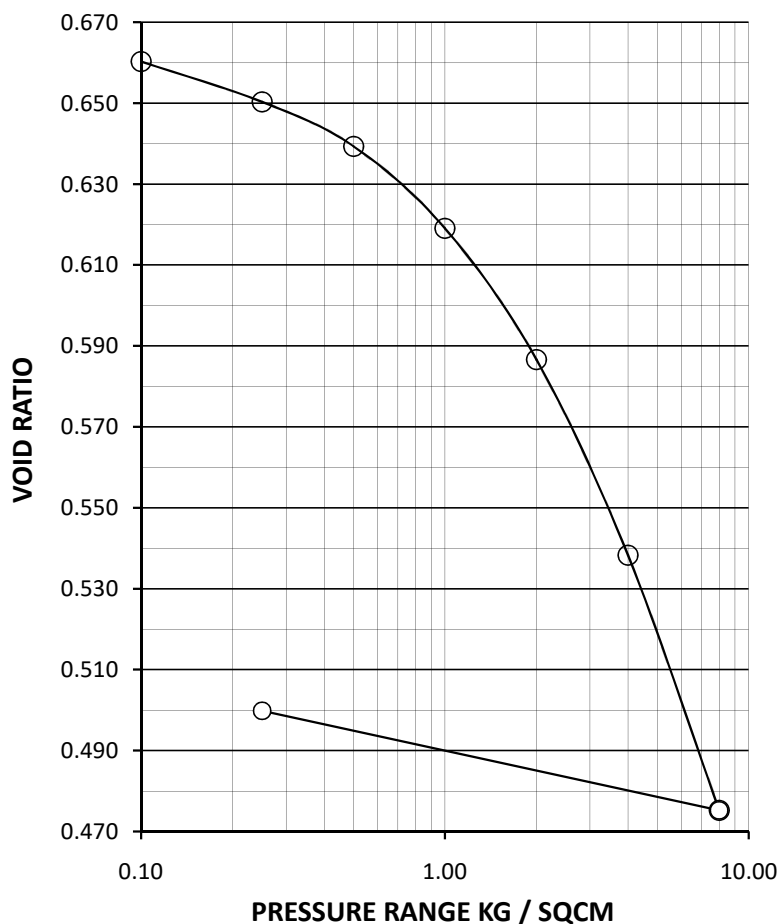
Sample Number: BH-102/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish silty clay.

Water content: Initial=27.2% Final =23.3% Initial Void Ratio =0.662

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	12	0.660	0.0120				
0.10 - 0.25	60	0.650	0.0401	46.67	0.0214	216.6	3.848
0.25 - 0.50	66	0.639	0.0266	38.20	0.0164	190.1	4.273
0.50 - 1.00	122	0.619	0.0247	40.98	0.0146	127.9	6.110
1.00 - 2.00	195	0.587	0.0200	54.36	0.0091	149.8	4.878
2.00 - 4.00	291	0.538	0.0152	63.57	0.0056	194.4	3.375
4.00 - 8.00	379	0.475	0.0102	55.41	0.0046	142.3	3.936
8.00 - 0.25	148	0.500	0.0022				

**e-logp Curve**

Job No. 4095

Sheet No.

CONSOLIDATION TEST RESULTS

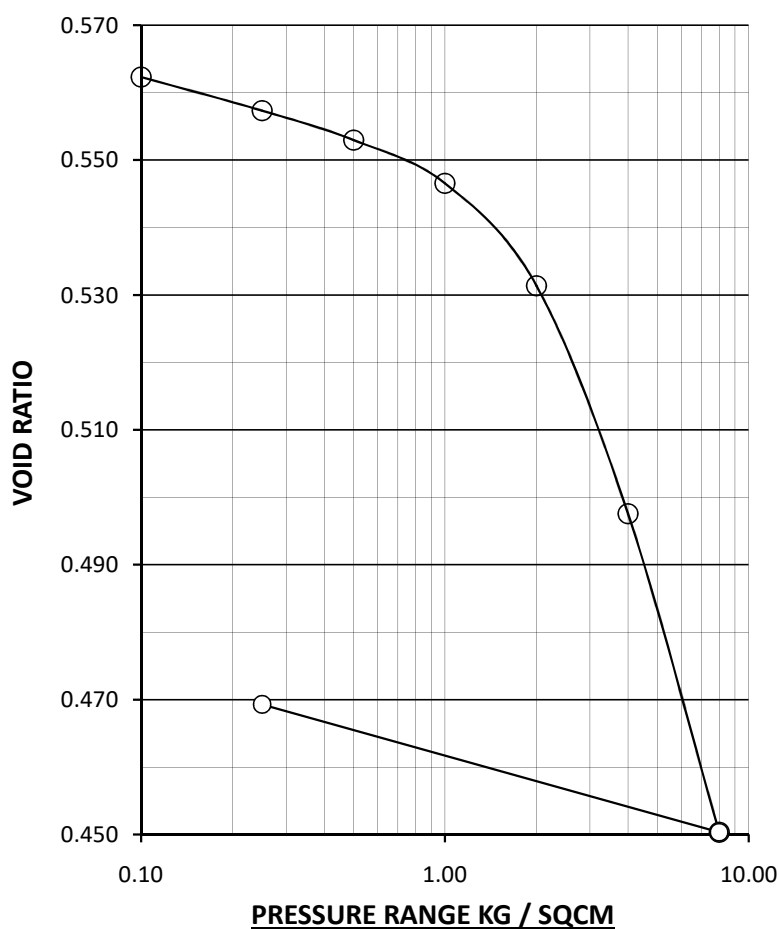
Sample Number: BH-104/UDS-01

Depth : 3-3.45 meters

Description : Reddish silty clay with kankar &amp; sand mixture.

Water content: Initial=20.9% Final =20.2% Initial Void Ratio =0.564

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	8	0.562	0.0080				
0.10 - 0.25	32	0.557	0.0214	43.75	0.0120	127.9	6.562
0.25 - 0.50	28	0.553	0.0112	37.90	0.0070	122.7	6.758
0.50 - 1.00	41	0.547	0.0083	48.78	0.0042	235.2	3.476
1.00 - 2.00	97	0.531	0.0098	68.04	0.0031	152.8	5.201
2.00 - 4.00	216	0.498	0.0110	66.20	0.0037	171.4	4.343
4.00 - 8.00	302	0.450	0.0079	64.90	0.0028	127.9	5.193
8.00 - 0.25	121	0.469	0.0017				

e-logp Curve

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

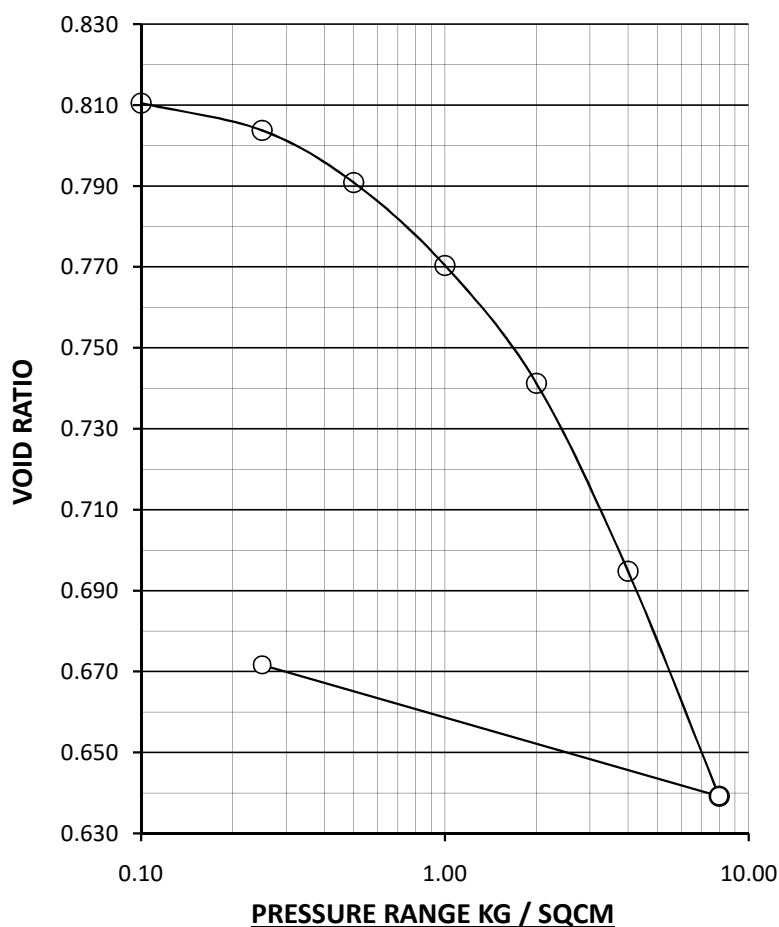
Sample Number: BH--105/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=27.4% Final =26.1% Initial Void Ratio =0.812

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	8	0.810	0.0080				
0.10 - 0.25	37	0.804	0.0247	54.05	0.0113	121.0	6.930
0.25 - 0.50	71	0.791	0.0285	60.56	0.0113	254.6	3.222
0.50 - 1.00	113	0.770	0.0229	42.48	0.0132	107.7	7.331
1.00 - 2.00	161	0.741	0.0165	42.24	0.0095	133.2	5.598
2.00 - 4.00	256	0.695	0.0133	54.69	0.0060	155.5	4.377
4.00 - 8.00	307	0.639	0.0082	47.56	0.0043	192.2	3.110
8.00 - 0.25	179	0.672	0.0026				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

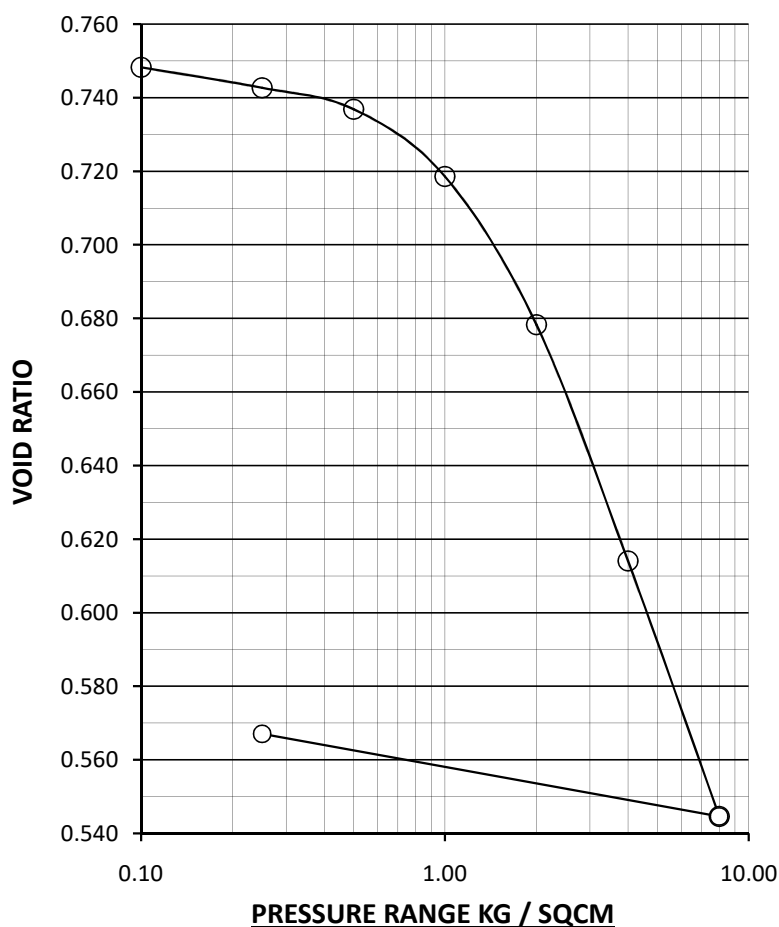
Sample Number: BH--107/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish brown clayey silt / silty clay with kankars and sand mixtu:

Water content: Initial=20.5% Final =21.9% Initial Void Ratio =0.751

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	14	0.748	0.0140				
0.10 - 0.25	32	0.743	0.0214	53.13	0.0100	121.0	6.902
0.25 - 0.50	33	0.737	0.0133	39.39	0.0081	240.6	3.425
0.50 - 1.00	104	0.719	0.0210	60.58	0.0083	194.4	4.123
1.00 - 2.00	230	0.678	0.0235	70.87	0.0068	106.1	7.041
2.00 - 4.00	366	0.614	0.0191	79.23	0.0040	103.0	6.365
4.00 - 8.00	396	0.545	0.0108	74.24	0.0028	122.7	4.456
8.00 - 0.25	128	0.567	0.0019				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

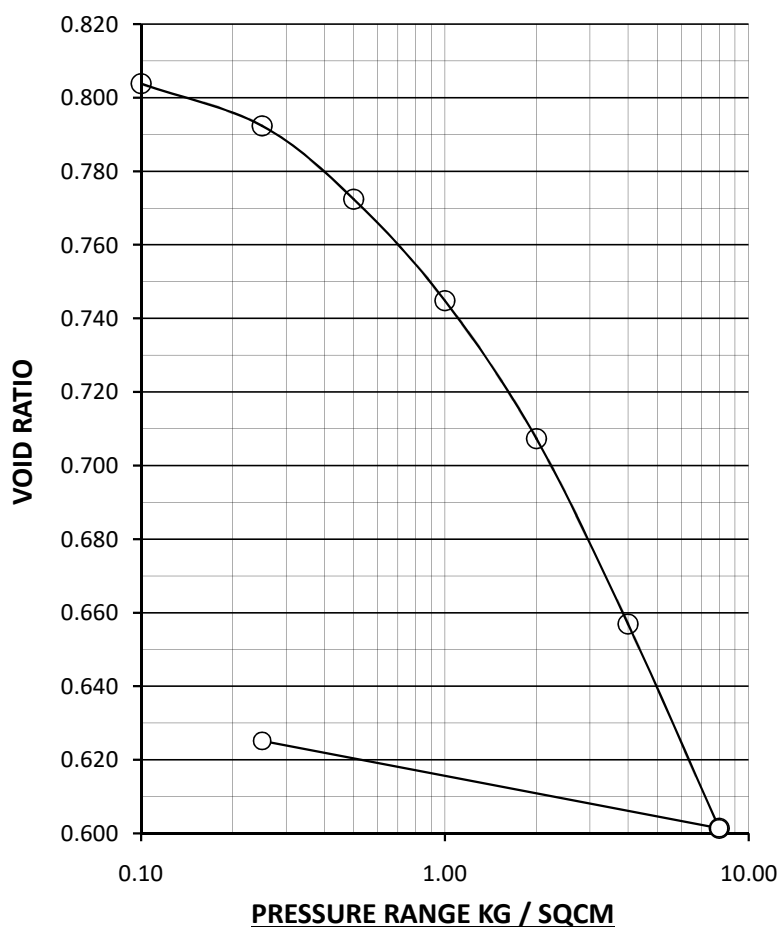
Sample Number: BH--107/UDS-02

Depth : 5.5-5.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=32.1% Final =25.8% Initial Void Ratio =0.81

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	34	0.804	0.0341				
0.10 - 0.25	63	0.792	0.0422	26.98	0.0308	269.0	3.059
0.25 - 0.50	110	0.772	0.0445	22.73	0.0344	301.1	2.638
0.50 - 1.00	152	0.745	0.0311	21.05	0.0246	381.0	1.973
1.00 - 2.00	207	0.707	0.0215	22.22	0.0167	190.1	3.658
2.00 - 4.00	278	0.657	0.0148	30.94	0.0102	252.2	2.471
4.00 - 8.00	306	0.601	0.0084	30.72	0.0058	345.6	1.565
8.00 - 0.25	131	0.625	0.0019				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

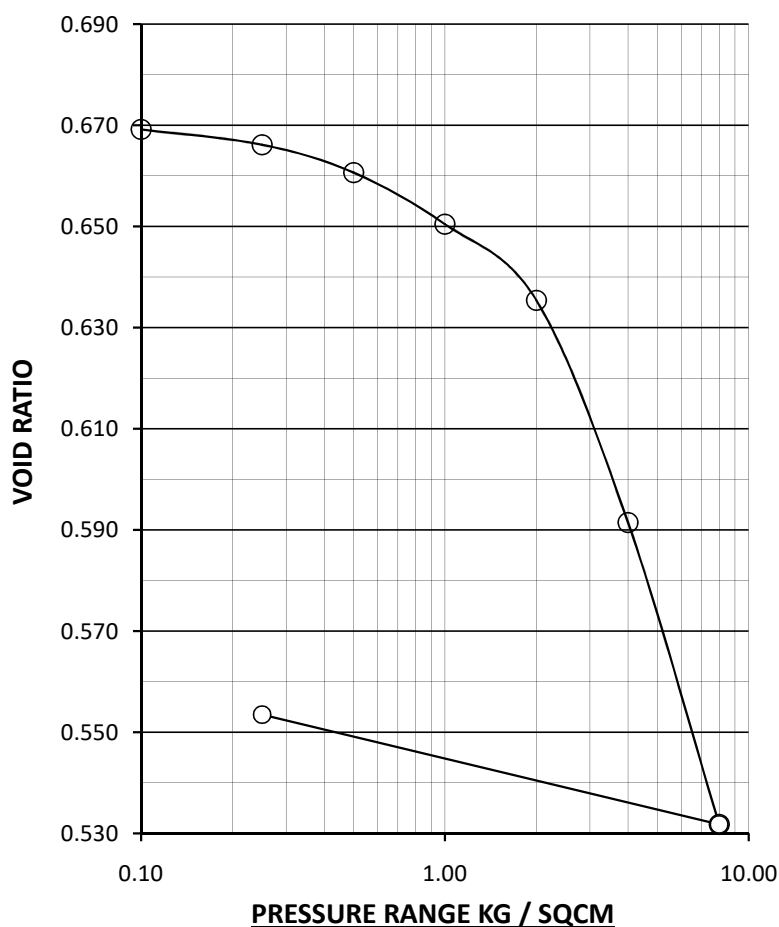
Sample Number: BH--110/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=20.4% Final =21.1% Initial Void Ratio =0.67

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	7	0.669	0.0070				
0.10 - 0.25	18	0.666	0.0120	27.78	0.0087	172.7	4.873
0.25 - 0.50	33	0.661	0.0132	48.48	0.0068	206.4	4.035
0.50 - 1.00	61	0.650	0.0123	49.18	0.0062	390.2	2.094
1.00 - 2.00	90	0.635	0.0091	58.89	0.0037	161.4	4.909
2.00 - 4.00	263	0.591	0.0134	73.00	0.0036	244.8	3.004
4.00 - 8.00	357	0.532	0.0094	71.71	0.0027	163.4	3.923
8.00 - 0.25	130	0.554	0.0018				

**e-logp Curve**

Job No. 4095

Sheet No.

CONSOLIDATION TEST RESULTS

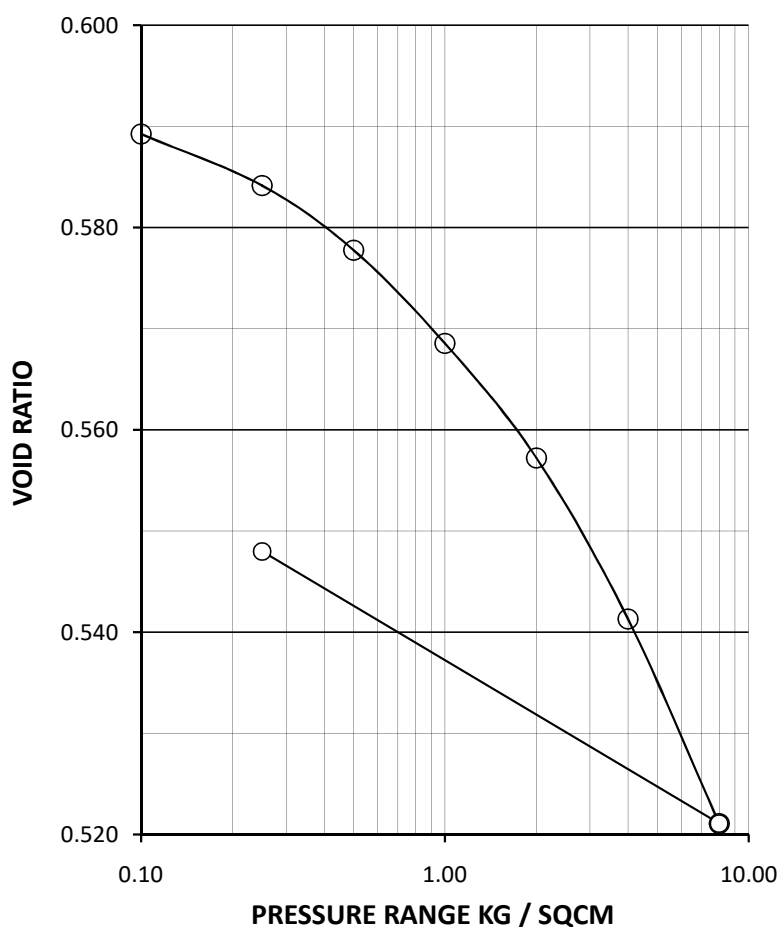
Sample Number: BH--111/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=19.4% Final =21.1% Initial Void Ratio =0.591

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	10	0.589	0.0100				
0.10 - 0.25	32	0.584	0.0214	46.88	0.0114	96.8	8.656
0.25 - 0.50	40	0.578	0.0161	45.00	0.0088	142.3	5.802
0.50 - 1.00	58	0.569	0.0117	50.00	0.0059	136.8	5.915
1.00 - 2.00	71	0.557	0.0072	57.75	0.0030	159.4	4.943
2.00 - 4.00	100	0.541	0.0051	64.00	0.0018	153.6	4.950
4.00 - 8.00	127	0.521	0.0033	50.39	0.0016	144.2	5.025
8.00 - 0.25	169	0.548	0.0023				

e-logp Curve

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

Sample Number: BH--111/UDS-02

Depth : 5.5-5.95 meters

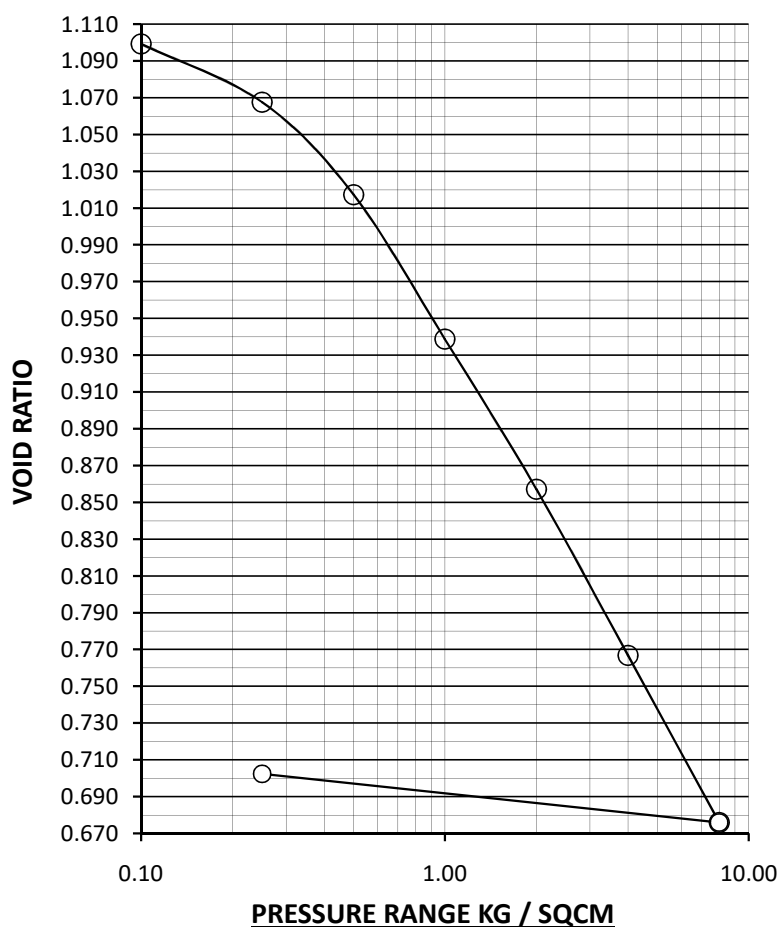
Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=23%

Final =24%

Initial Void Ratio =1.107

$P_1-P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	39	1.099	0.0390				
0.10 - 0.25	150	1.068	0.1004	59.30	0.0409	103.7	7.805
0.25 - 0.50	239	1.017	0.0975	59.60	0.0394	98.3	7.591
0.50 - 1.00	372	0.939	0.0777	58.24	0.0325	92.3	7.069
1.00 - 2.00	387	0.857	0.0421	59.91	0.0169	106.1	5.127
2.00 - 4.00	429	0.767	0.0243	65.37	0.0084	147.9	2.968
4.00 - 8.00	431	0.676	0.0129	57.53	0.0055	155.5	2.188
8.00 - 0.25	126	0.702	0.0020				

**e-logp Curve**



Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

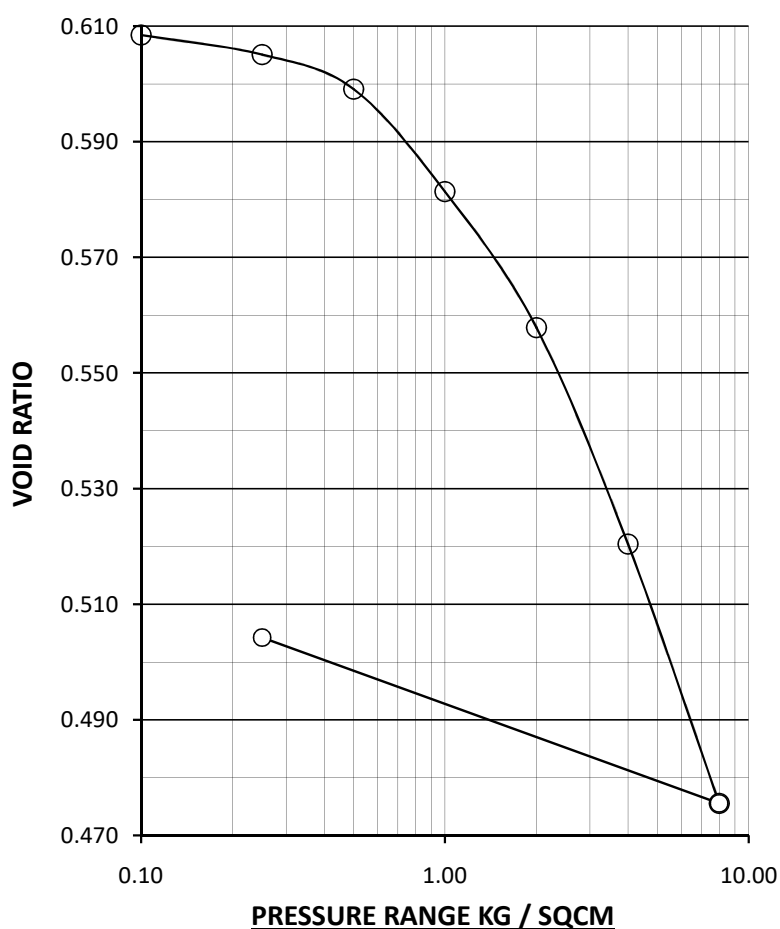
Sample Number: BH--112/UDS-01

Depth : 1.5-1.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=16.5% Final =20% Initial Void Ratio =0.61

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	8	0.608	0.0080				
0.10 - 0.25	21	0.605	0.0140	47.62	0.0074	169.0	4.960
0.25 - 0.50	37	0.599	0.0149	43.24	0.0084	131.4	6.304
0.50 - 1.00	110	0.581	0.0222	70.90	0.0065	157.1	5.118
1.00 - 2.00	146	0.558	0.0149	69.86	0.0045	115.9	6.575
2.00 - 4.00	232	0.520	0.0120	80.60	0.0023	124.4	5.648
4.00 - 8.00	278	0.476	0.0074	78.42	0.0016	136.8	4.577
8.00 - 0.25	178	0.504	0.0025				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

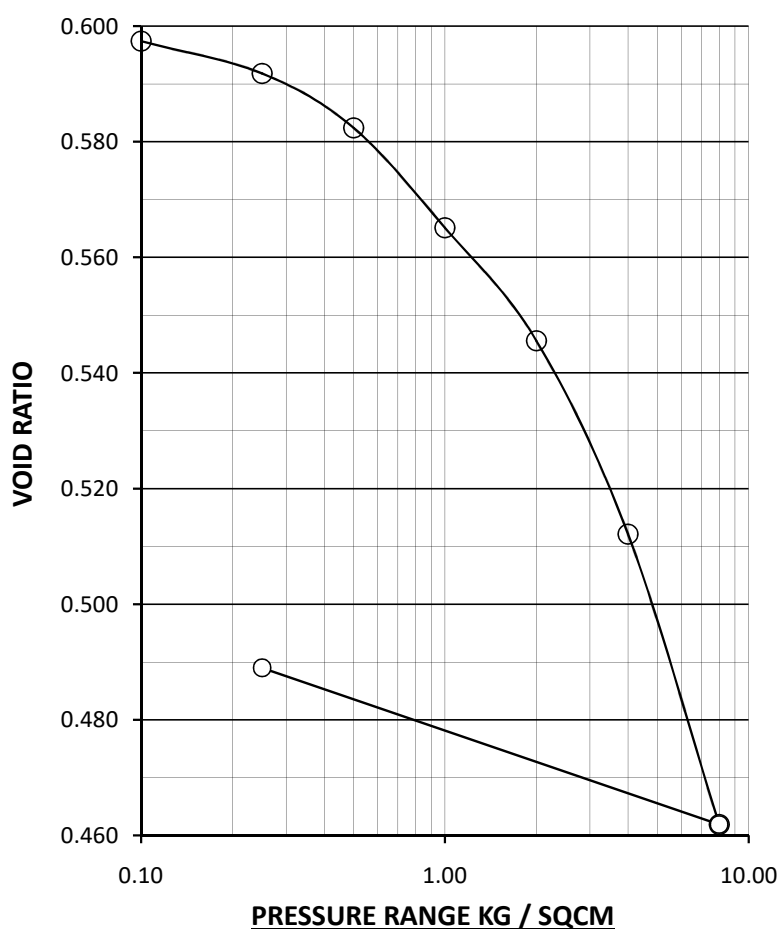
Sample Number: BH--113/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=17.5% Final =19.6% Initial Void Ratio =0.599

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	9	0.597	0.0090				
0.10 - 0.25	35	0.592	0.0234	54.29	0.0107	129.7	6.464
0.25 - 0.50	59	0.582	0.0237	50.85	0.0117	173.4	4.742
0.50 - 1.00	108	0.565	0.0218	70.37	0.0065	169.3	4.692
1.00 - 2.00	122	0.546	0.0125	55.74	0.0055	129.7	5.841
2.00 - 4.00	209	0.512	0.0108	65.07	0.0038	112.6	6.262
4.00 - 8.00	314	0.462	0.0083	70.06	0.0025	124.4	5.036
8.00 - 0.25	169	0.489	0.0024				

**e-logp Curve**

Job No. 4095

Sheet No.

CONSOLIDATION TEST RESULTS

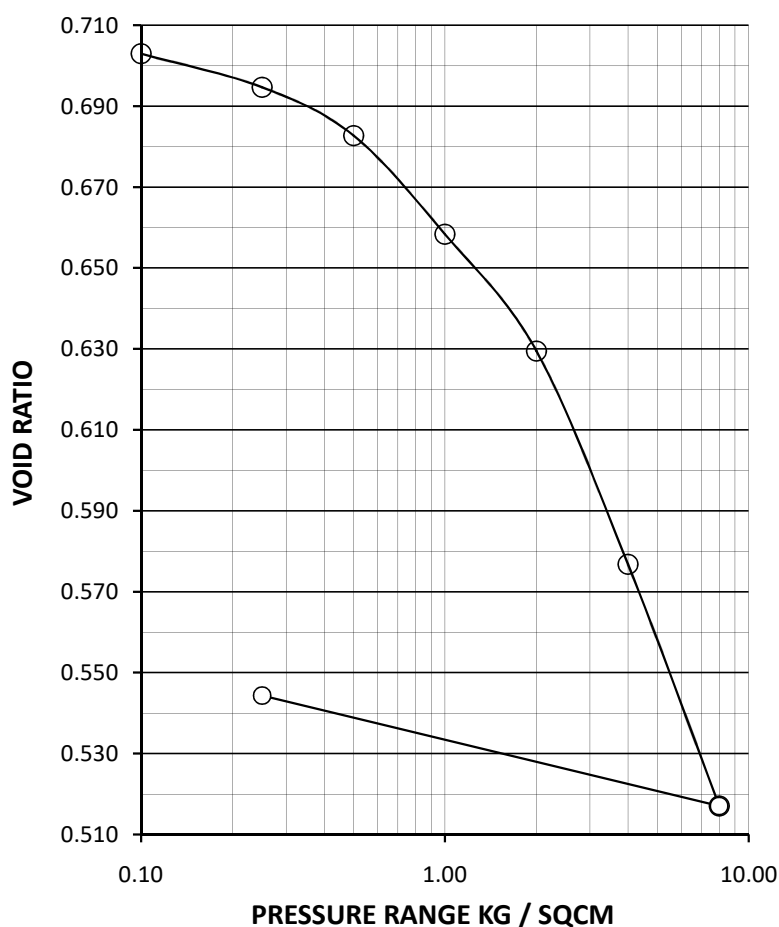
Sample Number: BH--114/UDS-02

Depth : 5.5-5.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=25.2% Final =22.3% Initial Void Ratio =0.707

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	26	0.703	0.0260				
0.10 - 0.25	49	0.695	0.0327	40.82	0.0194	87.8	9.480
0.25 - 0.50	70	0.683	0.0282	52.90	0.0133	153.6	5.292
0.50 - 1.00	143	0.658	0.0290	60.14	0.0116	95.3	8.167
1.00 - 2.00	169	0.629	0.0174	37.87	0.0108	173.4	4.199
2.00 - 4.00	309	0.577	0.0162	57.28	0.0069	311.9	2.100
4.00 - 8.00	350	0.517	0.0095	47.14	0.0050	240.0	2.335
8.00 - 0.25	160	0.544	0.0023				

e-logp Curve

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

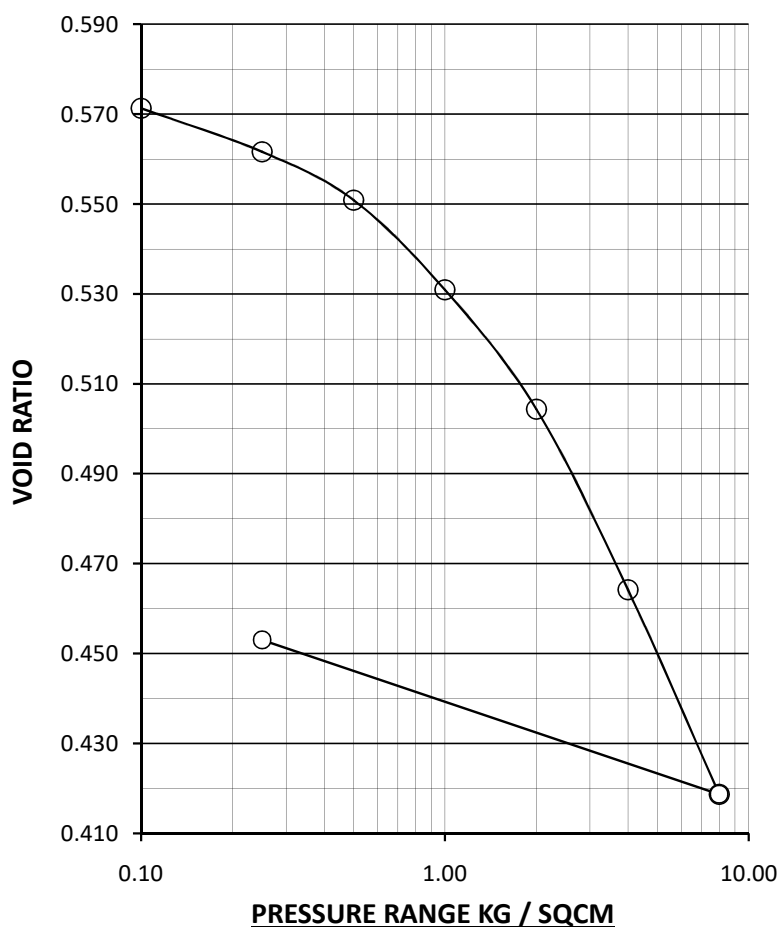
Sample Number: BH--117/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish brown clayey silt with sand mixture and rock pieces.

Water content: Initial=22.1% Final =18.7% Initial Void Ratio =0.577

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	37	0.571	0.0371				
0.10 - 0.25	61	0.562	0.0409	34.43	0.0268	195.3	4.203
0.25 - 0.50	68	0.551	0.0275	24.40	0.0208	235.2	3.399
0.50 - 1.00	126	0.531	0.0257	27.78	0.0186	133.2	5.765
1.00 - 2.00	168	0.504	0.0174	27.38	0.0126	171.4	4.208
2.00 - 4.00	254	0.464	0.0133	47.64	0.0070	161.4	4.069
4.00 - 8.00	288	0.419	0.0078	47.57	0.0041	188.0	3.076
8.00 - 0.25	217	0.453	0.0031				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

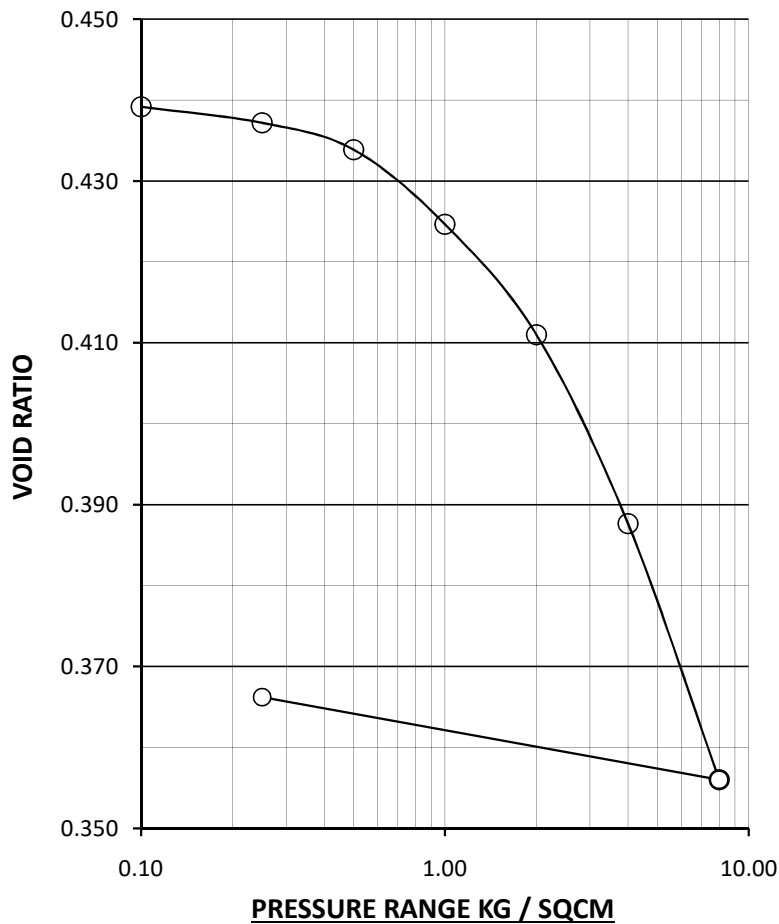
Sample Number: BH--117/UDS-03

Depth : 8.5-8.95 meters

Description : Greyish brown clayey silt with sand mixture.

Water content: Initial=15.1% Final =14% Initial Void Ratio =0.44

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	6	0.439	0.0060				
0.10 - 0.25	14	0.437	0.0093	35.71	0.0060	212.1	3.986
0.25 - 0.50	23	0.434	0.0092	17.39	0.0076	166.1	5.051
0.50 - 1.00	64	0.425	0.0128	18.75	0.0104	198.7	4.148
1.00 - 2.00	95	0.411	0.0096	21.05	0.0076	109.4	7.298
2.00 - 4.00	162	0.388	0.0083	54.94	0.0037	131.4	5.755
4.00 - 8.00	220	0.356	0.0057	61.82	0.0022	207.6	3.355
8.00 - 0.25	71	0.366	0.0010				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

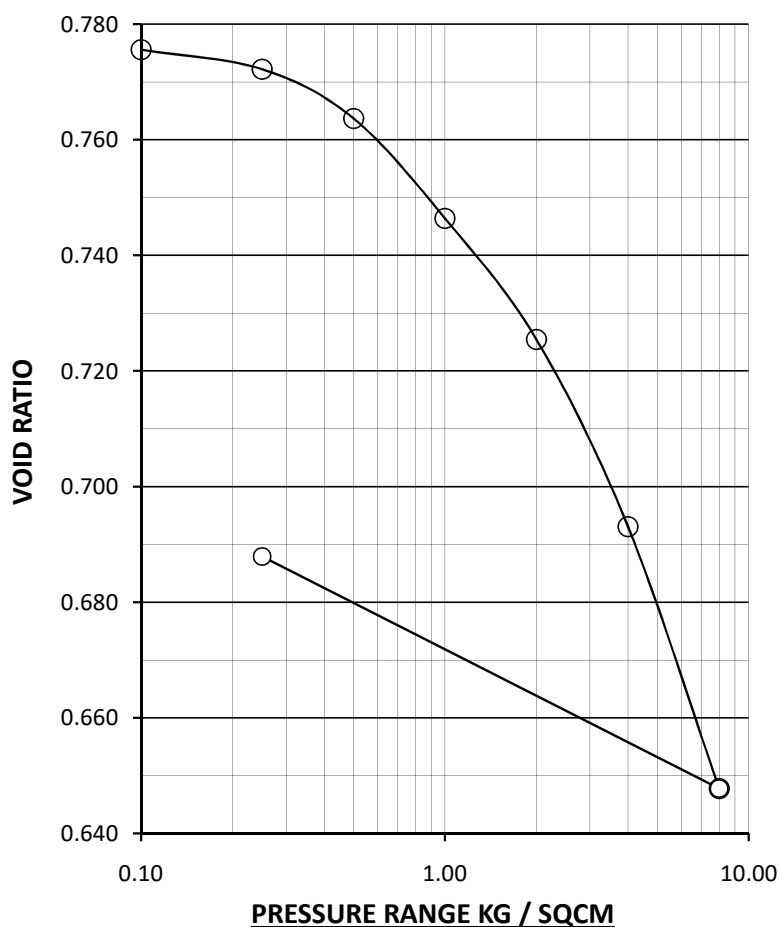
Sample Number: BH--118/UDS-02

Depth : 4.5-4.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=23.2% Final =24% Initial Void Ratio =0.778

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	14	0.776	0.0140				
0.10 - 0.25	19	0.772	0.0127	47.37	0.0067	96.8	8.684
0.25 - 0.50	48	0.764	0.0193	35.42	0.0124	264.6	3.133
0.50 - 1.00	97	0.746	0.0196	30.93	0.0135	112.6	7.148
1.00 - 2.00	118	0.725	0.0120	44.07	0.0067	144.2	5.341
2.00 - 4.00	182	0.693	0.0094	58.24	0.0039	175.4	4.116
4.00 - 8.00	255	0.648	0.0067	56.47	0.0029	175.4	3.735
8.00 - 0.25	226	0.688	0.0031				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

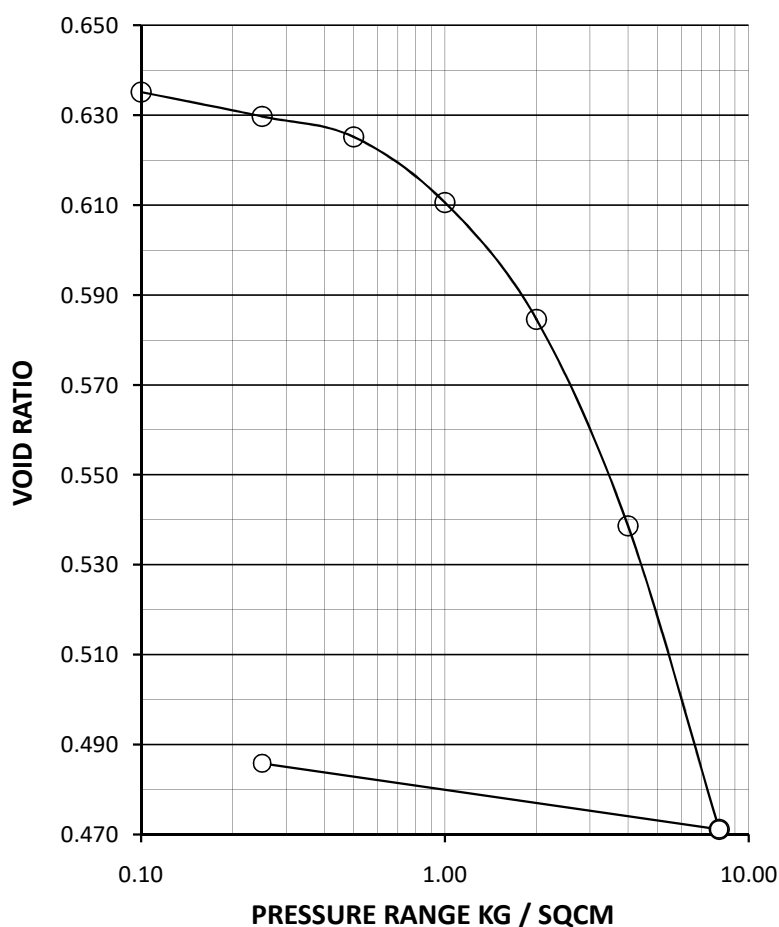
Sample Number: BH--119/UDS-01

Depth : 3-3.45 meters

Description : Reddish silty clay with rock pieces, sand mixture.

Water content: Initial=20.4% Final =19.8% Initial Void Ratio =0.638

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	19	0.635	0.0190				
0.10 - 0.25	33	0.630	0.0221	45.45	0.0120	101.6	8.197
0.25 - 0.50	28	0.625	0.0113	51.40	0.0055	111.4	7.384
0.50 - 1.00	89	0.611	0.0180	80.90	0.0034	121.0	6.639
1.00 - 2.00	158	0.585	0.0161	86.71	0.0021	138.6	5.503
2.00 - 4.00	280	0.539	0.0145	87.14	0.0019	103.0	6.741
4.00 - 8.00	411	0.471	0.0110	74.94	0.0027	136.8	4.328
8.00 - 0.25	89	0.486	0.0013				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

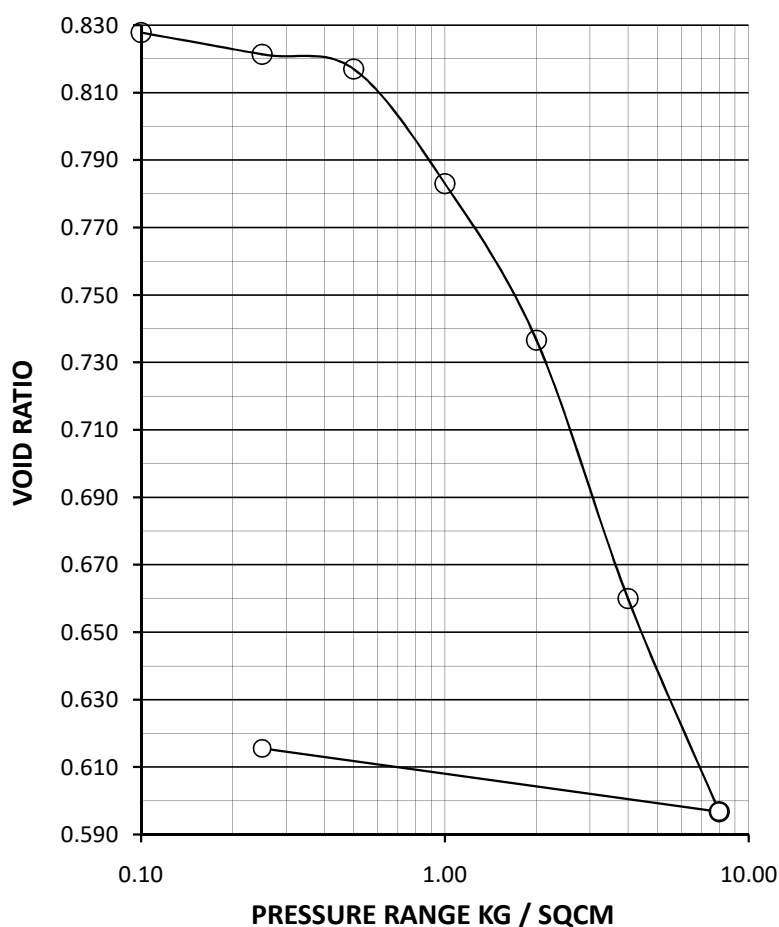
Sample Number: BH-119/UDS-02

Depth : 6-6.45 meters

Description : Reddish silty clay with traces of kanakr &amp; sand mixture.

Water content: Initial=26.5% Final =30.1% Initial Void Ratio =0.83

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	11	0.828	0.0110				
0.10 - 0.25	35	0.821	0.0233	42.86	0.0133	119.3	7.042
0.25 - 0.50	24	0.817	0.0096	50.80	0.0047	127.9	6.491
0.50 - 1.00	186	0.783	0.0374	86.02	0.0052	118.5	6.711
1.00 - 2.00	254	0.737	0.0260	89.37	0.0028	131.4	5.514
2.00 - 4.00	419	0.660	0.0221	92.84	0.0016	96.8	6.437
4.00 - 8.00	346	0.597	0.0095	92.20	0.0007	160.4	3.221
8.00 - 0.25	103	0.616	0.0015				

**e-logp Curve**



Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

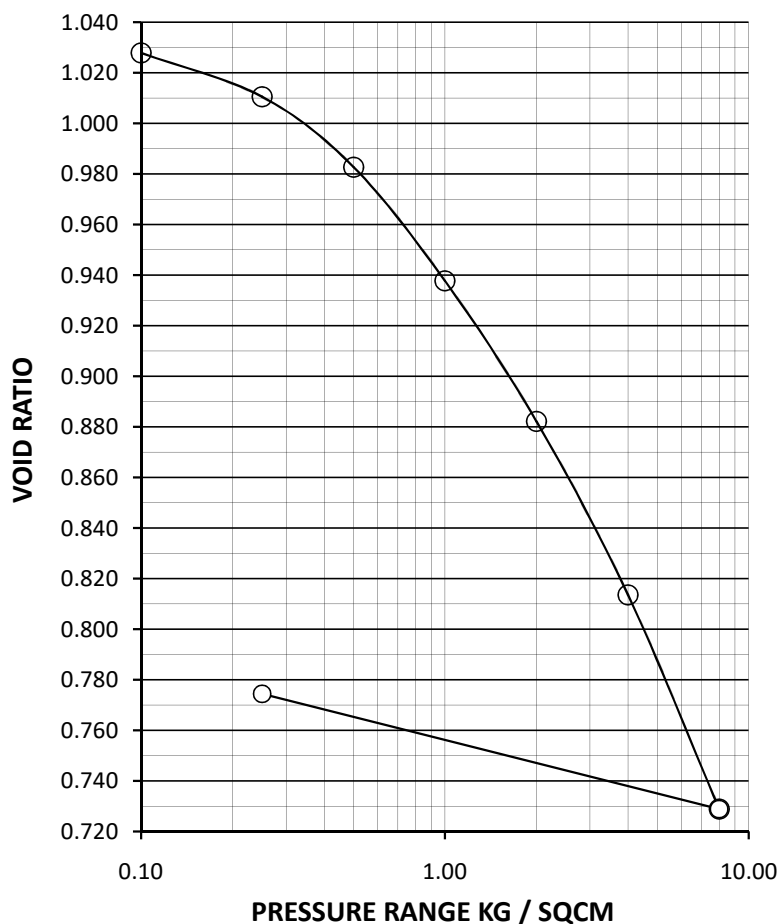
Sample Number: BH-120/UDS-01

Depth : 2.4-2.85 meters

Description : Reddish brown clayey silt.

Water content: Initial=37.6% Final =30.8% Initial Void Ratio =1.031

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	16	1.028	0.0160				
0.10 - 0.25	85	1.011	0.0569	28.24	0.0408	111.0	7.432
0.25 - 0.50	137	0.983	0.0555	35.77	0.0356	117.6	6.701
0.50 - 1.00	221	0.938	0.0454	53.85	0.0209	99.8	7.317
1.00 - 2.00	273	0.882	0.0287	39.19	0.0174	95.3	6.875
2.00 - 4.00	337	0.814	0.0182	49.85	0.0091	87.8	6.456
4.00 - 8.00	416	0.729	0.0117	55.53	0.0052	87.8	5.322
8.00 - 0.25	224	0.774	0.0034				

**e-logp Curve**

Job No. 4095

Sheet No.

CONSOLIDATION TEST RESULTS

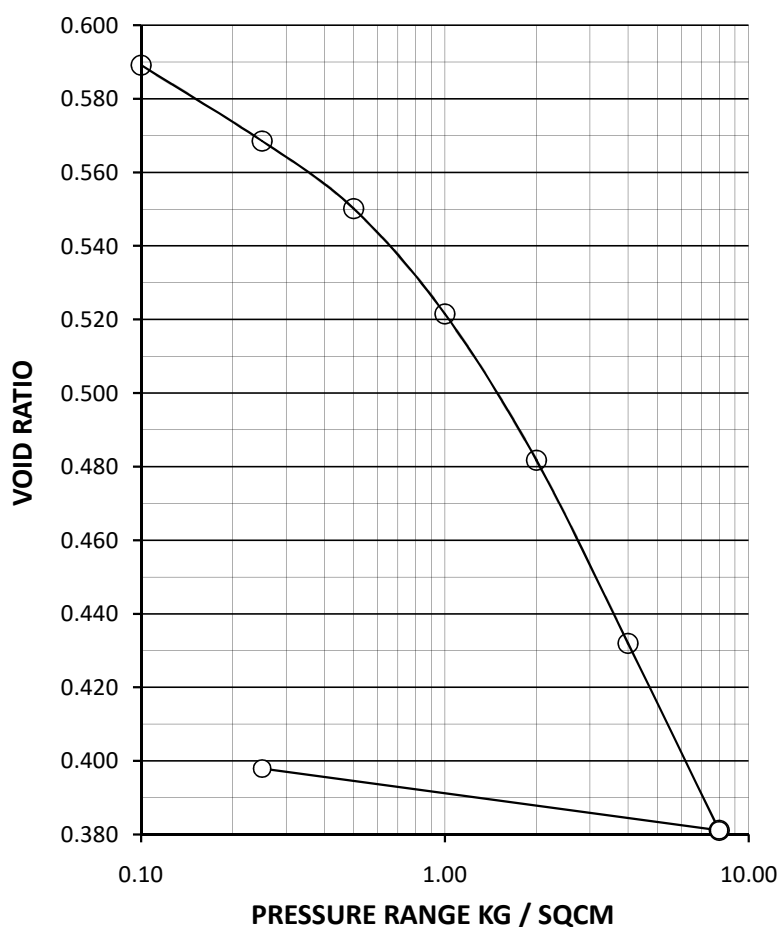
Sample Number: BH-121/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish silty clay with kankar &amp; sand mixture.

Water content: Initial=27.9% Final =22.4% Initial Void Ratio =0.594

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	33	0.589	0.0331				
0.10 - 0.25	129	0.569	0.0865	32.56	0.0583	137.7	5.889
0.25 - 0.50	115	0.550	0.0469	23.90	0.0357	230.9	3.339
0.50 - 1.00	179	0.522	0.0369	22.91	0.0285	306.5	2.363
1.00 - 2.00	249	0.482	0.0262	25.30	0.0195	227.7	2.893
2.00 - 4.00	311	0.432	0.0168	33.44	0.0112	128.4	4.498
4.00 - 8.00	318	0.381	0.0089	25.16	0.0066	211.9	2.326
8.00 - 0.25	105	0.398	0.0016				

e-logp Curve

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

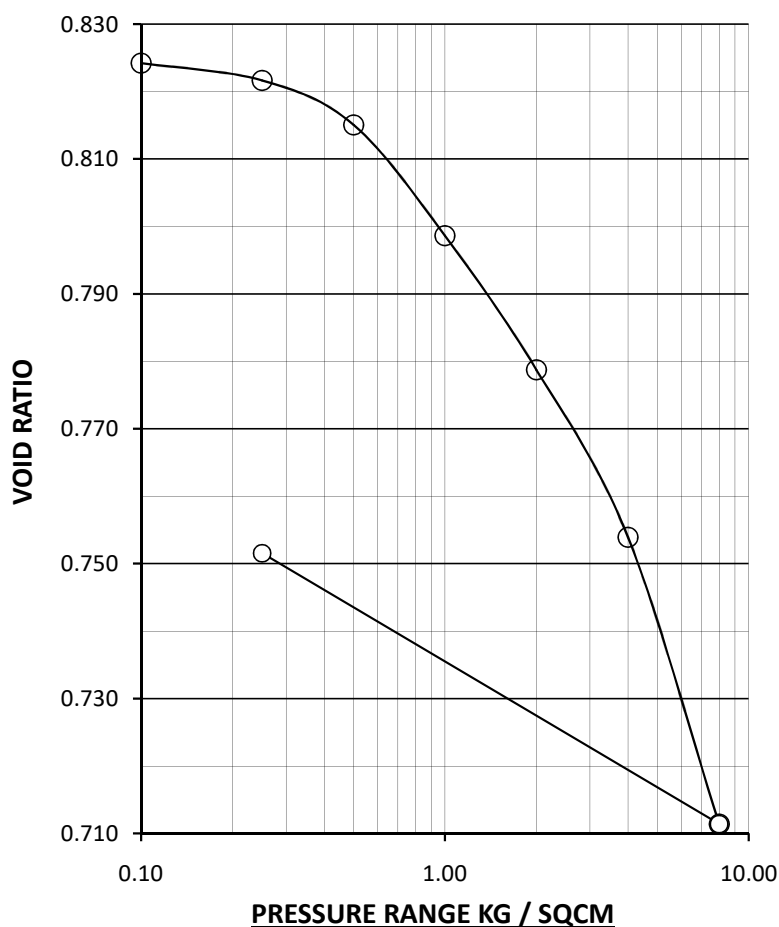
Sample Number: BH--123/UDS-01

Depth : 1.5-1.95 meters

Description : Reddish brown clayey silt with sand mixture

Water content: Initial=25.1% Final =25.6% Initial Void Ratio =0.825

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	6	0.824	0.0060				
0.10 - 0.25	14	0.822	0.0093	71.43	0.0027	98.4	8.571
0.25 - 0.50	36	0.815	0.0144	55.56	0.0064	100.4	8.316
0.50 - 1.00	90	0.799	0.0181	71.10	0.0052	121.0	6.727
1.00 - 2.00	109	0.779	0.0111	57.80	0.0047	126.2	6.192
2.00 - 4.00	136	0.754	0.0070	58.82	0.0029	203.1	3.651
4.00 - 8.00	233	0.711	0.0061	63.52	0.0022	167.3	4.090
8.00 - 0.25	220	0.752	0.0030				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

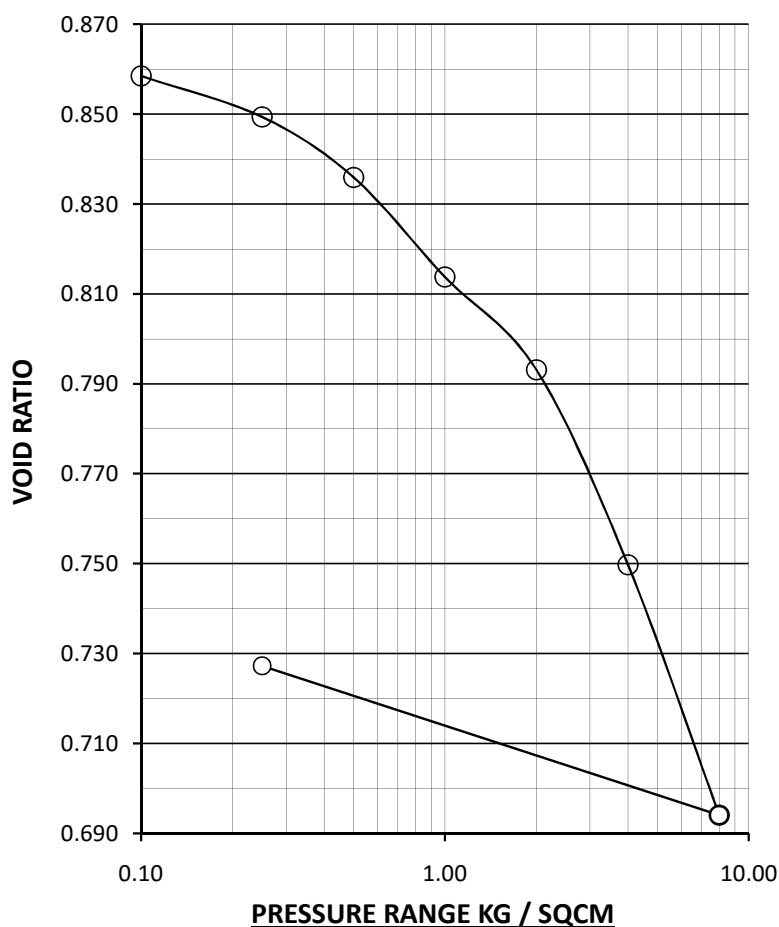
Sample Number: BH--123/UDS-03

Depth : 7.5-7.95 meters

Description : Yellowish grey clayey silt with sand mixture.

Water content: Initial=28.3% Final =27.1% Initial Void Ratio =0.863

$P_1-P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	27	0.858	0.0270				
0.10 - 0.25	49	0.849	0.0327	34.69	0.0214	175.4	4.745
0.25 - 0.50	72	0.836	0.0290	41.67	0.0169	351.4	2.312
0.50 - 1.00	119	0.814	0.0241	64.71	0.0085	360.2	2.168
1.00 - 2.00	111	0.793	0.0114	53.15	0.0053	375.0	1.984
2.00 - 4.00	233	0.750	0.0121	63.52	0.0044	279.9	2.466
4.00 - 8.00	299	0.694	0.0080	57.19	0.0034	151.7	4.030
8.00 - 0.25	178	0.727	0.0025				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

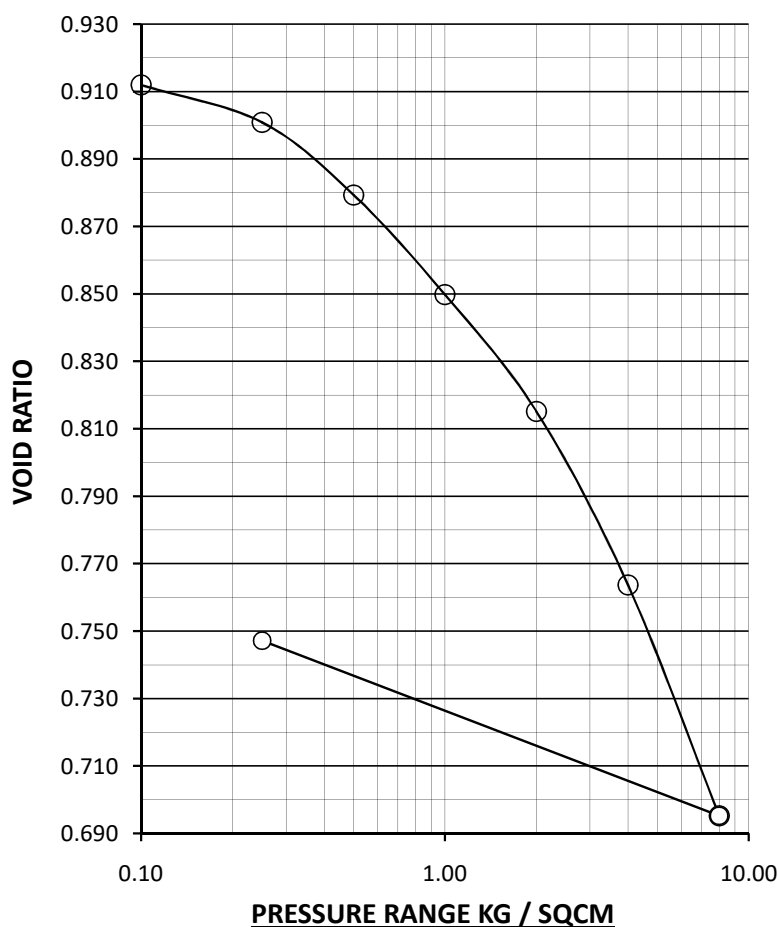
Sample Number: BH--124/UDS-01

Depth : 1.5-1.95 meters

Description : Yellowish grey clayey silt with traces of sand mixture.

Water content: Initial=31.2% Final =30.2% Initial Void Ratio =0.917

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	24	0.912	0.0240				
0.10 - 0.25	58	0.901	0.0388	29.31	0.0274	119.3	6.951
0.25 - 0.50	112	0.879	0.0452	37.50	0.0282	154.5	5.183
0.50 - 1.00	154	0.850	0.0314	37.66	0.0196	218.9	3.461
1.00 - 2.00	181	0.815	0.0188	40.33	0.0112	181.7	3.880
2.00 - 4.00	268	0.764	0.0142	55.22	0.0063	190.1	3.352
4.00 - 8.00	357	0.695	0.0097	48.46	0.0050	147.9	3.709
8.00 - 0.25	271	0.747	0.0040				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

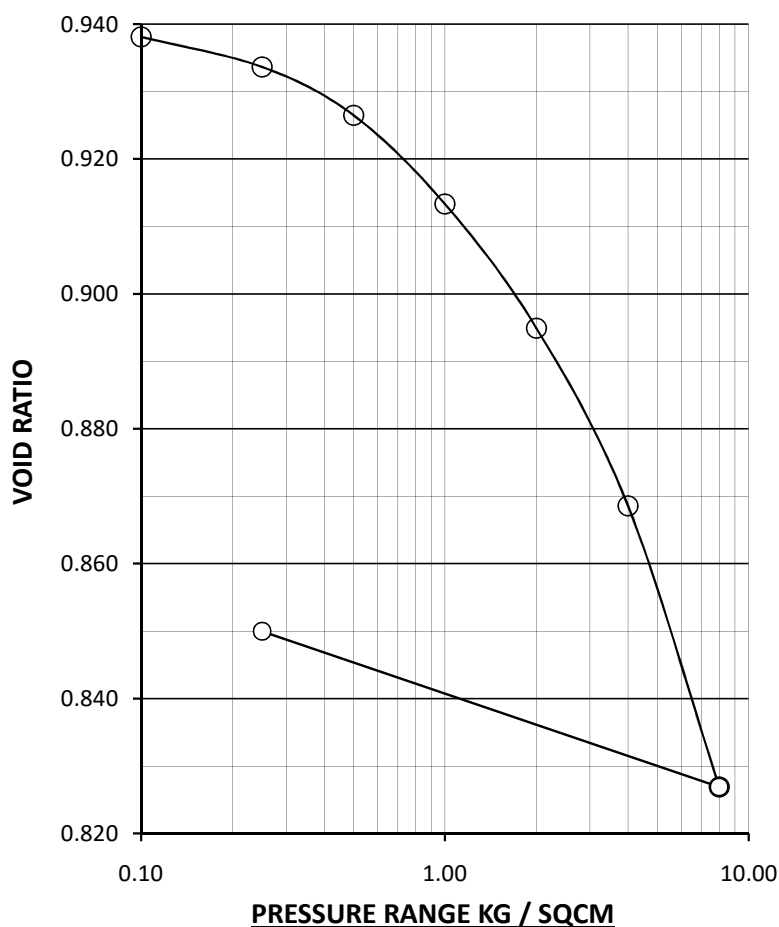
Sample Number: BH--128/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=29.5% Final =31.8% Initial Void Ratio =0.939

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	4	0.938	0.0040				
0.10 - 0.25	23	0.934	0.0153	61.60	0.0059	137.7	6.126
0.25 - 0.50	37	0.926	0.0148	53.00	0.0070	121.0	6.889
0.50 - 1.00	68	0.913	0.0137	66.18	0.0046	142.3	5.734
1.00 - 2.00	95	0.895	0.0096	57.89	0.0041	138.6	5.692
2.00 - 4.00	136	0.869	0.0070	65.44	0.0024	140.5	5.352
4.00 - 8.00	215	0.827	0.0056	62.79	0.0021	107.7	6.467
8.00 - 0.25	119	0.850	0.0016				

**e-logp Curve**

Job No. 4095

Sheet No.

CONSOLIDATION TEST RESULTS

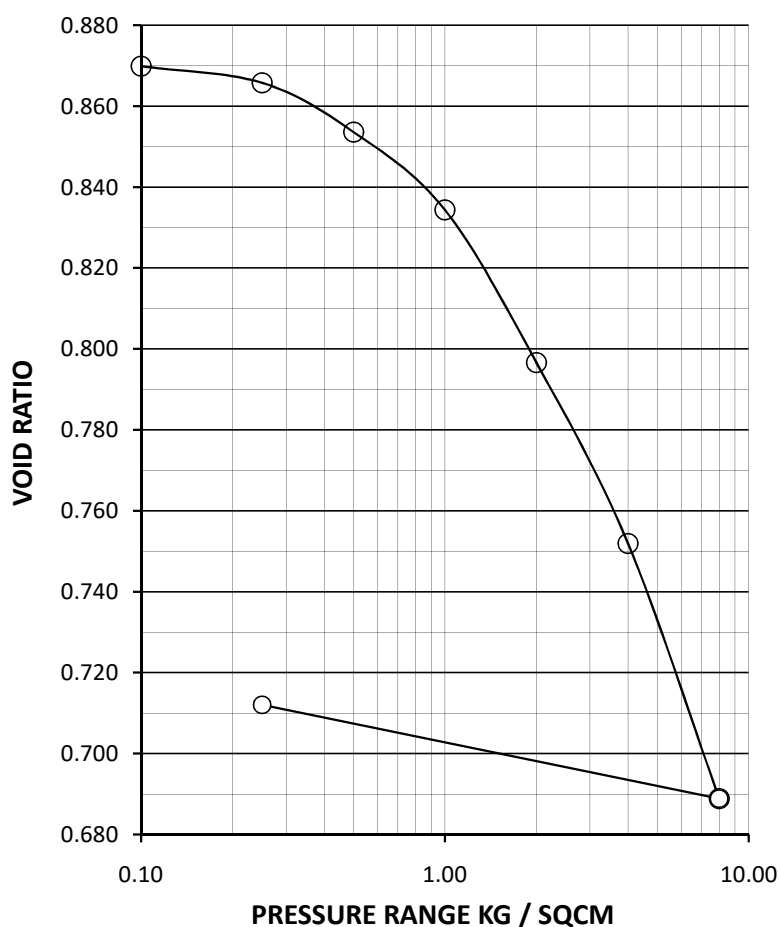
Sample Number: BH-128/UDS-02

Depth : 5.5-5.95 meters

Description : Reddish clayey silt with traces of sand mixture.

Water content: Initial=23.3% Final =31% Initial Void Ratio =0.871

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	5	0.870	0.0050				
0.10 - 0.25	22	0.866	0.0147	31.82	0.0100	142.4	5.923
0.25 - 0.50	65	0.854	0.0261	36.92	0.0164	136.8	6.058
0.50 - 1.00	103	0.834	0.0208	53.40	0.0097	93.8	8.542
1.00 - 2.00	202	0.797	0.0206	74.26	0.0053	144.8	5.189
2.00 - 4.00	239	0.752	0.0124	81.17	0.0023	103.0	6.629
4.00 - 8.00	337	0.689	0.0090	81.01	0.0017	185.9	3.216
8.00 - 0.25	124	0.712	0.0018				

e-logp Curve

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

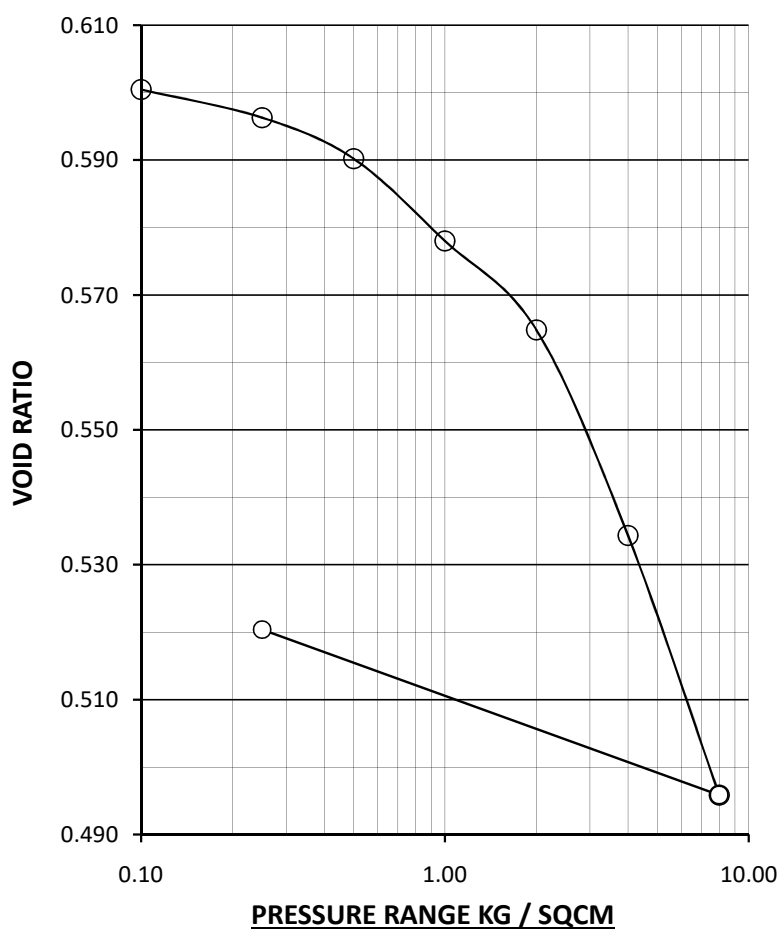
Sample Number: BH--129/UDS-01

Depth : 3-3.45 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=19.7% Final =20.2% Initial Void Ratio =0.603

$P_1-P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	17	0.600	0.0170				
0.10 - 0.25	26	0.596	0.0174	42.31	0.0100	240.9	3.472
0.25 - 0.50	38	0.590	0.0153	34.21	0.0101	320.2	2.579
0.50 - 1.00	76	0.578	0.0153	52.63	0.0073	348.5	2.315
1.00 - 2.00	82	0.565	0.0083	52.44	0.0040	208.1	3.752
2.00 - 4.00	190	0.534	0.0097	65.79	0.0033	303.8	2.427
4.00 - 8.00	240	0.496	0.0063	57.50	0.0027	169.3	3.960
8.00 - 0.25	153	0.520	0.0021				

**e-logp Curve**



Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

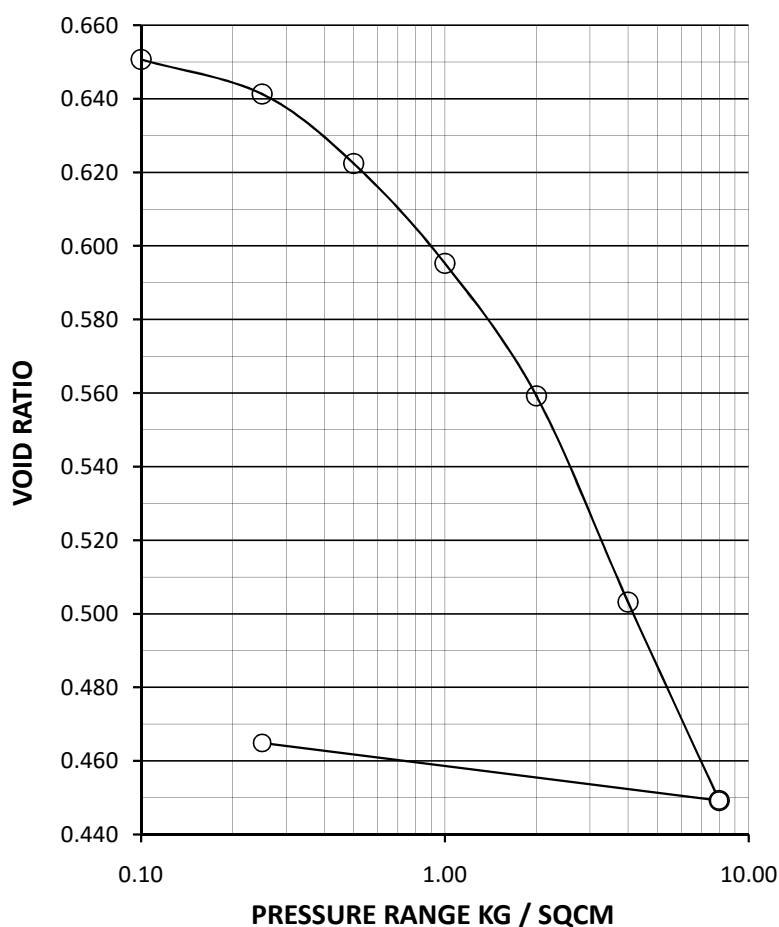
Sample Number: BH--130/UDS-01

Depth : 2.5-2.95 meters

Description : Reddish silty clay with rock pieces, kankar &amp; sand mixture.

Water content: Initial=28.1% Final =21.8% Initial Void Ratio =0.653

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	14	0.651	0.0140				
0.10 - 0.25	57	0.641	0.0381	31.58	0.0261	155.5	5.353
0.25 - 0.50	114	0.622	0.0460	17.54	0.0379	166.2	4.838
0.50 - 1.00	164	0.595	0.0334	24.39	0.0253	182.2	4.165
1.00 - 2.00	218	0.559	0.0226	26.15	0.0167	235.0	2.973
2.00 - 4.00	339	0.503	0.0180	37.76	0.0112	301.1	2.045
4.00 - 8.00	326	0.449	0.0090	33.13	0.0060	285.1	1.835
8.00 - 0.25	95	0.465	0.0014				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

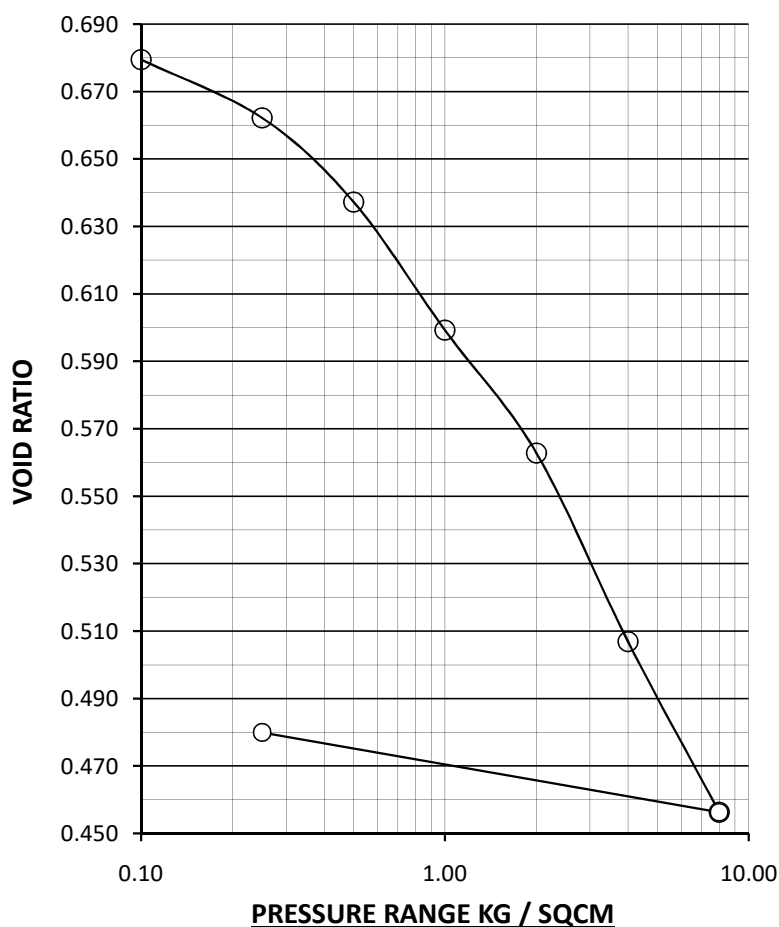
Sample Number: BH--131/UDS-01

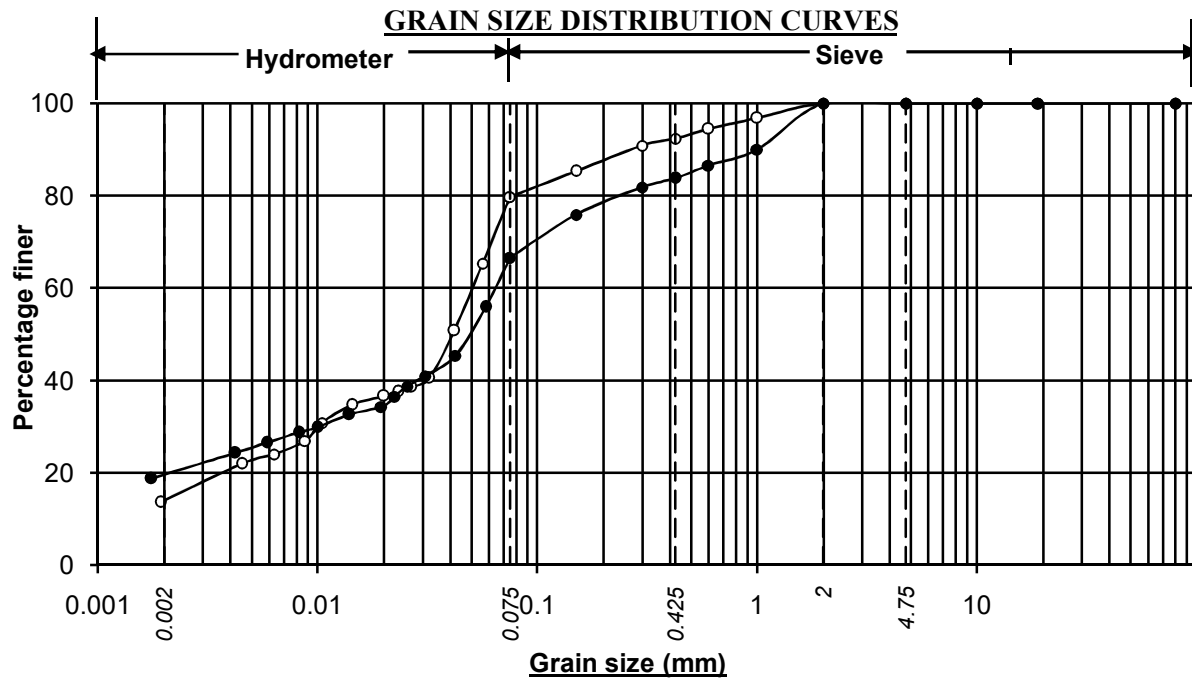
Depth : 2.5-2.95 meters

Description : Reddish brown clayey silt with sand mixture.

Water content: Initial=26.5% Final =19.1% Initial Void Ratio =0.694

$P_1-P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	87	0.679	0.0871				
0.10 - 0.25	102	0.662	0.0687	17.65	0.0565	181.7	4.406
0.25 - 0.50	147	0.637	0.0600	18.80	0.0487	166.4	4.566
0.50 - 1.00	224	0.599	0.0464	10.27	0.0416	170.4	4.117
1.00 - 2.00	215	0.563	0.0228	13.95	0.0196	155.2	4.094
2.00 - 4.00	330	0.507	0.0179	23.33	0.0137	143.1	3.899
4.00 - 8.00	298	0.456	0.0084	16.11	0.0070	194.0	2.448
8.00 - 0.25	139	0.480	0.0021				

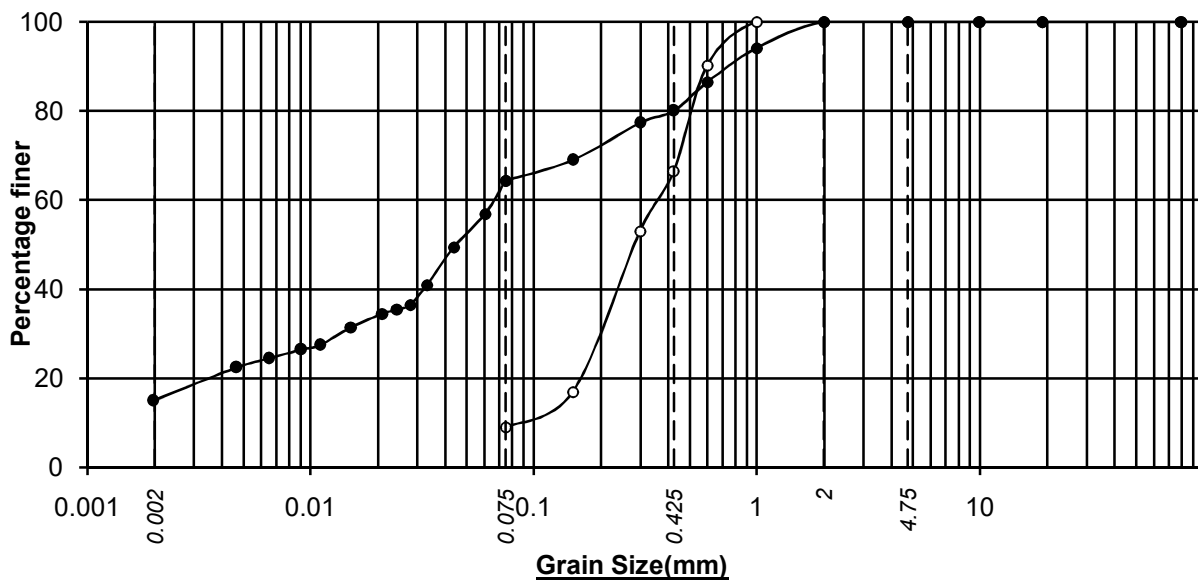
**e-logp Curve**



—○— BH--101,UDS-01, 3.00M

—●— BH--101,SPT-07, 11.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--101,UDS-01, 3.00M	14.0	65.7	12.7	7.6	0.0	20.3		0.0
BH--101,SPT-07, 11.00M	19.6	46.9	17.4	16.1	0.0	33.5		0.0



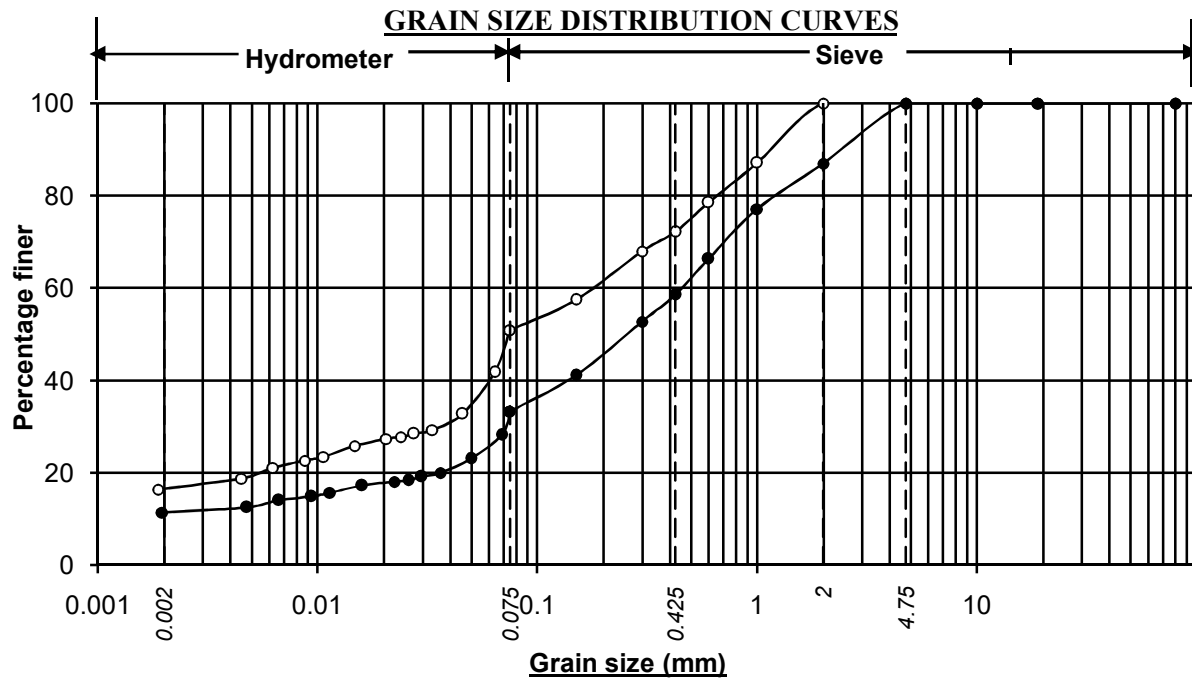
—○— BH--101,SPT-08, 12.50M

—●— BH--102,UDS-01, 3.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--101,SPT-08, 12.50M		9.0	57.5	33.5	0.0	91.0		0.0
BH--102,UDS-01, 3.00M	15.1	49.3	15.7	19.9	0.0	35.6		0.0

**Project:- Geotech. Inv. Work for 5th Stream A155 of R427 at Damanjodi, Odisha**

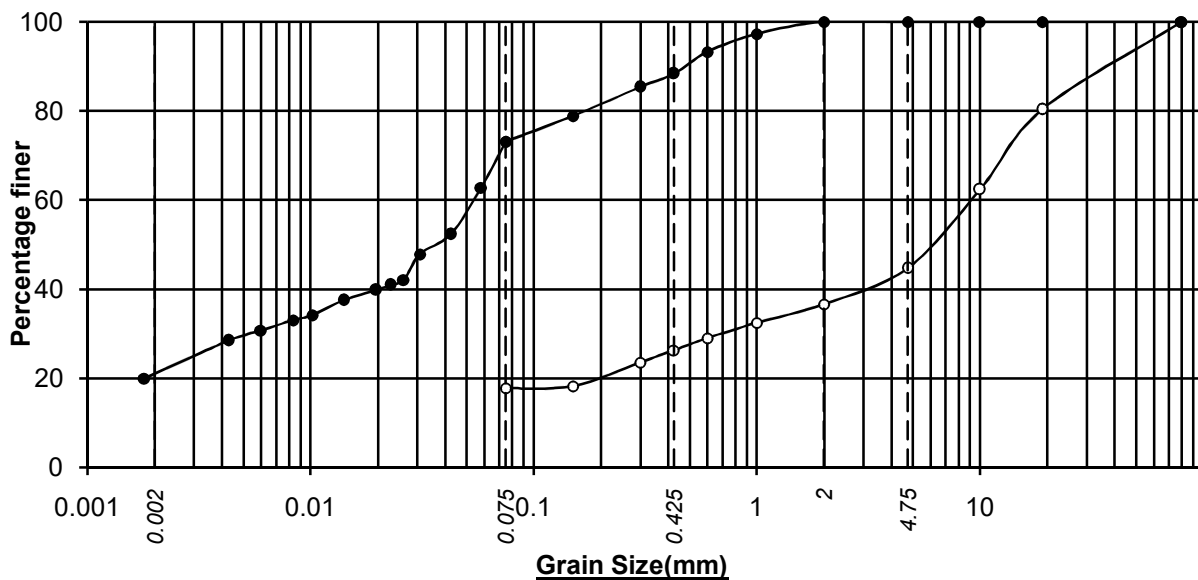
**Job No.****4095**



—○— BH--102,SPT-05, 7.00M

—●— BH--102,SPT-08, 11.10M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--102,SPT-05, 7.00M	16.6	34.3	21.3	27.8	0.0	49.1		0.0
BH--102,SPT-08, 11.10M	11.4	21.9	25.3	28.4	13.0	66.7		0.0



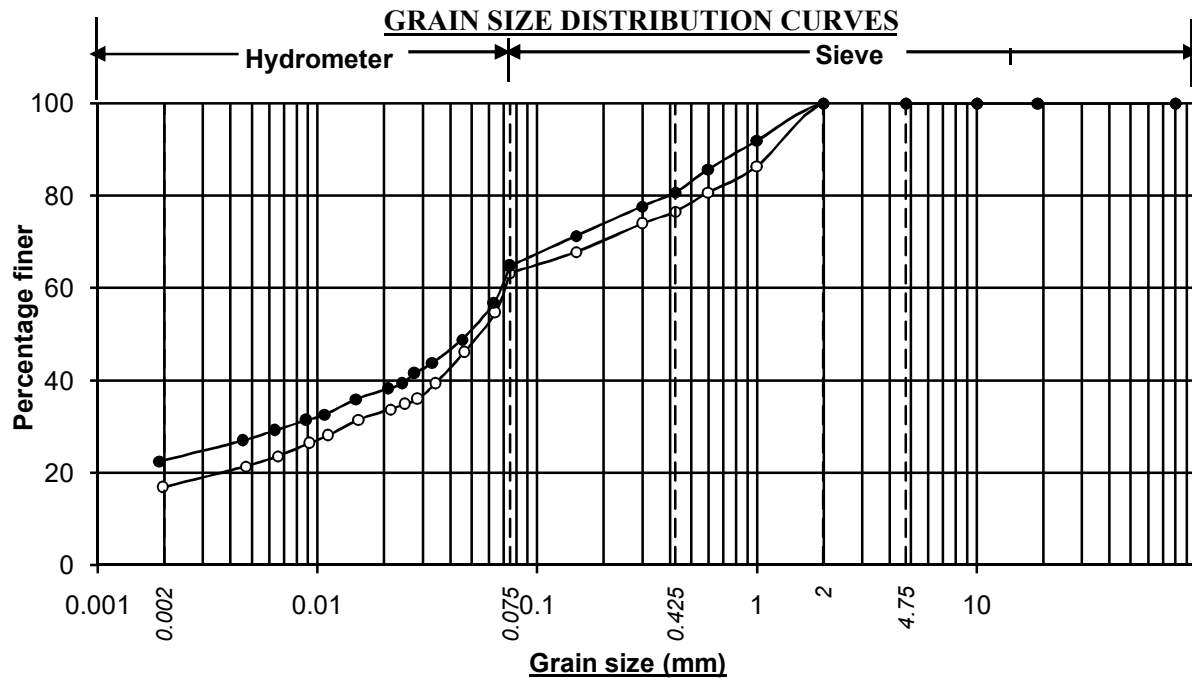
—○— BH--103,DS-01, 0.50M

—●— BH--104,UDS-01, 3.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--103,DS-01, 0.50M		17.8	8.4	10.3	8.2	26.9		55.3
BH--104,UDS-01, 3.00M	20.9	52.2	15.3	11.6	0.0	26.9		0.0

**Project:- Geotech. Inv. Work for 5th Stream Alignment Rectification at Damanjodi, Odisha**

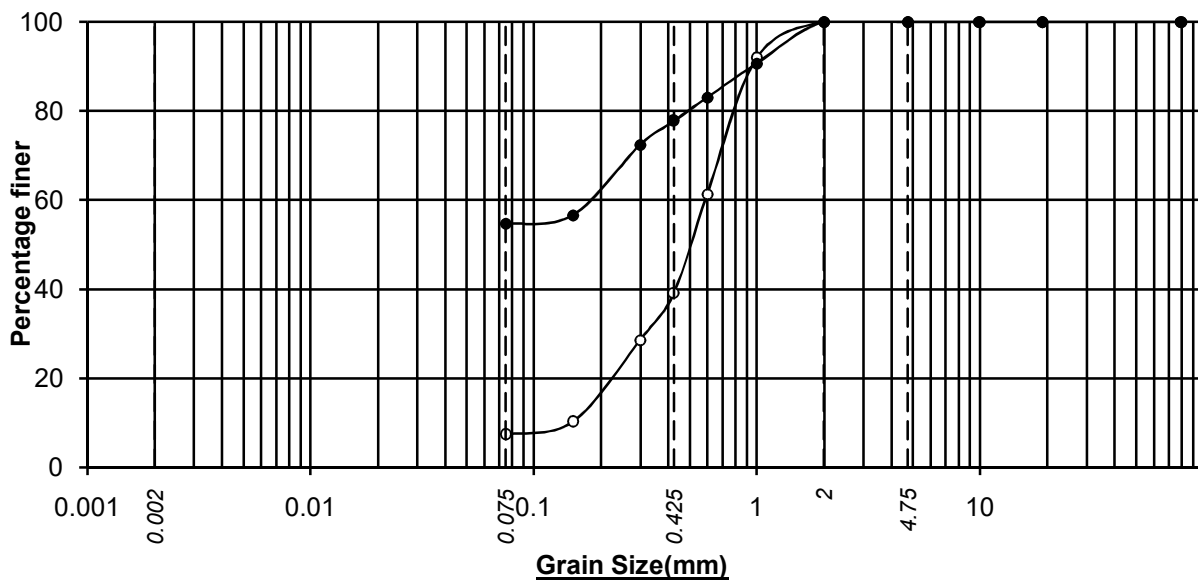
**Job No.****4095**



—○— BH--104,SPT-03, 5.00M

—●— BH--104,SPT-10, 15.60M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--104,SPT-03, 5.00M	16.9	46.3	13.4	23.4	0.0	36.8		0.0
BH--104,SPT-10, 15.60M	22.7	42.2	15.8	19.3	0.0	35.1		0.0



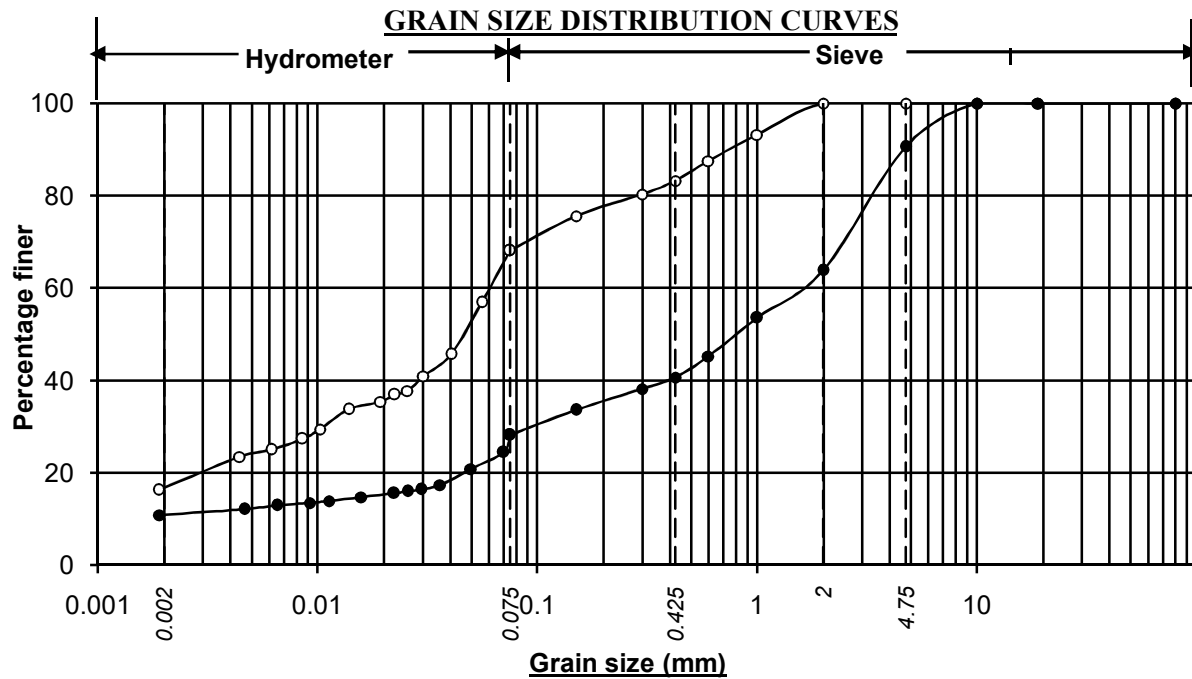
—○— BH--104,SPT-17, 25.50M

—●— BH--104,SPT-19, 28.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--104,SPT-17, 25.50M		7.4	31.8	60.8	0.0	92.6		0.0
BH--104,SPT-19, 28.50M		54.7	23.1	22.2	0.0	45.3		0.0

**Project:- Geotech. Inv. Work for 5th Stream A150 of R427**  
**Odisha**

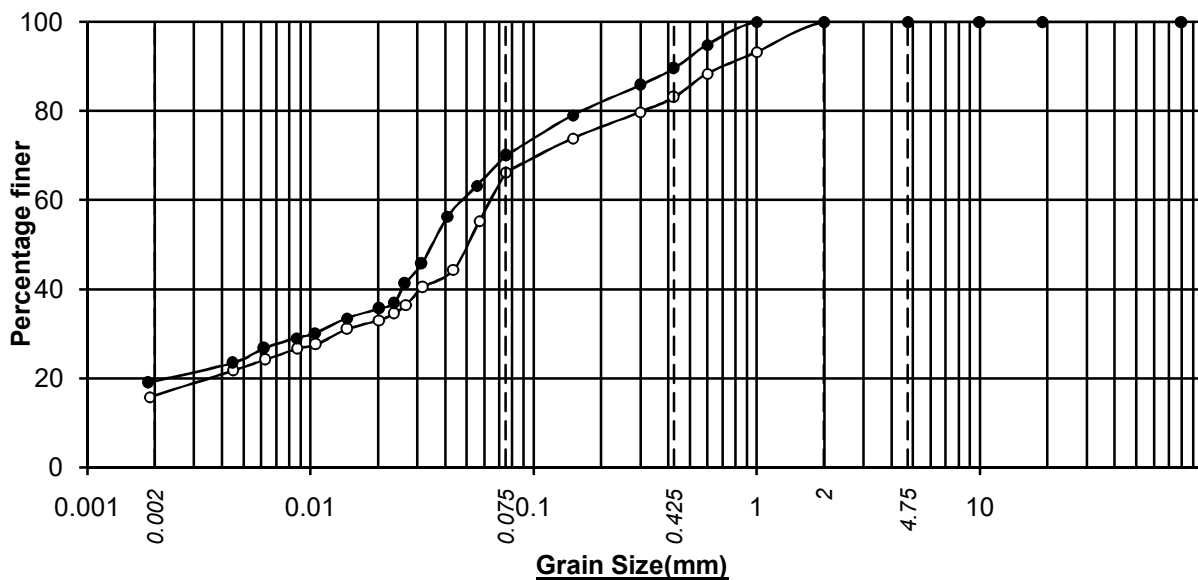
**Job No.****4095**



—○— BH--105,UDS-01, 2.50M

—●— BH--105,SPT-05, 7.20M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--105,UDS-01, 2.50M	16.7	51.5	15.0	16.8	0.0	31.8		0.0
BH--105,SPT-05, 7.20M	10.9	17.3	12.5	23.2	26.7	62.4		9.4



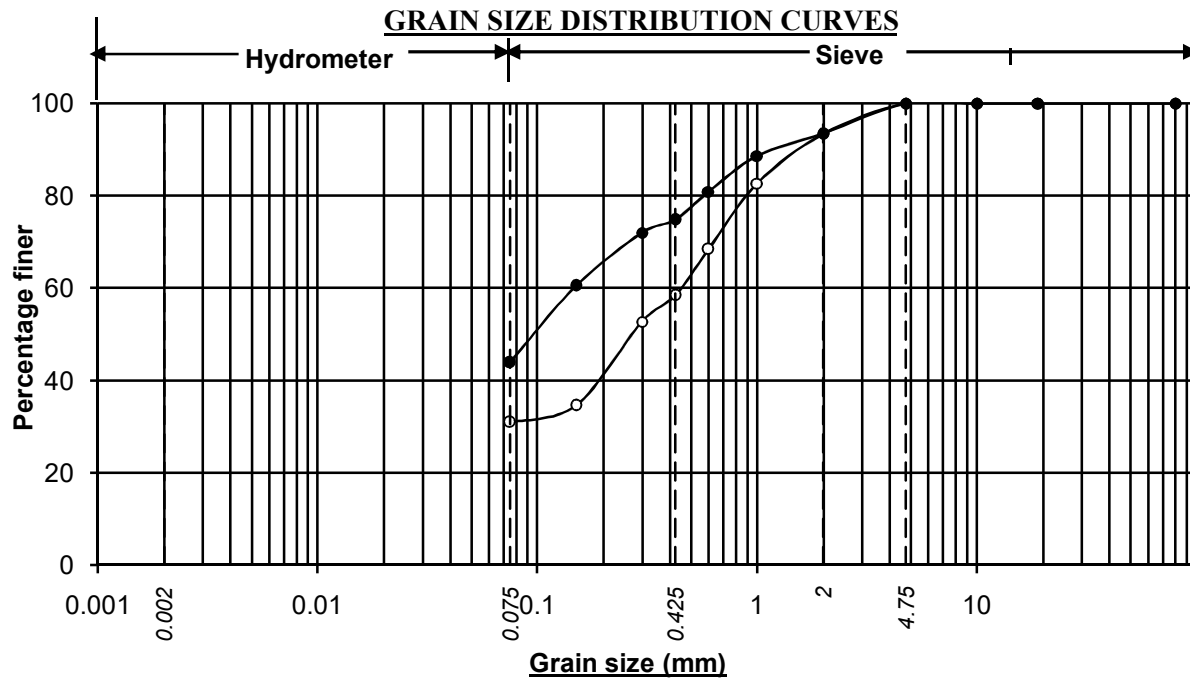
—○— BH--106,UDS-01, 2.50M

—●— BH--106,SPT-09, 13.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--106,UDS-01, 2.50M	16.1	50.1	16.9	16.9	0.0	33.8		0.0
BH--106,SPT-09, 13.00M	19.3	50.7	19.6	10.4	0.0	30.0		0.0

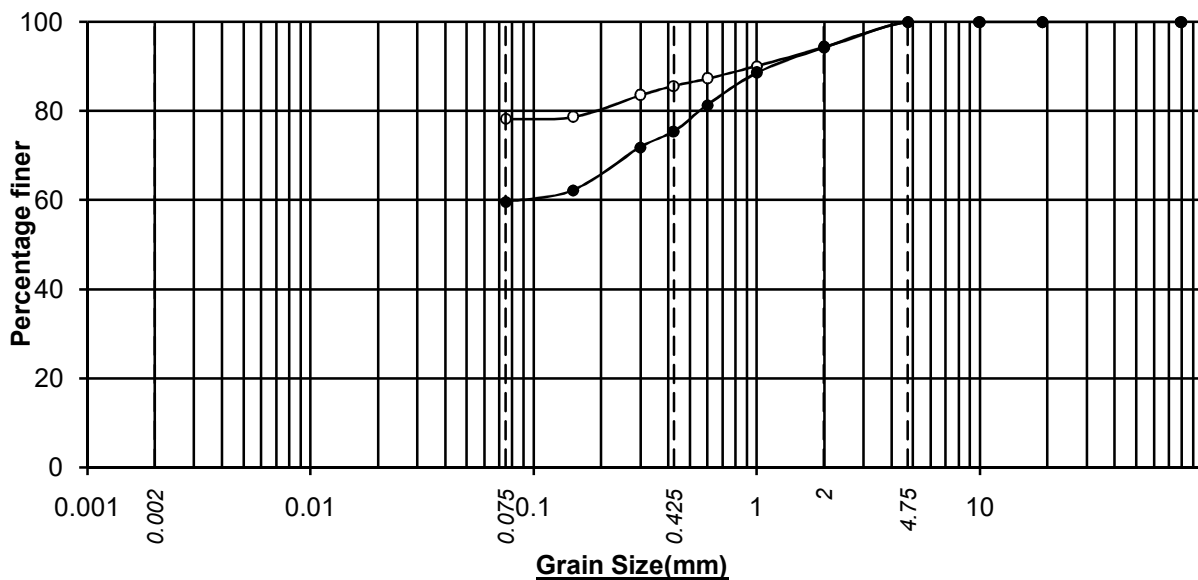
**Project:- Geotech. Inv. Work for 5th Stream A118 of R427 at Damanjodi, Odisha**

**Job No.****4095**



—○— BH--106,SPT-10, 14.50M      —●— BH--106,SPT-14, 20.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--106,SPT-10, 14.50M		31.0	27.4	35.0	6.6	69.0		0.0
BH--106,SPT-14, 20.50M		43.9	30.9	18.7	6.5	56.1		0.0



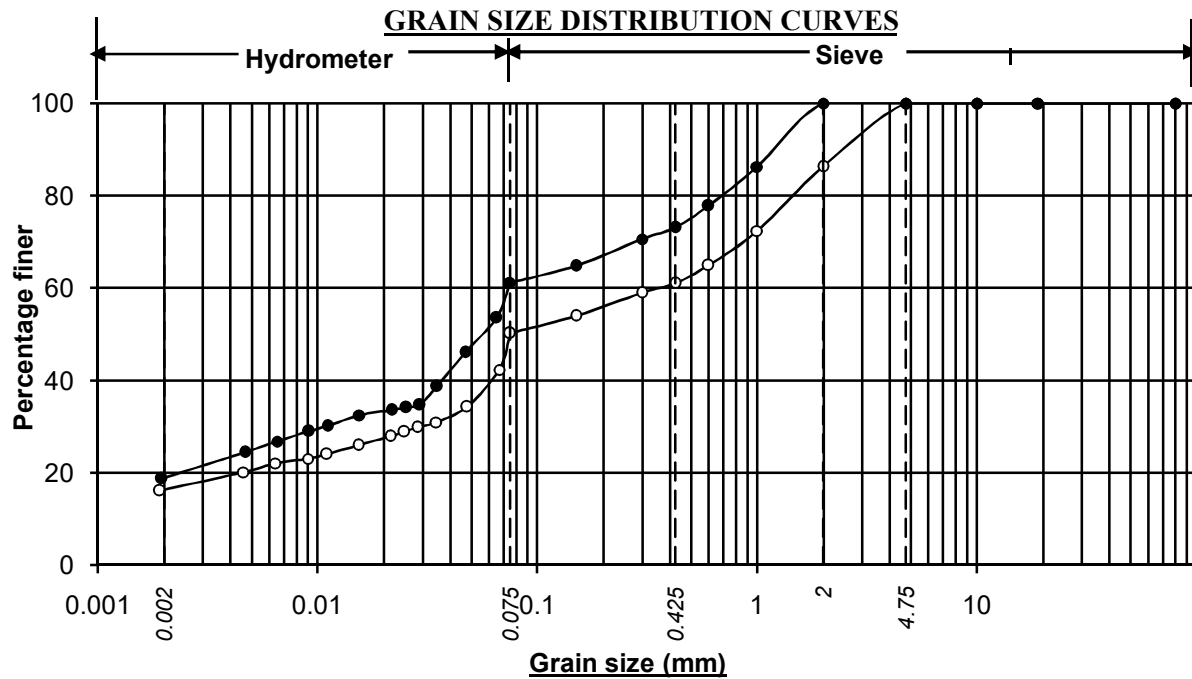
—○— BH--106,SPT-20, 29.50M      —●— BH--106,SPT-27, 40.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--106,SPT-20, 29.50M		78.3	7.3	8.7	5.7	21.7		0.0
BH--106,SPT-27, 40.00M		59.6	15.8	18.9	5.7	40.4		0.0

**Project:- Geotech. Inv. Work for 5th Stream A160 of R427 at Damanjodi, Odisha**

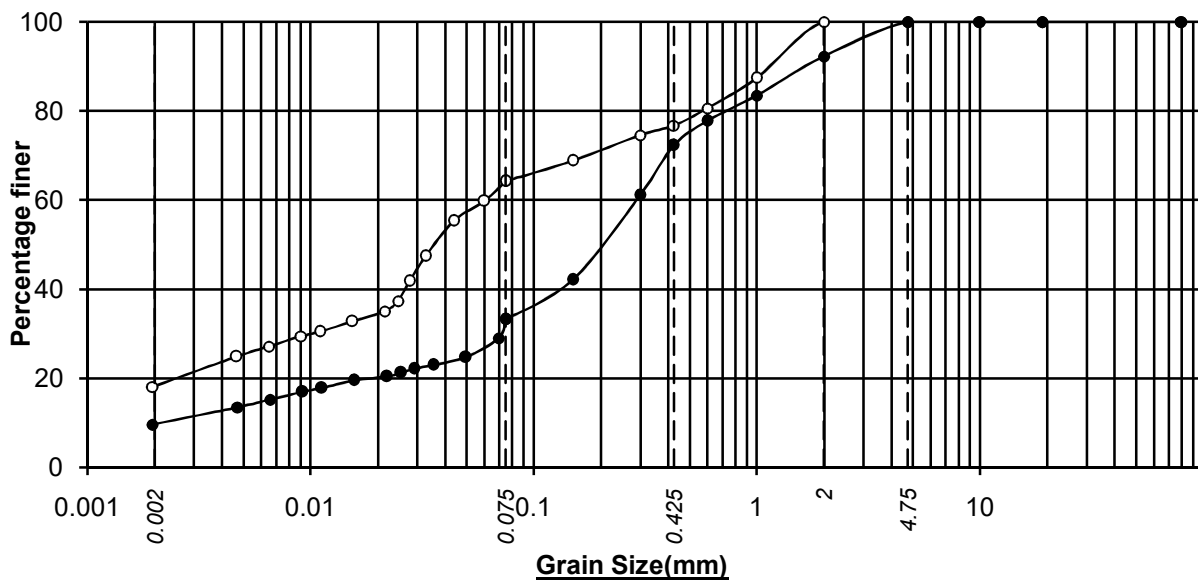
**Job No.**

**4095**



—○— BH--107, UDS-01, 2.50M      —●— BH--107, UDS-02, 5.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--107, UDS-01, 2.50M	16.4	33.9	10.8	25.3	13.6	49.7		0.0
BH--107, UDS-02, 5.50M	19.0	42.2	11.9	26.9	0.0	38.8		0.0



—○— BH--107, SPT-05, 7.50M      —●— BH--108, SPT-01, 1.50M

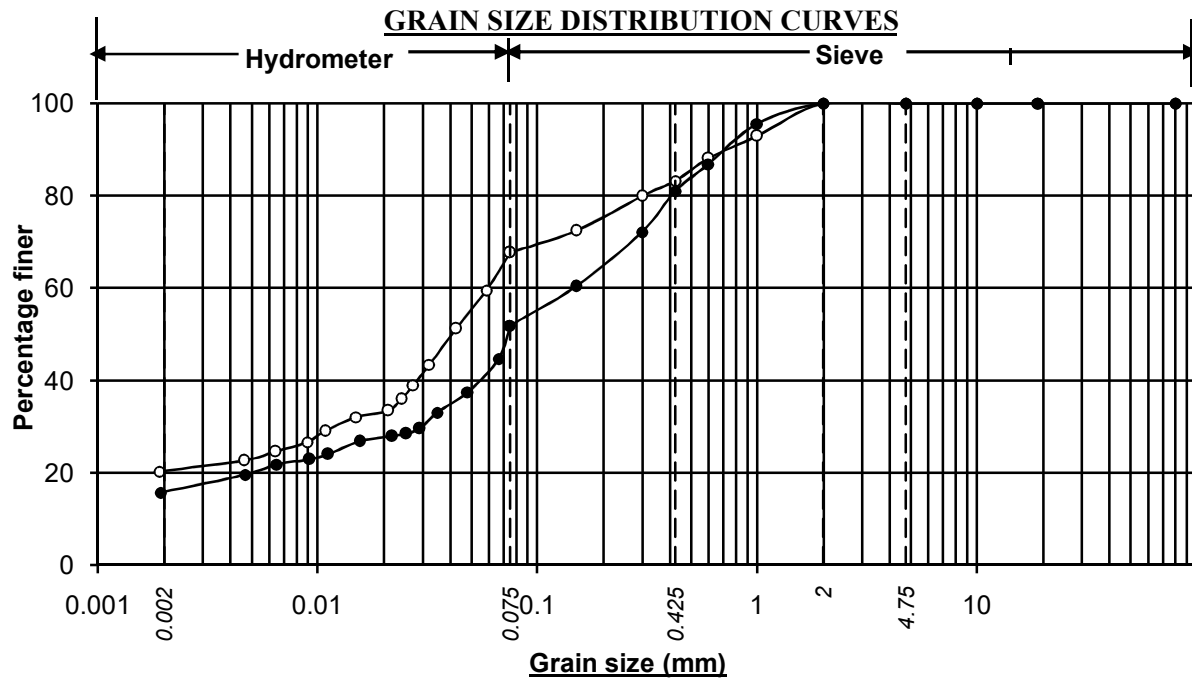
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--107, SPT-05, 7.50M	18.2	46.1	12.4	23.3	0.0	35.7		0.0
BH--108, SPT-01, 1.50M	9.6	23.6	39.1	19.9	7.8	66.8		0.0

**Project:- Geotech. Inv. Work for 5th Stream Alignment R427 at Damanjodi, Odisha**

**Job No.**

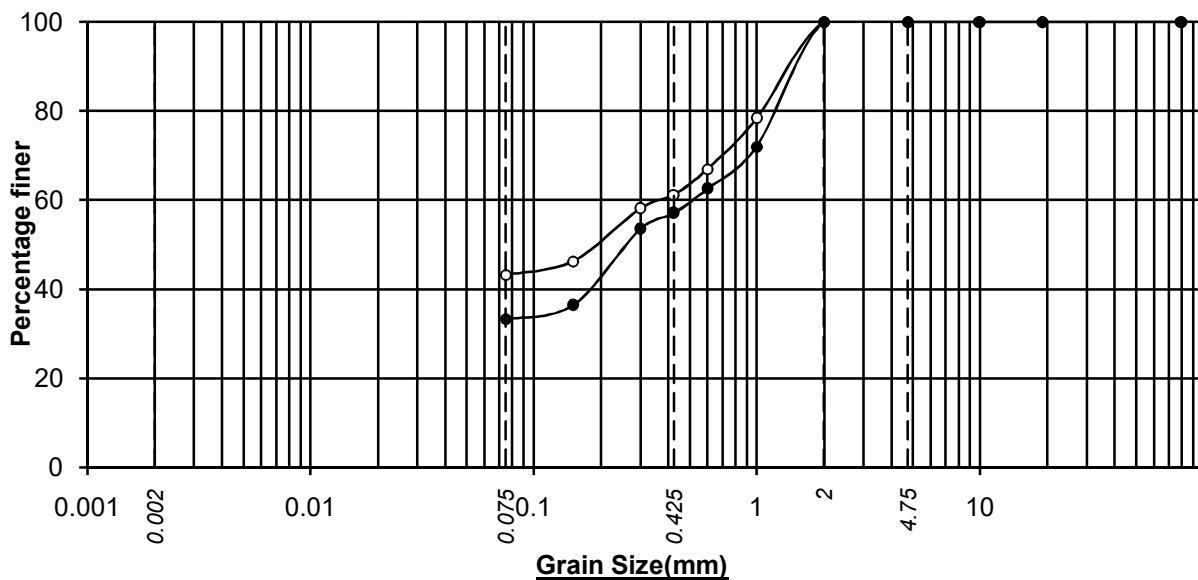
**4095**





—○— BH--108,SPT-07, 10.50M      —●— BH--108,SPT-14, 21.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--108,SPT-07, 10.50M	20.4	47.4	15.4	16.8	0.0	32.2		0.0
BH--108,SPT-14, 21.00M	15.8	36.0	29.2	19.0	0.0	48.2		0.0



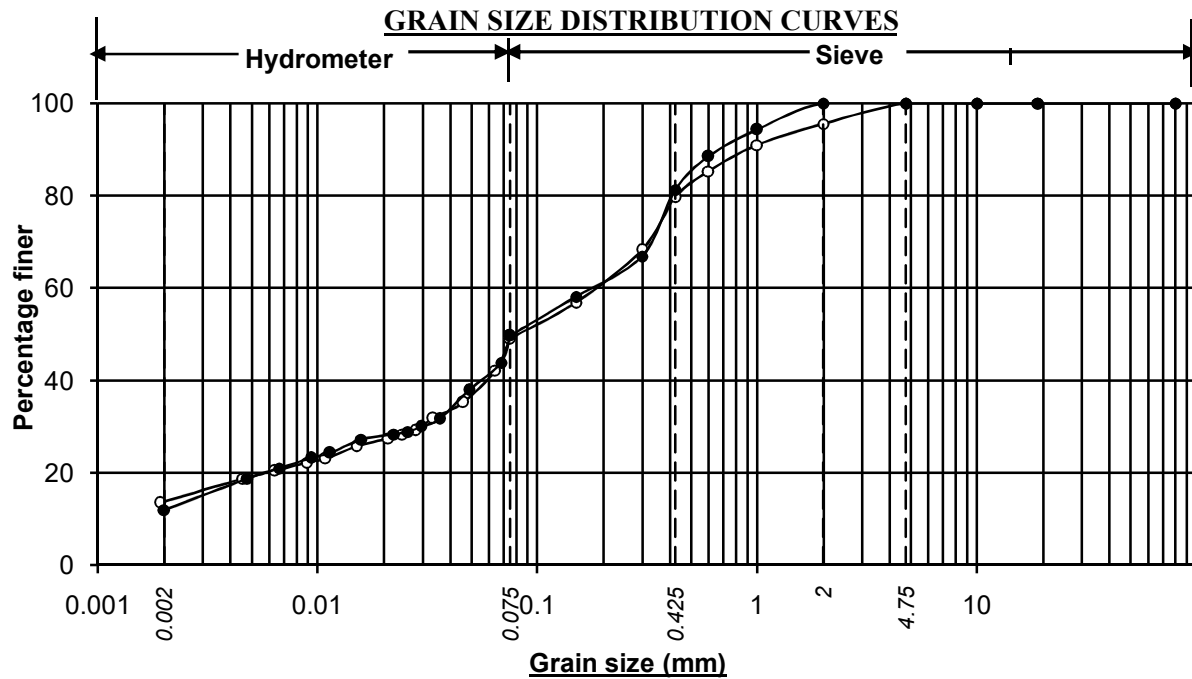
—○— BH--108,SPT-15, 22.50M      —●— BH--108,SPT-18, 27.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--108,SPT-15, 22.50M		43.2	18.0	38.8	0.0	56.8		0.0
BH--108,SPT-18, 27.00M		33.3	23.8	42.9	0.0	66.7		0.0

**Project:- Geotech. Inv. Work for 5th Stream A121 of R427, Odisha**

**Job No.**

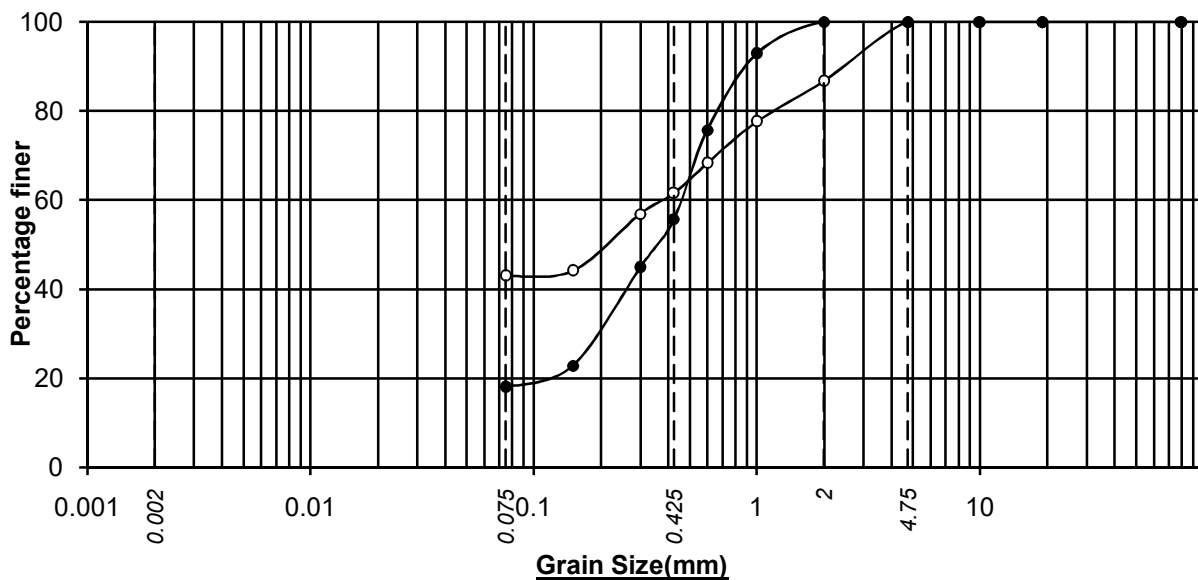
**4095**



—○— BH--109,SPT-01, 1.50M

—●— BH--109,SPT-09, 13.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--109,SPT-01, 1.50M	13.8	35.4	30.5	15.9	4.4	50.8		0.0
BH--109,SPT-09, 13.50M	11.9	37.8	31.6	18.7	0.0	50.3		0.0



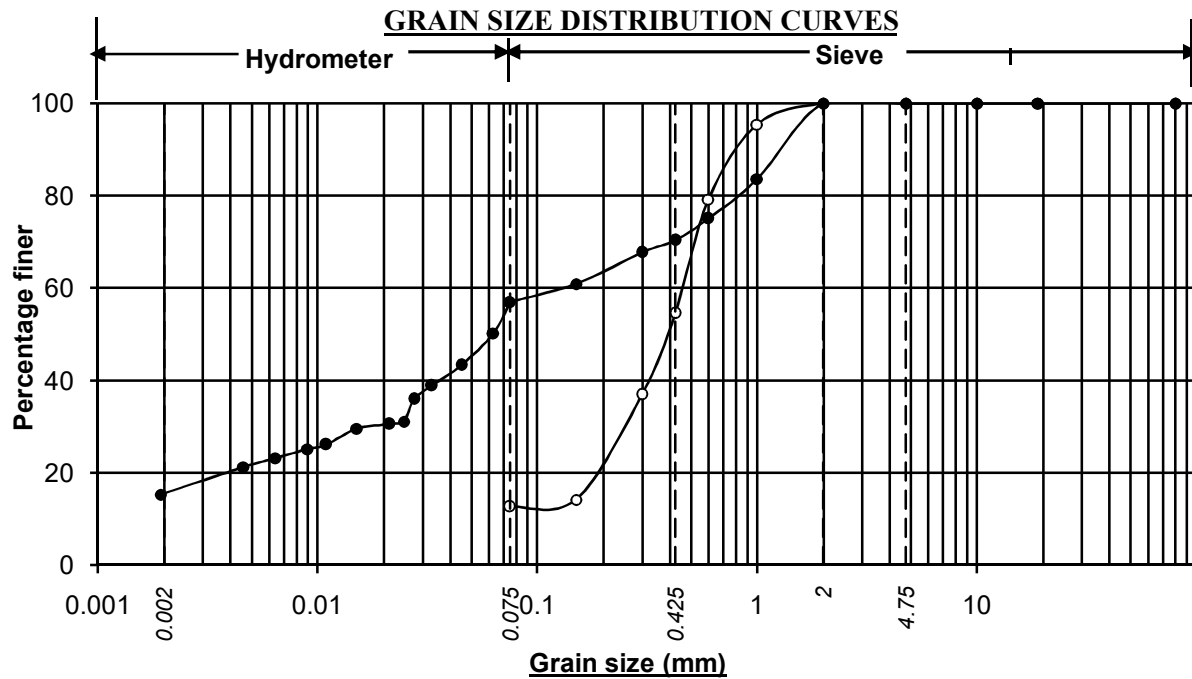
—○— BH--109,SPT-13, 20.00M

—●— BH--109,SPT-15, 23.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--109,SPT-13, 20.00M		43.0	18.5	25.2	13.3	57.0		0.0
BH--109,SPT-15, 23.00M		18.0	37.7	44.3	0.0	82.0		0.0

**Project:- Geotech. Inv. Work for 5th Stream A122 of R427**  
**Odisha**

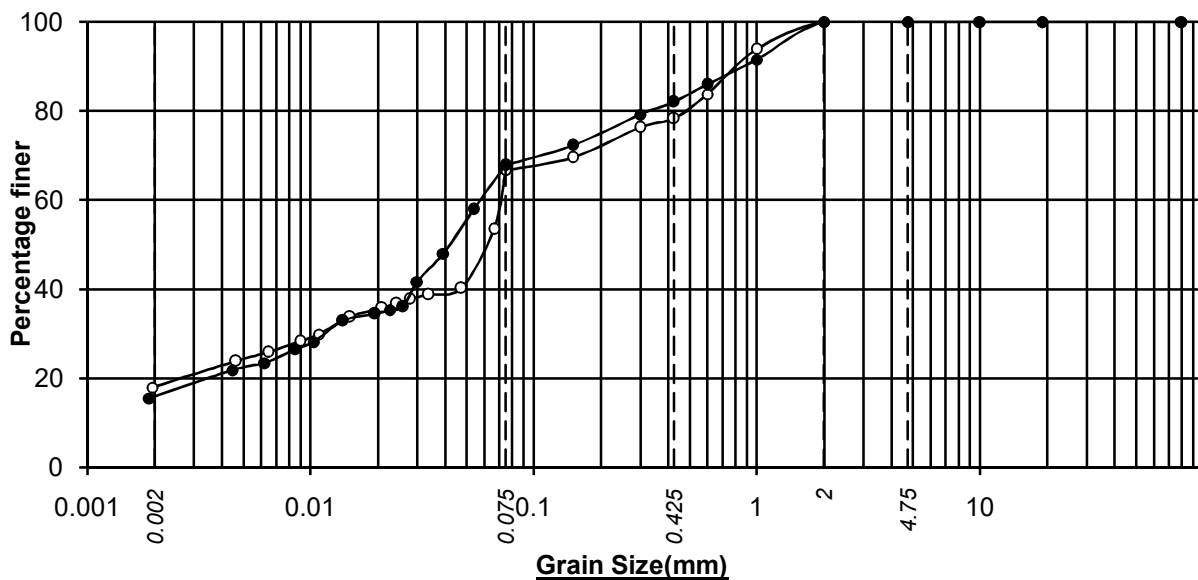
**Job No.****4095**



—○— BH--109,SPT-18, 27.50M

—●— BH--110,UDS-01, 2.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--109,SPT-18, 27.50M		12.7	41.9	45.4	0.0	87.3		0.0
BH--110,UDS-01, 2.50M	15.5	41.5	13.4	29.6	0.0	43.0		0.0



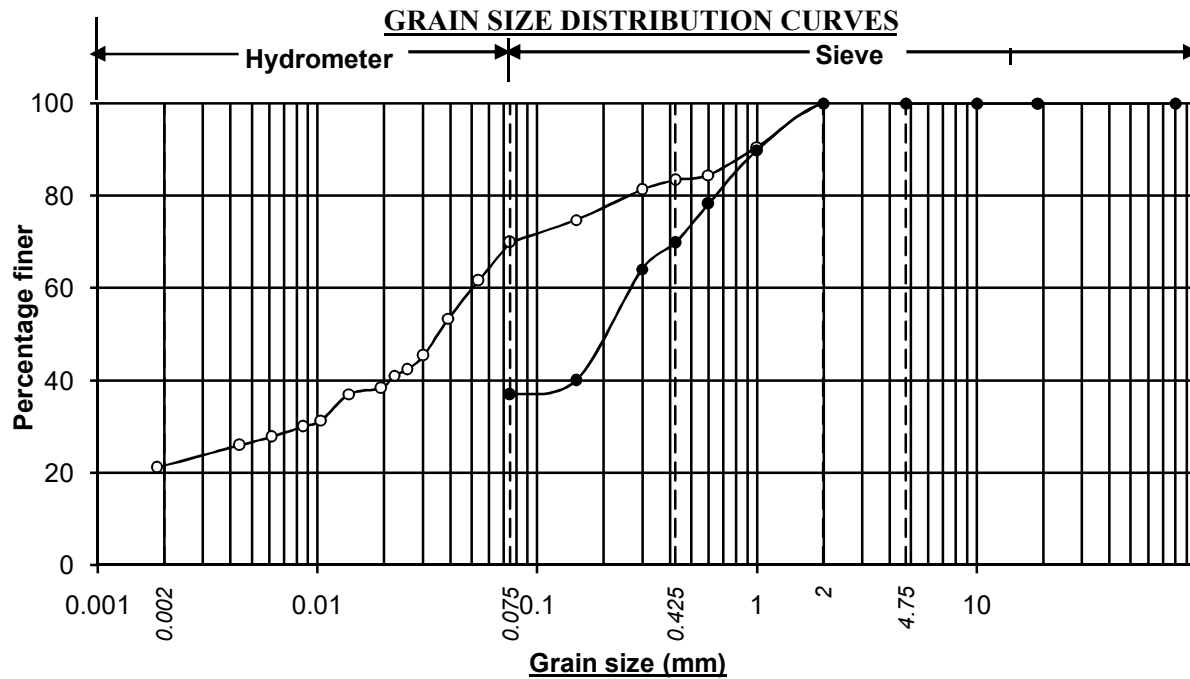
—○— BH--111,UDS-01, 2.50M

—●— BH--111,UDS-02, 5.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--111,UDS-01, 2.50M	18.1	48.7	11.6	21.6	0.0	33.2		0.0
BH--111,UDS-02, 5.50M	15.8	52.1	14.2	17.9	0.0	32.1		0.0

**Project:- Geotech. Inv. Work for 5th Stream Alignment R427 at Damanjodi, Odisha**

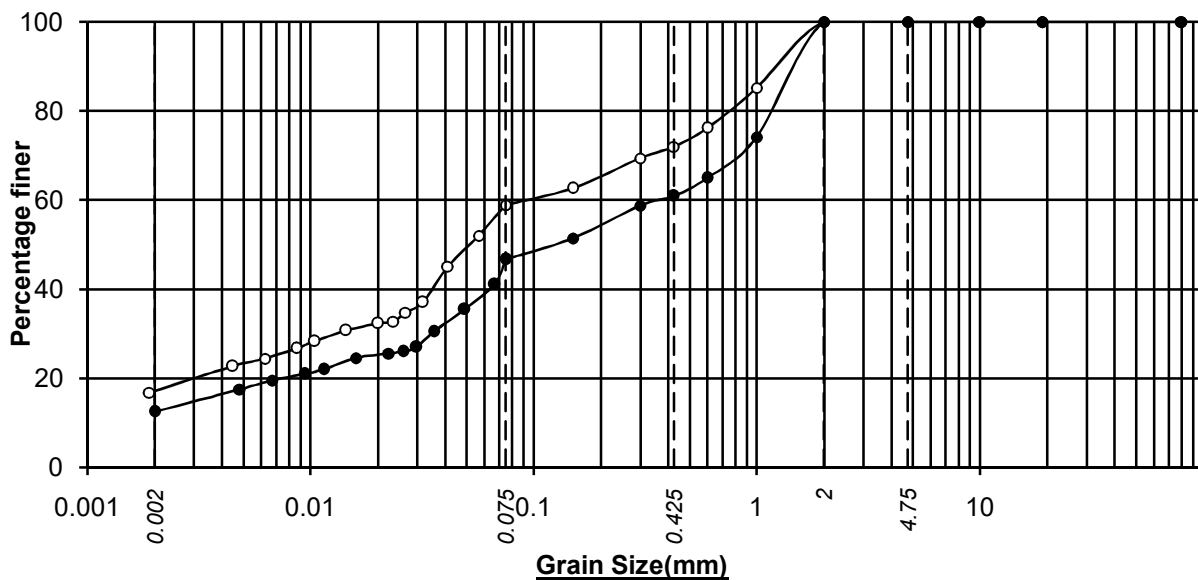
**Job No.****4095**



—○— BH--111,UDS-03, 8.50M

—●— BH--111,SPT-07, 10.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--111,UDS-03, 8.50M	21.6	48.4	13.4	16.6	0.0	30.0		0.0
BH--111,SPT-07, 10.50M		37.0	32.9	30.1	0.0	63.0		0.0



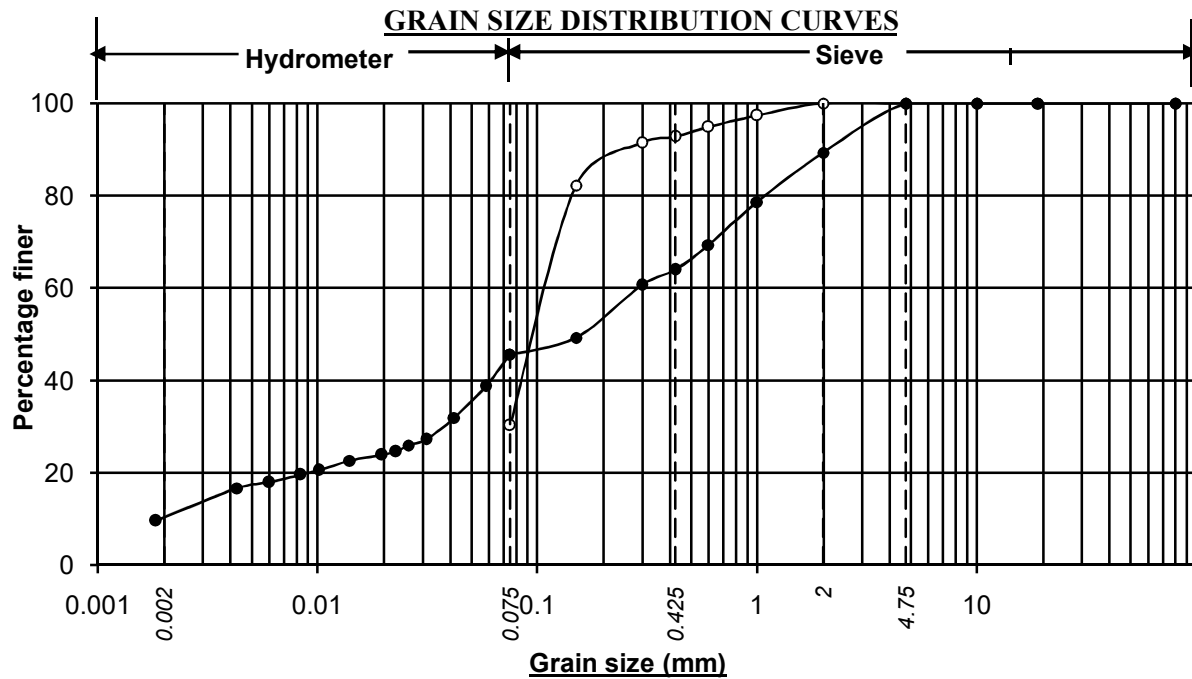
—○— BH--112,UDS-01, 1.50M

—●— BH--113,UDS-01, 2.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--112,UDS-01, 1.50M	17.1	41.8	13.1	28.0	0.0	41.1		0.0
BH--113,UDS-01, 2.50M	12.5	34.3	14.2	39.0	0.0	53.2		0.0

**Project:- Geotech. Inv. Work for 5th Stream A124 of R427 at Damanjodi, Odisha**

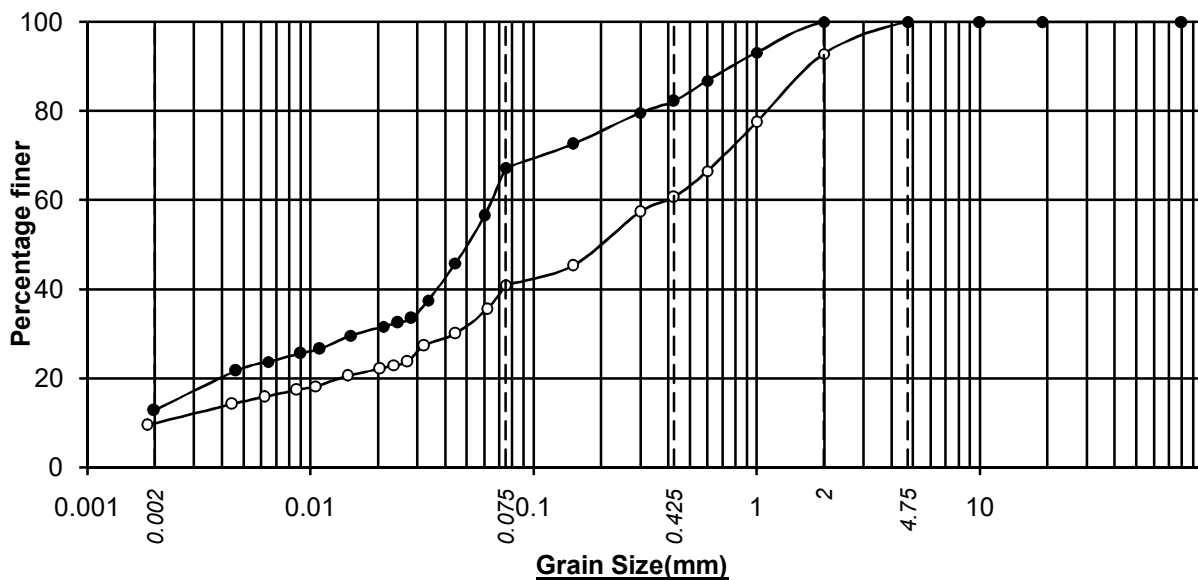
**Job No.****4095**



—○— BH--114, UDS-01, 2.50M

—●— BH--114, UDS-02, 5.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--114, UDS-01, 2.50M		30.3	62.5	7.2	0.0	69.7		0.0
BH--114, UDS-02, 5.50M	10.3	35.3	18.4	25.3	10.7	54.4		0.0



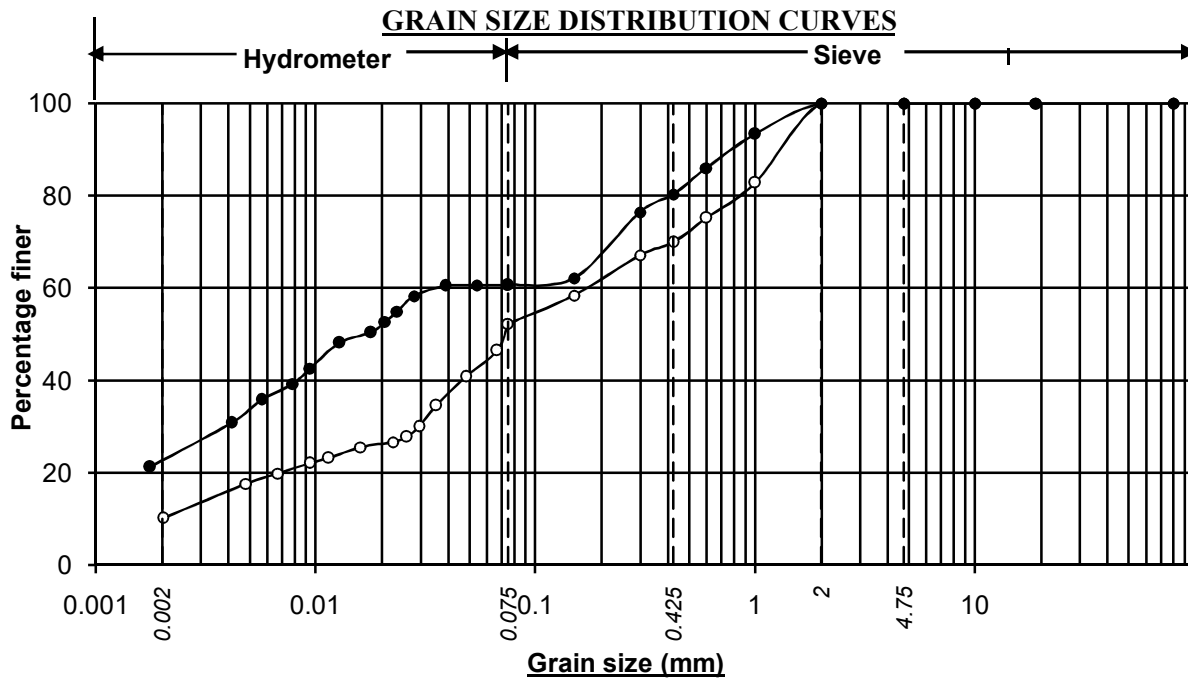
—○— BH--114, SPT-05, 7.50M

—●— BH--116, UDS-02, 5.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--114, SPT-05, 7.50M	9.9	31.0	19.8	32.1	7.2	59.1		0.0
BH--116, UDS-02, 5.50M	12.9	54.4	14.9	17.8	0.0	32.7		0.0

**Project:- Geotech. Inv. Work for 5th Stream A125 of R427, Odisha**

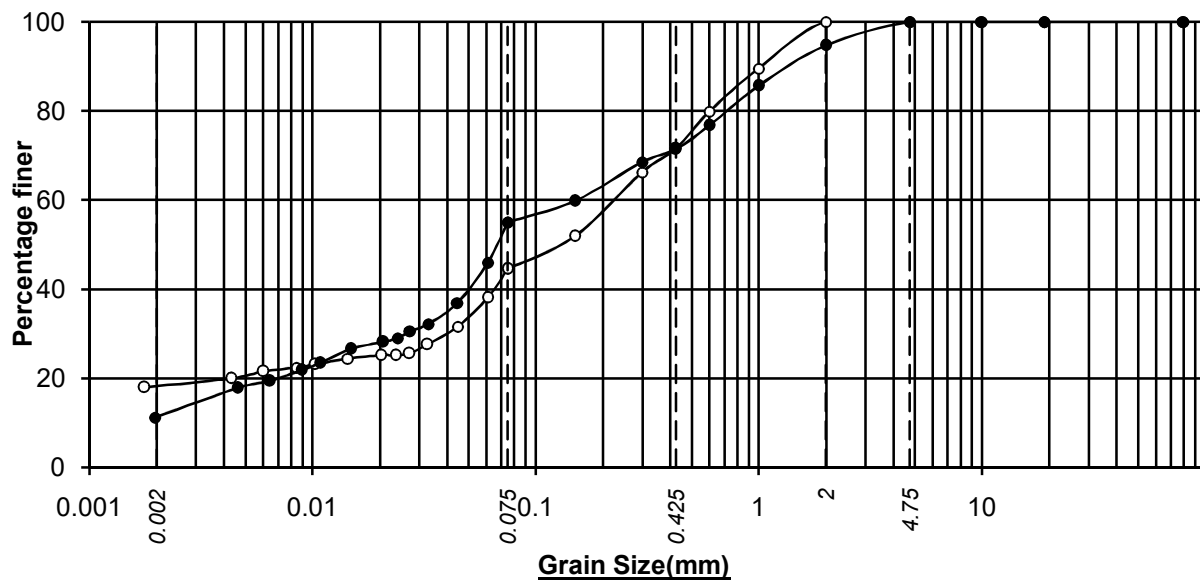
**Job No.****4095**



—○— BH--116,UDS-03, 8.50M

—●— BH--116,SPT-08, 12.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--116,UDS-03, 8.50M	10.1	42.2	17.7	30.0	0.0	47.7		0.0
BH--116,SPT-08, 12.00M	22.7	38.0	19.6	19.7	0.0	39.3		0.0



—○— BH--116,SPT-16, 24.00M

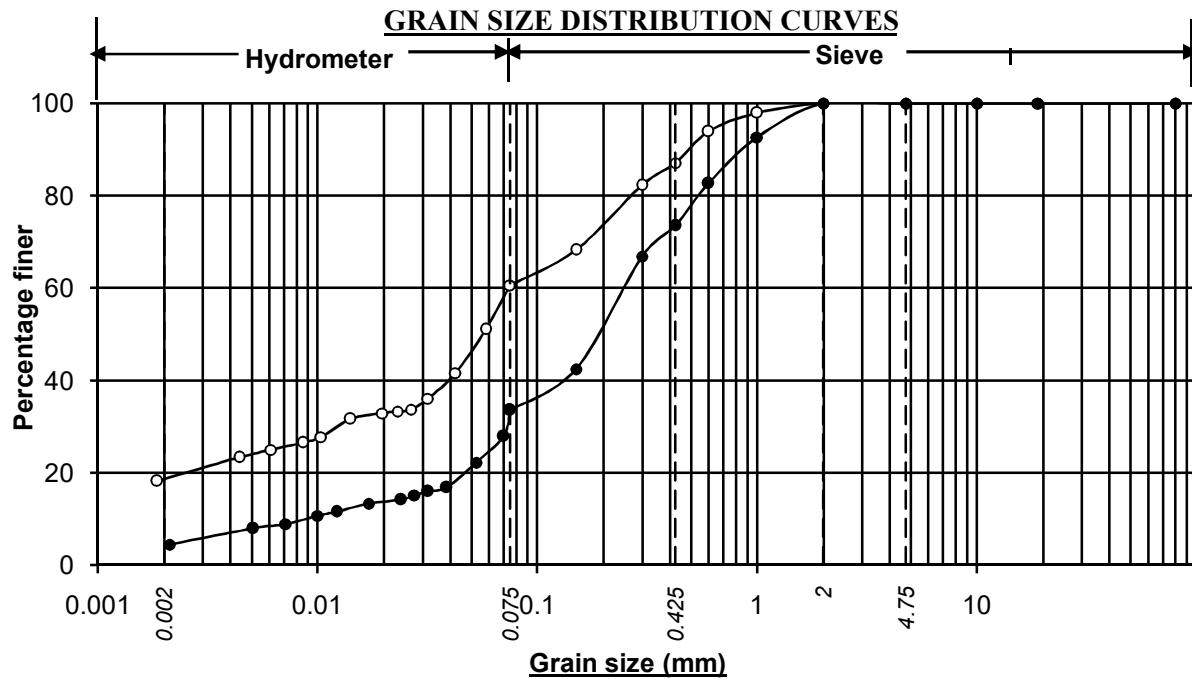
—●— BH--117,UDS-01, 2.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--116,SPT-16, 24.00M	18.3	26.3	27.0	28.4	0.0	55.4		0.0
BH--117,UDS-01, 2.50M	11.2	43.8	16.5	23.3	5.2	45.0		0.0

Project:- Geotech. Inv. Work for 5th Stream A126 of R427  
Odisha

Job No.

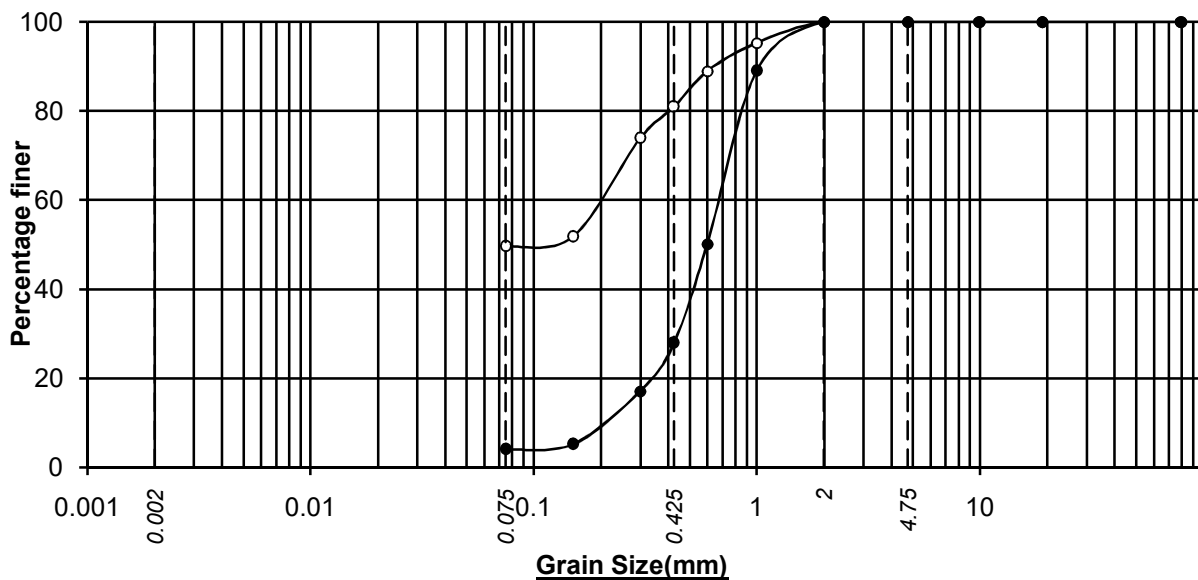
4095



—○— BH--117,UDS-03, 8.50M

—●— BH--117,SPT-09, 13.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--117,UDS-03, 8.50M	18.7	41.9	26.5	12.9	0.0	39.4		0.0
BH--117,SPT-09, 13.50M	4.2	29.5	39.9	26.4	0.0	66.3		0.0



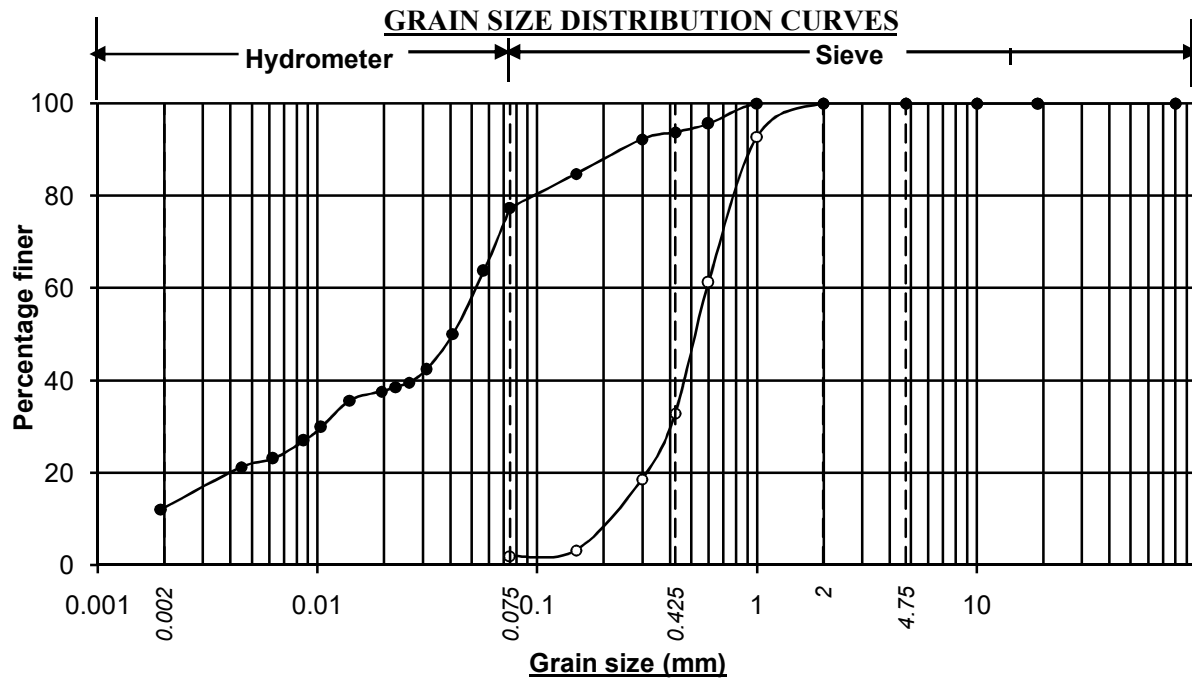
—○— BH--117,SPT-10, 15.00M

—●— BH--117,SPT-14, 21.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--117,SPT-10, 15.00M		49.6	31.3	19.1	0.0	50.4		0.0
BH--117,SPT-14, 21.00M		4.0	23.9	72.1	0.0	96.0		0.0

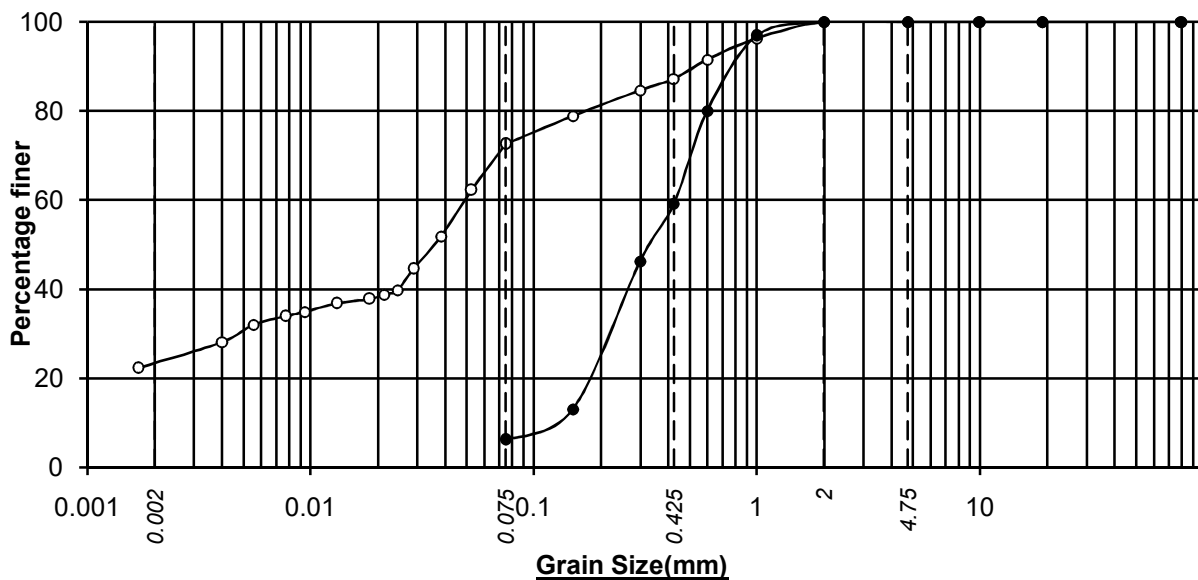
**Project:- Geotech. Inv. Work for 5th Stream A127 of R427 at Damanjodi, Odisha**

**Job No.****4095**



—○— BH--117, SPT-17, 25.50M      —●— BH--118, UDS-02, 4.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--117, SPT-17, 25.50M		1.9	31.0	67.1	0.0	98.1		0.0
BH--118, UDS-02, 4.50M	12.4	65.0	16.3	6.3	0.0	22.6		0.0



—○— BH--118, SPT-05, 7.62M      —●— BH--118, SPT-14, 21.00M

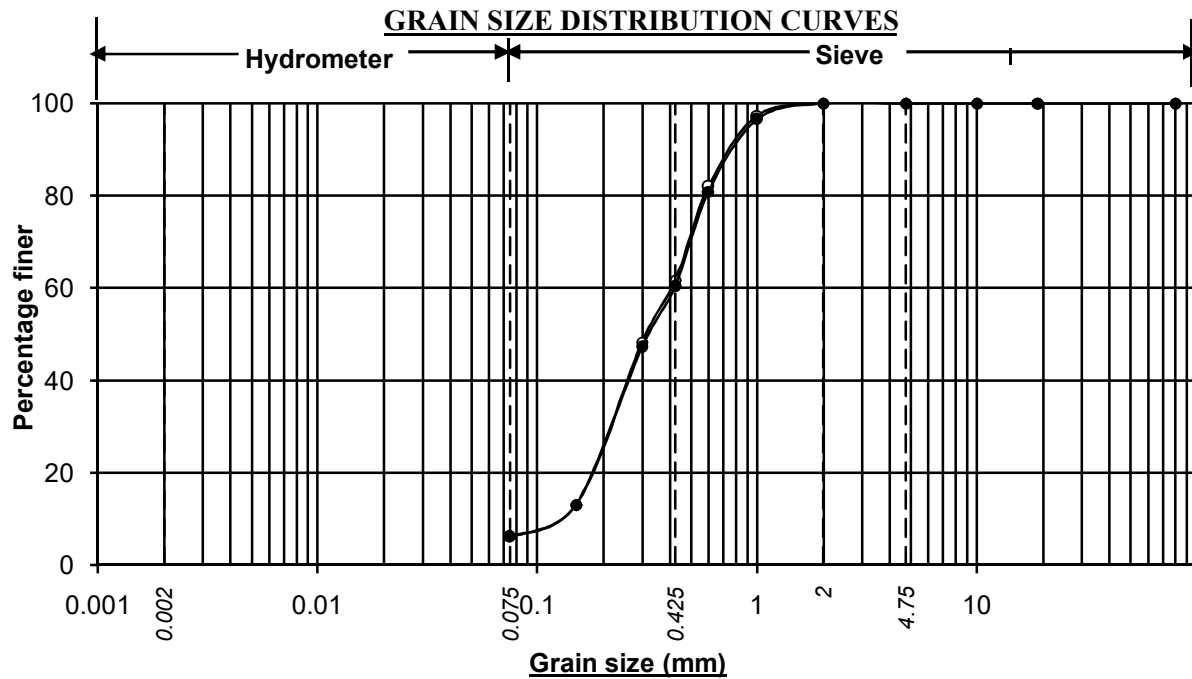
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--118, SPT-05, 7.62M	23.4	49.2	14.6	12.8	0.0	27.4		0.0
BH--118, SPT-14, 21.00M		6.1	53.1	40.8	0.0	93.9		0.0

**Project:- Geotech. Inv. Work for 5th Stream A128 of R427, Odisha**

**Job No.**

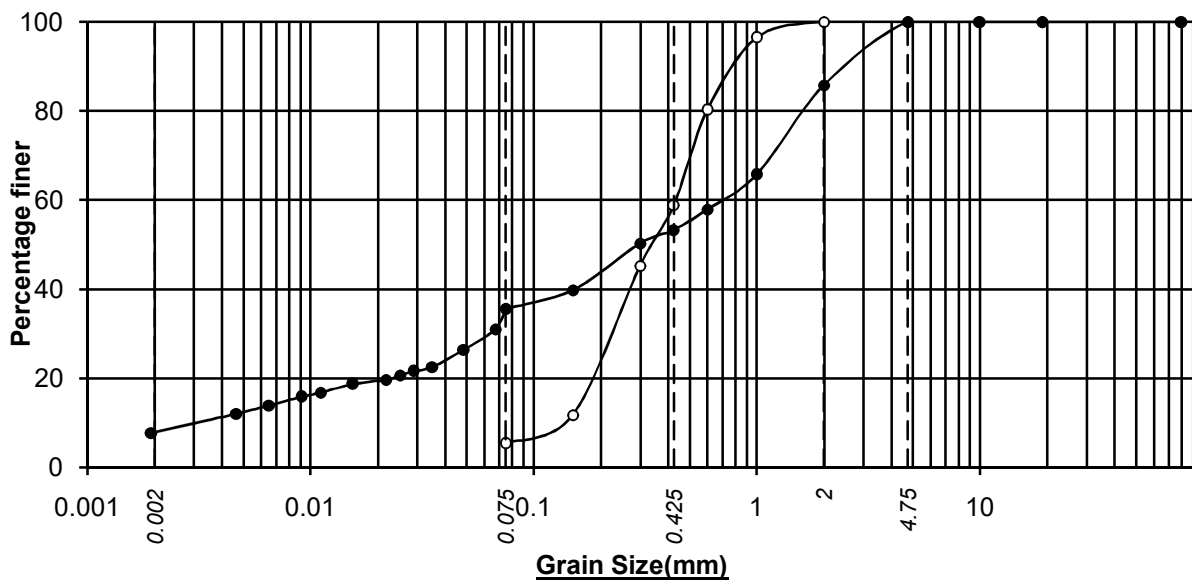
**4095**





—○— BH--118, SPT-15, 22.50M      —●— BH--118, SPT-18, 27.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--118, SPT-15, 22.50M		6.1	55.6	38.3	0.0	93.9		0.0
BH--118, SPT-18, 27.00M		6.3	54.1	39.6	0.0	93.7		0.0



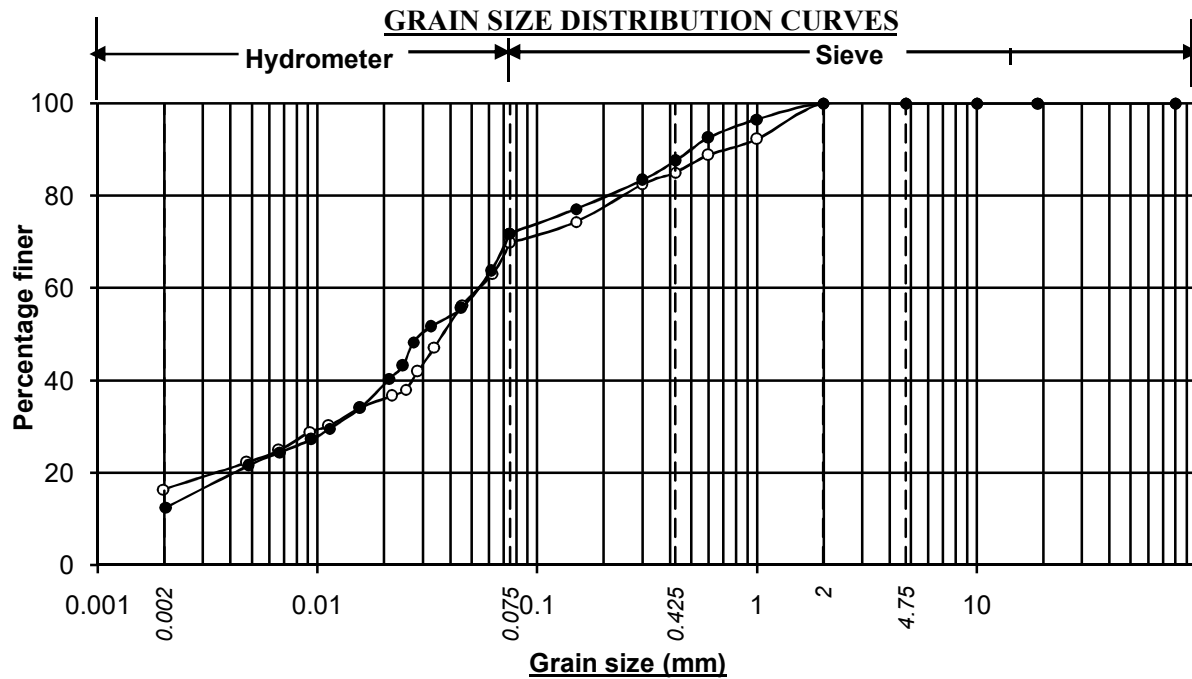
—○— BH--118, SPT-20, 30.00M      —●— BH--119, UDS-01, 3.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--118, SPT-20, 30.00M		5.3	53.6	41.1	0.0	94.7		0.0
BH--119, UDS-01, 3.00M	7.8	27.8	17.6	32.5	14.3	64.4		0.0

**Project:- Geotech. Inv. Work for 5th Stream A129 of R427 at Damanjodi, Odisha**

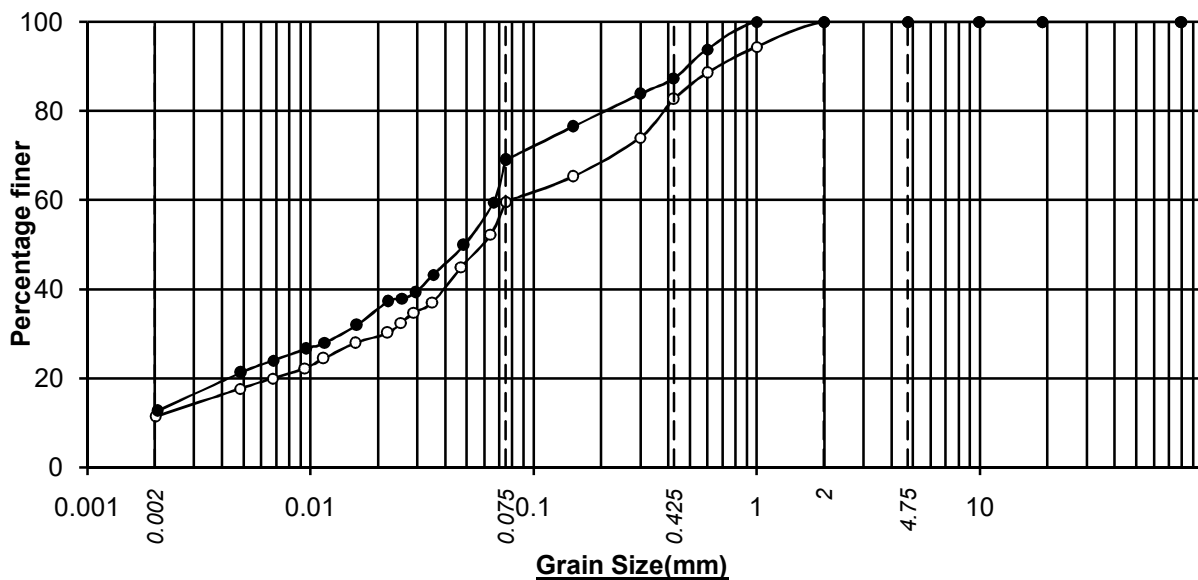
**Job No.**

**4095**



—○— BH--119,UDS-02, 6.00M      —●— BH--119,SPT-06, 9.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--119,UDS-02, 6.00M	16.4	53.4	15.2	15.0	0.0	30.2		0.0
BH--119,SPT-06, 9.50M	12.3	59.6	15.7	12.4	0.0	28.1		0.0



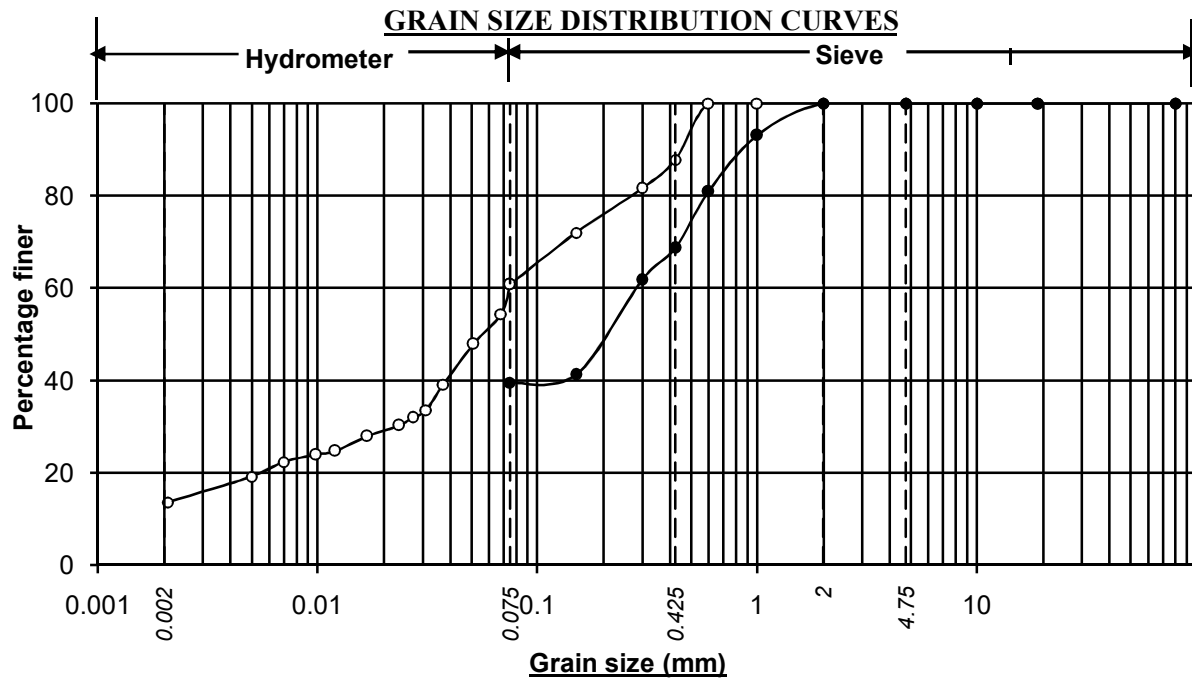
—○— BH--119,SPT-14, 21.50M      —●— BH--120,UDS-01, 2.40M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--119,SPT-14, 21.50M	11.3	48.3	23.1	17.3	0.0	40.4		0.0
BH--120,UDS-01, 2.40M	12.3	56.7	18.3	12.7	0.0	31.0		0.0

**Project:- Geotech. Inv. Work for 5th Stream A and R 427 at Damanjodi, Odisha**

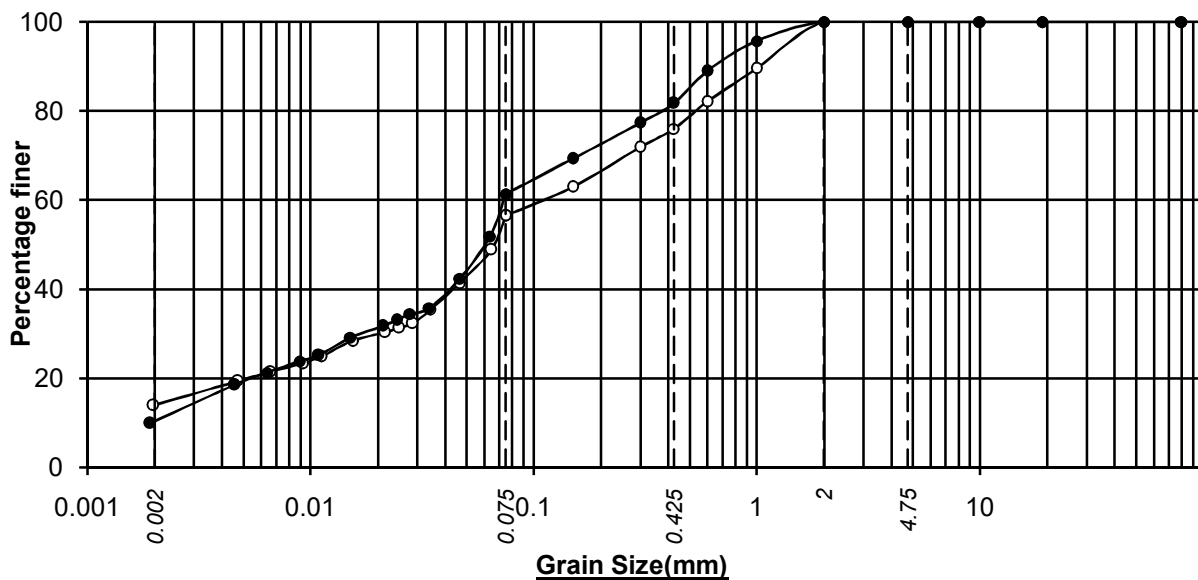
**Job No.**

**4095**



—○— BH--120,SPT-08, 12.50M      —●— BH--120,SPT-19, 29.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--120,SPT-08, 12.50M	13.3	47.5	27.0	12.2	0.0	39.2		0.0
BH--120,SPT-19, 29.00M		39.5	29.2	31.3	0.0	60.5		0.0



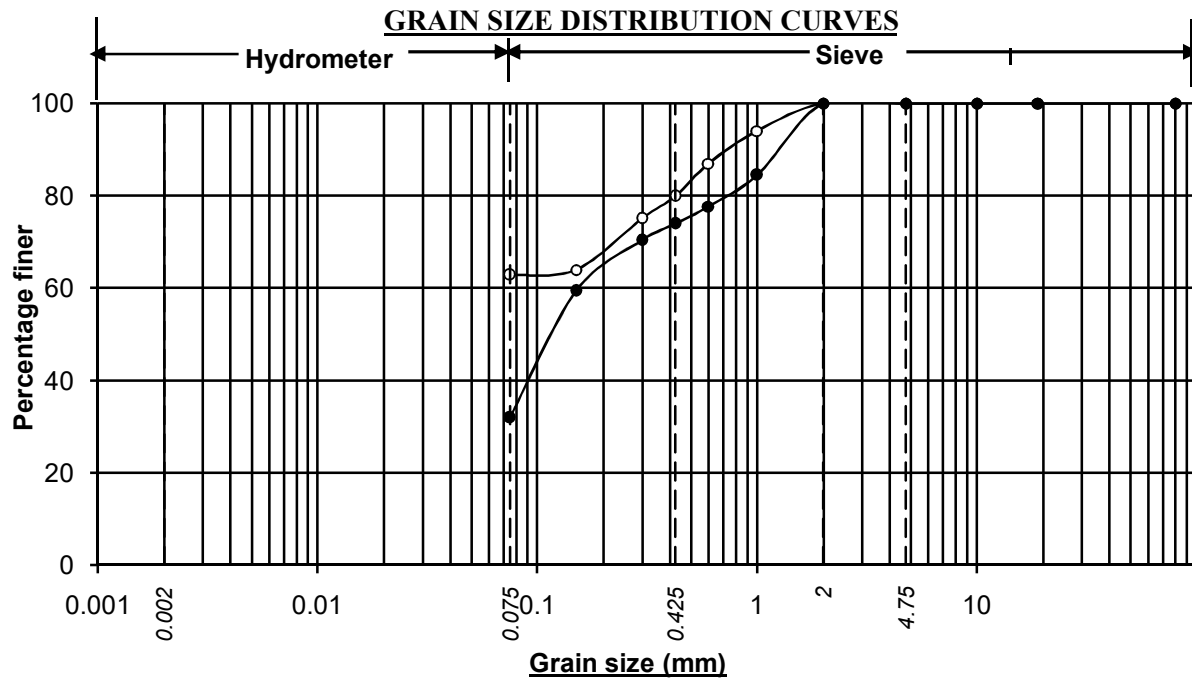
—○— BH--121,UDS-01, 2.50M      —●— BH--121,SPT-09, 13.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--121,UDS-01, 2.50M	14.0	42.5	19.5	24.0	0.0	43.5		0.0
BH--121,SPT-09, 13.00M	10.4	51.0	20.4	18.2	0.0	38.6		0.0

**Project:- Geotech. Inv. Work for 5th Stream A131 of R427 at Damanjodi, Odisha**

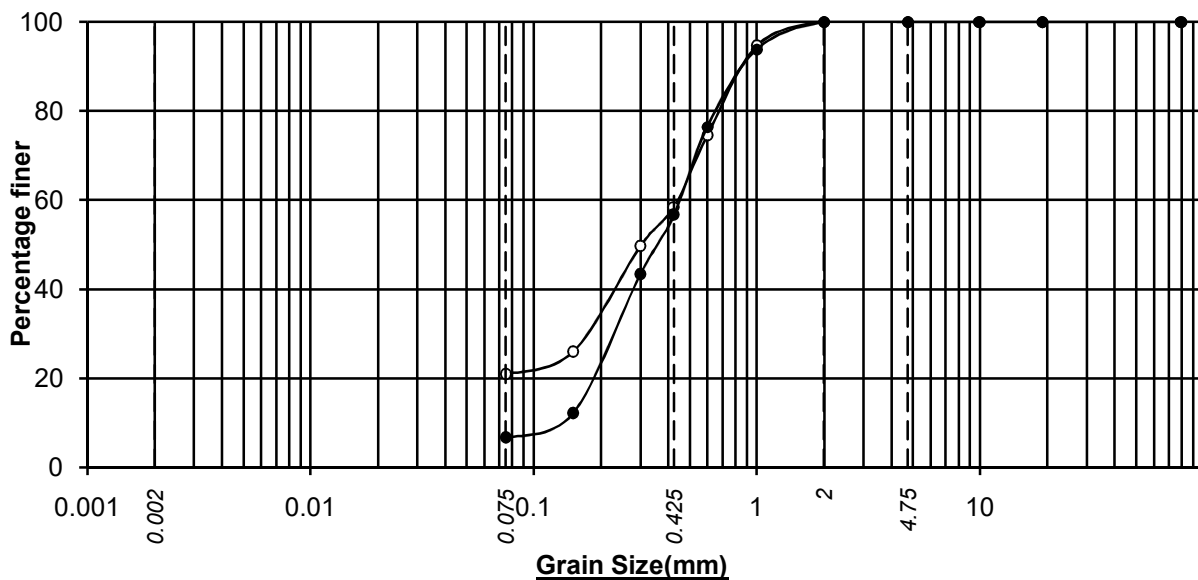
**Job No.**

**4095**



—○— BH--121,SPT-10, 14.50M      —●— BH--121,SPT-14, 20.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--121,SPT-10, 14.50M		62.9	17.1	20.0	0.0	37.1		0.0
BH--121,SPT-14, 20.50M		32.0	42.0	26.0	0.0	68.0		0.0



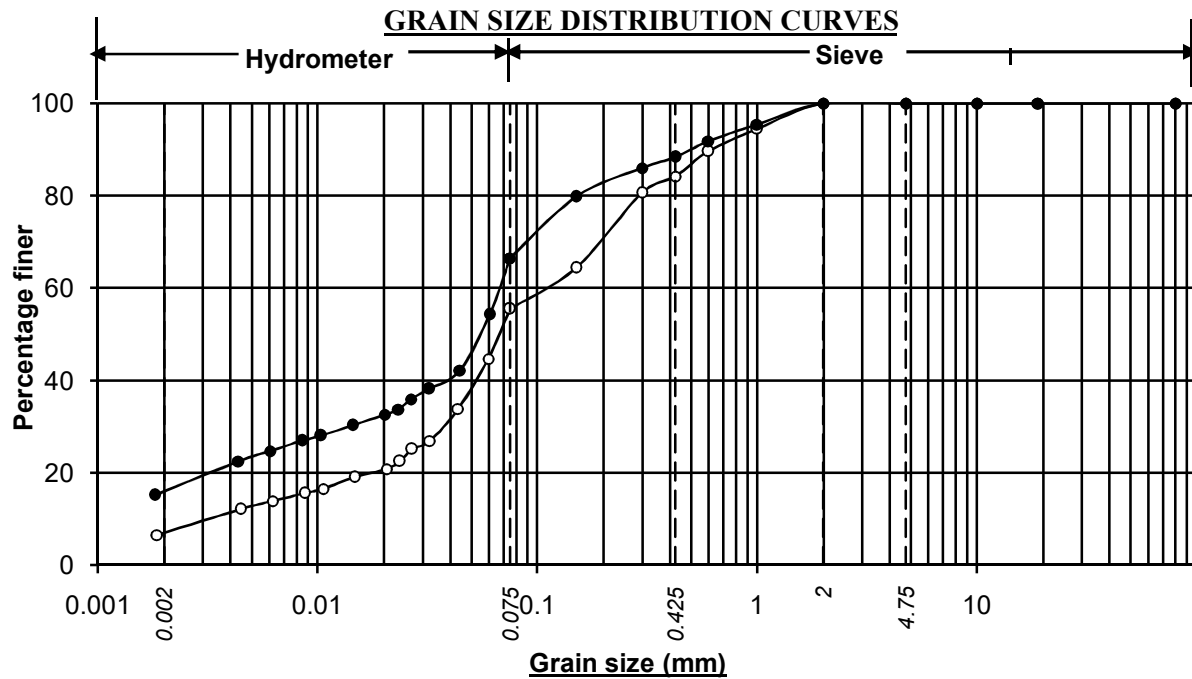
—○— BH--121,SPT-17, 25.00M      —●— BH--121,SPT-21, 30.30M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--121,SPT-17, 25.00M		20.9	37.5	41.6	0.0	79.1		0.0
BH--121,SPT-21, 30.30M		6.6	50.0	43.4	0.0	93.4		0.0

**Project:- Geotech. Inv. Work for 5th Stream A132 and R427 at Damanjodi, Odisha**

**Job No.**

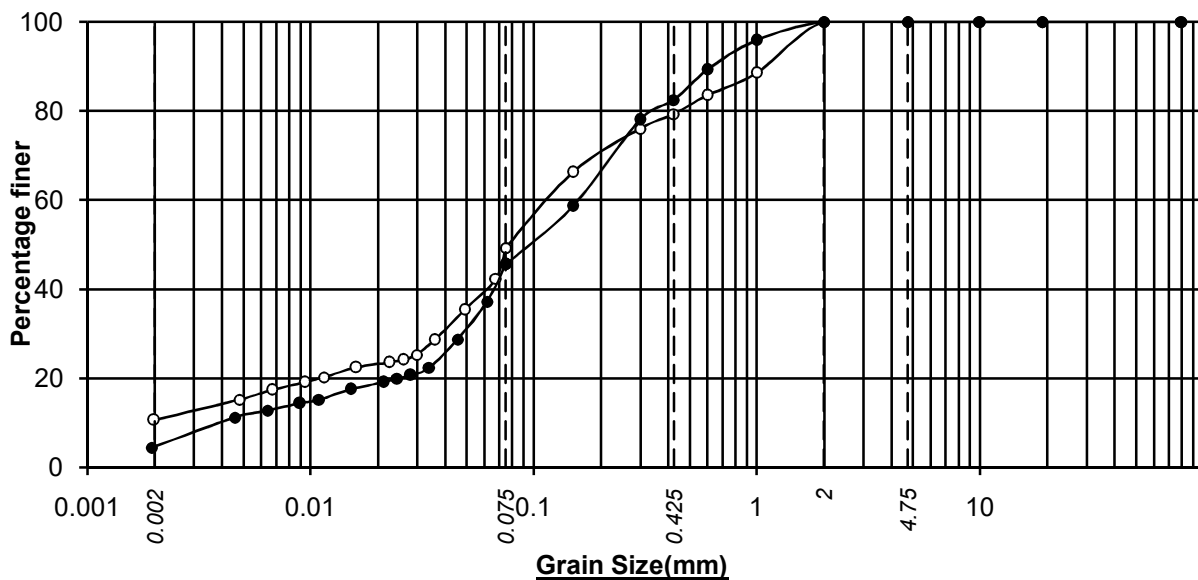
**4095**



—○— BH--122,SPT-01, 1.50M

—●— BH--123,UDS-01, 1.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--122,SPT-01, 1.50M	7.0	48.6	28.6	15.8	0.0	44.4		0.0
BH--123,UDS-01, 1.50M	16.0	50.4	22.0	11.6	0.0	33.6		0.0



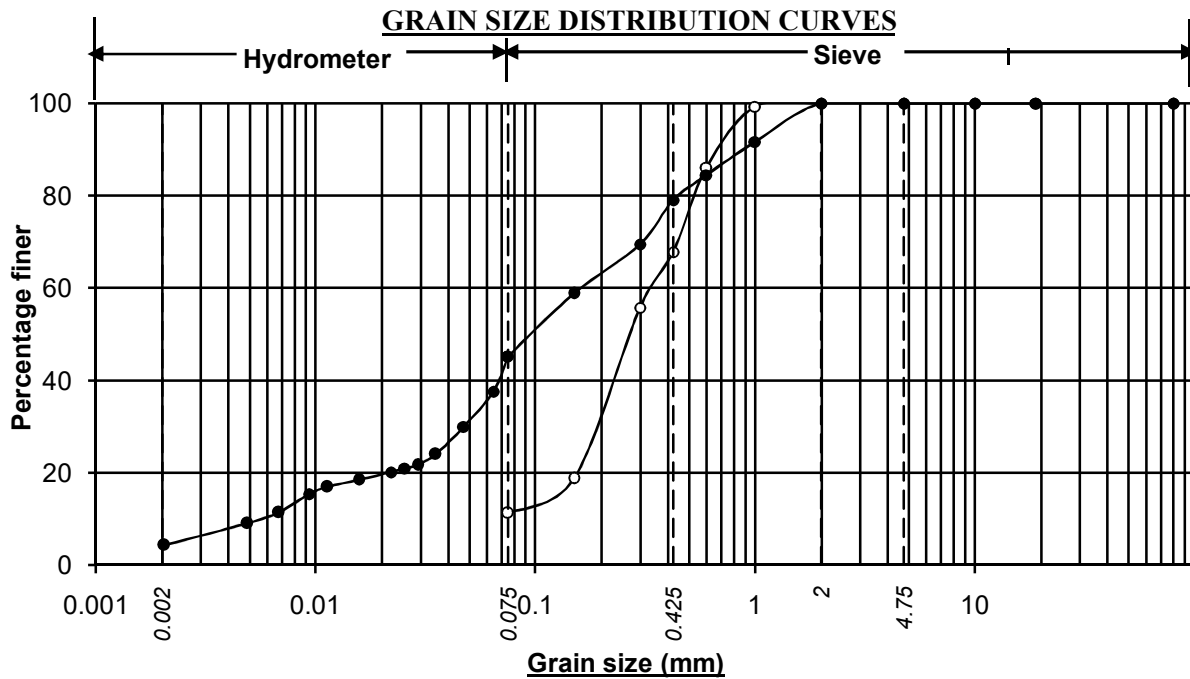
—○— BH--123,UDS-03, 7.50M

—●— BH--123,SPT-07, 11.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--123,UDS-03, 7.50M	10.7	38.6	30.0	20.7	0.0	50.7		0.0
BH--123,SPT-07, 11.00M	4.6	41.0	36.9	17.5	0.0	54.4		0.0

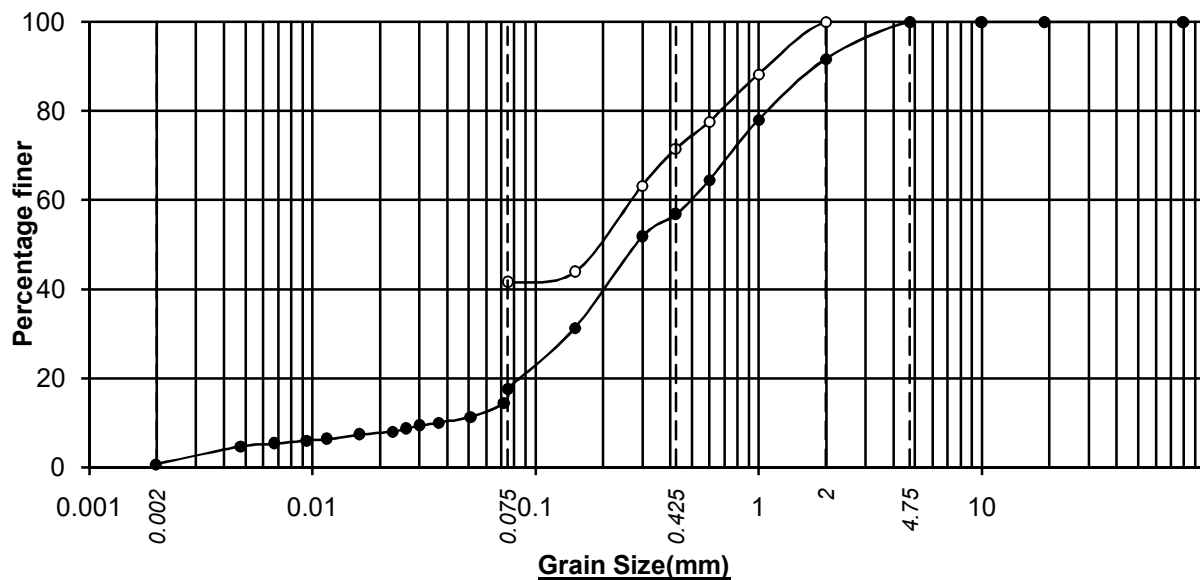
**Project:- Geotech. Inv. Work for 5th Stream Alignment R427 at Damanjodi, Odisha**

**Job No.****4095**



—○— BH--123, SPT-08, 12.50M      —●— BH--124, UDS-01, 1.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--123, SPT-08, 12.50M		11.3	56.5	32.2	0.0	88.7		0.0
BH--124, UDS-01, 1.50M	4.2	41.0	33.9	20.9	0.0	54.8		0.0



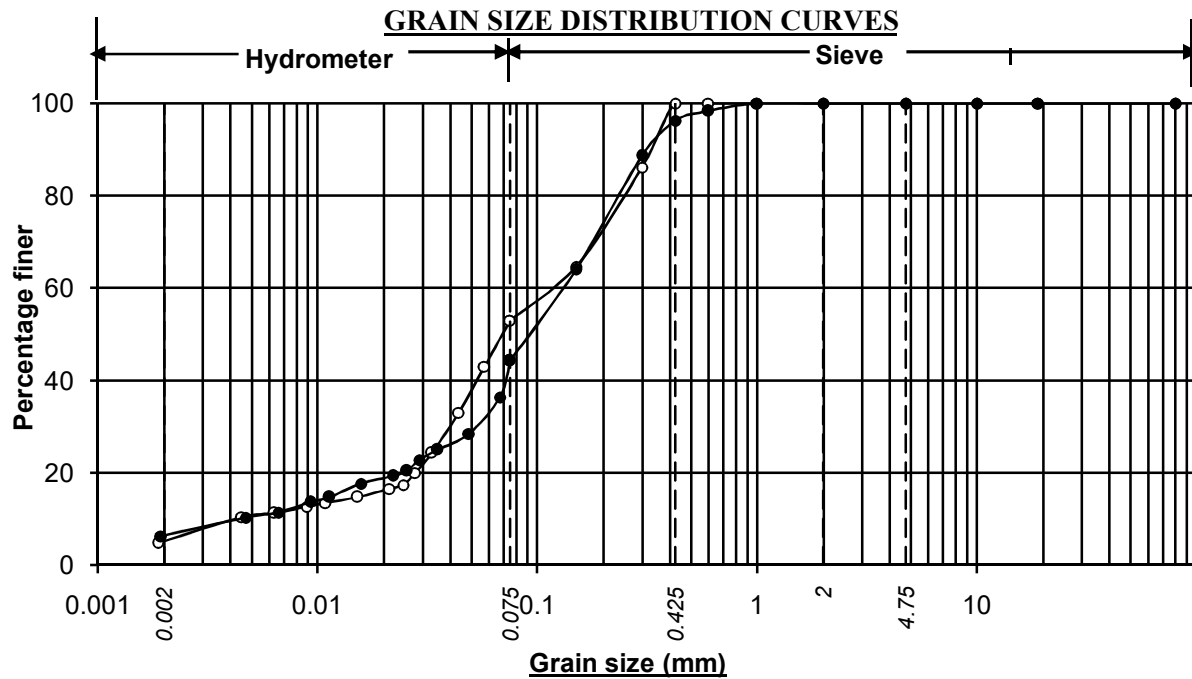
—○— BH--124, SPT-01, 1.95M      —●— BH--124, UDS-02, 4.20M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--124, SPT-01, 1.95M		41.6	30.0	28.4	0.0	58.4		0.0
BH--124, UDS-02, 4.20M	0.7	16.9	39.3	34.8	8.3	82.4		0.0

**Project:- Geotech. Inv. Work for 5th Stream A-75 of R427 at Damanjodi, Odisha**

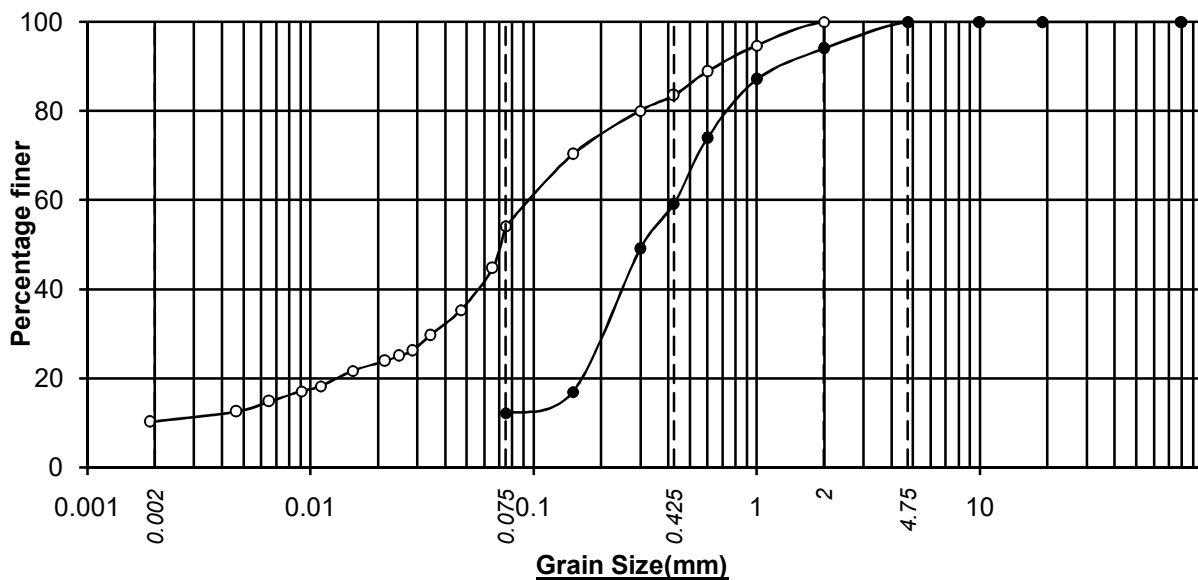
**Job No.**

**4095**



—○— BH--125,UDS-01, 3.00M      —●— BH--125,SPT-04, 6.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--125,UDS-01, 3.00M	5.2	47.8	47.0	0.0	0.0	47.0		0.0
BH--125,SPT-04, 6.50M	6.4	37.9	52.0	3.7	0.0	55.7		0.0



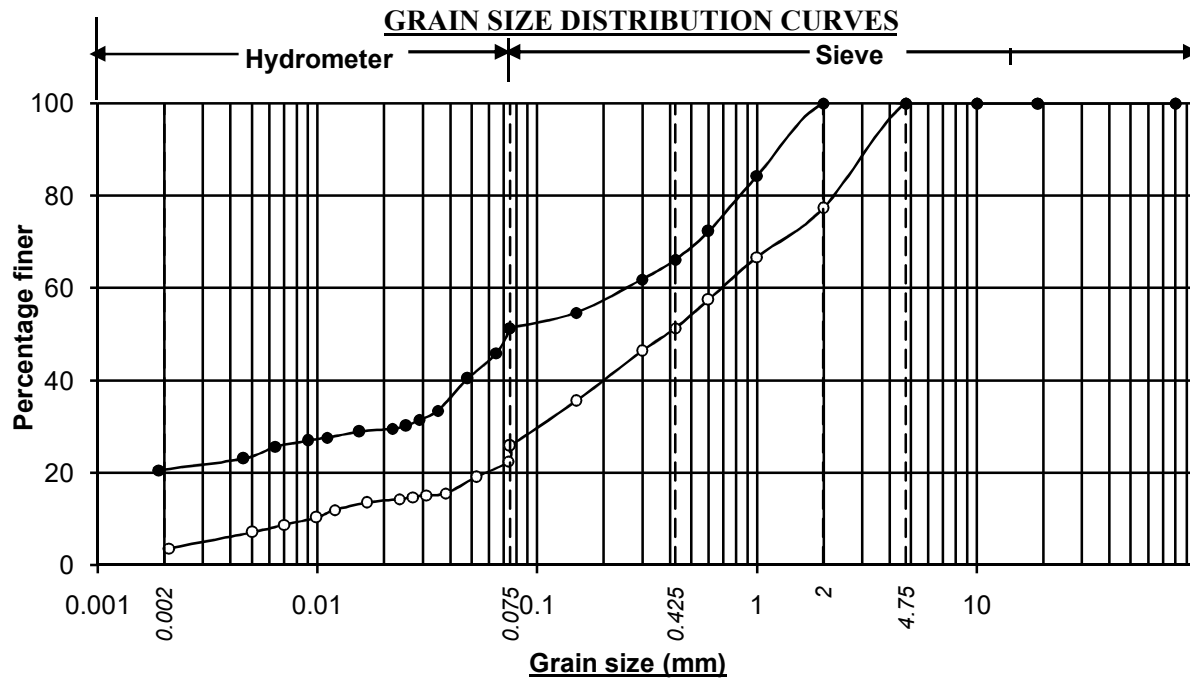
—○— BH--125,SPT-09, 14.00M      —●— BH--125,SPT-10, 15.30M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--125,SPT-09, 14.00M	10.4	43.8	29.4	16.4	0.0	45.8		0.0
BH--125,SPT-10, 15.30M		12.1	47.0	34.9	6.0	87.9		0.0

**Project:- Geotech. Inv. Work for 5th Stream A135 of R427 at Damanjodi, Odisha**

**Job No.**

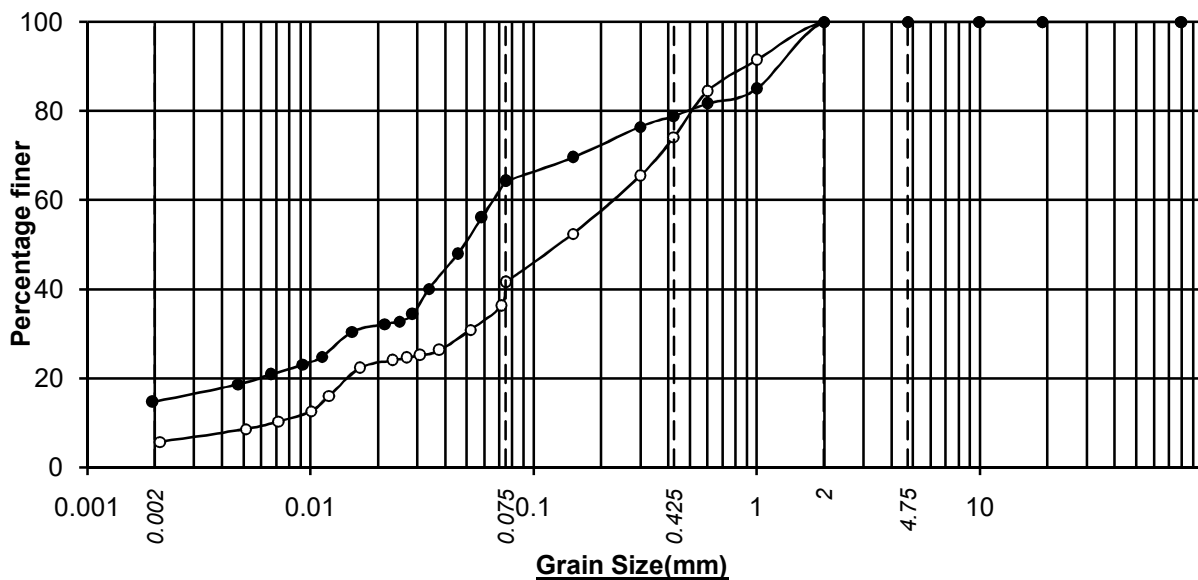
**4095**



—○— BH--127,SPT-01, 1.50M

—●— BH--127,SPT-09, 13.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--127,SPT-01, 1.50M	3.4	22.5	25.4	26.0	22.7	74.1		0.0
BH--127,SPT-09, 13.50M	20.7	30.6	14.9	33.8	0.0	48.7		0.0



—○— BH--127,SPT-19, 28.50M

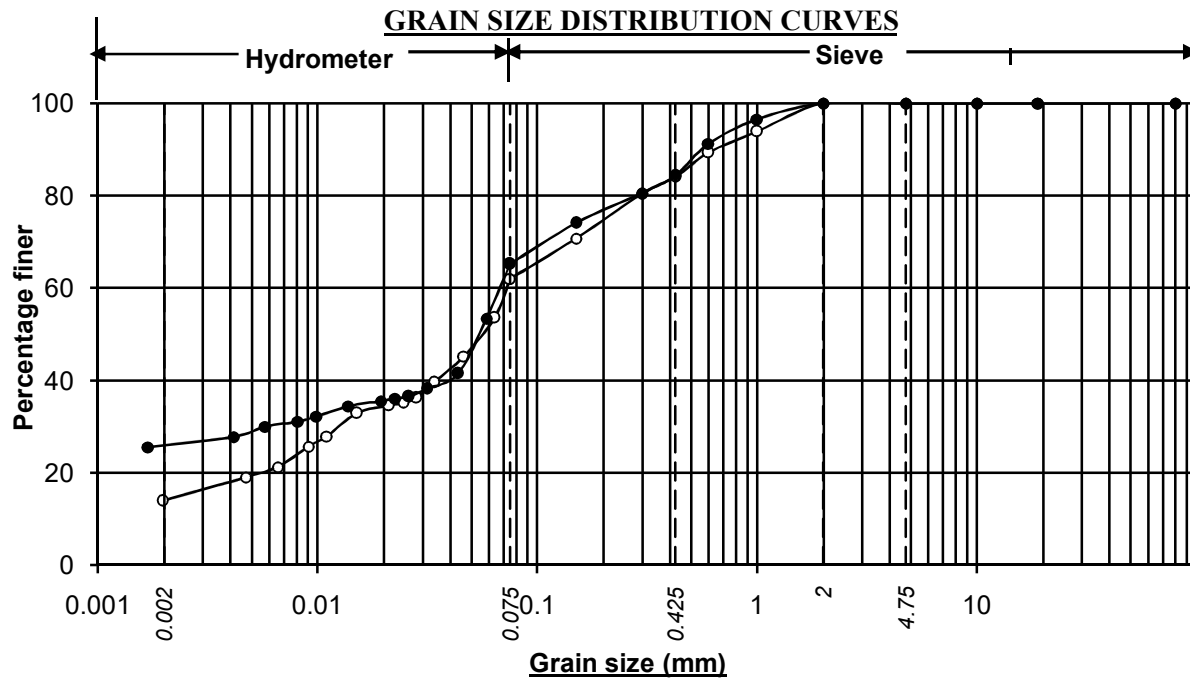
—●— BH--128,UDS-01, 2.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--127,SPT-19, 28.50M	5.5	36.1	32.5	25.9	0.0	58.4		0.0
BH--128,UDS-01, 2.50M	14.7	49.5	14.7	21.1	0.0	35.8		0.0

**Project:- Geotech. Inv. Work for 5th Stream A077 of R427 at Damanjodi, Odisha**

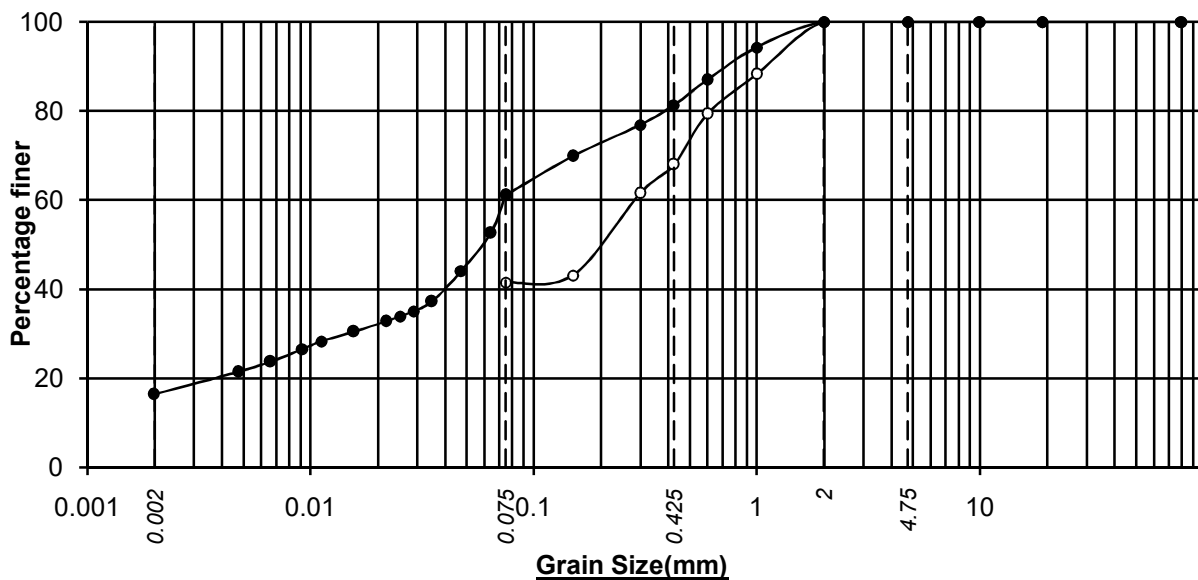
**Job No.****4095**





—○— BH--128,UDS-02, 5.50M      —●— BH--128,SPT-11, 16.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--128,UDS-02, 5.50M	14.0	48.0	22.1	15.9	0.0	38.0		0.0
BH--128,SPT-11, 16.00M	25.9	39.4	19.1	15.6	0.0	34.7		0.0



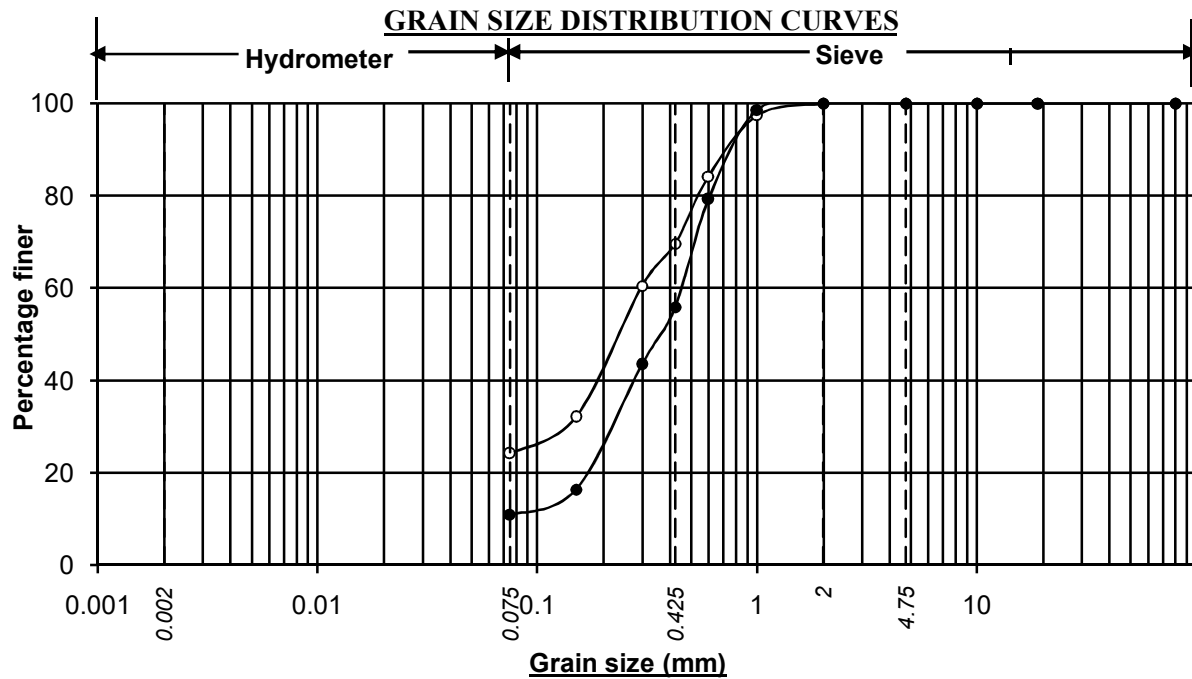
—○— BH--128,SPT-13, 19.00M      —●— BH--129,UDS-01, 3.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--128,SPT-13, 19.00M		41.5	26.5	32.0	0.0	58.5		0.0
BH--129,UDS-01, 3.00M	16.4	44.7	20.2	18.7	0.0	38.9		0.0

**Project:- Geotech. Inv. Work for 5th Stream A137 of R427, Odisha**

**Job No.**

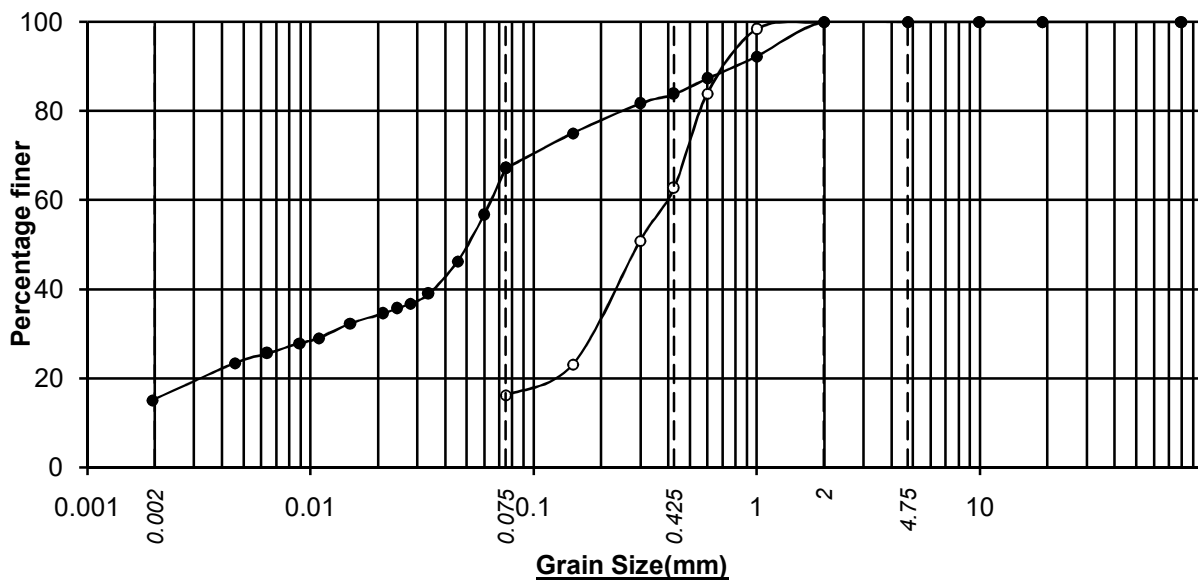
**4095**



—○— BH--129,SPT-04, 6.50M

—●— BH--129,SPT-09, 14.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--129,SPT-04, 6.50M		24.2	45.5	30.3	0.0	75.8		0.0
BH--129,SPT-09, 14.00M		10.9	45.0	44.1	0.0	89.1		0.0



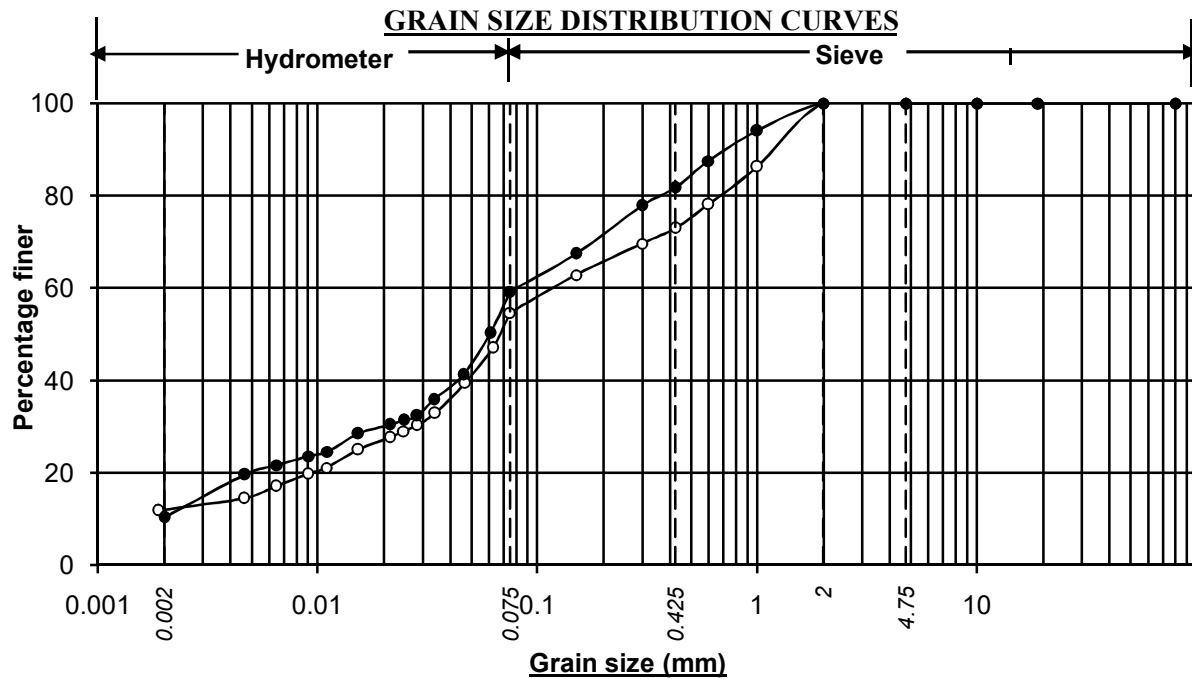
—○— BH--129,SPT-13, 20.00M

—●— BH--130,UDS-01, 2.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--129,SPT-13, 20.00M		16.1	46.6	37.3	0.0	83.9		0.0
BH--130,UDS-01, 2.50M	15.3	51.9	16.7	16.1	0.0	32.8		0.0

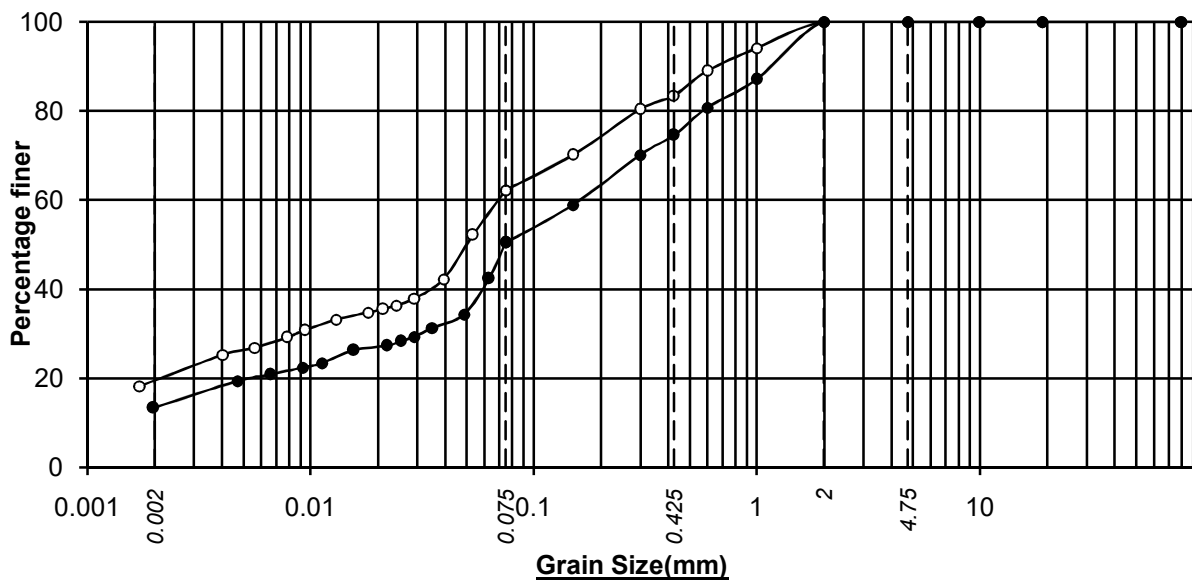
**Project:- Geotech. Inv. Work for 5th Stream A138 of R427 at Damanjodi, Odisha**

**Job No.****4095**



—○— BH--130,SPT-09, 13.00M      —●— BH--131,UDS-01, 2.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--130,SPT-09, 13.00M	12.0	42.6	18.4	27.0	0.0	45.4		0.0
BH--131,UDS-01, 2.50M	10.3	49.0	22.4	18.3	0.0	40.7		0.0



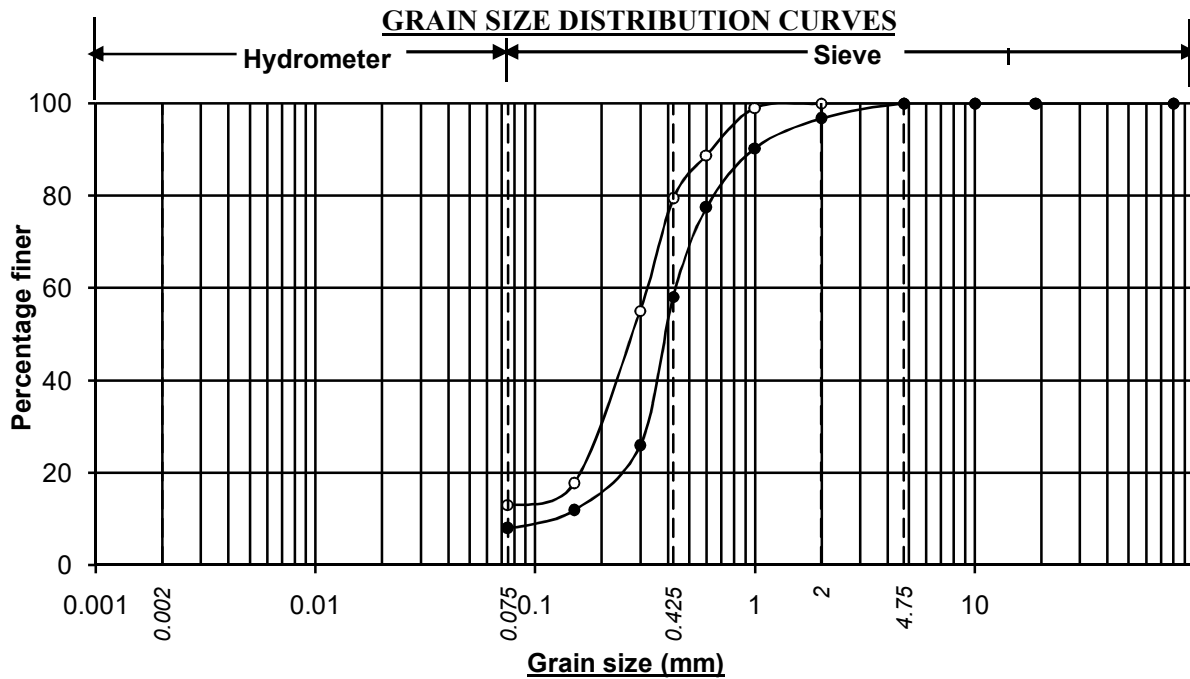
—○— BH--131,UDS-02, 5.50M      —●— BH--131,UDS-03, 8.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--131,UDS-02, 5.50M	19.4	42.8	21.3	16.5	0.0	37.8		0.0
BH--131,UDS-03, 8.50M	13.5	37.0	24.1	25.4	0.0	49.5		0.0

**Project:- Geotech. Inv. Work for 5th Stream A760 of R427 at Damanjodi, Odisha**

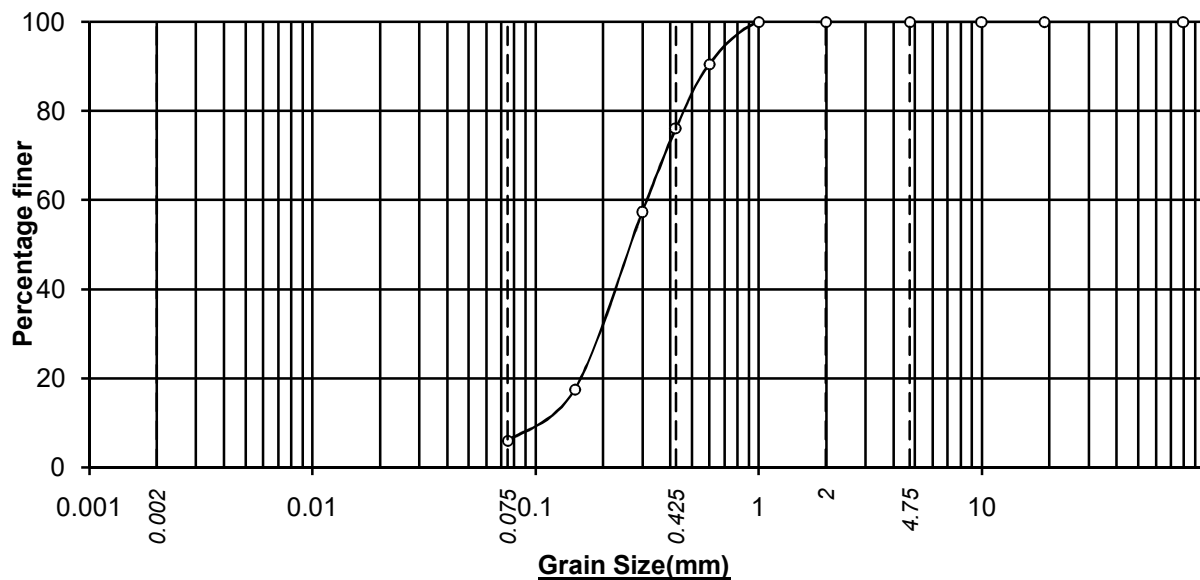
**Job No.**

**4095**



—○— BH--131,SPT-08, 11.50M      —●— BH--131,SPT-12, 17.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--131,SPT-08, 11.50M		13.0	66.4	20.6	0.0	87.0		0.0
BH--131,SPT-12, 17.50M		8.0	50.1	38.7	3.2	92.0		0.0



—○— BH--131,SPT-16, 23.50M      —●— #N/A

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH--131,SPT-16, 23.50M		6.0	70.1	23.9	0.0	94.0		0.0

**Project:- Geotech. Inv. Work for 5th Stream A140 and R427 at Damanjodi, Odisha**

**Job No.**

**4095**

## **PART IV: SAMPLE CALCULATION**

**Bearing Capacity around Lime Preparation-Crusher Area (BH-124), Size of foundation = 1m x 1m, Depth of foundation = 2.00m below FGL (FGL = 900.200M)**

The suggested founding level falls inside medium dense sand layer (i.e. layer IIIA).

The design field "N" = 16

After correction factor for Overburden Pressure and Dilatancy, Final Corrected "N" = 18, corresponding  $\phi = 33^\circ$

So, use  $C = 0$  kg/sqcm &  $\phi = 30^\circ$

#### **Design Strength Parameters for Stratum – IIIA:**

Treating the sand to be silty sand,  $E_s = 3(N+6) = 72$  kg/sqcm

Treating the sand to be normally consolidated sand,  $E_s = 5(N+15) = 165$  kg/sqcm

Thus average  $E_s = 119$  kg/sqcm

So, use  $E_s = 115$  kg/sqcm

#### **Design Strength Parameters for Stratum – III:**

The design "N" = 32

After correction factor for Overburden Pressure and Dilatancy, Final Corrected "N" = 26

Treating the sand to be silty sand,  $E_s = 3(N+6) = 96$  kg/sqcm

Treating the sand to be normally consolidated sand,  $E_s = 5(N+15) = 205$  kg/sqcm

[Refer to "Foundation Analysis and Design", 5<sup>th</sup> Edition, by J.E.Bowles, pp. No. 316, Table:5-6]

Thus average  $E_s = 151$  kg/sqcm

So, use  $E_s = 150$  kg/sqcm

#### **For Stratum – V & VI:**

From laboratory rock test results, it is seen that average Young's modulus values for layer V & VI = 41572 kg/sqcm (based on 7nos. tests) & 34710 kg/sqcm (based on 20nos. tests) respectively. This is for core samples and not truly representative of the entire layer. Considering the above and uncertain rock behaviour, we use Young's modulus for layer-V & VI = 5000 kg/sqcm & 10000 kg/sqcm respectively.

#### **Determination of Bearing Capacity:**

The Net Ultimate Bearing Capacity is given as:

$$q_{nu} = C.N_c.S_c.D_c + q.N_q.S_q.D_q + 0.5\gamma.B.N_\gamma.S_\gamma.D_\gamma - q$$

Where,

$N_c$ ,  $N_q$  and  $N_\gamma$  are bearing capacity factors,

$S_c$ ,  $S_q$  and  $S_\gamma$  are shape factors,

$D_c$ ,  $D_q$  and  $D_\gamma$  are depth factors,

And

$C$  = Cohesion

$q$  = Overburden pressure,

$B$  = Width of foundation,

$\gamma$  = Effective density below foundation.

#### **Considering general shear condition**

Cohesion,  $C = 0.00$  t/sqm

Using  $\phi = 36$  degree, the bearing capacity factors are:

$$N_c = 50.59$$

$$N_q = 37.75$$

$$N_\gamma = 56.31$$

Use,

Depth of Foundation =  $D_f = 2$  M (Below FGL)

Size of Foundation =  $B = 1$  M Square

Overburden Pressure =  $q = 2.000$  (Depth)  $\times$  0.90 (Submerged density) = 1.80 t/sqm (Assuming the ground water table is flushing with the ground level)

The Shape factors are [ IS:6403 - 1981 ]

$$S_c = 1.30$$

$$S_q = 1.20$$

$$S_\gamma = 0.80$$

The Depth factors are [ IS:6403 - 1981 ]

$$D_c = 1.79 \quad D_q = 1.39 \quad D_\gamma = 1.39$$

Computed Net Ultimate Bearing Capacity = 139.98 t/sqm

**Using a factor of safety of 2.5, Net Safe Bearing Capacity = 55.99 t/sqm**

**Considering local shear condition**

$$\phi' = \tan^{-1}(2/3 \tan \phi) = 19^\circ$$

Computed Net Ultimate Bearing Capacity = 16.40 t/sqm

**Using a factor of safety of 2.5, Net Safe Bearing Capacity = 6.56 t/sqm**

Therefore interpolated SBC for  $\phi$  of  $30^\circ = 6.56 + [(55.99-6.56)/(36-28) \times (30-28)] = 18.92$  t/sqm

Similarly, for 3m x 3m foundation, interpolated SBC = 21.15 t/sqm

The above bearing capacity should be checked against settlement criteria. This is shown below.

**Settlement Analysis**

**A) General Data:**

Width of foundation =	3.0	m
Length of foundation =	3.0	m
Depth of foundation =	2.00	m
Net Base Pressure =	1.8	kg/sqcm

**B) Subsoil Properties:**

**Layer - IIIA**

Young's Modulus =	115	kg/sqcm
Poisson Ratio, $\mu$ =	0.35	
Top of Stratum =	2.00	m
End of Stratum =	3.39	m
Geological factor, G =	1.00	
$m_{vc}$ =	0.0000	sqcm/kg

**Layer - III**

Young's Modulus =	150	kg/sqcm
Poisson Ratio, $\mu$ =	0.25	
Top of Stratum =	3.39	m
End of Stratum =	4.39	m
Geological factor, G =	1.00	
$m_{vc}$ =	0.0000	sqcm/kg

**Layer - V**

Young's Modulus =	5000	kg/sqcm
Poisson Ratio, $\mu$ =	0.25	
Top of Stratum =	4.39	m
End of Stratum =	8.00	m
Geological factor, G =	1.00	
$m_{vc}$ =	0.0000	sqcm/kg

**C) Calculation of Immediate Settlement:**

**Settlement at center**

$$\begin{aligned} M = L' / B' &= 1.000 \\ N = H / B' &= 0.927 \\ I_1 &= 0.128 \\ I_2 &= 0.084 \\ I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 &= 0.167 \\ \text{Immediate settlement } S_i &= 1.376 \text{ cm} \\ [q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s \end{aligned}$$

**Settlement at center**

$$\begin{aligned} M = L' / B' &= 1.000 \\ N = H / B' &= 0.456 \\ I_1 &= 0.041 \\ I_2 &= 0.071 \\ I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 &= 0.089 \\ \text{Immediate settlement } S_i &= 0.409 \text{ cm} \\ [q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s \end{aligned}$$

**Settlement at center**

$$\begin{aligned} M = L' / B' &= 1.000 \\ N = H / B' &= 1.340 \\ I_1 &= 0.200 \\ I_2 &= 0.078 \\ I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 &= 0.252 \\ \text{Immediate settlement } S_i &= 0.028 \text{ cm} \\ [q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s \end{aligned}$$

**Settlement at corner**

$$\begin{aligned} M = L' / B' &= 1.00 \\ N = H / B' &= 0.463 \\ I_1 &= 0.042693 \\ I_2 &= 0.071318 \\ I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 &= 0.076 \\ \text{Immediate settlement } S_i &= 0.312 \text{ cm} \end{aligned}$$

**Settlement at corner**

$$\begin{aligned} M = L' / B' &= 1.00 \\ N = H / B' &= 0.228 \\ I_1 &= 0.011 \\ I_2 &= 0.046 \\ I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 &= 0.042 \\ \text{Immediate settlement } S_i &= 0.096 \text{ cm} \end{aligned}$$

**Settlement at corner**

$$\begin{aligned} M = L' / B' &= 1.000 \\ N = H / B' &= 0.670 \\ I_1 &= 0.079 \\ I_2 &= 0.081 \\ I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 &= 0.134 \\ \text{Immediate settlement } S_i &= 0.008 \text{ cm} \end{aligned}$$

$$\begin{aligned} \text{Average } S_i \text{ for Stratum IIIA} &= 8.44 \text{ mm} \\ \text{Total immediate settlement} &= 11.14 \text{ mm} \end{aligned}$$

$$\begin{aligned} \text{Average } S_i \text{ for Stratum III} &= 2.52 \text{ mm} \\ \text{(for all the three layers)} \end{aligned}$$

$$\text{Average } S_i \text{ for Stratum V} = 0.18 \text{ mm}$$

$$\begin{aligned} \text{So, Total Settlement} &= 11.14 \text{ mm} \\ \text{Fox's Depth correction Factor} &= 0.80 \\ \text{Corrected total settlement} &= 8.92 \text{ mm} \end{aligned}$$

$$< 25 \text{ mm}$$

The calculated settlement is well within the permissible limit. So, use a net allowable bearing capacity of 18t/sqm for depth of foundation 2.00m below FGL.

**Bearing Capacity around Bauxite Handling Conveyor Area (BH-127 to BH-129), Size of foundation = 3m x 6m, Depth of foundation = 2.00m below FGL (FGL = EGL)**

The suggested founding level falls inside very stiff silty clay layer (i.e. layer I).

Average N in this layer = 13, corresponding cohesion from N value = 0.78 kg/sqcm<sup>1</sup>

In absence of any laboratory test results, use  $C = 0.75$  kg/sqcm &  $\phi = 0^\circ$

### **Design Strength Parameters for Stratum – I:**

Total soil modulus,  $E_s = 4.4 \times N = 57.20$  kg/sqcm

[Ref. to “History of Soil penetration testing” by B. B. Broms & N. Flodin in “Penetration Testing 1988”, ISPOT-1: vol.1, p – 185]

Undrained Young’s modulus,  $E_u = K \times C = 400 \times 0.75 = 300$  kg/sqcm

Again,  $1/E_s = 1/E_u + 1/E_d$  giving drained young's modulus,  $E_d = 70.68$  kg/sqcm

Now, we have,  $E_d = E_u/3 = 100$  kg/sqcm

[Refer to “Cone Penetration Testing” by A.C.Meigh, pp. No. – 53]

Considering the above, let us use  $E_d = 85$  kg/sqcm

From  $E_d$ ,  $m_{vc} = 1/G.E_d = 0.0157$  sqcm/kg [Geological Factor,  $G = 0.75$  &  $\mu = 0.35$ ]

Again from SPT “N”,  $m_{vc} = 1/5N = 0.0154$  sqcm/kg

[Refer to “Standard Penetration Test, State-of-the-art-Report” by Ivan K. Nixon in “Penetration testing 1” Edited by A.Verrujt, F.L.beringen & E.H.De Leeuw, pp. No. 11]

Thus average  $m_{vc} = [0.0157 + 0.0154]/2 = 0.0155$  sqcm/kg

### **1 Relation between SPT “N” and Shear Strength**

Widely used relationship is due to Terzaghi and Peck recommending  $C = N/16$

However, it has been seen over the years with stiffness in clay the shear strength does not increase as rapidly as proposed by Terzaghi.

Our experience also shows that for clays at medium to higher depth, the above relation does not hold good.

For Static Cone Penetration Tests, the recommendations for cone factor  $N_k$  generally are

$C = q_c/N_k$  where  $C$  = Cohesion in kg/sqcm and  $q_c$  = Cone resistance in Static Cone and

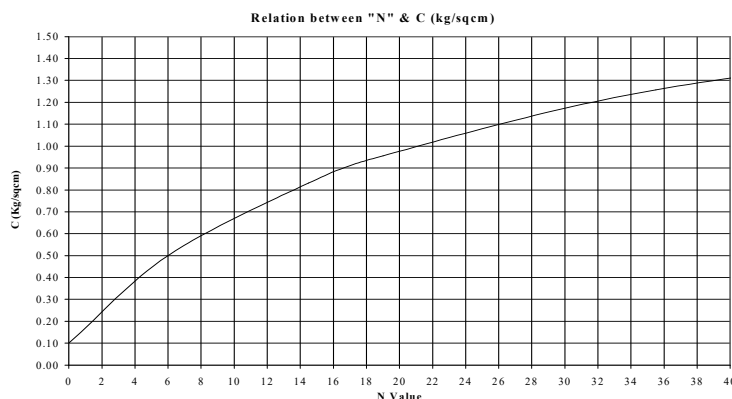
$N_k = 17, 21$  &  $27$  for normally consolidated clay, partly over consolidated clay and heavily over consolidated clay respectively

[Ref. Meigh, A.C (1987) : Cone Penetration Testing Methods and Interpretation, Butterworths, London, pp-43-47]

Taveres, A.X [Penetration Testing 1988, ISOPT-1, Volume-I, J.De Ruiter Editor, pp-375-379] has shown very clearly that a better correlation can be obtained with stiffness of the clay. From his experimental results he obtained,

Range of SPT ‘N’	$K = N/C$
$N < 10$	12.50
$10 < N < 20$	14.20
$20 < N < 30$	16.25
$30 < N < 40$	20.00

Over the years on the basis of the laboratory test results we have been using the following relations. However, for “N” value greater than 40, we use  $C = N/27$





**Design Strength Parameters for Stratum – II:**

Average N in this layer = 66, corresponding cohesion from N value = 2.44 kg/sqcm

From laboratory TRSH-UU test results, average C = 1.49 kg/sqcm &  $\phi = 5^\circ$

Thus average C = 1.97 kg/sqcm &  $\phi = 3^\circ$

Use C = 1.60 kg/sqcm &  $\phi = 0^\circ$

Total soil modulus,  $E_s = 4.4 \times N = 290.4$  kg/sqcm

Undrained Young's modulus,  $E_u = K \times C = 500 \times 1.6 = 800$  kg/sqcm

Again,  $1/E_s = 1/E_u + 1/E_d$  giving drained young's modulus,  $E_d = 455.89$  kg/sqcm

Now, we have,  $E_d = E_u/3 = 266.67$  kg/sqcm

Considering the above, let us use  $E_d = 360$  kg/sqcm

From  $E_d$ ,  $m_{vc} = 1/G.E_d = 0.0051$  sqcm/kg [Geological Factor,  $G = 0.55$  &  $\mu = 0.35$ ]

Again from SPT "N",  $m_{vc} = 1/5N = 0.0030$  sqcm/kg

Now, let us consider the  $m_{vc}$  value for the pressure range between 0.50 to 2.00 kg/sqcm

Sample No.	0.50 – 1.00kg/sqcm	1.00 – 2.00kg/sqcm
BH-128/UDS-01	0.0046	0.0041
BH-128/UDS-02	0.0097	0.0053
BH-129/UDS-01	0.0073	0.0040
<b>Average weighted <math>m_{vc}</math>, sqcm/kg over entire pressure range</b>	<b>0.0054</b>	

Giving more weightage to the laboratory test results,

Use  $m_{vc} = [2 \times 0.0054 + 0.0051 + 0.0030]/4 = 0.0047$  sqcm/kg

**For Stratum – IV:**

Let us use Young's modulus for layer-IV = 2500 kg/sqcm (as discussed earlier)

Cohesion, C = 7.50 t/sqm

Using  $\phi = 0$  degree, the bearing capacity factors are:

$N_c = 5.14$

$N_q = 1.00$

$N_\gamma = 0.00$

Use,

Depth of Foundation =  $D_f = 2$  M (Below Existing Ground level)

Width of Foundation =  $B = 3$  M

Length of Foundation =  $L = 6$  M

Overburden Pressure =  $q = 2.000$  (Depth)  $\times$  0.90 (Submerged density) = 1.80 t/sqm (Assuming the ground water table is flushing with the ground level)

The Shape factors are [ IS:6403 - 1981 ]

$S_c = 1.10$        $S_q = 1.10$        $S_\gamma = 0.80$

The Depth factors are [ IS:6403 - 1981 ]

$D_c = 1.13$        $D_q = 1.00$        $D_\gamma = 1.00$

Computed Net Ultimate Bearing Capacity = 48.28 t/sqm

**Using a factor of safety of 2.5, Net Safe Bearing Capacity = 19.31 t/sqm**

The above bearing capacity should be checked against settlement criteria. This is shown below.

### Settlement Analysis

#### A) General Data:

Width of foundation =	3.0	m
Length of foundation =	6.0	m
Depth of foundation =	2.0	m
Net Base Pressure =	1.9	kg/sqcm

#### B) Subsoil Properties:

##### Layer - I

Young's Modulus =	320	kg/sqcm
Poisson Ratio, $\mu$ =	0.35	
Top of Stratum =	2.00	m
End of Stratum =	3.10	m
Geological factor, G =	0.70	
$m_{vc}$ =	0.0161	sqcm/kg

##### Layer - II

Young's Modulus =	875	kg/sqcm
Poisson Ratio, $\mu$ =	0.35	
Top of Stratum =	3.10	m
End of Stratum =	8.00	m
Geological factor, G =	0.55	
$m_{vc}$ =	0.0035	sqcm/kg

#### C) Calculation of Immediate Settlement:

##### Settlement at center

$M = L' / B' =$	2.000
$N = H / B' =$	0.733
$I_1 =$	0.077
$I_2 =$	0.100
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.124
Immediate settlement $S_i =$	0.386 cm
$[q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s$	

##### Settlement at center

$M = L' / B' =$	1.732
$N = H / B' =$	2.390
$I_1 =$	0.339
$I_2 =$	0.087
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.379
Immediate settlement $S_i =$	0.366 cm
$[q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s$	

##### Settlement at corner

$M = L' / B' =$	2.00
$N = H / B' =$	0.367
$I_1 =$	0.022515
$I_2 =$	0.068690
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.054
Immediate settlement $S_i =$	0.085 cm

##### Settlement at corner

$M = L' / B' =$	1.73
$N = H / B' =$	1.195
$I_1 =$	0.164
$I_2 =$	0.106
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.213
Immediate settlement $S_i =$	0.103 cm

Average  $S_i$  for Stratum I= 2.36 mm

Total immediate settlement = 4.70 mm

Average  $S_i$  for Stratum II= 2.35 mm

(for both the layer)

#### D) Calculation of Consolidation Settlement:

Strata	From (M)	To (M)	Thickness (M)	Mid depth (M)	$\Delta P$ (kg/sqcm)	$m_{vc}$ , sqcm/kg	G	$S_c$ (cm)
Layer - I	2.00	2.55	0.55	0.28	1.66	0.0161	0.70	1.03
	2.55	3.10	0.55	0.83	1.31	0.0161	0.70	0.81
Layer - II	3.10	5.55	2.45	2.33	0.77	0.0035	0.55	0.36
	5.55	8.00	2.45	4.78	0.41	0.0035	0.55	0.19

Hence, Total Consolidation Settlement = 24.00 mm

So, Total Settlement = 28.70 mm

Fox's Depth correction Factor = 0.858

Corrected total settlement = 24.63 mm < 25mm

The calculated settlement is well within the permissible limit. So, use a net allowable bearing capacity of 19t/sqm for depth of foundation 2.00m below FGL.

## **PART V: PHOTOGRAPHS**



**Borehole**



**Borehole**



Rock Core



Rock Core





**Trial Pit**

**Job No: 4095**

**REPORT ON  
GEOTECHNICAL INVESTIGATION WORK FOR  
5<sup>th</sup> ALUMINA REFINERY AT DAMANJODI, ODISHA  
AND PORT FACILITIES AT VISAKHAPATNAM**

**Volume 3**

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**September – 2019  
Revised on 15<sup>th</sup> October, 2019**

## **LIST OF CONTENTS**

<b><u>SUBJECT</u></b>	<b><u>SHEET NUMBER</u></b>
<b>1. INTRODUCTION</b>	<b>2</b>
Field Test Location Map	4
<b>2. FIELD INVESTIGATIONS</b>	
General, Boring, Sampling, Standard Penetration Tests, Measurement of Water Table, Rotary Core Drilling, Trial Pits, Field C.B.R. Test, Cyclic Plate Load Test, Block Vibration Test & Electrical Resistivity test.	<b>5</b>
<b>3. LABORATORY TESTING</b>	<b>10</b>
<b>4. SUB-SOIL CONDITIONS, STRATIFICATION &amp; PROPERTIES</b>	<b>11</b>
Sub-Soil Conditions	11
Sub-Soil Stratifications	11
Generalized Soil Profile	12
Graphical Presentation	36
<b>5. DISCUSSION</b>	<b>37</b>
Cyclic Plate Load Test	37
Details of Structures	55
Use of Shallow Foundation	56
Use of Deep Foundation	66
Chemical Test Results	69
Possibility of Subsoil Liquefaction Due to Earthquake	69
Dewatering	70
Suitability of Existing Soil for Filling and Back-Filling	70
Excavation	70
<b>6. SUMMARY &amp; RECOMMENDATIONS</b>	<b>71</b>
<b>7. GEOLOGICAL LOGGING</b>	<b>72</b>
<b>8. BLOCK VIBRATION TEST</b>	<b>92</b>
<b>9. ELECTRICAL RESISTIVITY TEST</b>	<b>109</b>
<b>APPENDIX</b>	<b>115</b>



**REPORT ON**  
**GEOTECHNICAL INVESTIGATION WORK FOR**  
**5<sup>th</sup> ALUMINA REFINERY AT DAMANJODI, ODISHA**  
**AND PORT FACILITIES AT VISAKHAPATNAM**

**1. INTRODUCTION**

**M/s. National Aluminium Company Limited** has proposed the construction of 5<sup>th</sup> Alumina Refinery at Damanjodi, Odisha and Port facilities at Visakhapatnam. For designing foundation structures coming under this project, it was necessary to conduct a detailed Geotechnical Investigation Work to obtain engineering properties of the underlying soil and **M/s. National Aluminium Company Limited**, in turn, appointed **M/s. C. E. Testing Company Pvt. Ltd., Kolkata** as their Geotechnical Consultant.

The boreholes of 150 mm diameter were advanced by Shell and Auger method in soil. In rock, rotary core drilling of “NX” size was adopted. The scope also included conducting Standard Penetration Tests, collecting disturbed samples at regular intervals for identification and logging purposes, collecting undisturbed tube samples at suitable intervals or at change of strata whichever is earlier and testing these in the laboratory.

Based on the above, this report presents the Bore Logs, Soil Profile, laboratory and field Test Results.

The subsoil is characterised by a layer of very stiff silty clay followed by a hard silty clay / dense to very dense clayey silty sand / silty sand layer. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes.

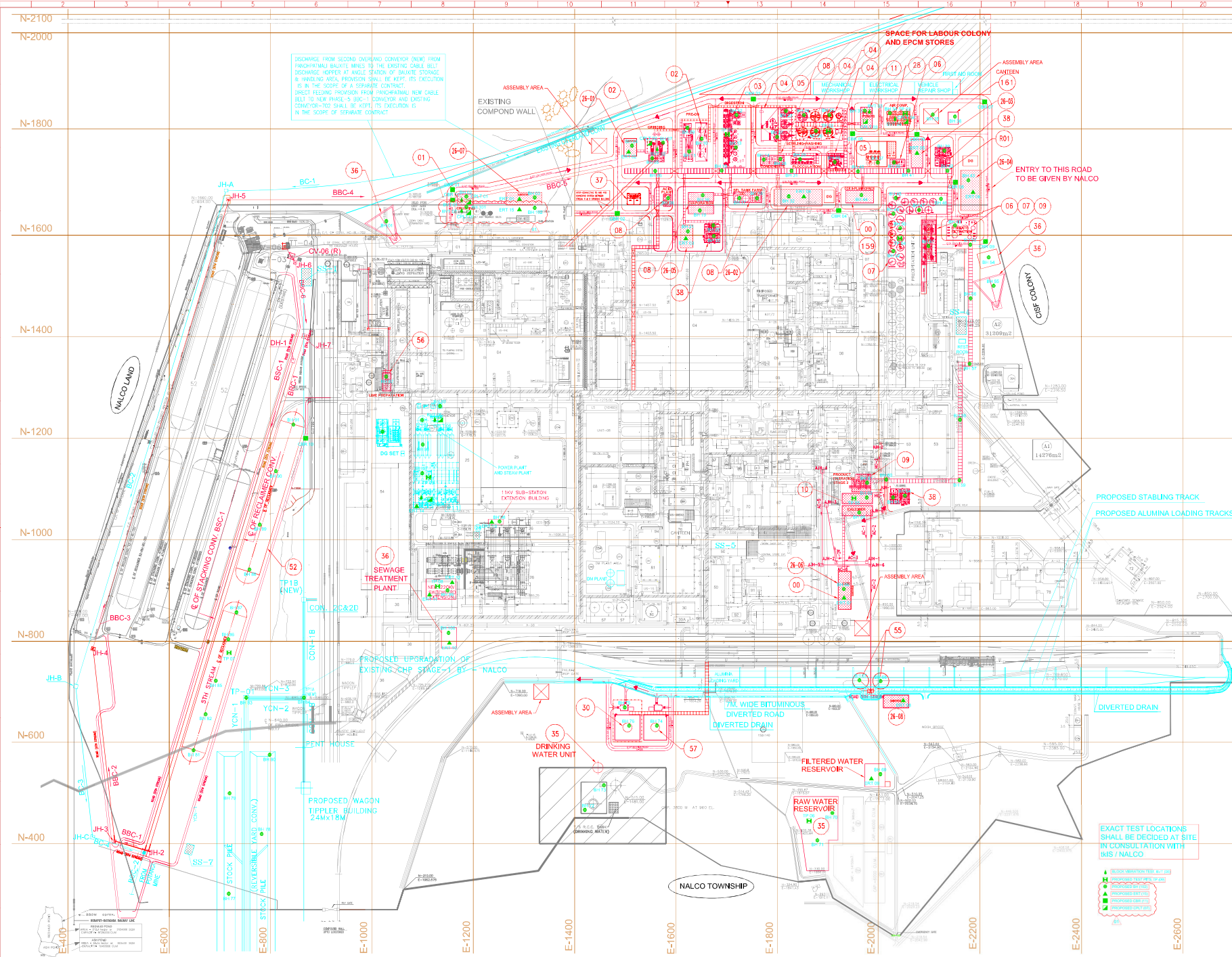
Considering the nature of the subsoil as revealed from field tests and laboratory tests most suitable type of foundation is recommended. However, this is discussed in details later.

The scope of the 1<sup>st</sup> phase of work comprised of sinking 67 nos. bore holes. The scope also includes TP (Trial Pit – 11 Nos.), ERT (Electrical Resistivity Tests – 22 Nos.), and Field CBR Tests – 5 Nos. Based on the above, a comprehensive report was prepared and submitted during the month of April, 2018. For easy handling, that Report was divided into two parts (volumes). The first part deals with subsoil condition and foundation recommendations, whereas the second part contains the borelog data sheets, Field and laboratory test results.

- **Volume – 1:– Main Report with Recommendations.**
- **Volume – 2:– Borelogs, Field & Laboratory Test results.**

The scope of the work in the present phase comprised of sinking 38 nos. bore holes. The scope also includes, TP (Trial Pit – 8 Nos.), CPLT (Cyclic Plate Load Tests – 7 Nos.), ERT (Electrical Resistivity Tests – 01 No.), BVT (Block Vibration Test – 7 Nos.) and Field CBR Tests – 5 Nos. Based on the above a comprehensive report (**Volume -3**) is now being prepared & submitted.

In case of any variance / conflict in the recommendations, then Volume 3 shall be referred.



**GENERAL NOTES:-**

- ALL CO-ORDINATES, DIMENSIONS & ELEVATIONS IN METRE UNLESS OTHERWISE STATED.
- ALL LEVELS ARE ABSOLUTE LEVELS WRT MEAN SEA LEVEL.
- THIS LAYOUT IS TO BE REFERRED ONLY FOR CONCEPTUAL LOCATION OF THE UNITS.
- THE LEVELS OF THE UNITS ARE PRESENTLY HOLD DUE TO NON-AVAILABILITY OF CONTOUR SURVEY. IT SHALL BE FINALIZED ONLY AFTER RECEIPT OF CONTOUR SURVEY.
- THE UNIT SIZES AND CO-ORDINATES SHALL BE CONFIRMED AFTER RECEIPT OF UNIT FOOT PLANS FROM LENDER AND PRELIMINARY NETWORK DATA.
- THE LOCATION OF NEW CAUSTIC AND FUEL OIL UNLOADING STATION IS UNDER HOLD. TO BE CONFIRMED DURING THE COURSE OF DETAILED ENGINEERING.
- FEASIBILITY OF UPGRADE OF EXISTING PIPE RACKS FOR THE NEW PIPE LINES / CABLE TRAYS SHALL BE CONFIRMED ONLY AFTER SITE SURVEY.
- THE REQUIREMENT OF ADDITIONAL PIPE RACKS SHALL BE INDICATED BASED ON THE RESULTS OF THE SAME.
- THE EXTENT OF RAW WATER RESERVOIR AND FILTERED WATER RESERVOIR IS UNDER HOLD. IT SHALL BE CONFIRMED DURING THE COURSE OF DETAILED ENGINEERING.
- NO UNDERGROUND SPRING IS ENVISAGED IN THE FACILITIES UNDER HIS SCOPE.
- PREVAILING WIND DIRECTION MOVING FROM SW DIRECTION CONSIDERED FROM WIND ROSE.
- PASSIVE FIRE PROTECTION (i.e. FIRE-PROOFING) IS NOT APPLICABLE.

**NEW UNITS / AREA SCHEDULE**

UNITS / AREA NO.	UNITS / AREA DESCRIPTION
01	BAUXITE STORAGE AND HANDLING
02	SECONDARY CRUSHING
03	INDIRECT BAUXITE SLURRY HEATING (BESH) & PREDESICCATION
04	DIGESTION
05	ACID CLEANING PREPARATION
06	MUD SETTLING
07	TRI-CALCIUM ALUMINATE (TCA) PREPARATION
08	MUD WASHING
09	FLOCCULANT PREPARATION
10	SECURITY FILTRATION
11	CAUSTICIZATION
12	HEAT INTERCHANGER
13	HYDRATE FILTRATION
14	PRECIPITATION
15	SEED GRINDING
16	CAUSTIC CLEANING PREPARATION (INCLUDED IN PRECIPITATION)
17	HYDRATE CLASSIFICATION
18	PRODUCT HYDRATE FILTRATION STAGE-1
19	PRODUCT HYDRATE FILTRATION STAGE-2
20	HYDRATE TRANSFER
21	CALCINATION UNIT
22	EVAPORATION
23	CONDENSATE TANK FARM
24	LIME PREPARATION (SLAKING)
25	RESIDUE PUMPING
26	TANK FARM FOR EVAPORATION
27	ALUMINA STORAGE AND HANDLING
28	CAUSTIC SODA RECEIPT & STORAGE
29	EFFLUENT TREATMENT PLANT
30	SEWAGE TREATMENT PLANT
31	RAW WATER RESERVOIR
32	DRINKING WATER UNIT
33	COOLING TOWERS & COOLING WATER DISTRIBUTION
34	PLANT AIR AND INSTRUMENT AIR SYSTEM
35	FIRE WATER STORAGE
36-01 TO 08	MAIN PIPE RACK FOR MAIN PLANT SUBSTATION
37	CCR
38	FUEL OIL UNLOADING AND STORAGE

• LIST PACKAGES

**REFERENCE DRAWINGS**

DRAWING No.	DESCRIPTION
11253-B-01-0001	PLAN GENERAL LAYOUT
202-005F-1-0A-0001	PLOT PLAN PRELIMINARY
2632B-03-02-ELU-0002	LAYOUT PLAN & SECTION FOR 220KV/132KV NALCO DAMANDADI SOLIDWORKS
11253-B-02-0001	GENERAL LAYOUT NALCO DAMANDADI ALUMINA REFINERY
	PLOT PLAN SUPERIMPOSED ON REVENUE MAP

**LEGEND:**

————	COMPOUND WALL (EXISTING)	————	NEW FACILITIES IN HIS SCOPE
————	PIPERACK (EXISTING)	————	NEW FACILITIES BY OTHER
————	PIPERACK (EXISTING)	————	NEW PIPE RACK ROUTING
————	ROADS (EXISTING)	————	NEW FENCING
————	EXTENSION OF EXISTING		
————	PIPERACK (EXISTING)		

**HOLD LIST**

- FUEL OIL UNLOADING STATION.
- CAUSTIC SODA UNLOADING STATION.
- FILTERED WATER RESERVOIR.
- RAW WATER RESERVOIR.

**EXACT TEST LOCATIONS SHALL BE DECIDED AT SITE IN CONSULTATION WITH NIS / NALCO**

• TEST LOCATIONS FOR ALL TESTS  
• PROPOSED TEST LOCATIONS  
• PROPOSED TEST LOCATIONS  
• PROPOSED TEST LOCATIONS

**Category Codes**

Category	Code	Description
Approved	01	Approved
Approved	02	Approved for Review / Comments
Approved	03	Approved for Engineering
Approved	04	Approved for Estimation
Approved	05	Approved for Tender Preparation
Approved	06	Approved for Construction

**Category Codes**

Category	Code	Description
Approved	01	Approved
Approved	02	Approved for Manufacturing / Construction With Comments
Approved	03	Approved for Information / Records
Approved	04	Approved for Information / Records
Approved	05	Approved for Information / Records
Approved	06	Approved for Information / Records

Contract No. 66-6695-700 Document ID 6695-CVC-000-LA-0001 Part No. 01

Drawn by: [Name] Checked by: [Name] Approved by: [Name]

Scale: 1:2500

Project Name: 1.0 MTPA ALUMINA REFINERY STREAMS DAMANDADI ODISHA

Client: thyssenkrupp

Revision: 1

Date: 11/04/18

By: [Name]

Check: [Name]

Approved: [Name]

Scale: 1:2500

Project Name: 1.0 MTPA ALUMINA REFINERY STREAMS DAMANDADI ODISHA

Client: thyssenkrupp

Revision: 1

Date: 11/04/18

By: [Name]

Check: [Name]

Approved: [Name]

796 of 1127

Page 4/115

## 2. FIELD INVESTIGATIONS

### 2.1. GENERAL:

In an attempt for finalisation in the design of foundation for these proposed structures to be constructed at this site, Geotechnical Investigation was envisaged. The entire Investigation programme had been divided mainly into two parts, I) Field works & II) Laboratory tests.

- I) Field works unfold the sub-surface deposit types and their characteristics and
- II) Laboratory tests part would help determining the relevant physical and geotechnical properties of the sub-surface deposits leading to finalisation of foundation depths of the structures and the bearing capacity with particular reference to the sub-surface types and their strength parameters and settlement potentials at the site.

A list of the bore holes with the reduced level and standing water level are presented in a tabular form below.

Structure Name	BH No.	Co-ordinate (M)			Terminating Depth (M)	SWL (M)	Top of rock below EGL (M)
		E	N	R.L.			
Secondary Crushing	BH-02	1186.379	1676.642	920.540	19.00	0.95	12.00
Substation-07	BH-03	1321.199	1674.859	916.878	15.00	1.05	7.00
Substation-01	BH-04	1513.967	1776.985	924.123	14.00	1.50	6.00
Bauxite Grinding	BH-05	1552.967	1752.060	925.833	14.00	1.40	2.00
Pipe Rack	BH-06	1558.875	1726.956	926.018	15.00	1.70	1.00
Bauxite Grinding	BH-07	1574.412	1783.060	932.982	12.00	1.30	3.00
Acid Plant	BH-08	1584.329	1673.462	929.150	10.00	1.20	3.00
Predisilication	BH-09	1622.310	1812.044	935.969	10.00	1.10	3.00
Bauxite Grinding	BH-10	1650.537	1790.675	934.267	8.00	0.60	1.00
Predisilication	BH-11	1625.883	1765.662	942.896	11.00	1.20	3.00
Digestion	BH-12	1719.296	1837.678	931.492	11.00	1.70	3.00
	BH-13	1718.192	1773.698	929.710	15.00	1.80	2.00
Condensate Tank Farm	BH-14	1773.145	1749.587	926.641	23.00	0.90	13.00
Pipe Rack	BH-15	1689.950	1728.028	930.859	22.00	1.40	12.00
Evaporation	BH-16	1652.733	1679.321	932.205	13.00	1.05	2.00
SFL Tank Farm	BH-17	1724.933	1673.462	926.346	30.00	0.95	18.00
	BH-18	1759.683	1673.462	924.555	18.00	1.30	4.00
Settling, Washing	BH-23	1816.806	1845.589	930.580	18.50	0.80	13.50
	BH-24	1852.521	1837.440	932.530	18.50	0.85	12.50
	BH-25	1902.511	1837.440	936.764	17.00	1.10	9.00
	BH-26	1876.164	1805.964	932.111	14.00	0.95	8.00
	BH-27	1799.504	1794.233	927.920	22.00	0.80	17.00
Condensate Tank Farm	BH-28	1805.690	1750.719	926.222	24.00	0.90	17.00

Structure Name	BH No.	Co-ordinate (M)			Terminating Depth (M)	SWL (M)	Top of rock below EGL (M)
		E	N	R.L.			
Flocculation	BH-29	1844.816	1749.977	928.062	22.00	0.95	16.00
Pipe Rack	BH-31	1828.029	1727.370	926.214	19.00	1.10	12.00
Substation-02	BH-32	1822.464	1676.936	924.563	22.00	1.10	12.00
HCSD Pumps	BH-33	1972.733	1845.819	942.775	10.00	1.10	3.00
Substation US-504	BH-34	2022.207	1841.331	948.899	8.00	1.10	1.00
Assembly Area	BH-35	2106.648	1838.335	955.696	8.00	1.10	1.00
Canteen	BH-36	2150.363	1834.306	947.193	8.00	0.80	2.00
Hydrate Filtration	BH-38	2030.281	1744.105	936.867	7.00	0.80	0.00
Cooling Towers	BH-39	2129.297	1767.147	935.629	7.00	0.80	1.00
Pipe Rack	BH-41	2058.380	1727.668	938.612	7.00	0.80	0.00
	BH-42	2135.611	1727.667	927.451	8.00	0.60	0.00
Substation-04	BH-43	2176.876	1708.679	920.031	10.00	0.40	1.00
Precipitation	BH-45	2033.526	1673.948	929.139	7.00	1.45	0.00
	BH-46	2122.851	1672.078	921.742	7.00	1.35	0.00
Bauxite Handling-conveyor	BH-126	487.339	398.579	902.607	40.00	4.30	11.00

## 2.2. BORING:

Boring was carried out by Shell and Auger method to sink nominal 150mm diameter bore holes to depths envisaged by using a mechanical winch.

## 2.3. SAMPLING:

Nominal 100 mm diameter undisturbed samples were recovered. The sampling equipment used consists of a two-tier assembly of sample tubes 450 mm in length fitted at its lower end. The sampling assembly was driven by means of a jarring link to its full length or as far downs as was found practicable. As the soil is very stiff to hard and contains sand mixtures / calcareous nodules, cutting shoe was used with a area ratio < 20%. After withdrawal the ends of the tubes were sealed with wax and capped before onward transmission to the laboratory. At close intervals in depth disturbed samples were collected for identification and logging purpose. These were tagged and packed in polythene packets and transported to the laboratory.

## 2.4. STANDARD PENETRATION TESTS:

Standard Penetration Tests were conducted in the bore holes at intervals of 1.5M to 3.0M

depth or at change of strata whichever is earlier using a split spoon sampler. The split spoon sampler used is of a Standard design having an outer diameter of 50.8 mm and inner diameter of 35 mm, driven with a monkey weighing 63.5 kgs, falling freely through 75cms. A record of the number of blows required to penetrate every 15cms to a maximum depth of 45cms was made. The first 15cm of drive are considered to be seating drive and are neglected. The total blows required for second & third 15cm of penetration is counted and termed as penetration resistance "N". On completion of a test, the split spoon sampler was opened and soil specimens were preserved in polythene bags for logging purpose.

All the boreholes were sunk with winch. However, raising of hammer for SP Tests were done manually. Hence there will not be any inertia loss and the efficiency of hammer blows should be considered as 100%.

## 2.5. MEASUREMENT OF WATER TABLE:

Standing water level after 24 hours of removal of casing was noted and shown in the profile.

## 2.6. ROTARY CORE DRILLING:

This drilling technique is regarded as the most satisfactory method of assessing the character of rock formations, which lie at depth below the ground surface. Specimens of rock in the form of cylindrical cores are recovered from the drill holes by means of a core barrel. Double barrel technique is adopted according to field condition. The core barrel is provided at its lower end with a detachable shoe or core bit, which is of diamond. All rotary core bits were of NX size.

## 2.7. TRIAL PITS:

Eight (8) nos. Trial Pits were excavated for physical verification of subsoil with depth. The co-ordinates of the Trial Pit locations are presented below.

Trial Pit No.	Co-ordinate (M)			Depth (M)	Standing Water Level(M)
	Easting	Northing	R.L.		
TP – 01	1701.164	1799.250	932.490	3.50	Not found
TP – 02	1900.524	1805.292	934.111	3.50	Not found
TP – 03	2012.097	1852.526	948.749	3.50	Not found
TP –17	2324.897	1860.384	939.500	3.50	Not found
TP –18	2451.973	2039.380	943.957	3.50	Not found
TP –19	2737.221	1939.843	966.095	3.50	Not found
TP –20	2815.519	1622.555	963.586	3.00	Not found
TP –21	2809.932	1581.381	964.853	2.00	Not found



## 2.8. FIELD C.B.R. TEST:

The test was carried out in accordance with IS 2720 (Part 31) : 1969 (and Amendment 1). 5 nos. Field C.B.R. Tests (unsoaked & soaked) were conducted. The co-ordinates of the test locations are presented below.

FCBR No.	Co-ordinate (M)			Depth (M)
	E	N	R.L.	
CBR-01	1190.917	1665.692	920.131	1.00
CBR-03	1752.524	1869.148	931.115	1.00
CBR-05	1948.369	1800.688	936.139	1.00
CBR-06	2075.378	1799.269	950.703	1.00
CBR-07	2209.664	1860.534	937.672	1.00

## 2.9. CYCLIC PLATE LOAD TEST:

Seven (7) set of Plate Load Tests (Cyclic type) were conducted **using a 600mm square plate**. Test is continued upto a maximum desired loading intensity or specified plate settlement which ever is earlier. The load is applied through a hydraulic jack. The reaction for applying the load on the plate is obtained by a loading platform with sandbags. After applying the load increments, settlement records are made at intervals of 1, 2.25, 4, 6.25, 9, 16, 25 & 60 minutes and thereafter at an interval of an hour. When the rate of plate settlement reduced to 0.02 mm per minute, the final reading of the dial gauges is recorded. The applied load is then released and the plate allowed to rebound. When no further rebound occurs or the rate of rebound becomes negligible, the readings of the dial gauges are again noted. The load then is increased gradually till its magnitude acquires a value equal to the proposed next higher stage of loading which is to be maintained constantly and the final dial gauge readings are noted as earlier. The entire load is then reduced to zero and final dial gauge readings recorded when the rate of rebound becomes negligible. The coordinate of test locations are given below.

PLT No.	Type of Tests	Plate size (mm x mm)	Co-ordinates (M)		R. L. (M)	Depth (M)
			E	N		
CPLT-01	Cyclic Type	600 x 600	1190.917	1665.692	920.131	2.00
CPLT-02	Cyclic Type	600 x 600	1547.885	1781.661	926.888	2.00
CPLT-03	Cyclic Type	600 x 600	1973.875	1824.754	940.732	2.00
CPLT-04	Cyclic Type	600 x 600	2016.635	1866.429	949.381	2.00
CPLT-05	Cyclic Type	600 x 600	1107.509	1067.493	899.797	2.00
CPLT-06	Cyclic Type	600 x 600	1102.575	1239.259	901.643	2.00
CPLT-07	Cyclic Type	600 x 600	1191.039	1644.314	916.153	2.00

## 2.10. BLOCK VIBRATION TEST:

Seven (7) nos. Block Vibration Tests were carried out to determine the dynamic properties of the layer for the construction of machine foundation at the following location. The details of test results has been presented in section-8.

BVT No.	Co-ordinates		R. L. (M)
	Easting	Northing	
BVT-1	1178.222	1666.248	920.380
BVT-2	1562.737	1769.669	927.919
BVT-3	1981.769	1843.962	943.651
BVT-4	2031.968	1828.799	948.651
BVT-5	1102.433	1231.516	901.545
BVT-6	1106.428	1071.731	899.556
BVT-7	1187.212	1641.795	916..150

## 2.11. ELECTRICAL RESISTIVITY TESTS:

One(1) no. Electrical Resistivity Test was carried out at the following location. The test procedure and the test result are presented in Section 9.

ERT	Co-ordinate (M)		R.L. (M)
	E	N	
ERT-15	2017.500	1829.000	948.099



### 3. LABORATORY TESTING

For proper identification and classification of the sub-soil deposits and for deriving adequate information regarding its relevant physical and geotechnical properties at the site under investigation, the following laboratory tests were conducted on the soil / rock samples collected from the exploratory bore holes:

**On Soil Samples:**

1. Grain size analysis (Sieve as well as Hydrometer).
2. Determination of Liquid Limit and Plastic Limit.
3. Determination of Natural Moisture Content.
4. Determination of Specific Gravity.
5. Determination of Bulk & Dry Unit Weight.
6. Strength determination by Triaxial Unconsolidated Undrained Test (UU).
7. Chemical tests on soil samples to determine pH value, Sulphate, Chloride & organic matter content etc.

**On Rock Samples:**

1. Determination of Bulk Density, Water Content, Specific Gravity & Porosity of Rock.
2. Determination of Unconfined Compressive Strength of Rock samples (Saturated & Dry State)
3. Determination of Point Load Strength Index.

Laboratory test results are presented in a tabular form in the Appendix.

**All the tests were conducted as per relevant Indian Standard Specifications.**

## 4. SUBSOIL CONDITION, STRATIFICATION AND PROPERTIES

### 4.1. SUB-SOIL CONDITIONS:

The boring records showing the various soils met with are enclosed in the Appendix. These are prepared from field logs after proper modifications in the light of the laboratory test results and observation of disturbed and penetrometer soil samples. The results of the Standard Penetration Tests are given as 'N' values in these boring records. The sub-soil profiles (as obtained from field and Laboratory test results) across the bore holes are shown under Fig.2.01 to 2.23 giving description, consistency and colour of each strata. The "N" values are shown in the profiles as well as presented in the borelogs in the Appendix. The laboratory test results and the back up sheets are also presented there.

### 4.2. SUB-SOIL STRATIFICATIONS:

The subsoil is characterised by a layer of very stiff silty clay followed by a hard silty clay / dense to very dense clayey silty sand / silty sand layer. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes. The description of each layer is presented below.

#### 4.2.1. STRATUM - I:

This layer consists of very stiff, reddish brown, silty clay with moorum & kankar. The properties of this layer are presented below.

Liquid limit %	38
Plastic Limit %	20
<b>GRAIN SIZE</b>	
Gravel %	02
Sand %	43
(Silt + Clay) %	55

#### 4.2.2. STRATUM - II:

This layer consists of hard, reddish brown / greyish brown, silty clay with moorum & decomposed rock fragments. The properties of this layer are presented below.

Specific Gravity	2.67
Liquid limit %	39
Plastic Limit %	21
<b>GRAIN SIZE</b>	
Gravel %	05
Sand %	52
(Silt + Clay) %	43



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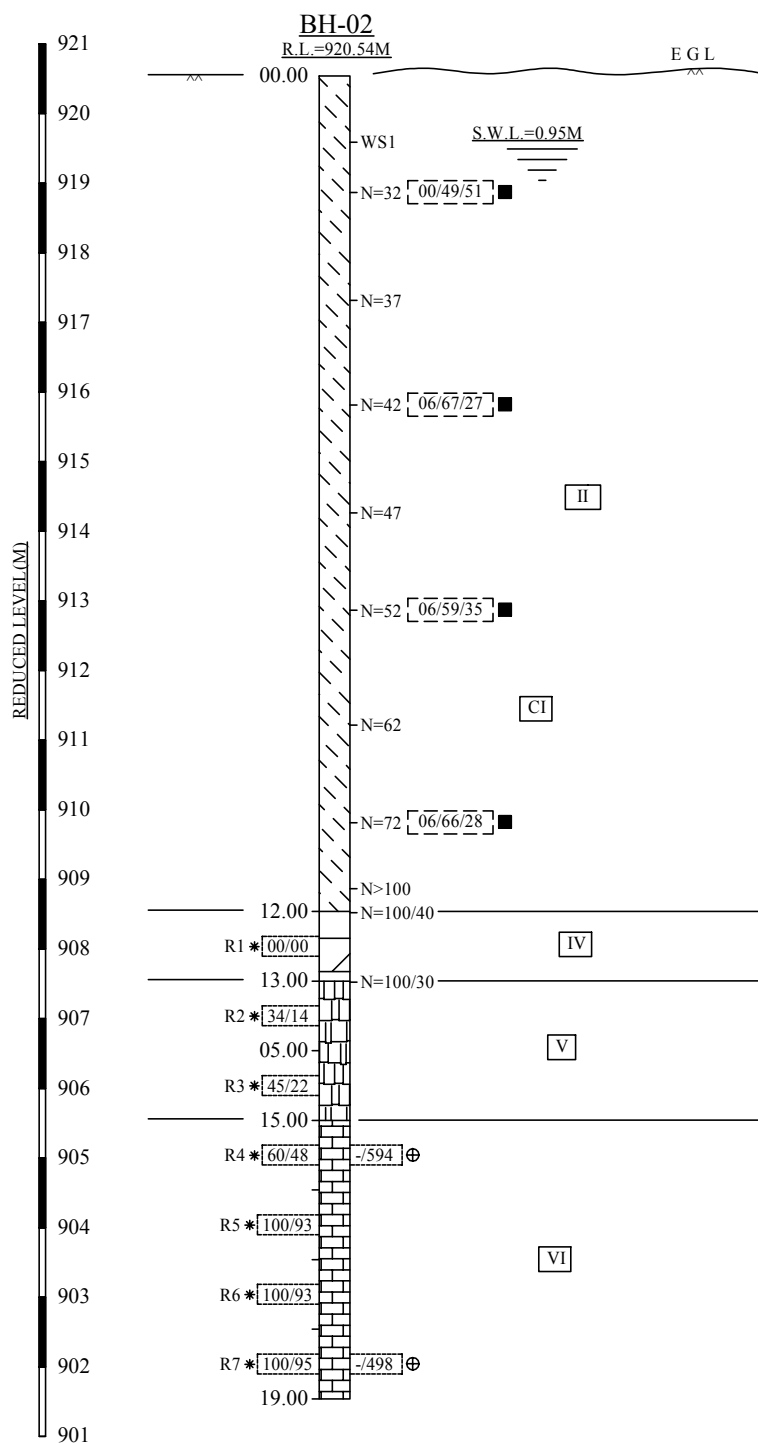
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II → HARD, REDDISH BROWN / GREYISH BROWN, SILTY CLAY WITH MOORUM & DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY WEATHERED, LIGHT GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

V → MODERATELY WEATHERED, LIGHT BLACKISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → SLIGHTLY WEATHERED / FRESH, LIGHT BLACKISH GREY, FINE GRAINED, SLIGHTLY FRACTURED ROCK.

N means 'N' value  
WS means Water Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.01 : SUB-SOIL PROFILE

(Secondary Crushing)

804 of 1127



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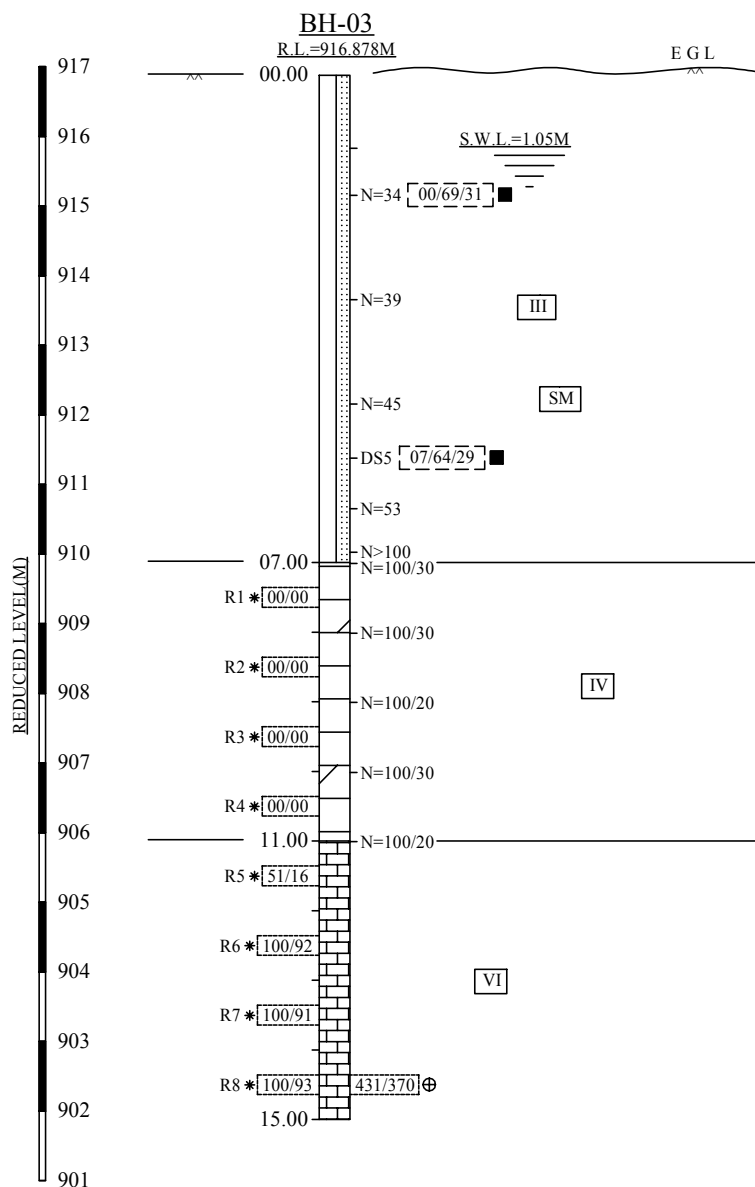
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III → DENSE TO VERY DENSE, BROWNISH GREY, SILTY SAND WITH DECOMPOSED ROCK FRAGMENTS. OBSERVED MOORUM.

IV → COMPLETELY WEATHERED, LIGHT GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, LIGHT BLACKISH GREY, FINE GRAINED, SLIGHTLY FRACTURED ROCK.

N means 'N' value  
DS means Disturbed Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.02 : SUB-SOIL PROFILE

(Substation-07)

805 of 1127



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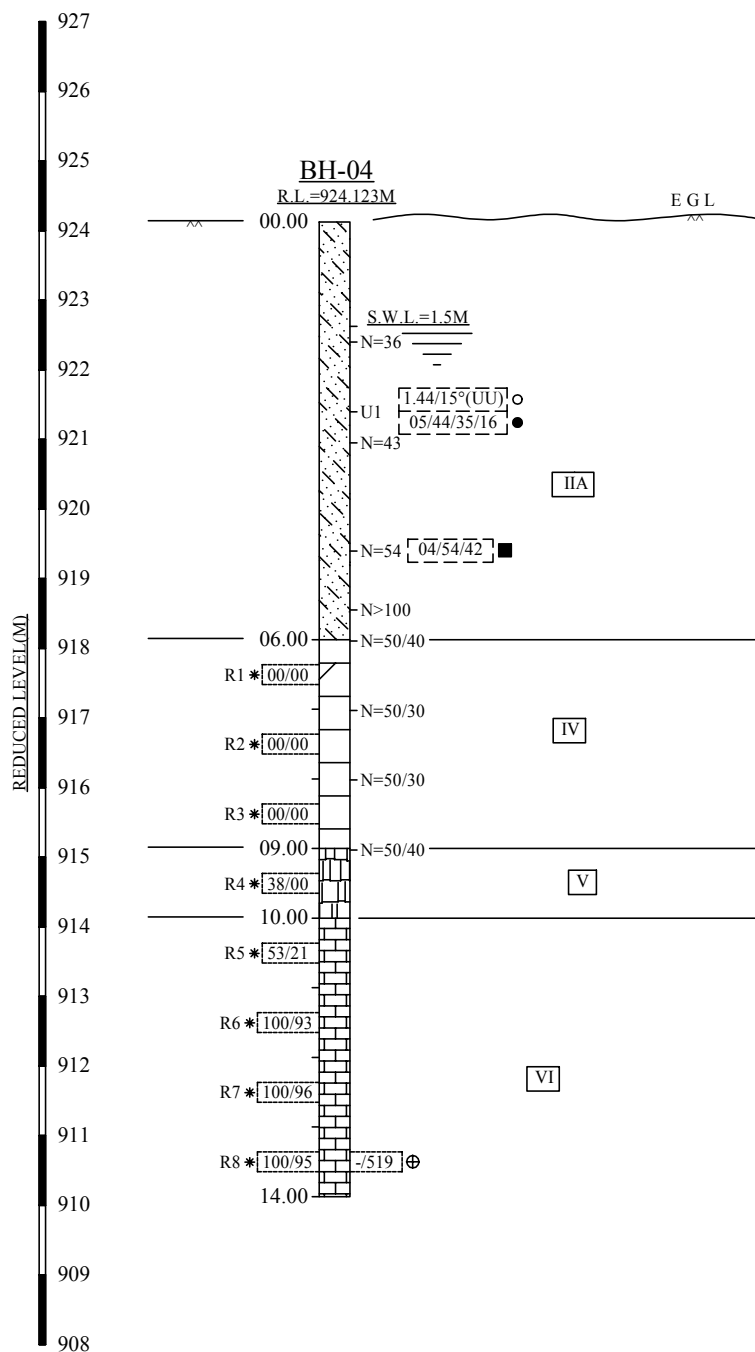
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Created on : 04/09/2019

Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY WEATHERED, LIGHT GREY / YELLOWISH GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

U means UDS  
N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
○ C(kg/sqcm) / Ø(°) values  
● Gravel/Sand/Silt/Clay %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.03 : SUB-SOIL PROFILE

(Substation-01)

806 of 1127



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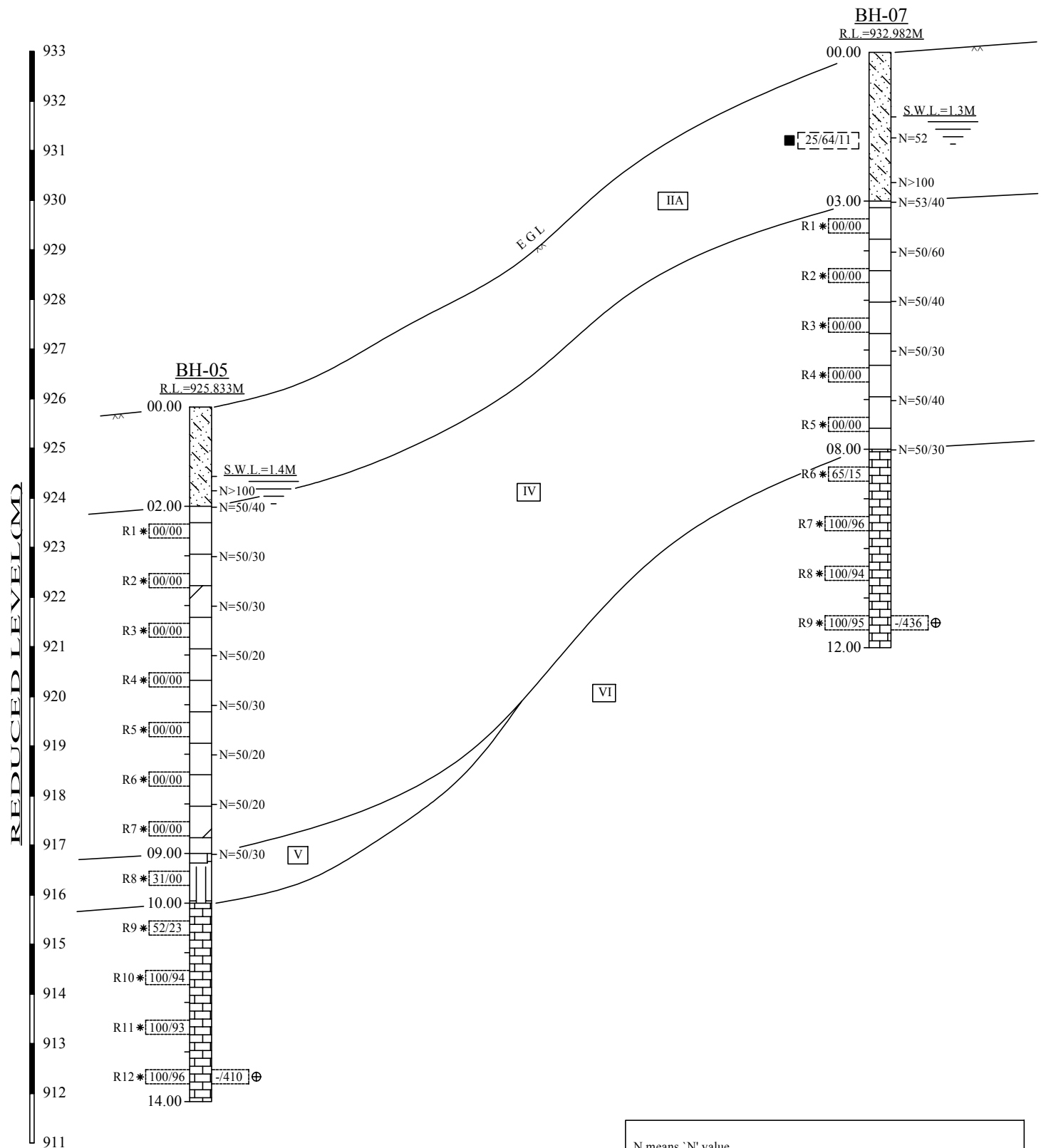
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Created on : 06/08/2019

Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY WEATHERED, LIGHT GREY / YELLOWISH GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

FIG. 2.04 : GENERALISED SOIL PROFILE

(Bauxite Grinding)



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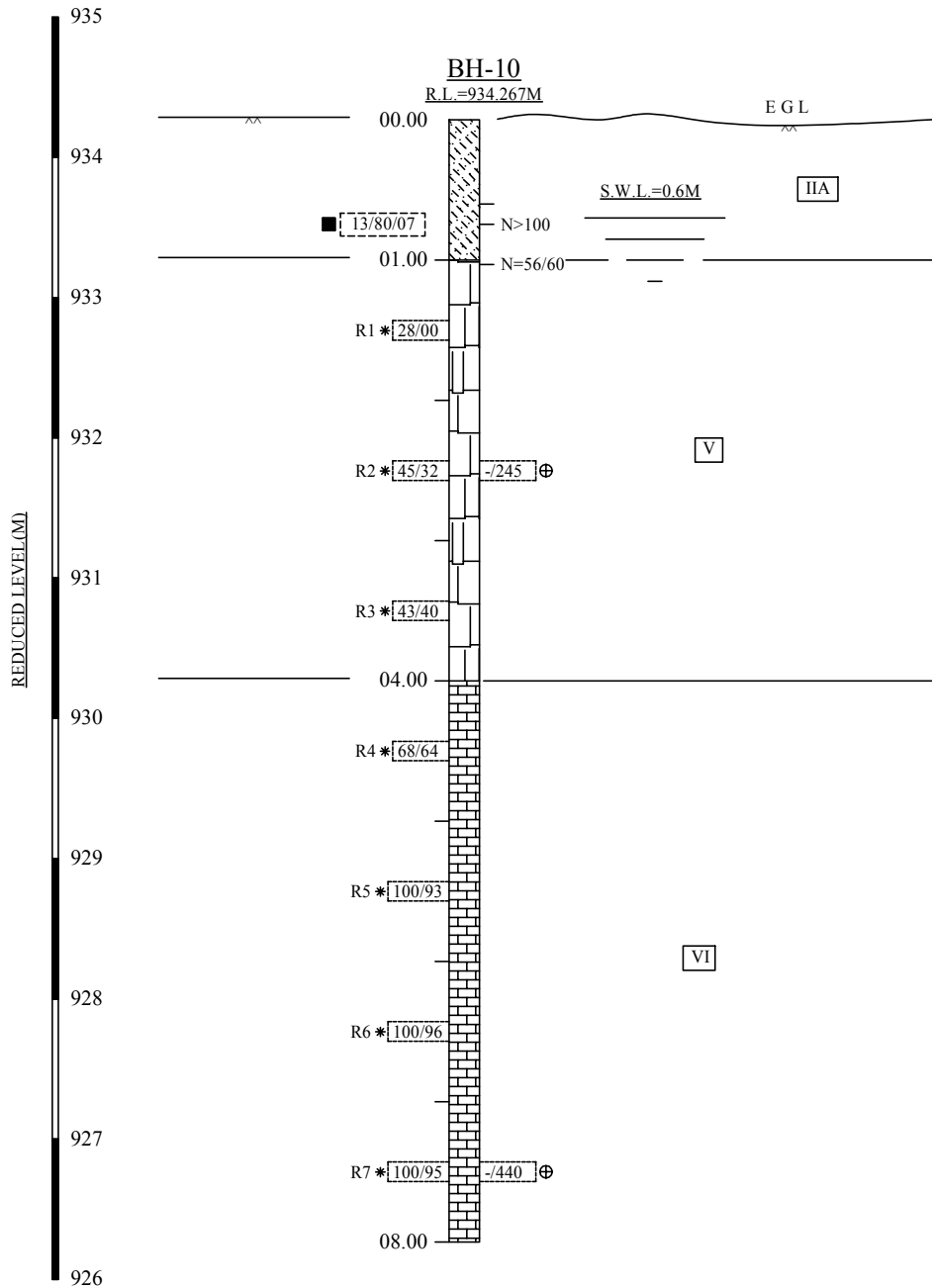
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Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH DECOMPOSED ROCK FRAGMENTS.

V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

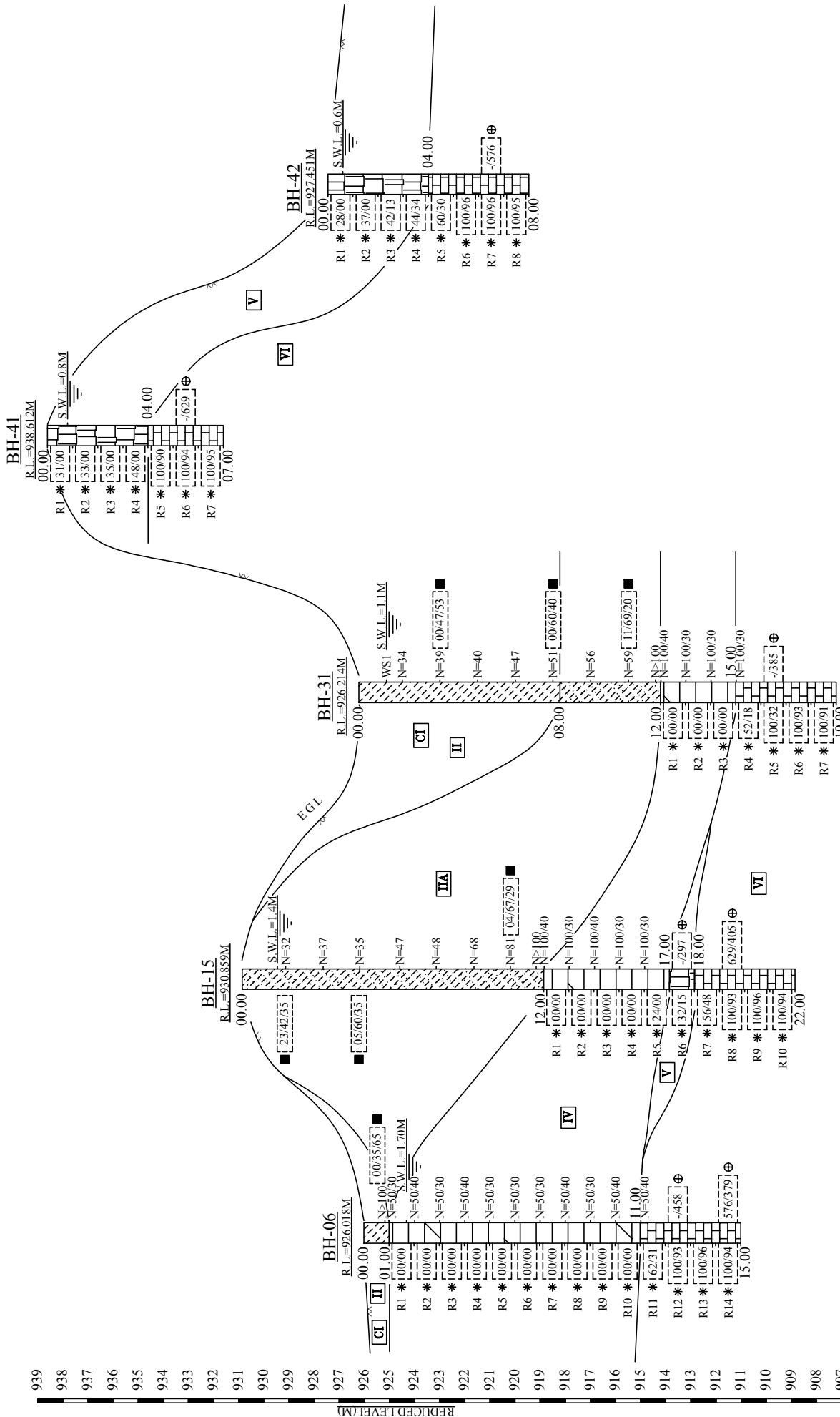
VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.05 : SUB-SOIL PROFILE

(Bauxite Grinding)

808 of 1127



IIA → HARD, REDDISH BROWN, MOORUM WITH DECOMPOSED ROCK FRAGMENTS.

II → HARD, REDDISH BROWN / GREYISH BROWN, SILTY CLAY WITH MOORUM & DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY/HIGHLY WEATHERED, LIGHT GREY / WHITISH GREY, FINE/MEDIUM GRAINED, FRACTURED ROCK / DECOMPOSED & DISINTEGRATED ROCK FRAGMENTS COLLECTED AS SLUDGE.

V → HIGHLY WEATHERED, WHITISH GREY / LIGHT BLACKISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY TO SLIGHTLY FRACTURED ROCK.

FIG. 2.06 : GENERALISED SOIL PROFILE  
(Main Pipe Rack for Main Plant)





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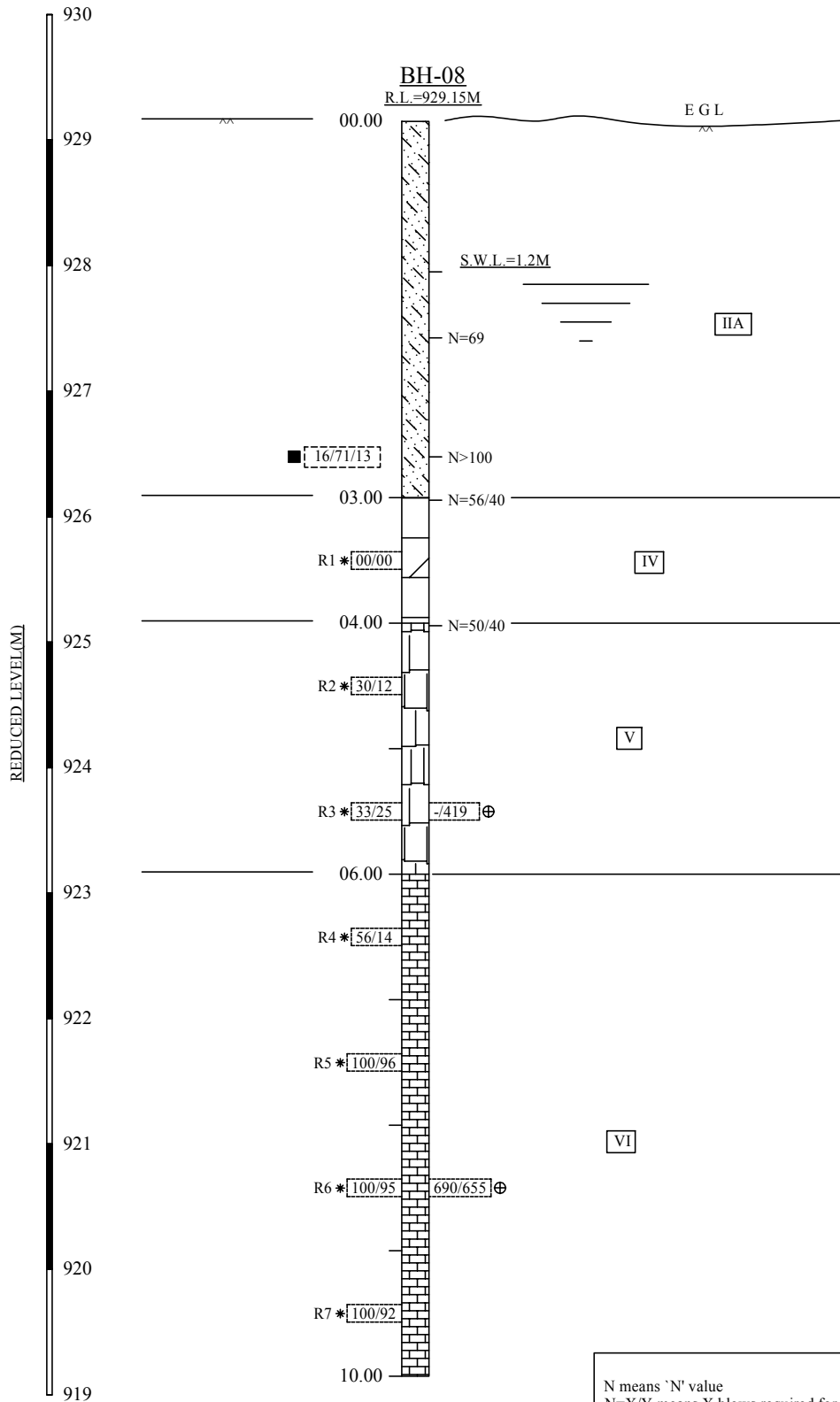
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Job No : 4095

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Created on : 11/09/2019

Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH SAND MIXTURE, DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY WEATHERED, LIGHT GREY, MEDIUM GRAINED, HIGHLY FRACTURED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

FIG. 2.07 : SUB-SOIL PROFILE

(Acid Plant)

810 of 1127



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

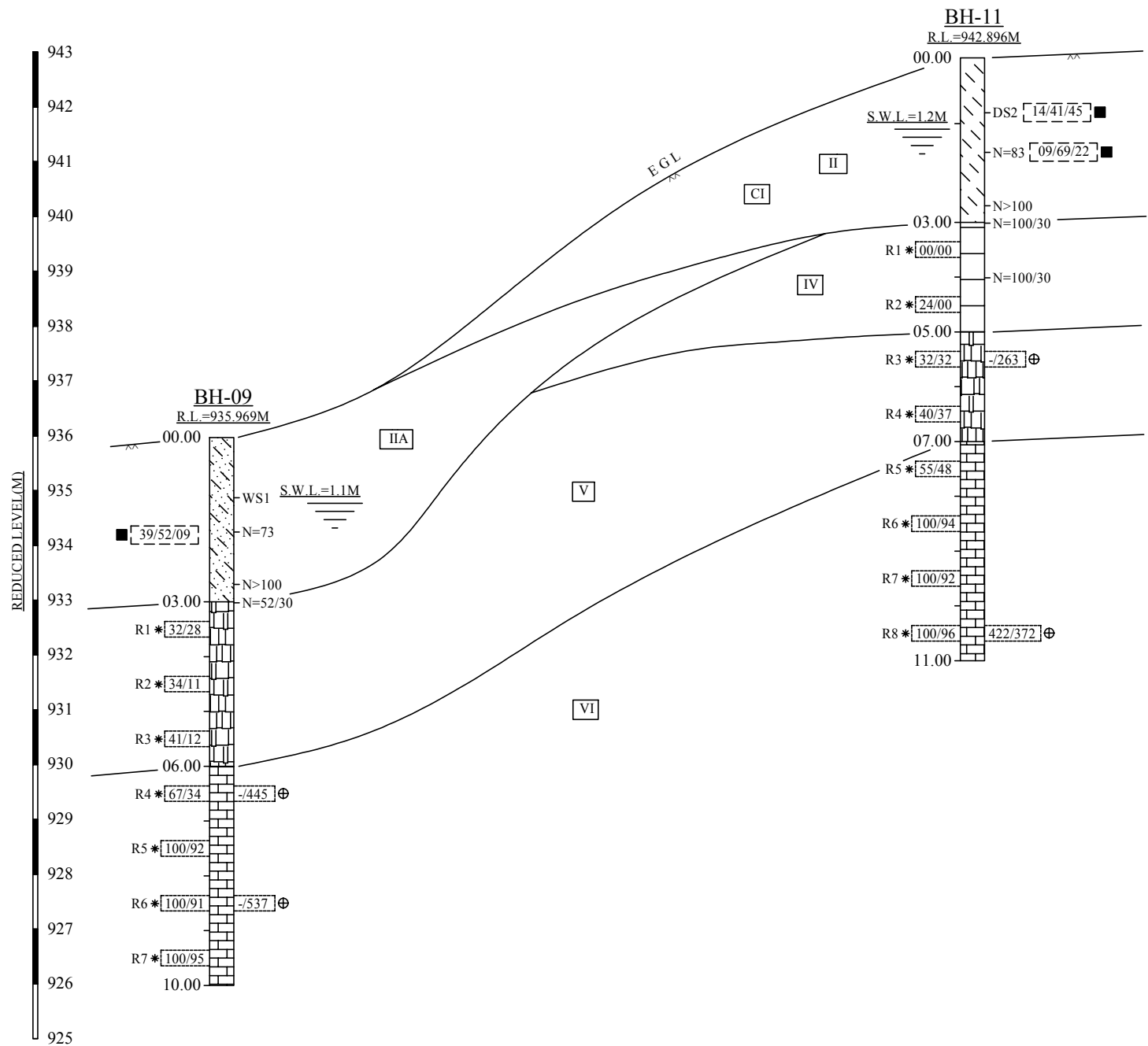
CETEST

Job No : 4095

Created by : SKD

Created on : 11/09/2019

Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH DECOMPOSED ROCK FRAGMENTS.

II → HARD, REDDISH BROWN / GREYISH BROWN, SILTY CLAY WITH MOORUM & DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY WEATHERED, LIGHT GREY / YELLOWISH GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

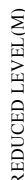
V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

N means 'N' value  
WS means Water Sample  
DS means Disturbed Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.08 : GENERALISED SOIL PROFILE

(Predisilication)



N means 'N' value  
WS means Water Sample  
 $N = X/Y$  means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

~~812 of 1127~~



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

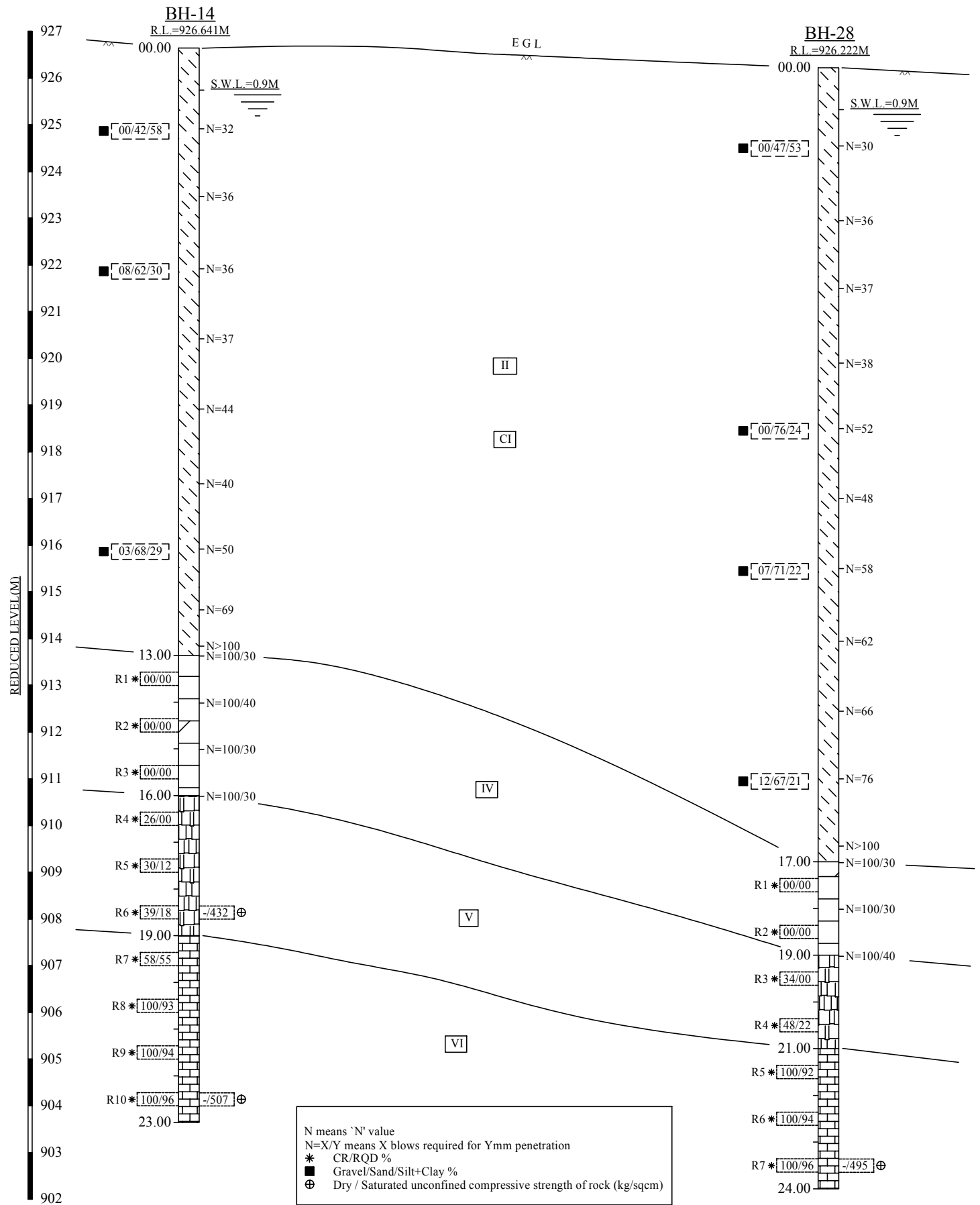
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Job No : 4095

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Created on : 11/09/2019

Sheet No:



II → HARD, REDDISH BROWN / GREYISH BROWN, SILTY CLAY WITH MOORUM & DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY TO HIGHLY WEATHERED, LIGHT GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY / LIGHT BLACKISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY / LIGHT BLACKISH GREY, FINE GRAINED, SLIGHTLY FRACTURED ROCK.

FIG. 2.10 : GENERALISED SOIL PROFILE

(Condensate Tank Farm)

813 of 1127



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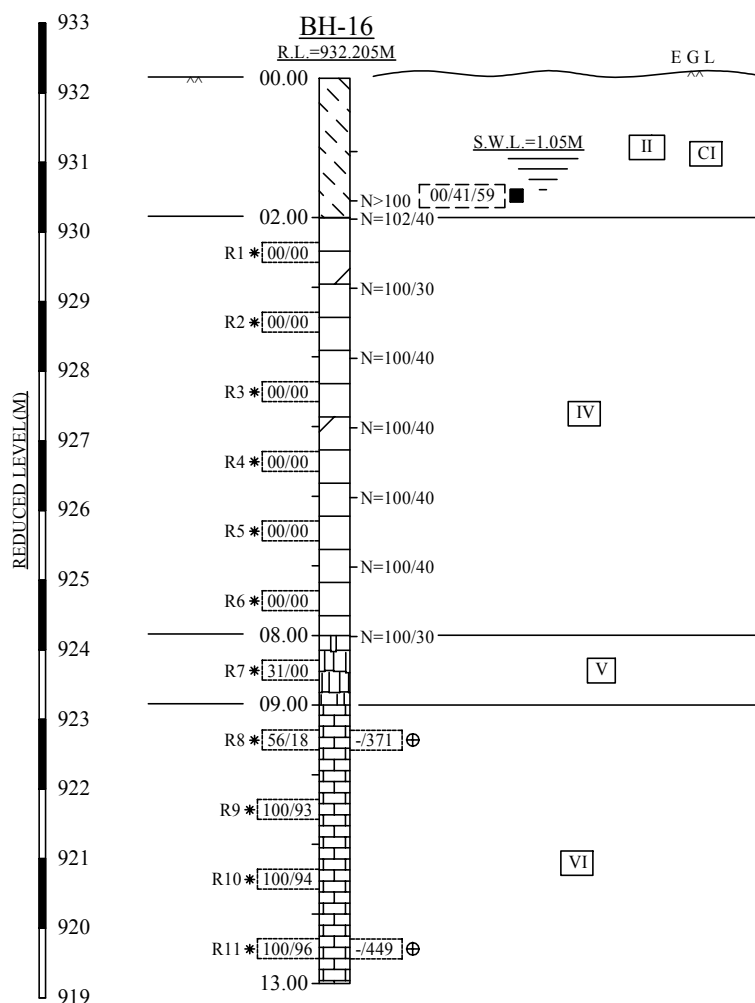
CETEST

Job No : 4095

Created by : SK D

Created on : 11/09/2019

Sheet No:



- II → HARD, REDDISH BROWN, CLAYEY SILT WITH SAND MIXTURE, MOORUM & DECOMPOSED ROCK FRAGMENTS.  
IV → COMPLETELY WEATHERED, LIGHT GREY / YELLOWISH GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.  
V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.  
VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.11 : SUB-SOIL PROFILE  
(Evaporation)



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

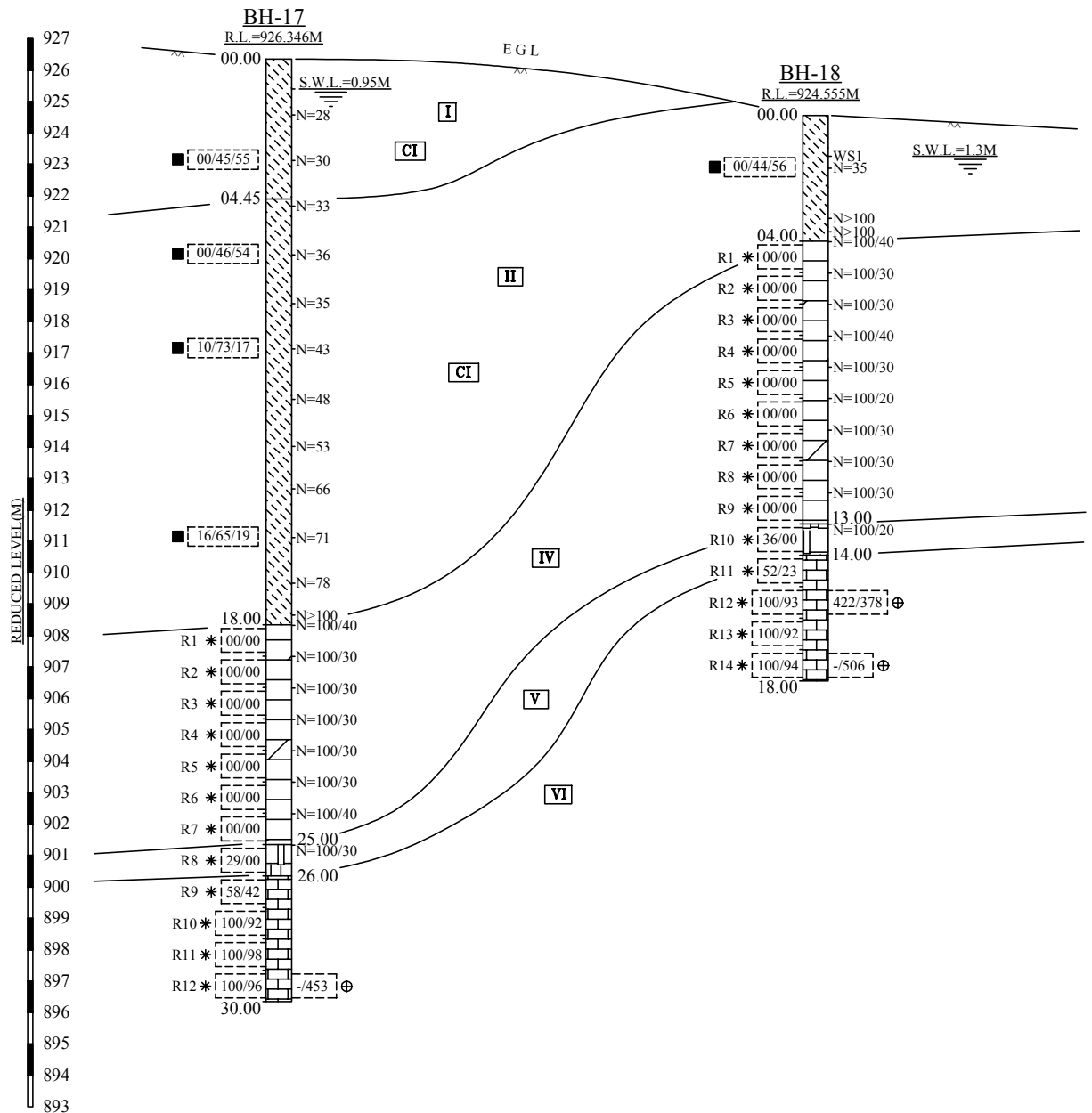
**CETEST**

Job No : 4095

Created by : SKD

Created on : 11/9/2019

Sheet No:



- I → VERY STIFF, REDDISH BROWN, SILTY CLAY WITH MOORUM & KANKAR.
- II → HARD, REDDISH BROWN / GREYISH BROWN, SILTY CLAY WITH MOORUM & DECOMPOSED ROCK FRAGMENTS.
- IV → COMPLETELY WEATHERED, LIGHT GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK FRAGMENTS COLLECTED AS SLUDGE.
- V → HIGHLY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.
- VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY TO SLIGHTLY FRACTURED ROCK.

N means 'N' value  
WS means Water Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.12 : GENERALISED SOIL PROFILE  
(SFL Tank Farm)

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Job No : 4095

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Created on : 09/8/2019

Sheet No:

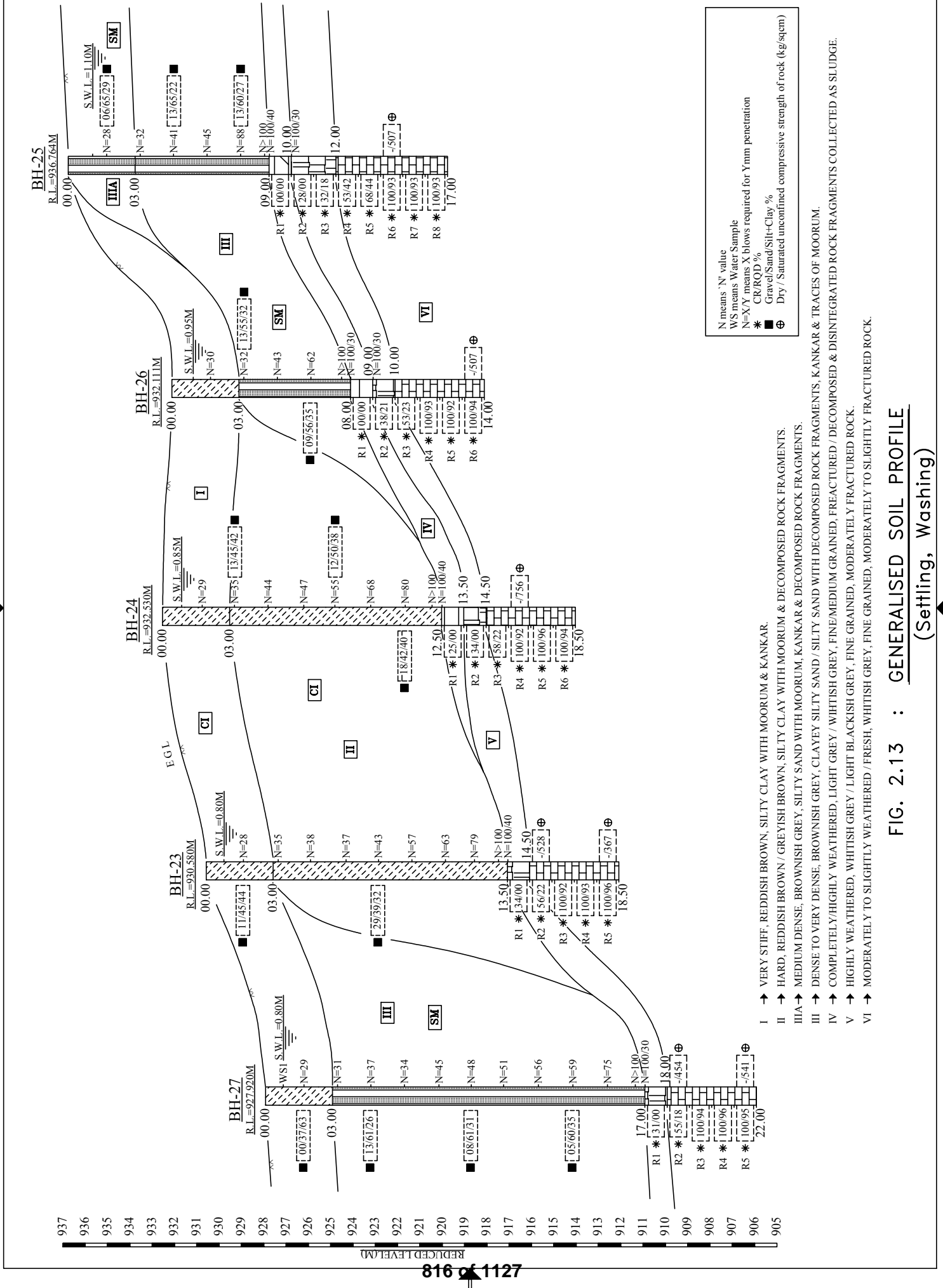


FIG. 2.13 : GENERALISED SOIL PROFILE  
(Settling, Washing)



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

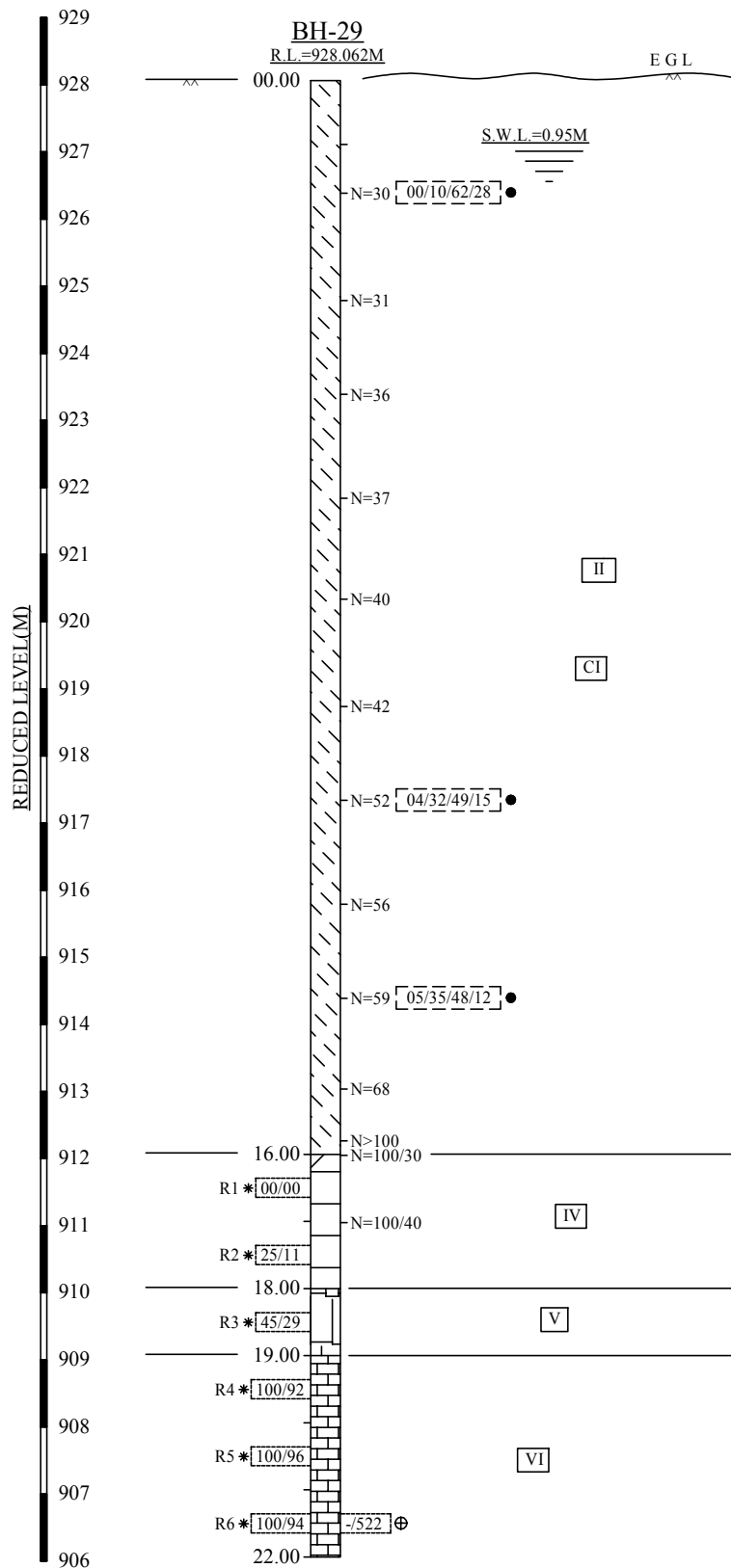
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Job No : 4095

Created by : SKD

Created on : 30/08/2019

Sheet No:



II → HARD, REDDISH BROWN / GREYISH BROWN, SILTY CLAY WITH MOORUM & DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY TO HIGHLY WEATHERED, LIGHT GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

V → MODERATELY WEATHERED, LIGHT BLACKISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → FRESH, LIGHT BLACKISH GREY, FINE GRAINED, SLIGHTLY FRACTURED ROCK.

N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
● Gravel/Sand/Silt/Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.14 : SUB-SOIL PROFILE

(Floculation)  
817 9 1127





Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

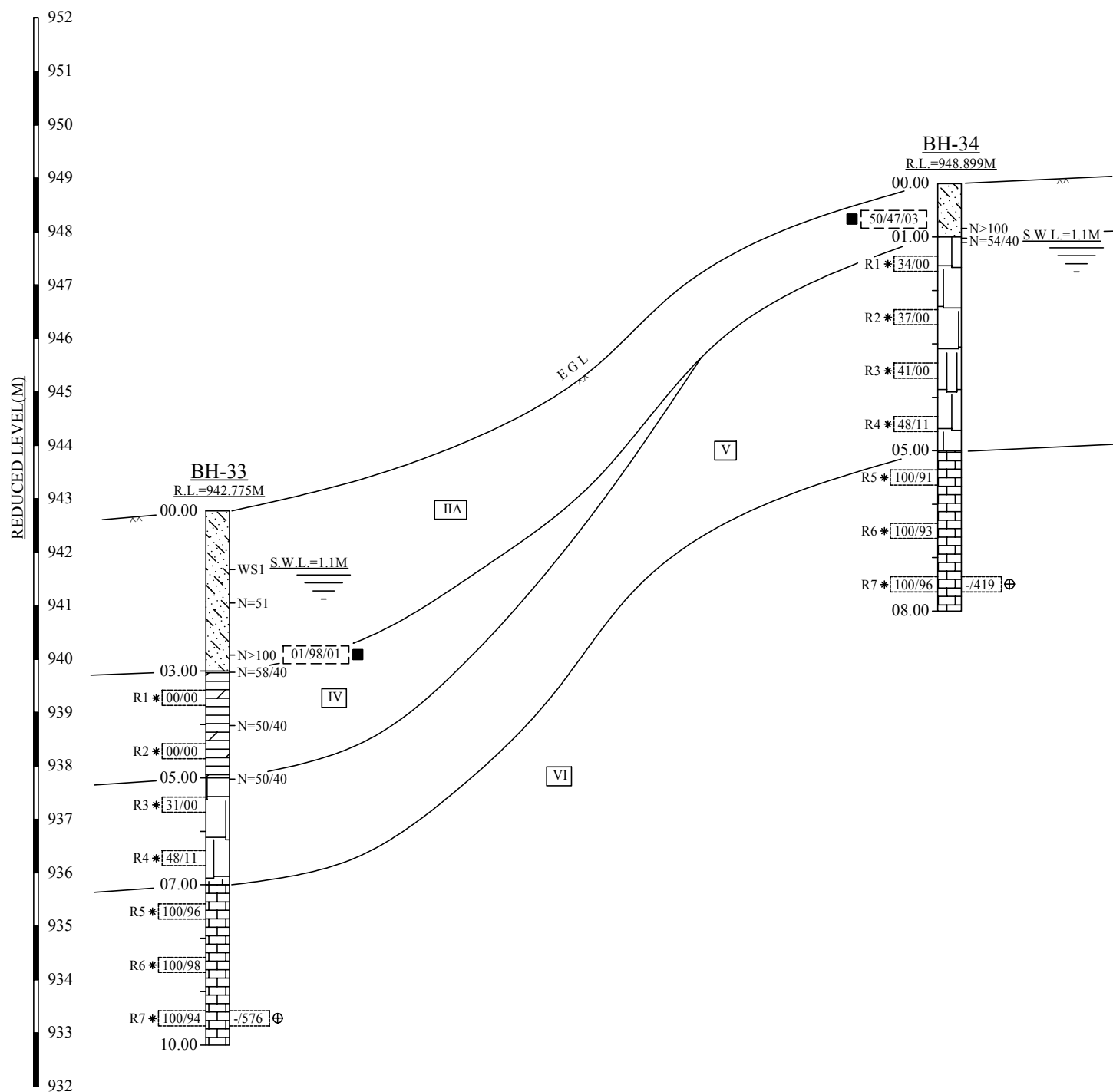
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Job No : 4095

Created by : SKD

Created on : 05/09/2019

Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH DECOMPOSED ROCK FRAGMENTS.

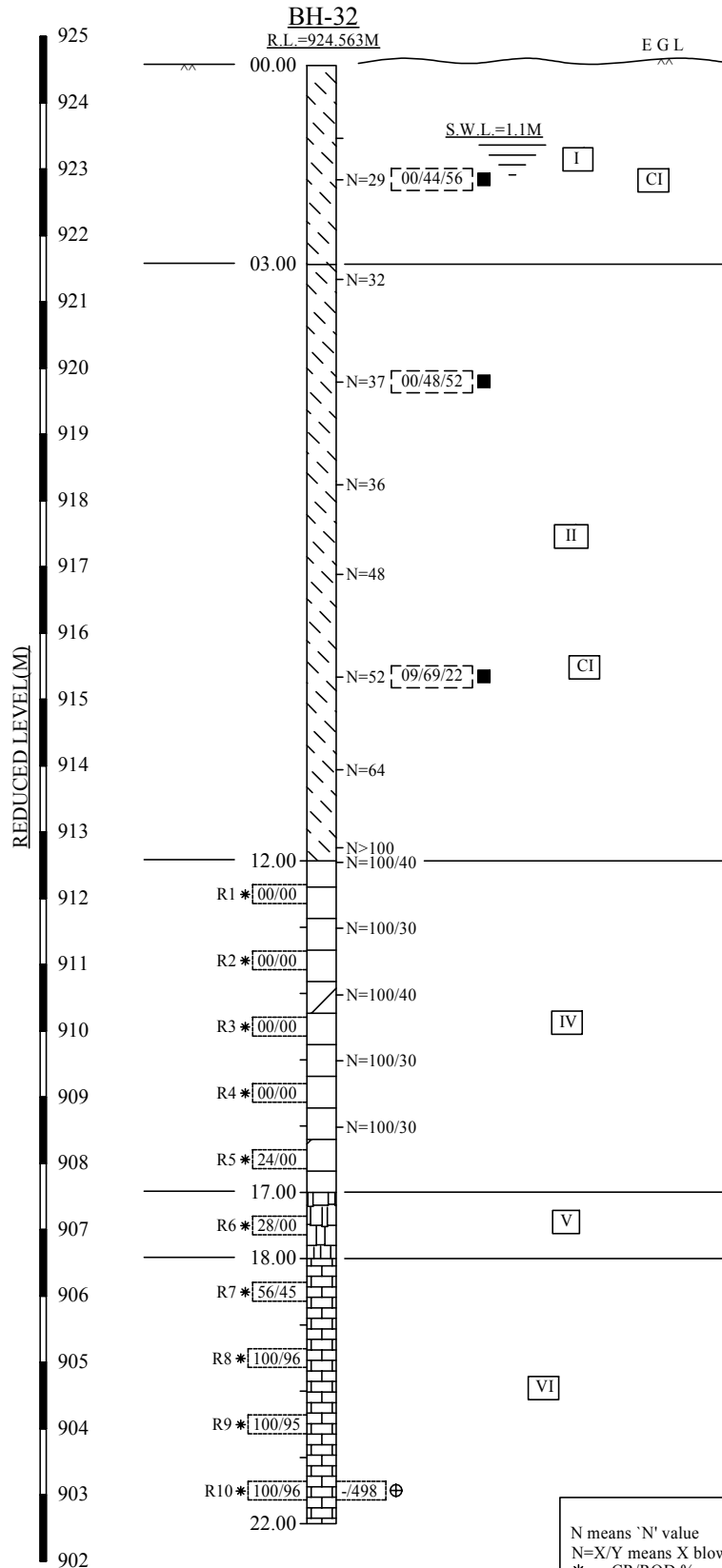
IV → COMPLETELY WEATHERED, LIGHT GREY / YELLOWISH GREY, MEDIUM GRAINED, DECOMPOSED & DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

N means 'N' value  
WS means Water Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.15 : GENERALISED SOIL PROFILE  
(HCSD Pumps, Substation US-504)



I → VERY STIFF, REDDISH BROWN, SILTY CLAY WITH MOORUM &amp; KANKAR.

II → HARD, REDDISH BROWN / GREYISH BROWN, SILTY CLAY WITH MOORUM &amp; DECOMPOSED ROCK FRAGMENTS.

IV → COMPLETELY TO HIGHLY WEATHERED, LIGHT GREY, MEDIUM GRAINED, DECOMPOSED &amp; DISINTEGRATED ROCK PARTICLES COLLECTED AS SLUDGE.

V → HIGHLY WEATHERED, LIGHT GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, LIGHT GREY TO WHITISH GREY, FINE GRAINED, MODERATELY TO SLIGHTLY FRACTURED ROCK.

FIG. 2.16 : SUB-SOIL PROFILE

(Substation-02)



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

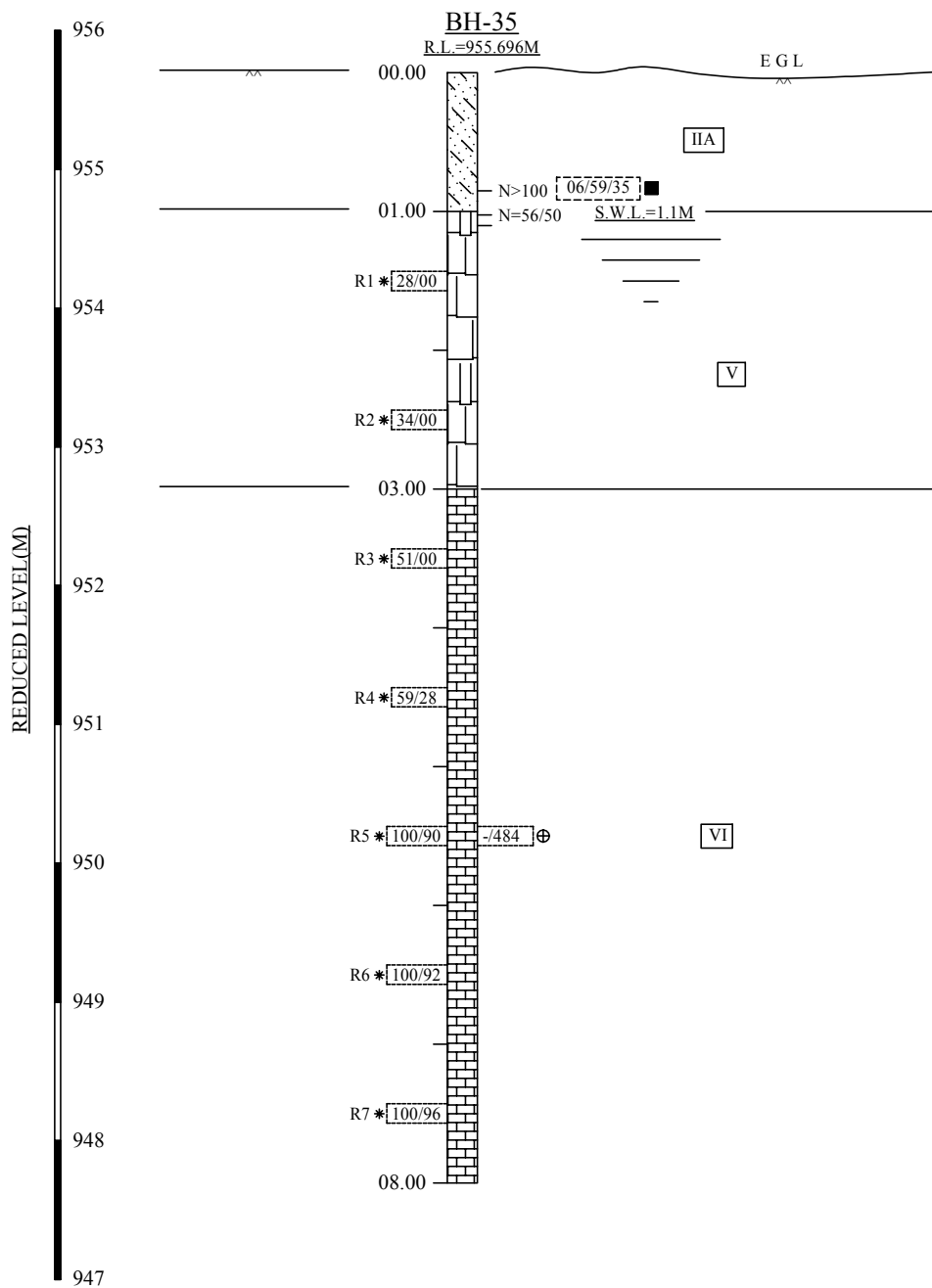
CETEST

Job No : 4095

Created by : SK D

Created on : 11/09/2019

Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH DECOMPOSED ROCK FRAGMENTS.

V → HIGHLY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.17 : SUB-SOIL PROFILE

(Assembly Area)

820 of 1127



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

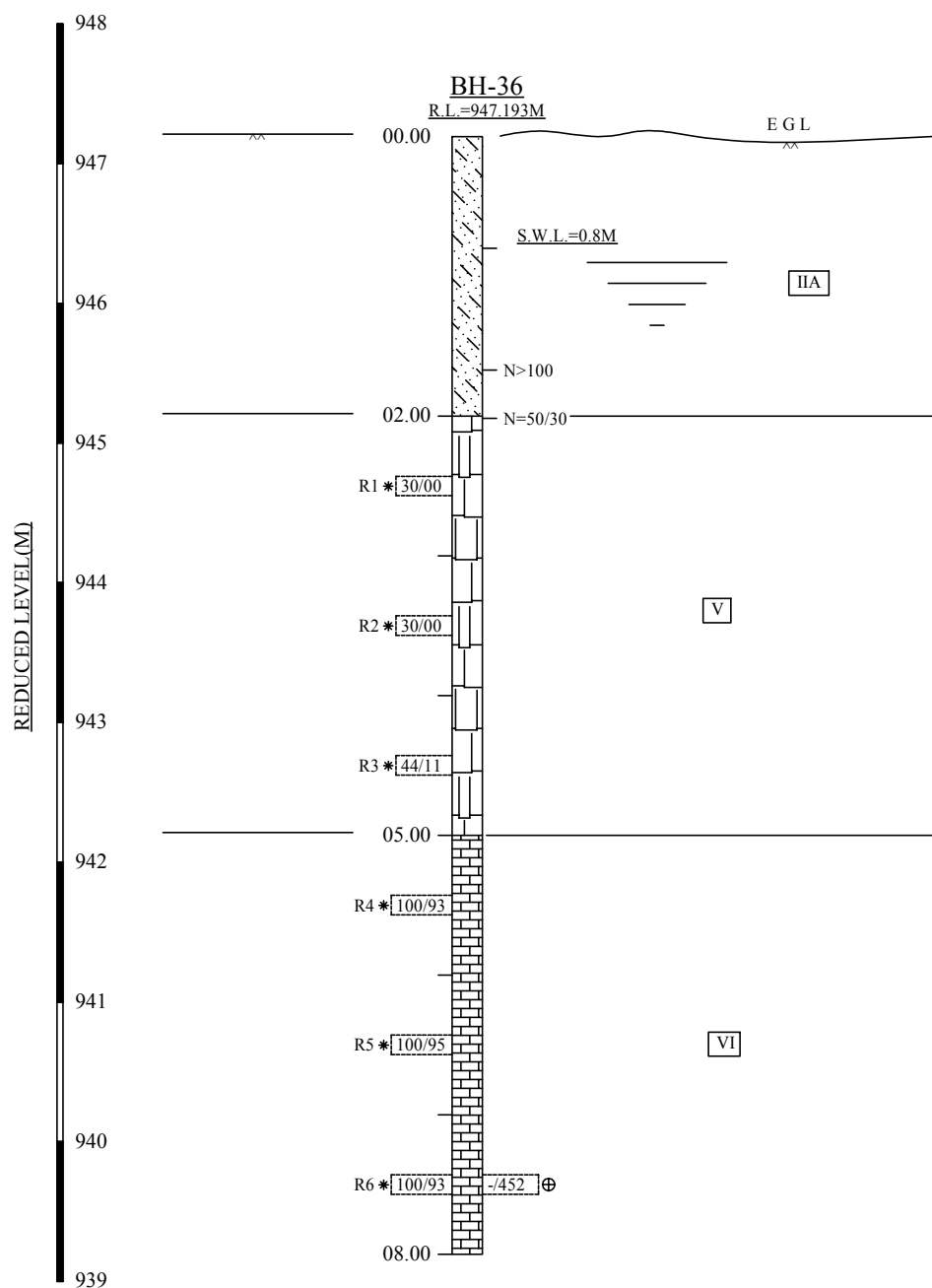
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Job No : 4095

Created by : SKD

Created on : 12/09/2019

Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH DECOMPOSED ROCK FRAGMENTS.

V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

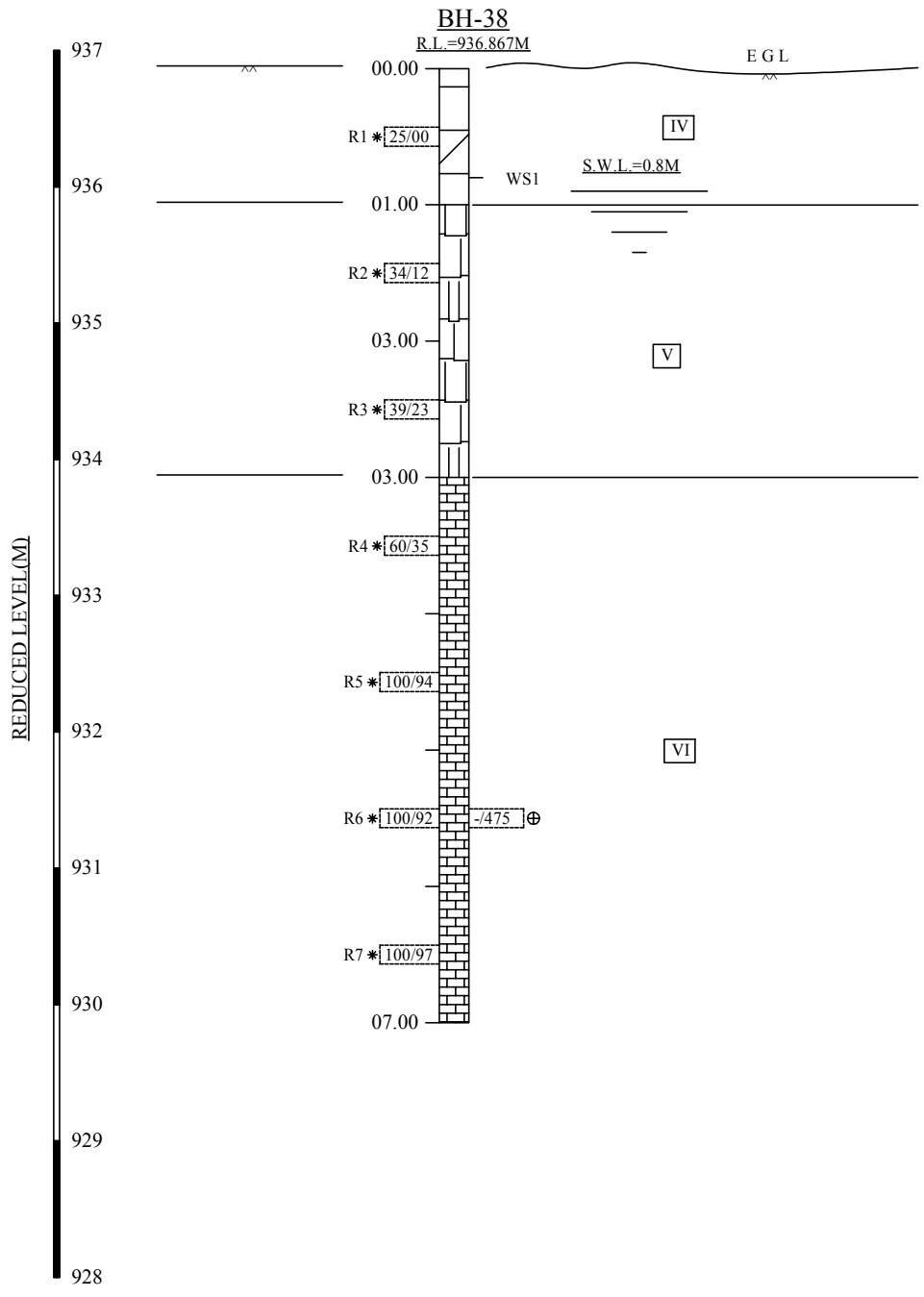
VI → FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.18 : SUB-SOIL PROFILE

(Canteen)

821 of 1127



IV → HIGHLY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.  
V → HIGHLY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.  
VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY TO SLIGHTLY FRACTURED ROCK.

WS means Water Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.19 : SUB-SOIL PROFILE  
(Hydrate Filtration)



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

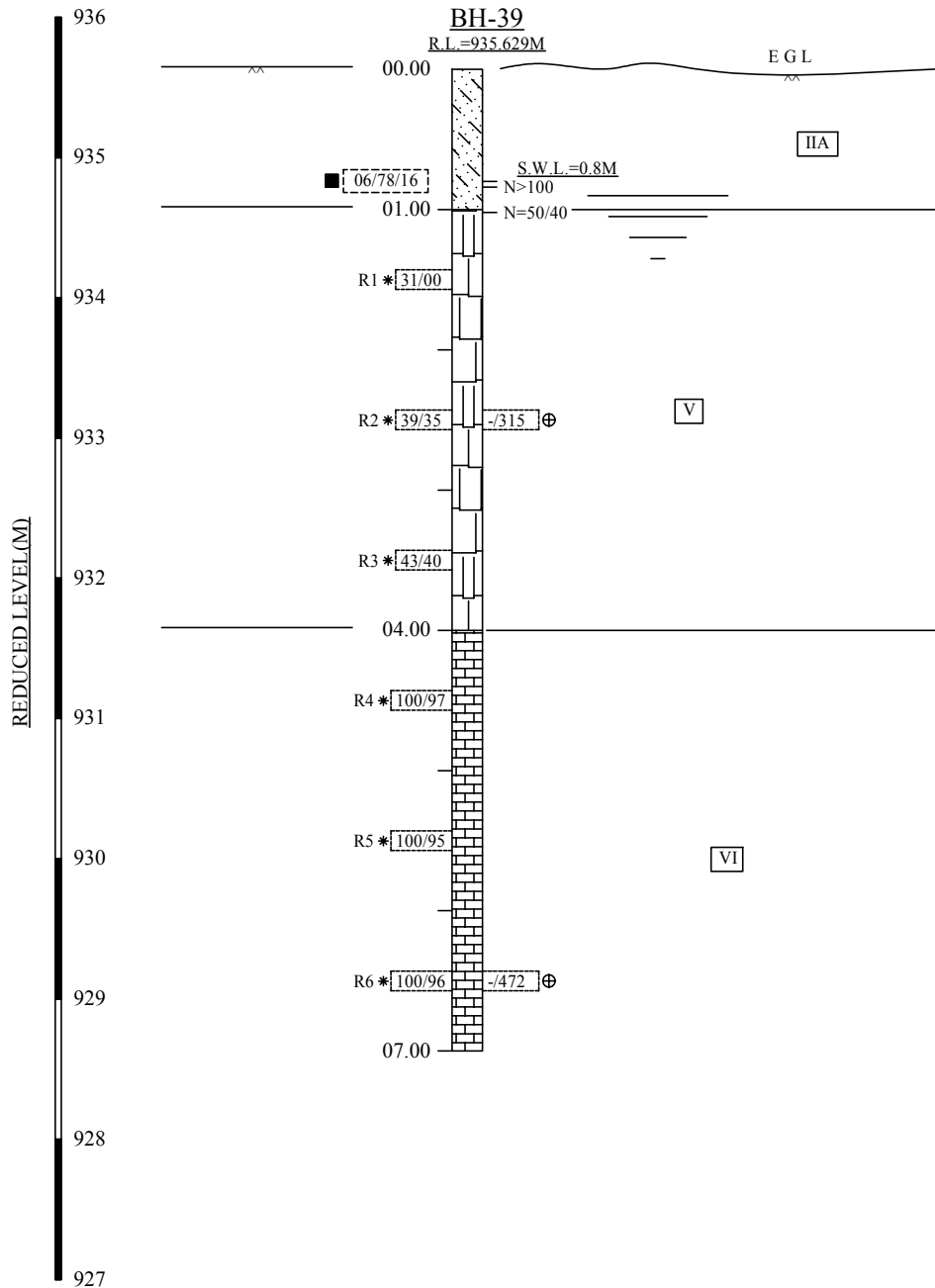
CETEST

Job No : 4095

Created by : SKD

Created on : 12/09/2019

Sheet No:



IIA → HARD, REDDISH BROWN, MOORUM WITH SAND MIXTURE & DECOMPOSED ROCK FRAGMENTS.

V → HIGHLY TO MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → FRESH, WHITISH GREY, FINE GRAINED, SLIGHTLY FRACTURED ROCK.

N means 'N' value  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.20 : SUB-SOIL PROFILE

(Cooling Towers & Cooling Water Distribution)



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

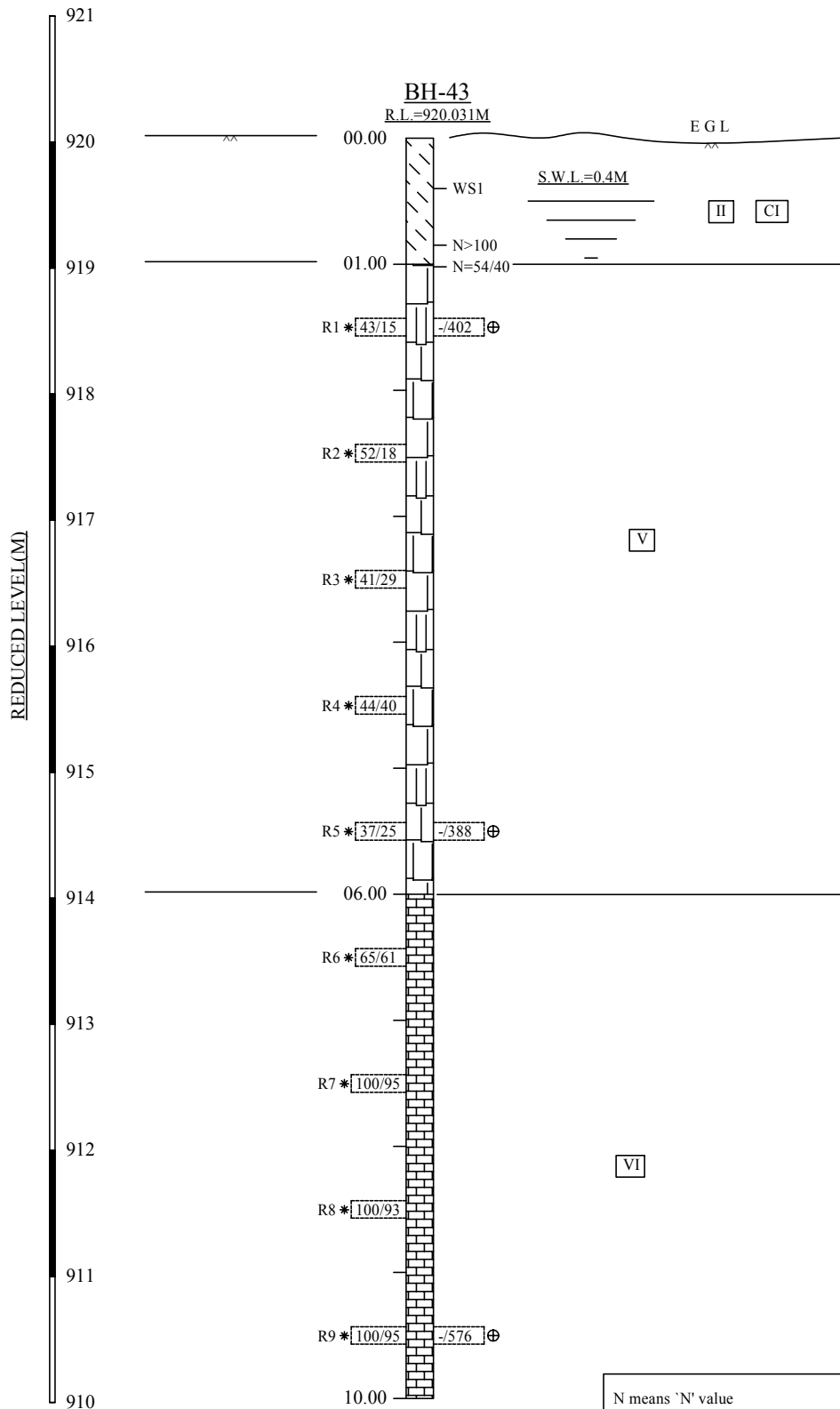
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Job No : 4095

Created by : SK D

Created on : 12/09/2019

Sheet No:



N means 'N' value  
WS means Water Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

II → HARD, REDDISH BROWN, CLAYEY SILT WITH TRACES OF SAND MIXTURE & MOORUM. OBSERVEED DECOMPOSED ROCK FRAGMENTS.

V → HIGHLY/MODERATELY WEATHERED, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

VI → SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, SLIGHTLY FRACTURED ROCK.

FIG. 2.21 : SUB-SOIL PROFILE

(Substation-04)

824 of 1127



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

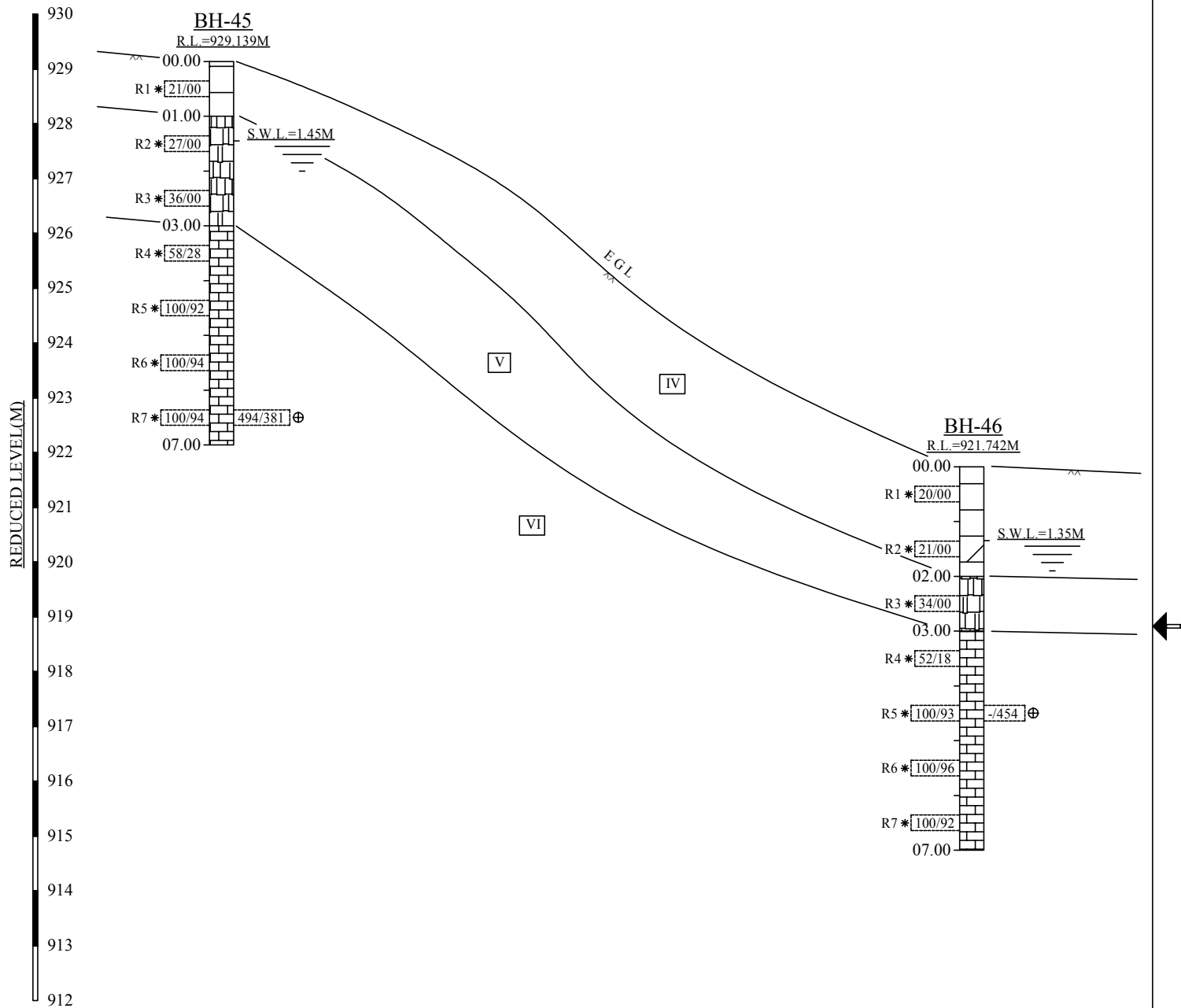
CETEST

Job No : 4095

Created by : SKD

Created on : 12/09/2019

Sheet No:



IV → COMPLETELY TO HIGHLY WEATHERED, WHITISH GREY, FINE GRAINED, HIGHLY FRACTURED ROCK.

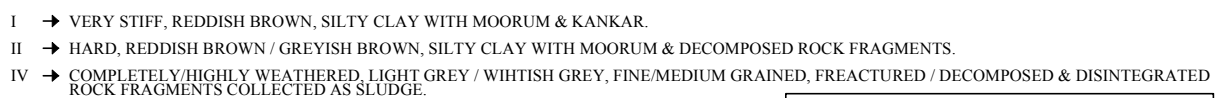
V → HIGHLY WEATHERED, WHITISH GREY, FINE GRAINED, FRACTURED ROCK.

VI → MODERATELY TO SLIGHTLY WEATHERED / FRESH, WHITISH GREY, FINE GRAINED, MODERATELY FRACTURED ROCK.

N=X/Y means X blows required for Ymm penetration  
\* CR/QD %  
⊕ Dry / Saturated unconfined compressive strength of rock (kg/sqcm)

FIG. 2.22 : GENERALISED SOIL PROFILE  
(Precipitation)





N means 'N' value  
WS means Water Sample  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
■ Gravel/Sand/Silt+Clay %

(Bauxite Handling Conveyor)

#### 4.2.3. STRATUM - IIA:

This layer consists of hard, reddish brown, moorum with decomposed rock fragments. The average properties of this layer are presented below.

Bulk Density, gms/cc	2.08	Liquid limit %	40
Dry Density, gms/cc	1.76	Plastic Limit %	21
Natural Water Content %	19		
Specific gravity	2.67	<b>GRAIN SIZE</b>	
<b>TRSH-UU:</b>		Gravel %	15
Cohesion kg/sqcm	1.44	Sand %	63
Friction angle °	15°	(Silt + Clay) %	22

#### 4.2.4. STRATUM - IIIA:

This layer (observed only around BH-25) consists of medium dense, brownish grey silty sand with kankar, moorum & decomposed rock fragments. The properties of this layer are presented below.

##### GRAIN SIZE

Gravel %	06
Sand %	65
(Silt + Clay) %	29

#### 4.2.4. STRATUM - III:

This layer consists of dense to very dense, brownish grey clayey silty sand / silty sand with clay binder, kankar, moorum & decomposed rock fragments. The properties of this layer are presented below.

##### GRAIN SIZE

Gravel %	09
Sand %	61
(Silt + Clay) %	30

#### 4.2.5. STRATUM - IV:

This is rock layer and consists of completely / highly weathered, light grey / whitish grey, fine / medium grained, fractured rock / decomposed & disintegrated rock particles collected as sludge. The core recovery of this layer ranges from 00% to 25% with nil RQD. The following test was carried out on the rock samples viz.

##### 1. Determination of Point Load Strength Index.

The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.624	Specific Gravity	2.663
Dry Density, gms/cc	2.619	Porosity %	1.712
Water Content %	0.212	Point Load Strength Index, kg/sqcm	13.01

#### 4.2.6. STRATUM - V:

This is also rock layer and consists of highly to moderately weathered, whitish grey / light blackish grey, fine grained, moderately fractured rock. Core recovery of this layer ranges from 26% to 48% and RQD varies from 0% to 40%.

The following tests were carried out on the rock samples viz.

1. Unconfined Compressive Strength determination of the rock samples after 24 hours full submergence and thereafter air drying before testing (i.e. saturated condition).
2. Determination of Point Load Strength Index.

The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.878	Porosity %	0.649
Dry Density, gms/cc	2.874	UCS (saturated), kg/sqcm	345
Water Content %	0.144	Point Load Strength Index, kg/sqcm	24.59
Specific Gravity	2.900		

#### 4.2.7. STRATUM - VI:

This is rock layer and consists of moderately to slightly weathered / fresh, whitish grey / light blackish grey, fine grained, moderately to slightly fractured rock. Core recovery of this layer ranges from 51% to 100% and RQD varies from 15% to 98%.

The following tests were carried out on the rock samples viz.

1. Unconfined Compressive Strength determination of the rock samples as collected from the field (i.e. insitu condition).
2. Unconfined Compressive Strength determination of the rock samples after 24 hours full submergence and thereafter air drying before testing (i.e. saturated condition).
3. Determination of Point Load Strength Index.

The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.958	UCS (dry), kg/sqcm	524
Dry Density, gms/cc	2.954	UCS (saturated), kg/sqcm	463
Water Content %	0.123	Co-efficient of Softening	0.922
Specific Gravity	2.928		
Porosity %	0.550	Point Load Strength Index, kg/sqcm	41.56

#### 4.3. GRAPHICAL PRESENTATION:

The detailed Laboratory Test Results in tabular form are given in the Appendix. The back up sheets are also presented there as given in below:

1. *Strength envelopes from Triaxial Tests.*
2. *Grain size distribution curves for sieve and hydrometer tests.*

## 5. DISCUSSION

### 5.1. CYCLIC PLATE LOAD TEST:

Seven no. (7) Cyclic Plate Load Tests were conducted in the site in this zone at specified depth using 600mm square plate. Load (Vs.) settlement plots is made in arithmetic scale to calculate Allowable Bearing Capacity. The calculations are presented below separately.

### DETERMINATION OF SAFE BEARING CAPACITY:

For clayey soil, we can write,  $S_p = S_f \times (B_p / B_f)$

For sandy soil / weathered rock, we can write,  $\frac{S_p}{S_f} = \left[ \frac{B_p}{B_f} \times \frac{(B_f + 30)}{(B_p + 30)} \right]^2$

### CPLT – 03:

i) Final load = 80.00 t/sqm, final settlement = 8.22mm < 12mm

Hence, using a FOS of 2.00 (refer IS: 1888-1982, Cl. 4.7.), safe load becomes (80.00/2.0) = 40 t/sqm

ii)  $B_f$  = Width of footing = 2m(say),  $B_p$  = Size of test plate = 0.60m

$S_f$  = Limiting Settlement of footing = 12mm and  $S_p$  = Settlement of test plate.

Hence,  $S_p = S_f \times [(B_p / B_f) \times ((B_f + 30) / (B_p + 30))]^2 = 12 \times 0.588 = 9.50\text{mm}$  (with initial correction 2.45mm) > 8.22mm

Hence, safe bearing capacity = 40 t/sqm

Based on the above data, the safe bearing capacity value for different footing size is presented below.

Test Location	Depth (M)	Recommended Safe Bearing Capacity, T/M <sup>2</sup>											
		Foundation width = 1m			Foundation width = 2m			Foundation width = 3m			Foundation width = 4m		
		S= 12mm	S= 25mm	S= 40mm	S= 12mm	S= 25mm	S= 40mm	S= 12mm	S= 25mm	S= 40mm	S= 12mm	S= 25mm	S= 40mm
CPLT-01	2.00	--	40	40	--	40	40	--	30	40	--	22	36
CPLT-03	2.00	40	--	--	40	--	--	40	--	--	40	--	--
CPLT-02	2.00	--	40	40	--	40	40	--	40	40	--	40	40
CPLT-04	2.00	--	40	40	--	40	40	--	40	40	--	40	40
CPLT-05	2.00	--	9	9	--	9	9	--	6	9	--	5	8
CPLT-06	2.00	--	24	24	--	24	24	--	24	24	--	24	24
CPLT-07	2.00	--	40	40	--	36	40	--	28	38	--	24	32

Where S = limiting settlement

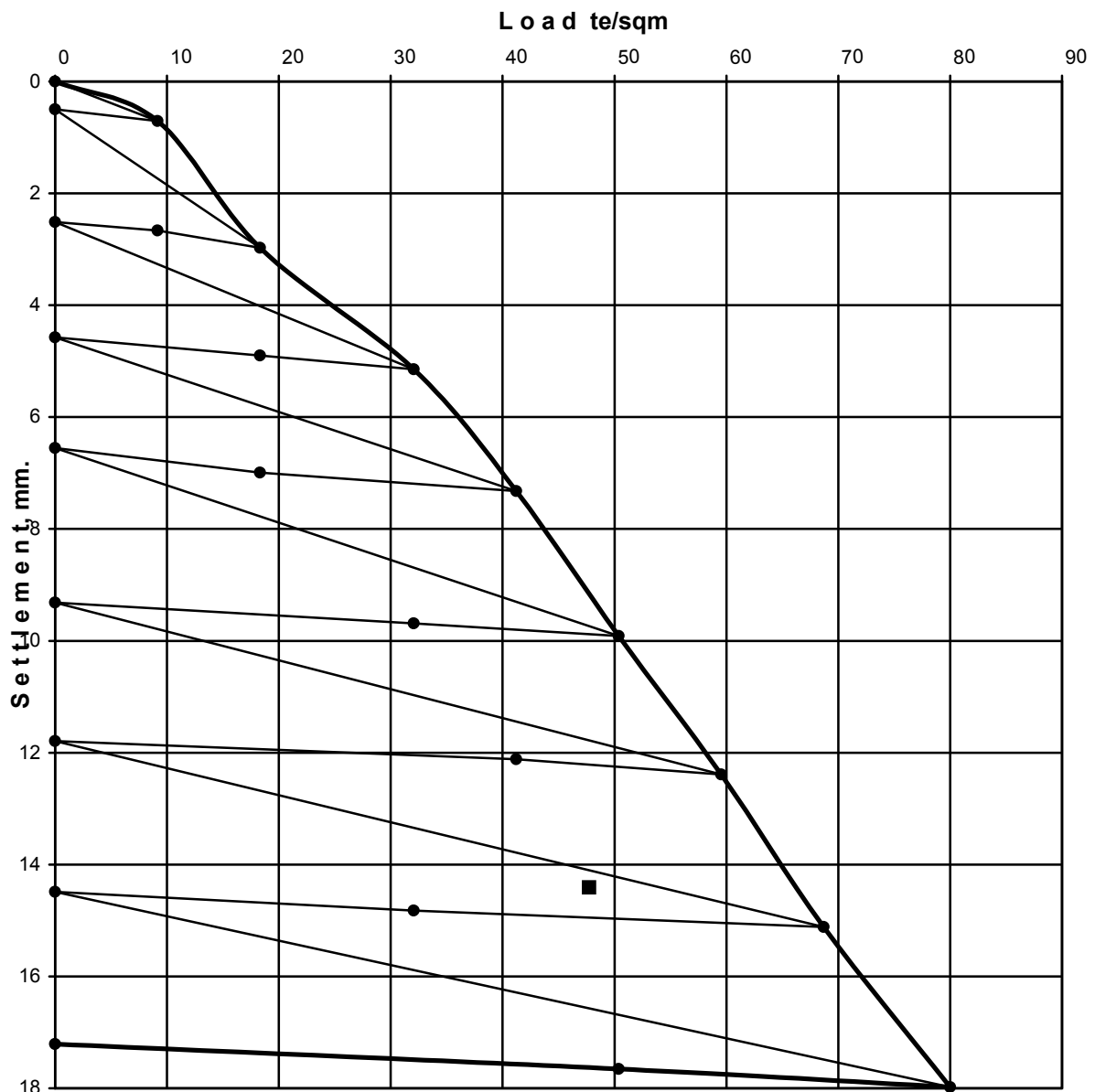
**CYCLIC PLATE LOAD TEST NO.1**

Commenced on: 28/08/2019  
 Completed on: 29/08/2019  
 Pit size: 2.00mx 2.00mx2.00m(depth)  
 Load on pr.guage/divn.=10Kg/sq.cm  
 Load on jack/divn. = 1.65te  
 Plate size: 0.60mX0.60m  
 Load on plate/divn.=4.58te/sq.m.  
**Test Type: Cyclic PLT**

Co-ordinates:  
 E = 1190.917M.  
 N = 1665.692M.  
 RL = 920.131M.

Description of Soil :-  
 (0.00m-2.00m):- Reddish brown, silty clay with moorum.

S.W.L.= Not found.



**FIG.3.1 LOAD VS SETTLEMENT GRAPH FOR CPT-1**

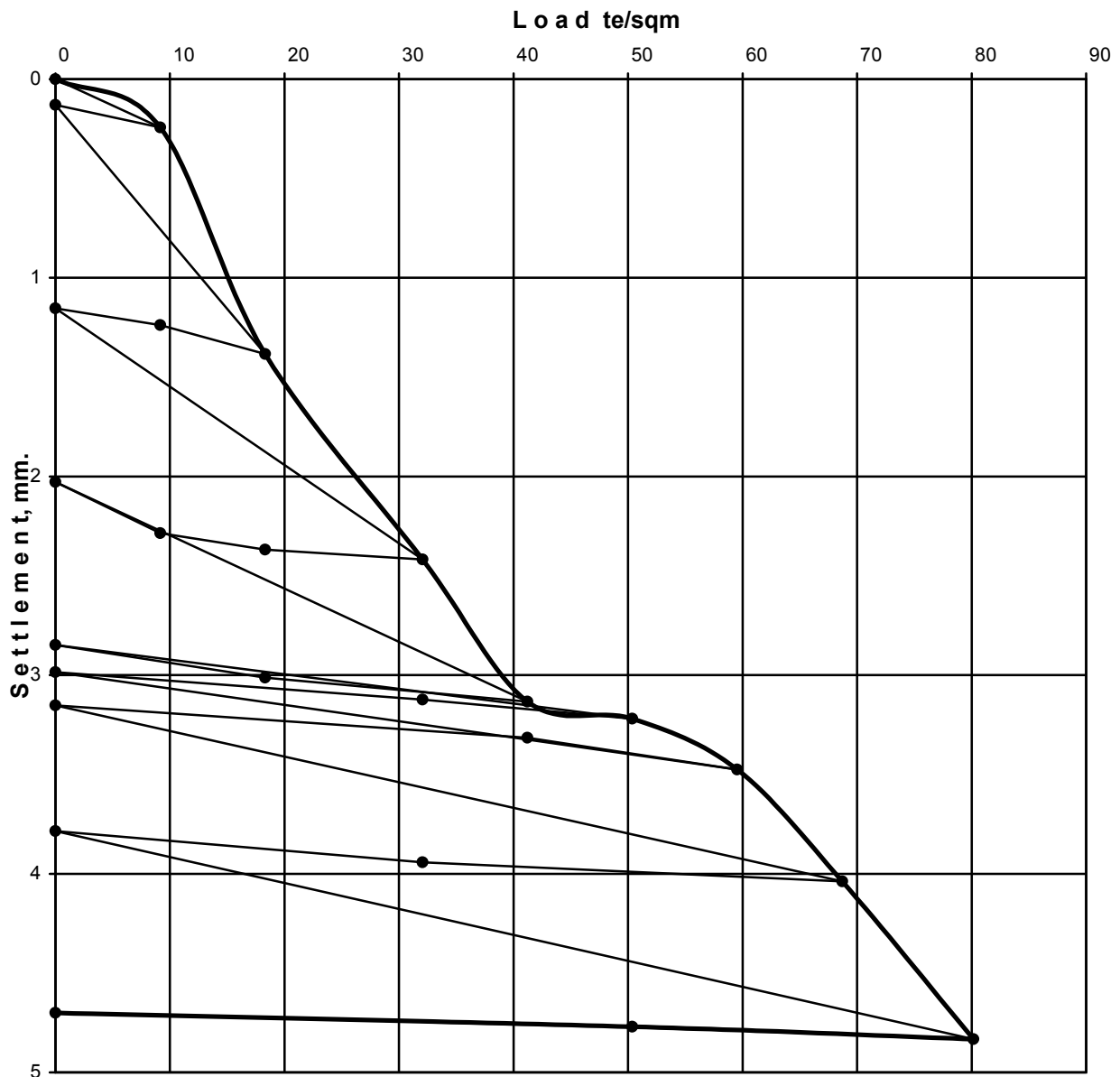
**CYCLIC PLATE LOAD TEST NO.2**

Commenced on: 26/08/2019  
 Completed on: 27/08/2019  
 Pit size: 2.00mx 2.00mx2.00m(depth)  
 Load on pr.guage/divn.=10Kg/sq.cm  
 Load on jack/divn. = 1.65ton  
 Plate size: 0.60mX0.60m  
 Load on plate/divn.=4.58t/sq.m.  
**Test Type: Cyclic PLT**

Co-ordinates:  
 E = 1547.885M.  
 N = 1781.661M.  
 RL = 926.888M.

S.W.L.= Not found.

Description of Soil :-  
 (0.00m-1.80m):- Reddish brown, silty clay with moorum.  
 (1.80m-2.00m):- Reddish brown, silty clay with noorum & decomposed rock.



**FIG. 3.2 LOAD VS SETTLEMENT GRAPH FOR CPLT-2**

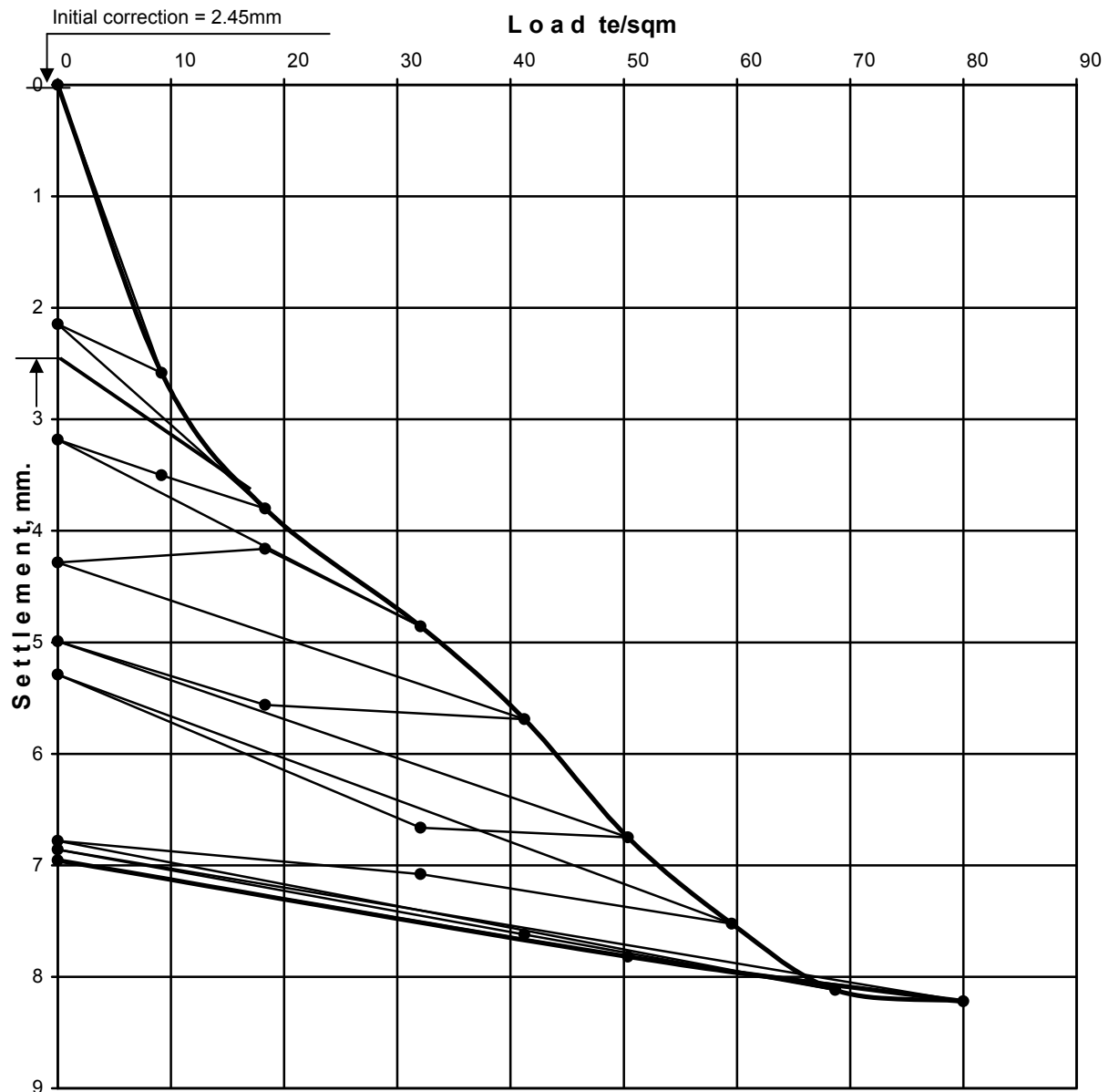
**CYCLIC PLATE LOAD TEST NO.3**

Commenced on: 30/08/2019  
 Completed on: 31/08/2019  
 Pit size: 2.00mx 2.00mx2.00m(depth)  
 Load on pr. guage/divn.=10Kg/sq.cm  
 Load on jack/divn. = 1.65te  
 Plate size: 0.60mX0.60m  
 Load on plate/divn.=4.58te/sq.m.  
**Test Type: Cyclic PLT**

Co-ordinates:  
 E = 1973.875M.  
 N = 1824.754M.  
 RL = 940.732M.

Description of Soil :-  
 (0.00m-2.00m):- Brownish grey, decomposed rock with  
 rock pcs.

S.W.L.= Not Found



**FIG. 3.3 LOAD VS SETTLEMENT GRAPH FOR CPLT-3**

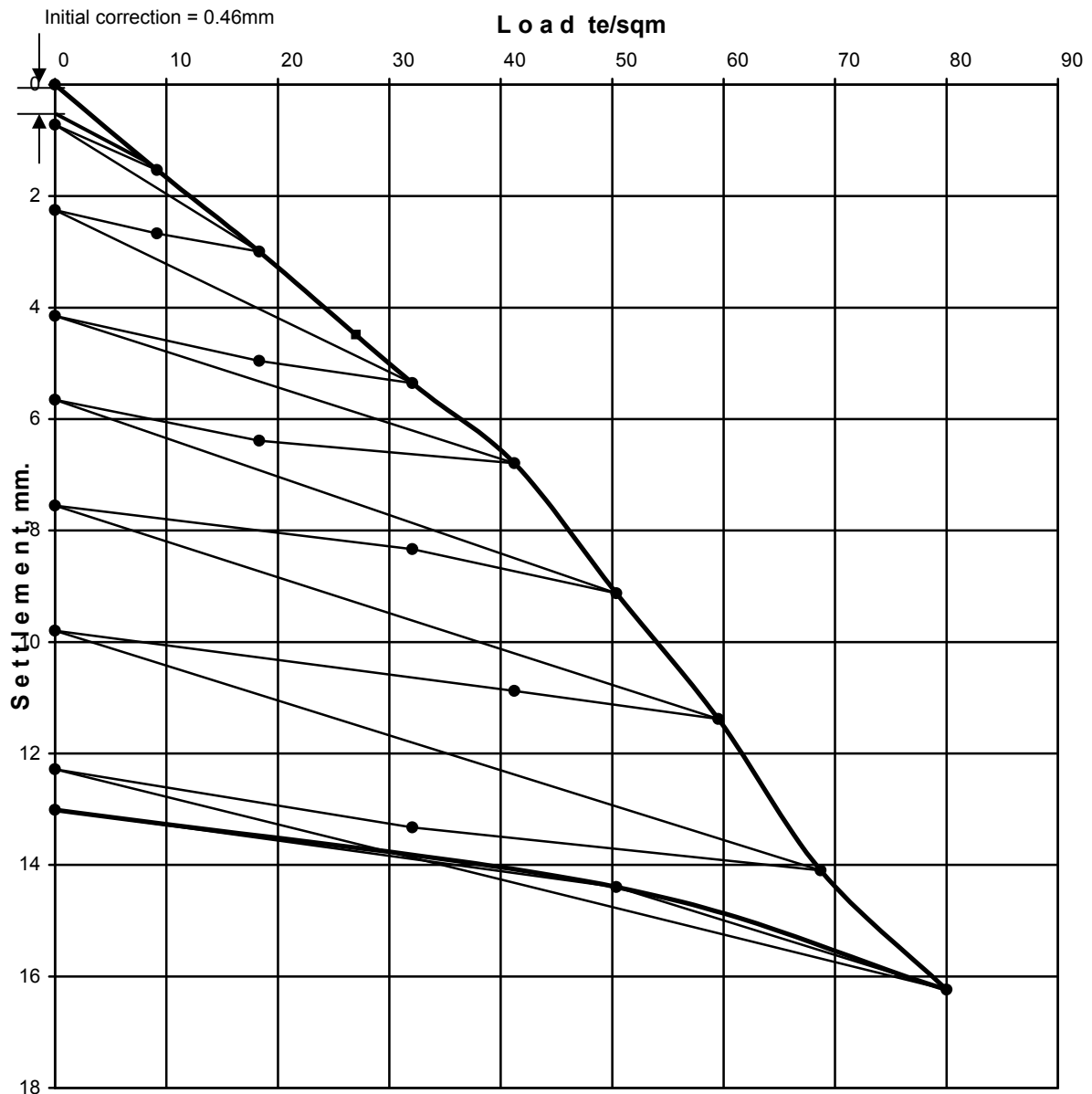
**CYCLIC PLATE LOAD TEST NO.4**

Commenced on: 01/09/2019  
 Completed on: 02/09/2019  
 Pit size: 2.00mx 2.00mx2.00m(depth)  
 Load on pr.guage/divn.=10Kg/sq.cm  
 Load on jack/divn. = 1.65te  
 Plate size: 0.60mX0.60m  
 Load on plate/divn.=4.58te/sq.m.  
**Test Type: Cyclic PLT**

Co-ordinates:  
 E = 2016.635M.  
 N = 1866.429M.  
 RL = 949.381M.

Description of Soil :- Brownish grey, silty sand with decomposed rock.

S.W.L.= Not found.



**FIG.3.4 LOAD VS SETTLEMENT GRAPH FOR CPLT-4**



**CYCLIC PLATE LOAD TEST NO.5**

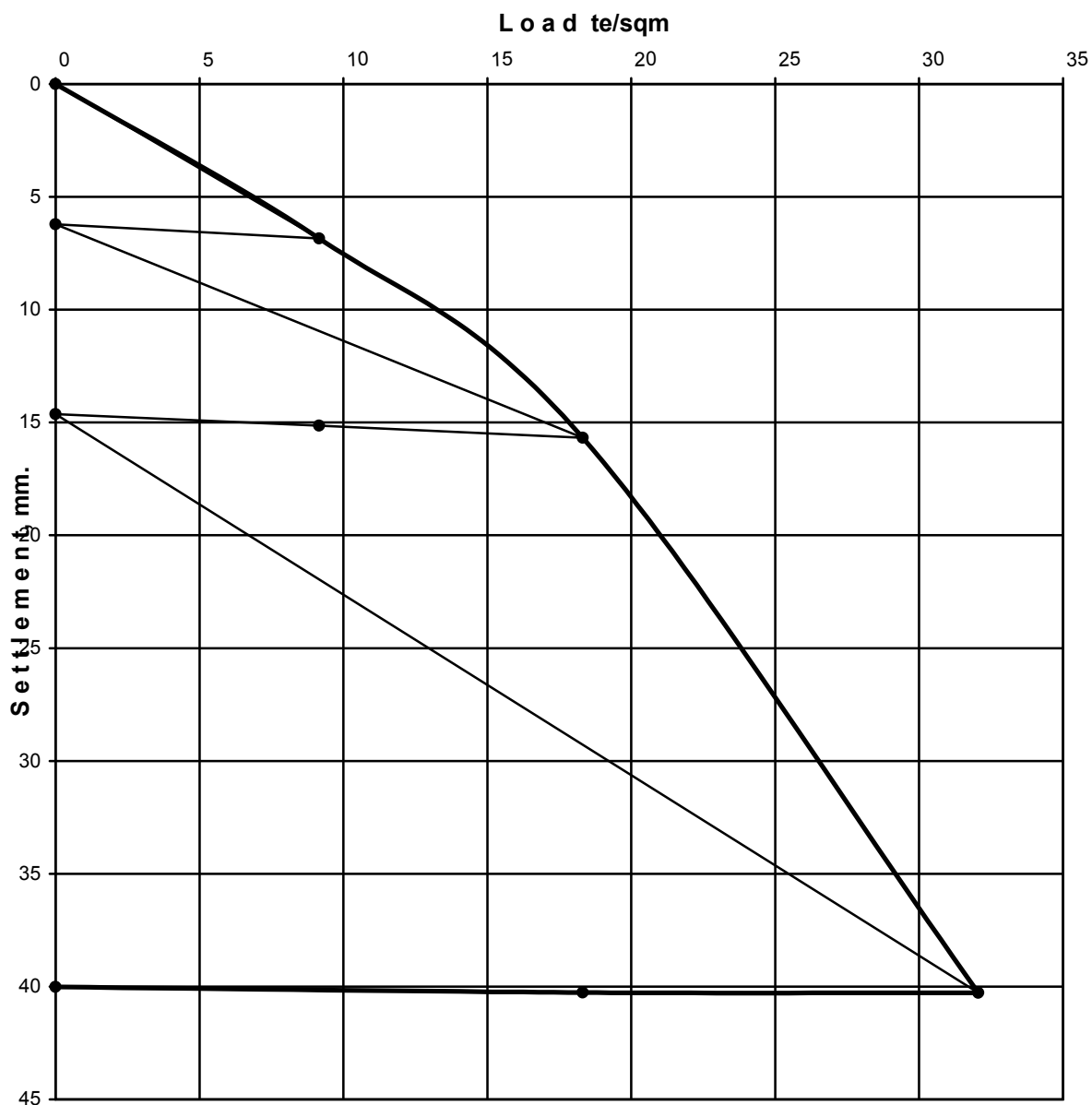
Commenced on: 04/09/2019  
Completed on: 04/09/2019  
Pit size: 2.00mx 2.00mx2.00m(depth)  
Load on pr.guage/divn.=10Kg/sq.cm  
Load on jack/divn. = 1.65te  
Plate size: 0.60mX0.60m  
Load on plate/divn.=4.58te/sq.m.

**Test Type: Cyclic PLT**

Co-ordinates:  
E = 1107.509M.  
N = 1067.493M.  
RL = 899.797M.

Description of Soil :-  
(0.00m-2.00m):- Reddish brown, silty clay. Obs. moorum.

S.W.L.= Not found.



**FIG.3.5 LOAD VS SETTLEMENT GRAPH FOR CPT-5**

**CYCLIC PLATE LOAD TEST NO.6**

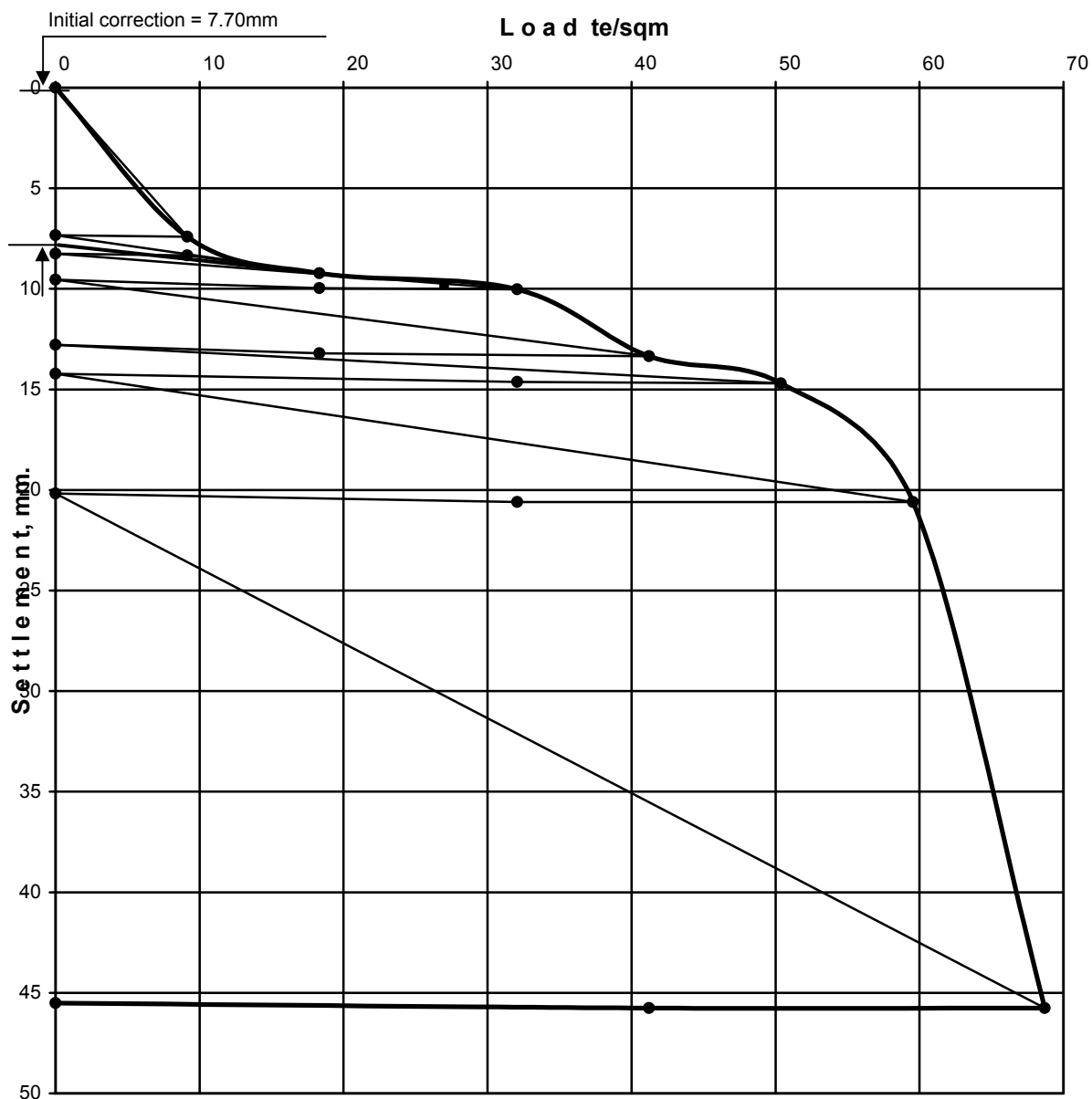
Commenced on: 06/09/2019  
 Completed on: 06/09/2019  
 Pit size: 2.00mx 2.00mx2.00m(depth)  
 Load on pr.guage/divn.=10Kg/sq.cm  
 Load on jack/divn. = 1.65te  
 Plate size: 0.60mX0.60m  
 Load on plate/divn.=4.58te/sq.m.

**Test Type: Cyclic PLT**

Co-ordinates:  
 E = 1102.575M.  
 N = 1239.259M.  
 RL = 901.643M.

S.W.L.= Not found.

Description of Soil :-  
 (0.00m-0.30m):- Whitish grey, lime.  
 (0.30m-0.70m):- Reddish brown, clayey silt with brick bats.  
 (0.70m - 2.00m):- Reddish brown, silty clay. Obs. moorum.



**FIG.3.6 LOAD VS SETTLEMENT GRAPH FOR CPLT-6**

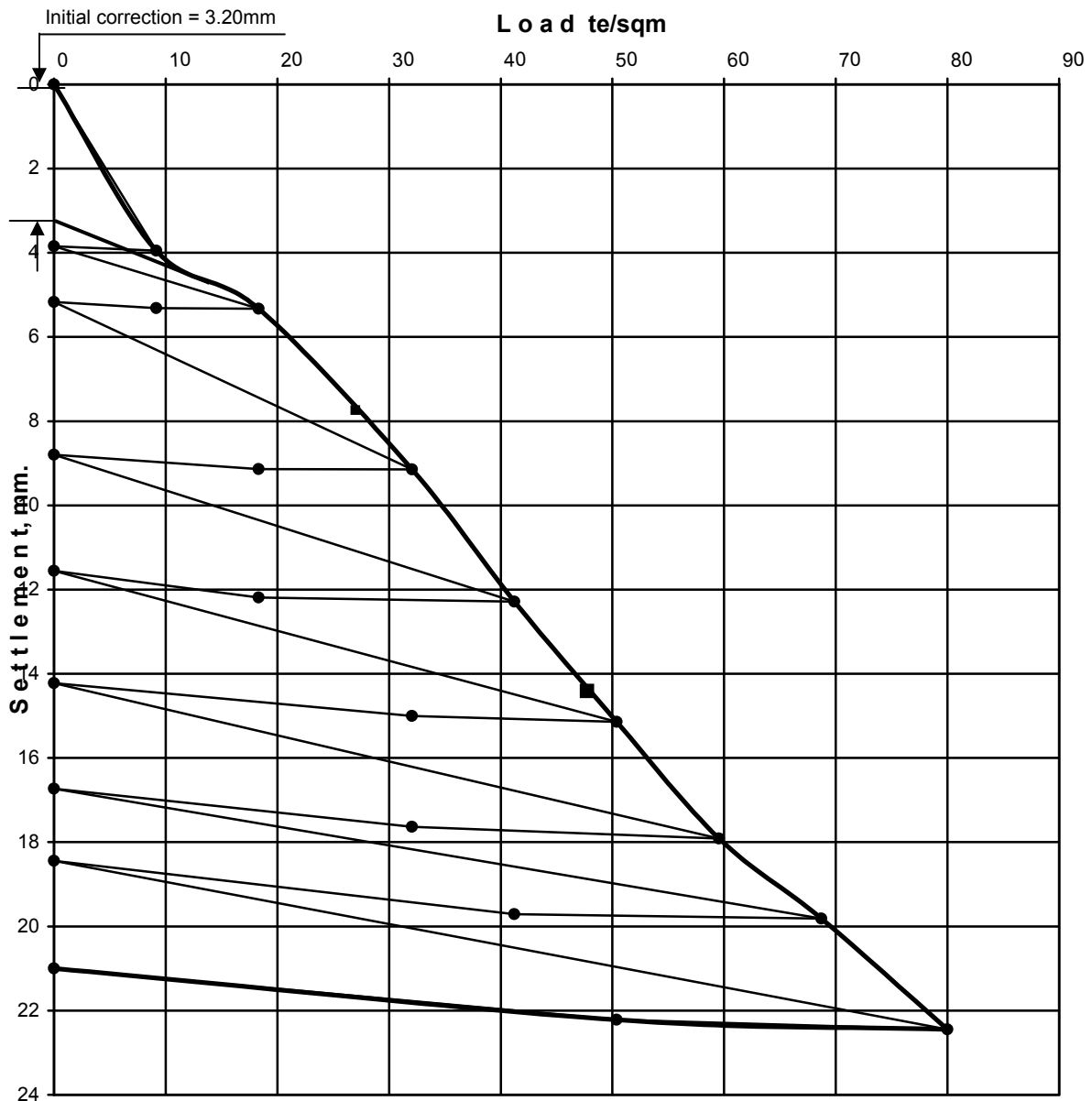
**CYCLIC PLATE LOAD TEST NO.7**

Commenced on: 08/09/2019  
 Completed on: 09/09/2019  
 Pit size: 2.00mx 2.00mx2.00m(depth)  
 Load on pr.guage/divn.=10Kg/sq.cm  
 Load on jack/divn. = 1.65te  
 Plate size: 0.60mX0.60m  
 Load on plate/divn.=4.58te/sq.m.  
**Test Type: Cyclic PLT**

Co-ordinates:  
 E = 1191.039M.  
 N = 1644.314M.  
 RL = 916.153M.

Description of Soil :-  
 (0.00m-2.00m):- Reddish brown, silty clay with moorum.

S.W.L.= Not found.



**FIG.3.07 LOAD VS SETTLEMENT GRAPH FOR CPLT-7**

**SUBGRADE MODULUS:**

Subgrade Modulus is obtained from Plate Load Tests as  $K = P/S$ . Where P = Plate Load corresponding to settlement S under working load. The final results values are presented in a tabular form below.

Test No.	Depth (M)	Subgrade Modulus for Plate as per IS 9214, Kg/cm <sup>3</sup>	Subgrade Modulus for Plate, correcting as per IS 9214 Kg/cm <sup>3</sup>
CPLT-01	2.00	9.38	6.39
CPLT-02	2.00	13.68	8.65
CPLT-03	2.00	13.84	8.72
CPLT-04	2.00	8.16	5.69
CPLT-05	2.00	1.41	1.10
CPLT-06	2.00	15.71	8.13
CPLT-07	2.00	9.20	6.28

The Subgrade modulus value is inversely proportional to the square root of the foundation area up to a base area of 10 sqm and then remains constant. The calculated subgrade modulus values for different foundation areas are presented below.

Test No.	Depth (M)	Subgrade Modulus, (kg/cu cm)			
		Foundation Area = 1 sqm	Foundation Area = 4 sqm	Foundation Area = 5 sqm	Foundation Area = 10 sqm or above
CPLT-01	2.00	3.83	1.92	1.71	1.21
CPLT-02	2.00	5.19	2.60	2.32	1.64
CPLT-03	2.00	5.23	2.62	2.34	1.65
CPLT-04	2.00	3.41	1.71	1.53	1.08
CPLT-05	2.00	0.66	0.33	0.30	0.21
CPLT-06	2.00	4.88	2.44	2.18	1.54
CPLT-07	2.00	3.77	1.88	1.69	1.19

**Sample Calculation of Subgrade Modulus for foundation area 5 Sq.m of CPLT-03****For Plate**

Safe Load, corresponding to 1.25mm settlement = 17.30 t/sqm

Subgrade Modulus for Plate,  $K = P/S = 17.30/1.25 = 13.84 \text{ Kg/cm}^3$

Applying correction for plate bending, as per Clause 5.1.3 & Fig.5 of IS:9214, corrected Subgrade Modulus =  $11.17 \text{ Kg/cm}^3$

Since the test was conducted on 600mm square plate (i.e. smaller than 75cm dia.), corrected Subgrade Modulus as per Clause 5.1.1 & Fig.3 of IS: 9214 =  $11.17 / 1.28 = 8.72 \text{ Kg/cm}^3$

**For Foundation**

Corrected Subgrade Modulus of plate =  $8.72 \text{ Kg/cm}^3$

Area of plate =  $60 \times 60 \text{ sq.cm} = 0.60 \times 0.60 \text{ sq.m}$

Area of footing =  $5 \text{ sq.m}$

Subgrade Modulus of foundation =  $8.72 \times \sqrt{(0.60 \times 0.60)/5} \text{ Kg/cm}^3 = 2.34 \text{ Kg/cm}^3$

**ELASTIC COMPRESSION:**

This load test was of cyclic type. Here, after application of each load increment and full stabilisation of plate settlement, the applied load was reduced to zero and the settlement records were noted till full stabilisation. Thereafter, the next load increment was applied.

The elastic rebounds at these load intensities are calculated (As per IS 5249-1992, Pg-6) from the field data and are graphically presented in graph. The coefficient of elastic uniform compression,  $C_u$  is obtained as  $C_u = P / S_e$  kg/cucm

**CPLT- 01:**

From the load vs elastic rebound plot, the slope of the trend line =  $C_u = (60-30)/(0.68-0.34) = 88.42$  kg/cucm

Now, for a foundation size of 10 sqm (3m x 3.33m, say), the corresponding value will be,

$$C_{u10sqm} = 88.42 \times \sqrt{[(0.60 \times 0.60) / 10]} = 16.74 \text{ kg/cucm}$$

**CPLT- 02:**

From the load vs elastic rebound plot, the slope of the trend line =  $C_u = (60-30)/(0.26-0.13) = 230.77$  kg/cucm

Now, for a foundation size of 10 sqm (3m x 3.33m, say), the corresponding value will be,

$$C_{u10sqm} = 230.77 \times \sqrt{[(0.60 \times 0.60) / 10]} = 43.78 \text{ kg/cucm}$$

**CPLT- 03:**

From the load vs elastic rebound plot, the slope of the trend line =  $C_u = (60-30)/(1.08-0.54) = 55.56$  kg/cucm

Now, for a foundation size of 10 sqm (3m x 3.33m, say), the corresponding value will be,

$$C_{u10sqm} = 55.56 \times \sqrt{[(0.60 \times 0.60) / 10]} = 10.54 \text{ kg/cucm}$$

**CPLT- 04:**

From the load vs elastic rebound plot, the slope of the trend line =  $C_u = (60-30)/(1.95-0.98) = 30.86$  kg/cucm

Now, for a foundation size of 10 sqm (3m x 3.33m, say), the corresponding value will be,

$$C_{u10sqm} = 30.86 \times \sqrt{[(0.60 \times 0.60) / 10]} = 5.85 \text{ kg/cucm}$$

**CPLT- 05:**

From the load vs elastic rebound plot, the slope of the trend line =  $C_u = (30-10)/(0.69-0.23) = 43.65$  kg/cucm

Now, for a foundation size of 10 sqm (3m x 3.33m, say), the corresponding value will be,

$$C_{u10sqm} = 43.65 \times \sqrt{[(0.60 \times 0.60) / 10]} = 8.28 \text{ kg/cucm}$$

**CPLT- 06:**

From the load vs elastic rebound plot, the slope of the trend line =  $C_u = (60-30)/(0.47-0.23) = 129.59 \text{ kg/cucm}$

Now, for a foundation size of 10 sqm (3m x 3.33m, say), the corresponding value will be,

$$C_{u10sqm} = 129.59 \times \sqrt{[(0.60 \times 0.60) / 10]} = 24.59 \text{ kg/cucm}$$

**CPLT- 07:**

From the load vs elastic rebound plot, the slope of the trend line =  $C_u = (60-30)/(1.09-0.55) = 54.95 \text{ kg/cucm}$

Now, for a foundation size of 10 sqm (3m x 3.33m, say), the corresponding value will be,

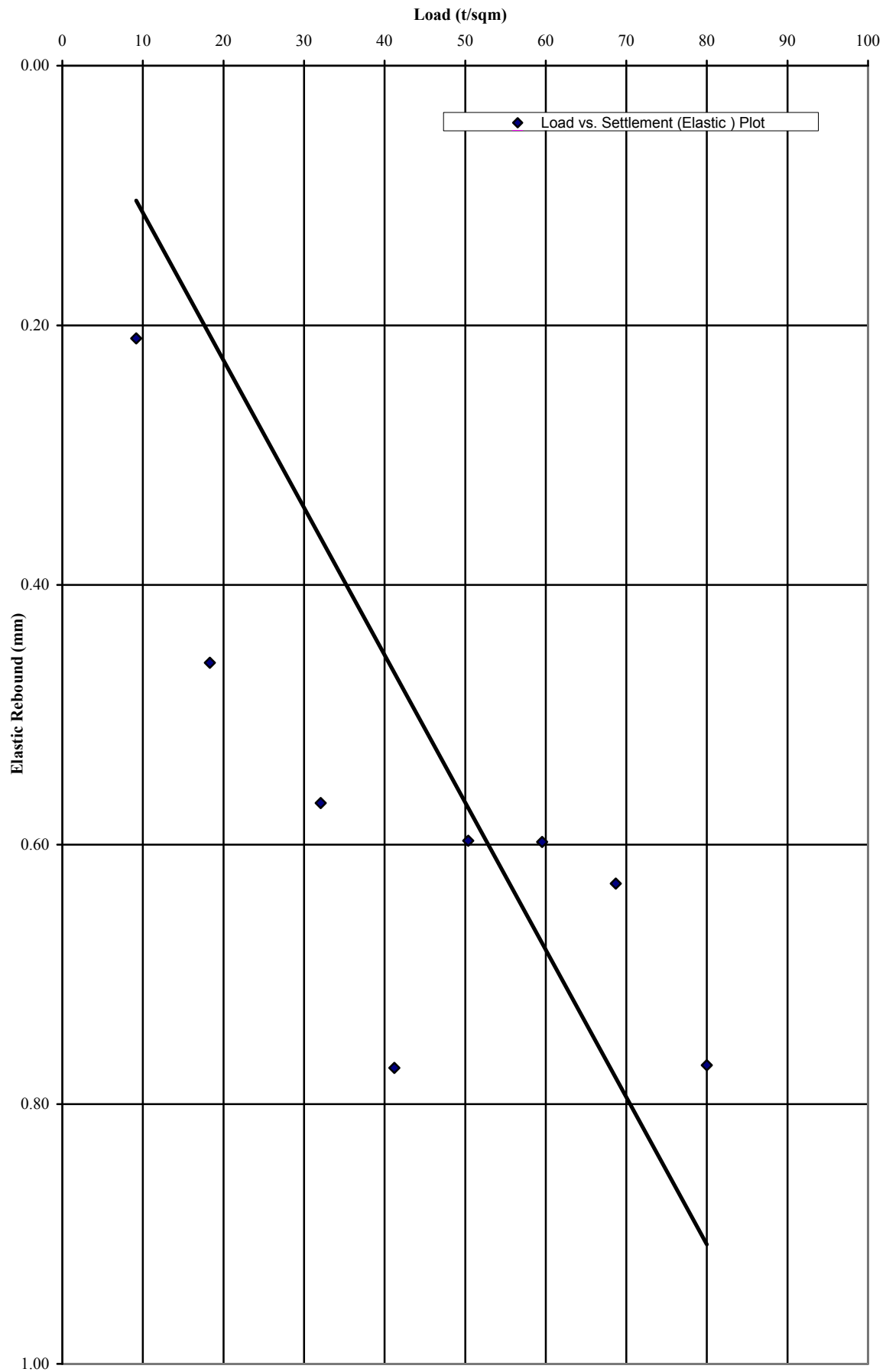
$$C_{u10sqm} = 54.95 \times \sqrt{[(0.60 \times 0.60) / 10]} = 10.43 \text{ kg/cucm}$$

**Note:** Following relations are to be used to calculate the coefficient of non uniform compression & shear (as per IS: 5249).

Coefficient of elastic uniform shear,  $C_\tau = 0.50C_u$

Co-efficient of elastic non-uniform compression =  $3.46C_\tau$

Coefficient of elastic non-uniform shear =  $1.50C_\tau$



**Fig. 3.08 Load Vs. Elastic Rebound Plot (CPLT-01)**  
840 of 1127

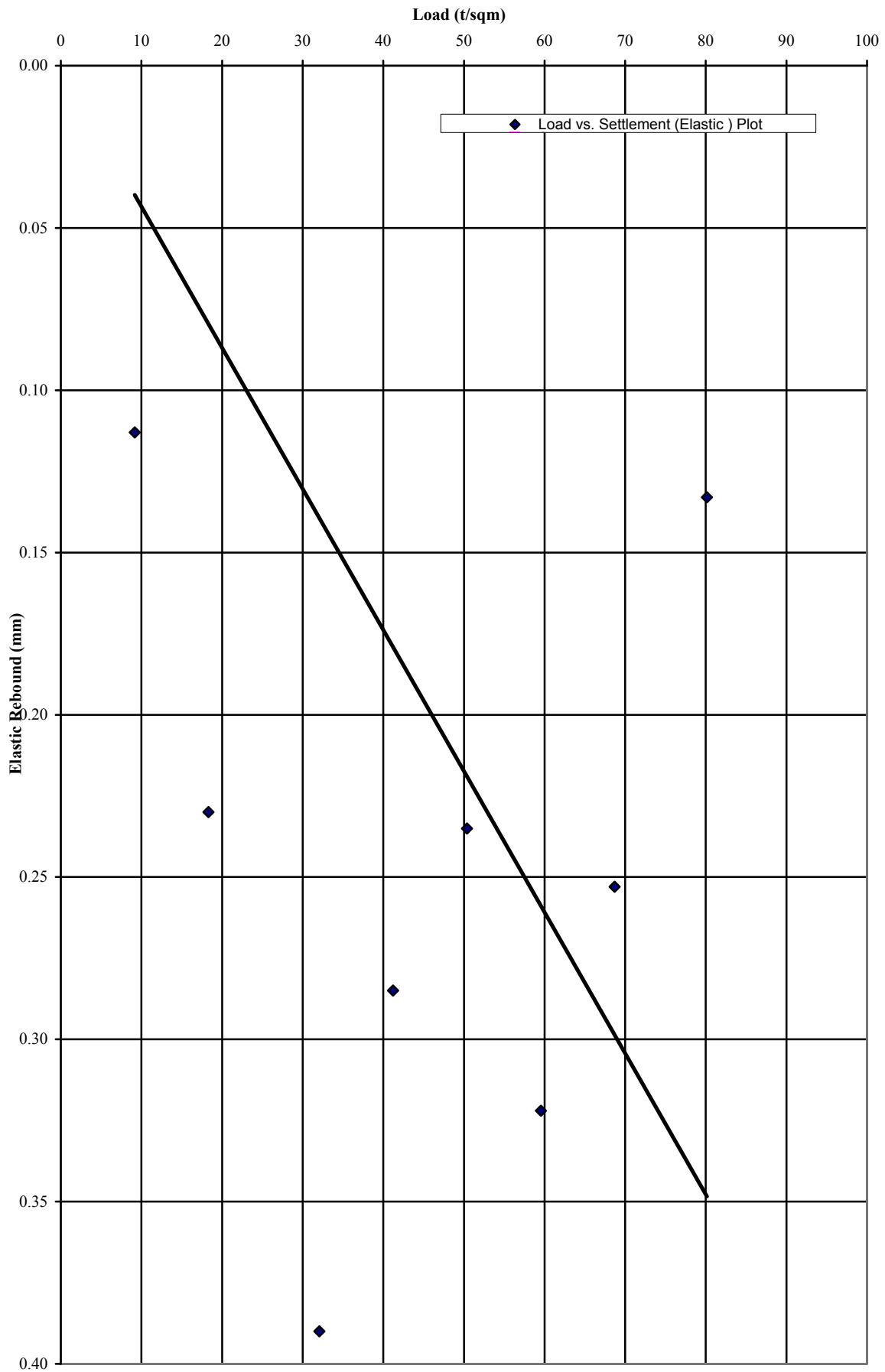
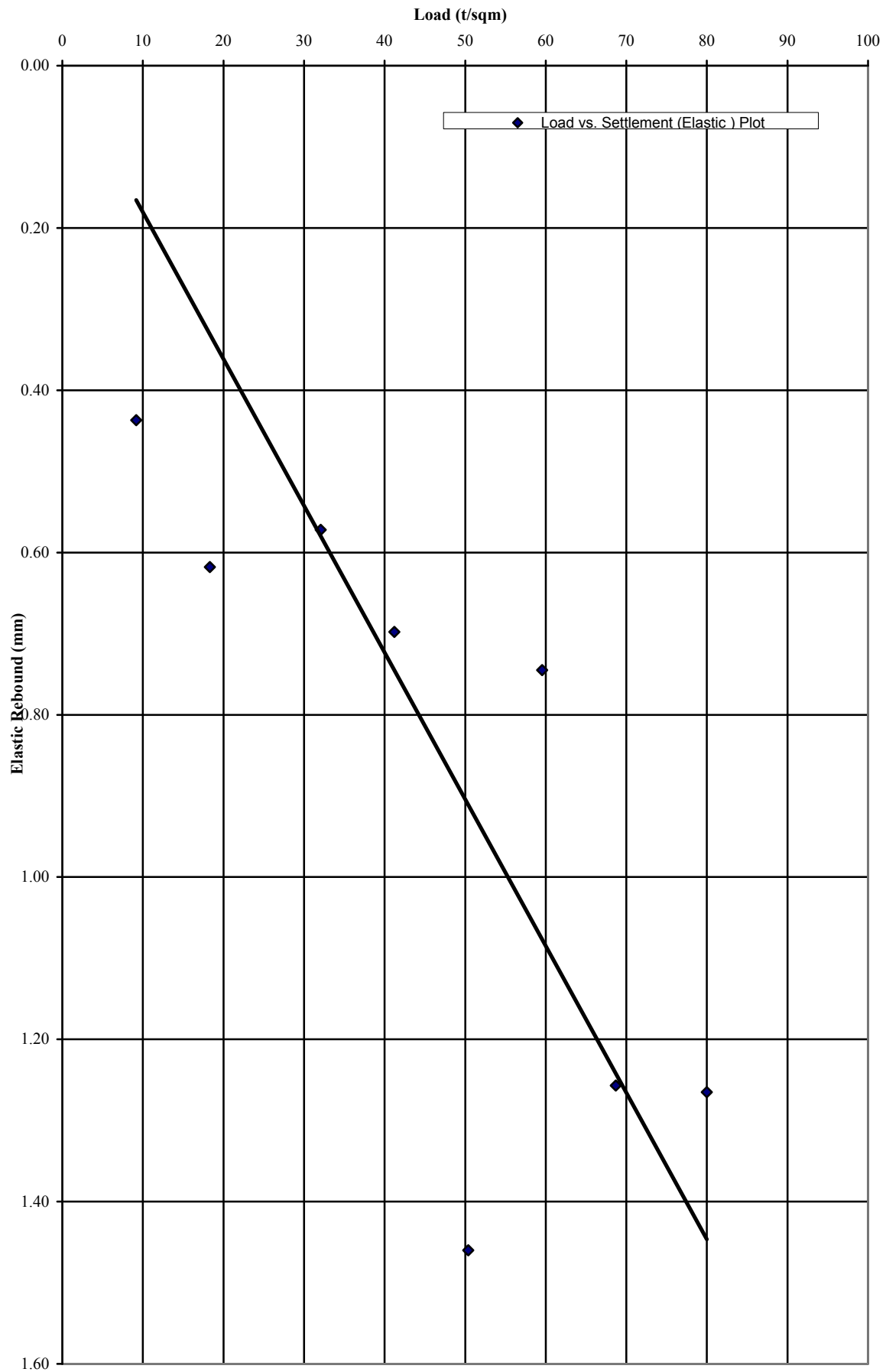


Fig. 3.09 Load Vs. Elastic Rebound Plot (CPLT-02)  
841 of 1127





**Fig. 3.10 Load Vs. Elastic Rebound Plot (CPLT-03)**  
842 of 1127

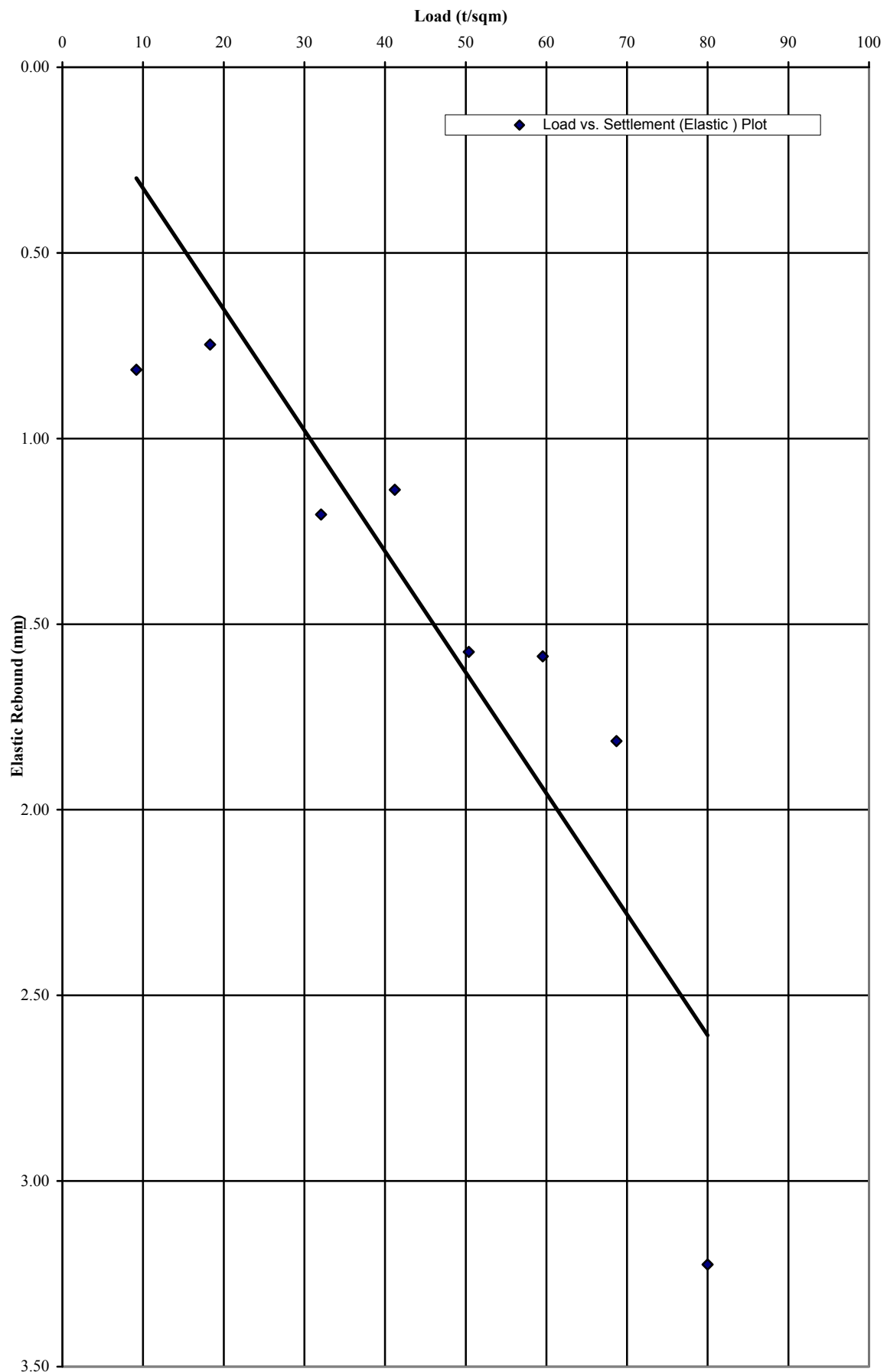


Fig. 3.11 Load Vs. Elastic Rebound Plot (CPLT-04)

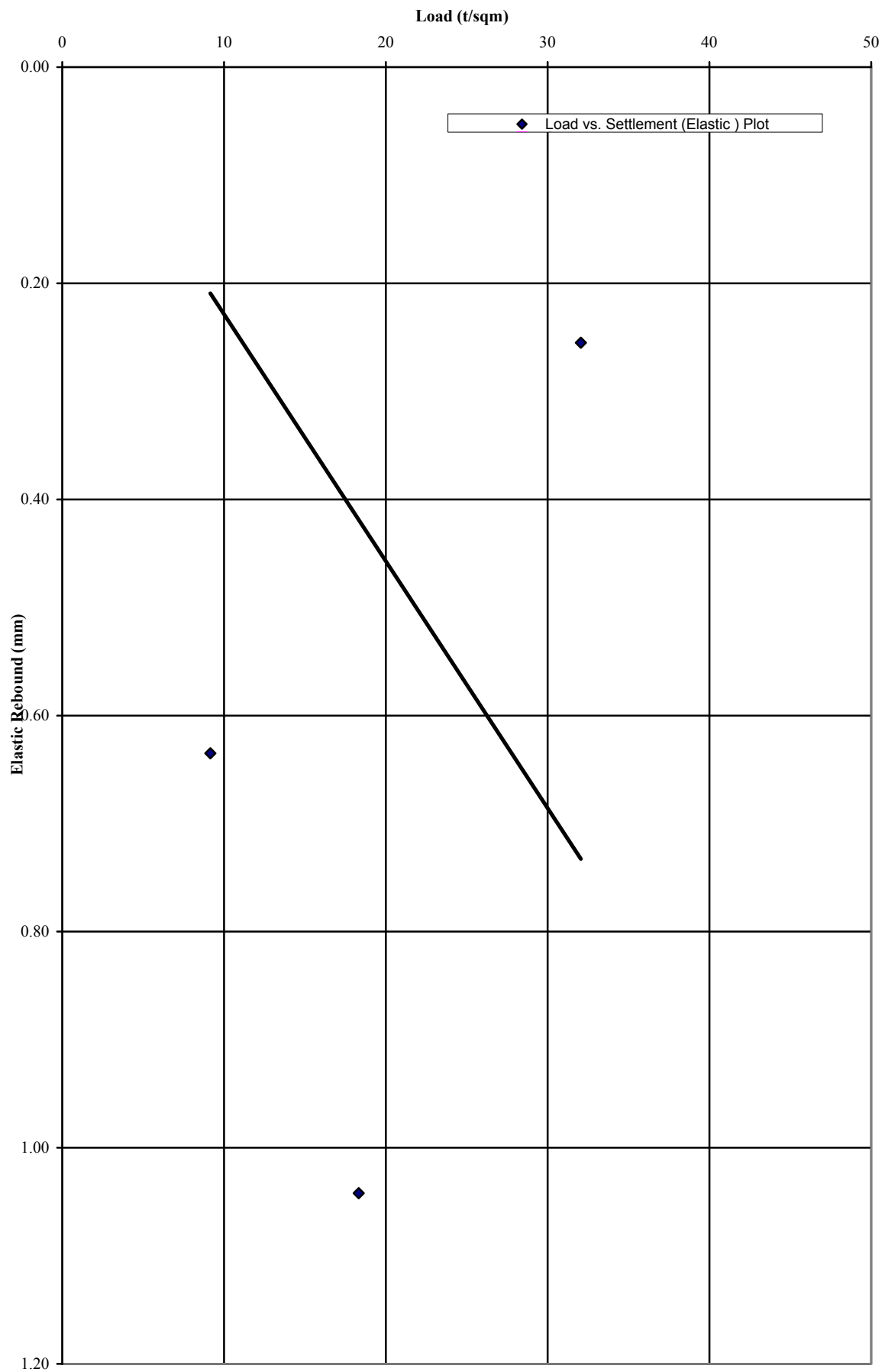


Fig. 3.12 Load Vs. Elastic Rebound Plot (CPLT-05)  
844 of 1127

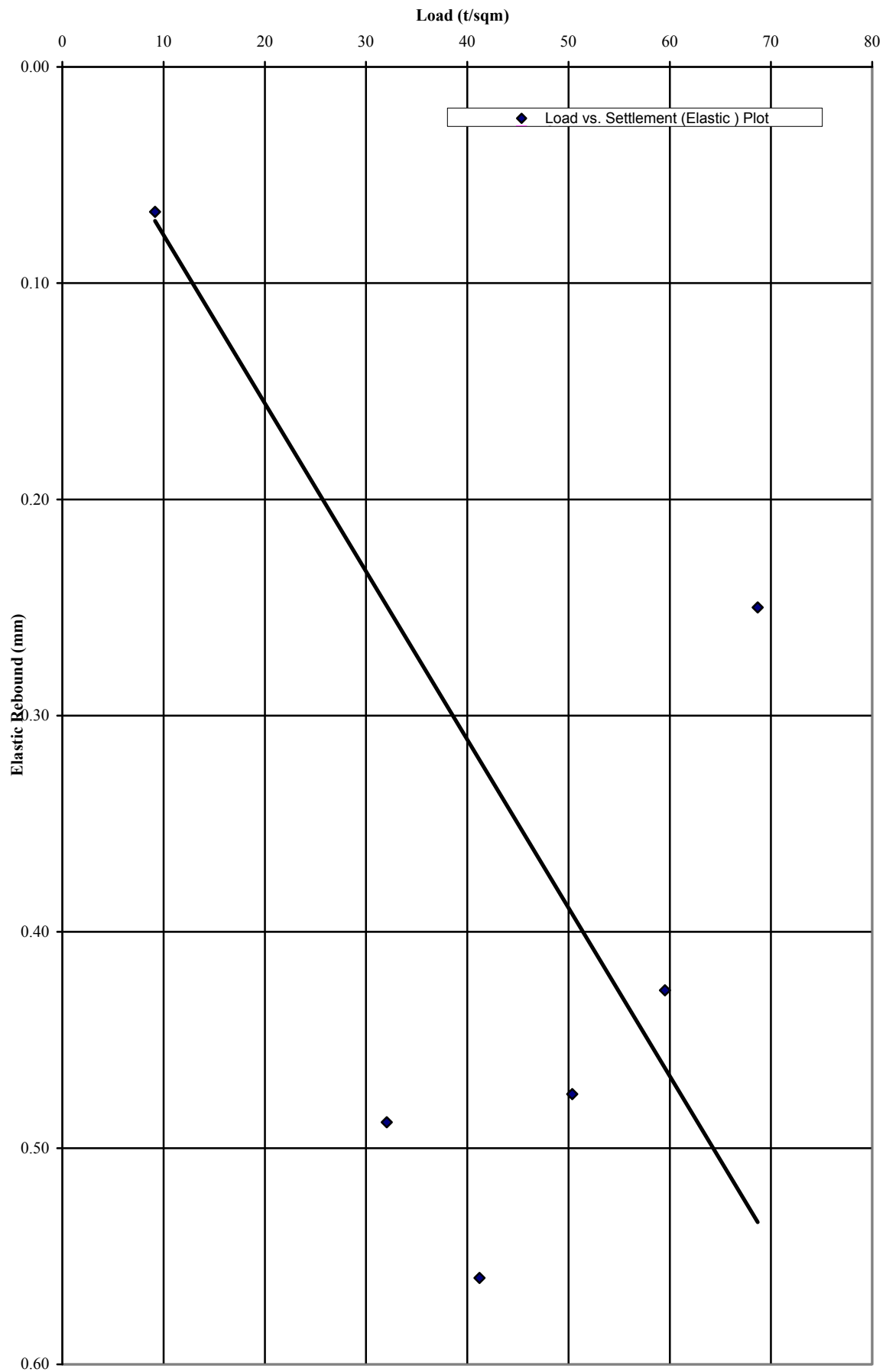


Fig. 3.13 Load Vs. Elastic Rebound Plot (CPLT-06)

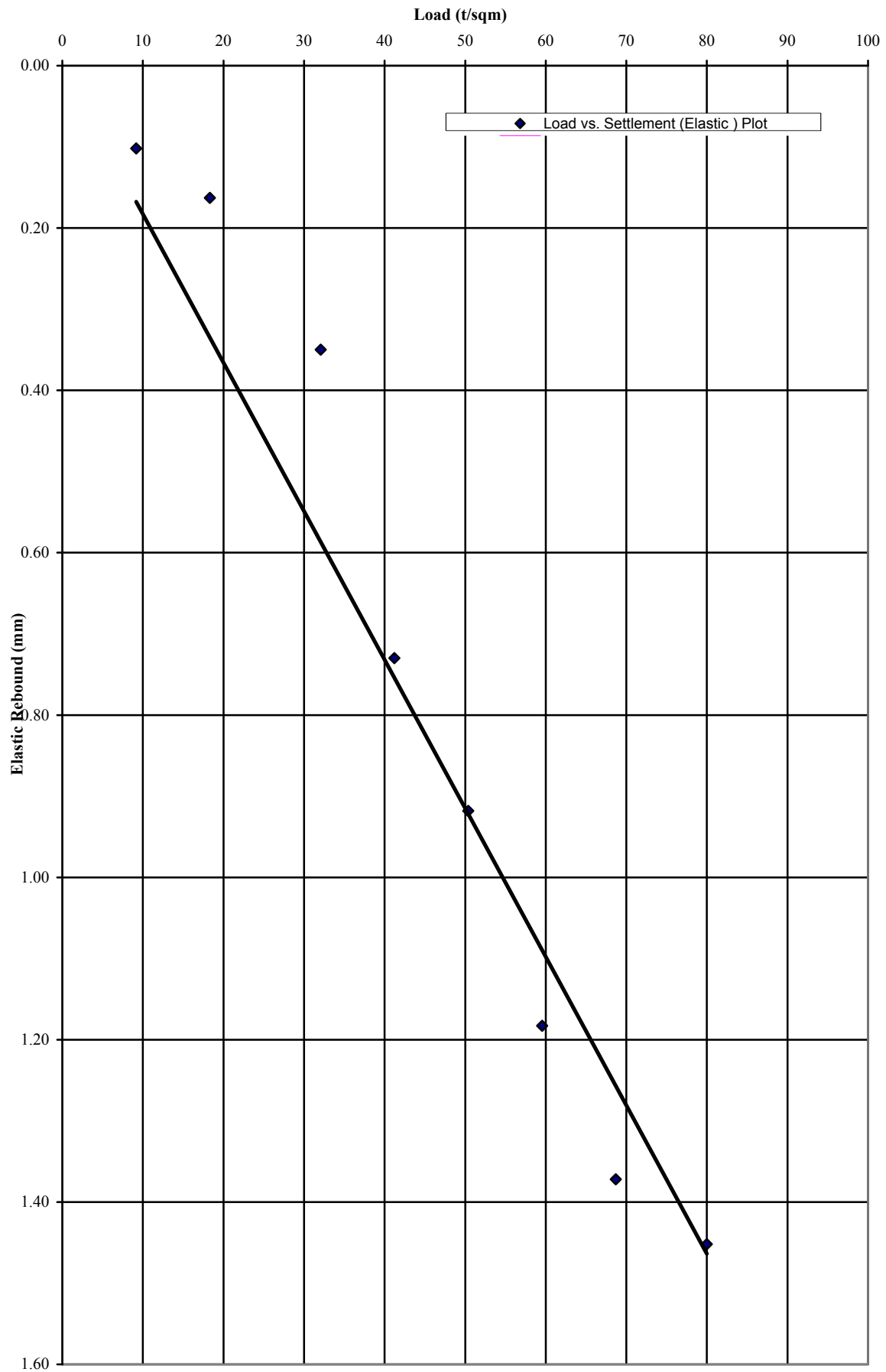


Fig. 3.14 Load Vs. Elastic Rebound Plot (CPLT-07)

## 5.2. DETAILS OF STRUCTURES:

The subsoil quality, thickness of each layer varies widely within the zone of investigation. Again, the type of structures to be constructed is different with different requirement. Considering all these aspect, the entire area is subdivided in to the following.

Sl. No.	Structure Name	Bore Hole Points	Reference Figure No.
1	Secondary Crushing	BH-02	2.01
2	Substation-07	BH-03	2.02
3	Substation-01	BH-04	2.03
4	Bauxite Grinding	BH-05, 07	2.04
5		BH-10	2.05
6	Main Pipe Rack for Main Plant	BH-06, 15, 31, 41 & 42	2.06
7	Acid Plant	BH-08	2.07
8	Predisilication	BH – 09, 11	2.08
9	Digestion	BH-12, 13	2.09
10	Condensate Tank Farm	BH-14, 28	2.10
11	Evaporation	BH-16	2.11
12	SFL Tank Farm	BH-17, 18	2.12
13	Settling, Washing	BH-23 to 27	2.13
14	Flocculation	BH-29	2.14
15	HCS D Pumps, Substation US-504	BH-33, 34	2.15
16	Substation-02	BH-32	2.16
17	Assembly Area	BH-35	2.17
18	Canteen	BH-36	2.18
19	Hydrate Filtration	BH-38	2.19
20	Cooling Towers & Cooling Water Distribution	BH-39	2.20
21	Substation-04	BH-43	2.21
22	Precipitation	BH-45, 46	2.22
23	Bauxite Handling-conveyor	BH-126	2.23

### 5.3. USE OF SHALLOW FOUNDATION:

Bearing capacity is calculated based on BH-23.

Place the foundation at 3.5m below FGL (FGL = 933.000M)

Founding level falls inside very stiff clay layer i.e. layer I.

N value in this layer = 28, So, estimated cohesion from N value = 1.14 kg/sqcm

However, to be in safer side, use  $C = 1.00$  and  $\Phi = 0^\circ$

#### 5.3.1. Evaluation of Strength and Deformation Parameters:

##### For Stratum – I:

Total soil modulus,  $E_s = 4.4 \times N = 123.2$  kg/sqcm

[Ref. to “History of Soil penetration testing” by B. B. Broms & N. Flodin in “Penetration Testing 1988”, ISPOT-1: vol.1, p – 185]

Undrained Young's modulus,  $E_u = K \times C = 500 \times 1.00 = 500$  kg/sqcm

Again,  $1/E_s = 1/E_u + 1/E_d$  giving drained young's modulus,  $E_d = 163.48$  kg/sqcm

Now, we have,  $E_d = E_u/3 = 166.67$  kg/sqcm

[Refer to “Cone Penetration Testing” by A.C.Meigh, pp. No. – 53]

Considering the above, let us use  $E_d = 146$  kg/sqcm

From  $E_d$ ,  $m_{vc} = 1/G.E_d = 0.0101$  sqcm/kg [Geological Factor,  $\lambda = 0.60$  &  $\mu = 0.35$ ]

Again from SPT “N”,  $m_{vc} = 1/5N = 0.0071$  sqcm/kg

[Refer to “Standard Penetration Test, State-of-the-art-Report” by Ivan K. Nixon in “Penetration testing 1” Edited by A.Verrujt, F.L.beringen & E.H.De Leeuw, pp. No. 11]

Use  $m_{vc} = [0.0101 + 0.0071]/2 = 0.0086$  sqcm/kg

##### For Stratum II

Average N value in this layer = 50, So, estimated cohesion from N value = 1.85 kg/sqcm

However, to be in safer side, use  $C = 1.50$ kg/sqcm and  $\Phi = 0^\circ$

Total soil modulus,  $E_s = 4.4 \times N = 220$  kg/sqcm

Undrained Young's modulus,  $E_u = K \times C = 500 \times 1.50 = 750$  kg/sqcm

Again,  $1/E_s = 1/E_u + 1/E_d$  giving drained young's modulus,  $E_d = 311.32$  kg/sqcm

Now, we have,  $E_d = E_u/3 = 250$  kg/sqcm

Considering the above, let us use  $E_d = 280$  kg/sqcm

From  $E_d$ ,  $m_{vc} = 1/G.E_d = 0.0065$  sqcm/kg [Geological Factor,  $\lambda = 0.55$  &  $\mu = 0.35$ ]

Again from SPT “N”,  $m_{vc} = 1/5N = 0.0040$  sqcm/kg

Use  $m_{vc} = [0.0065 + 0.0040]/2 = 0.0052$  sqcm/kg

##### For Stratum IV, V & VI

Use Young's modulus,  $E_s$  for layer IV, V & VI = 2500 kg/sqcm, 5000 kg/sqcm & 10000 kg/sqcm respectively (based on our earlier investigation data).

### 5.3.2. Determination of Bearing Capacity:

The Net Ultimate Bearing Capacity is given as:

$$q_{nu} = C.N_c.S_c.D_c + q.N_q.S_q.D_q + 0.5\gamma.B.N_\gamma.S_\gamma.D_\gamma - q$$

Where,

$N_c$ ,  $N_q$  and  $N_\gamma$  are bearing capacity factors,

$S_c$ ,  $S_q$  and  $S_\gamma$  are shape factors,

$D_c$ ,  $D_q$  and  $D_\gamma$  are depth factors,

And

$C$  = Cohesion

$q$  = Overburden pressure,

$B$  = Width of foundation,

$\gamma$  = Effective density below foundation.

Use depth of foundation = 3.50m below FGL & size of footing = 3m x 6m

Cohesion,  $C = 10.00$  t/sqm

Using  $\phi = 0$  degree, the bearing capacity factors are:

$$N_c = 5.14$$

$$N_q = 1.00$$

$$N_\gamma = 0.00$$

Use,

Depth of Foundation =  $D_f = 3.5$  M (Below Finished Ground level)

Width of Foundation =  $B = 3$  M

Length of Foundation =  $L = 6$  M

Overburden Pressure =  $q = 3.500$  (Depth) x  $0.90$  (Submerged density) =  $3.15$  t/sqm (Assuming the ground water table is flushing with the ground level)

The Shape factors are [ IS:6403 - 1981 ]

$$S_c = 1.10 \quad S_q = 1.10 \quad S_\gamma = 0.80$$

The Depth factors are [ IS:6403 - 1981 ]

$$D_c = 1.23 \quad D_q = 1.00 \quad D_\gamma = 1.00$$

Computed Net Ultimate Bearing Capacity =  $70.11$  t/sqm

**Using a factor of safety of 2.5, Net Safe Bearing Capacity = 28.04 t/sqm**

The above bearing capacity should be checked against settlement criteria. This is shown below.



**SETTLEMENT CALCULATION:****Settlement Analysis****A) General Data:**

Width of foundation =	3.0	m
Length of foundation =	6.0	m
Depth of foundation =	3.5	m
Net Base Pressure =	2.6	kg/sqcm

**B) Subsoil Properties:****Layer - I**

Young's Modulus =	500	kg/sqcm
Poisson Ratio, $\mu$ =	0.35	
Top of Stratum =	3.50	m
End of Stratum =	5.42	m
Geological factor, $\lambda$ =	0.60	
$m_{vc}$ =	0.0086	sqcm/kg

**Layer - II**

Young's Modulus =	750	kg/sqcm
Poisson Ratio, $\mu$ =	0.35	
Top of Stratum =	5.42	m
End of Stratum =	9.50	m
Geological factor, $\lambda$ =	0.55	
$m_{vc}$ =	0.0052	sqcm/kg

**C) Calculation of Immediate Settlement:***Settlement at center*

$M = L' / B' =$	2.000	
$N = H / B' =$	1.280	
$I_1 =$	0.175	
$I_2 =$	0.111	
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.227	
Immediate settlement $S_i =$	0.621	cm
$[q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s$		

*Settlement at center*

$M = L' / B' =$	1.610	
$N = H / B' =$	1.659	
$I_1 =$	0.244	
$I_2 =$	0.097	
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.289	
Immediate settlement $S_i =$	0.399	cm
$[q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s$		

*Settlement at corner*

$M = L' / B' =$	2.00	
$N = H / B' =$	0.640	
$I_1 =$	0.061572	
$I_2 =$	0.094828	
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.105	
Immediate settlement $S_i =$	0.144	cm

*Settlement at corner*

$M = L' / B' =$	1.61	
$N = H / B' =$	0.829	
$I_1 =$	0.098	
$I_2 =$	0.099	
$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 =$	0.144	
Immediate settlement $S_i =$	0.100	cm

Average  $S_i$  for Stratum I = 3.82 mm

Total immediate settlement = 6.32 mm

Average  $S_i$  for Stratum II = 2.49 mm

(for both the layer)

**D) Calculation of Consolidation Settlement:**

Strata	From (M)	To (M)	Thickness (M)	Mid depth (M)	$\Delta P$ (kg/sqcm)	$m_{vc}$ sqcm/kg	$\lambda$	$S_c$ (cm)
Layer - I	3.50	4.46	0.96	0.48	2.08	0.0086	0.60	1.03
	4.46	5.42	0.96	1.44	1.42	0.0086	0.60	0.70
Layer - II	5.42	7.46	2.04	2.94	0.88	0.0052	0.55	0.51
	7.46	9.50	2.04	4.98	0.53	0.0052	0.55	0.31

Hence, Total Consolidation Settlement = 25.56 mm

So, Total Settlement = 31.87 mm

Foxe's Depth correction Factor = 0.76

**Corrected total settlement = 24.33 mm**

The calculated settlement is well within permissible limit. So, use a net allowable bearing capacity of 26t/sqm for depth of foundation of 3.50m below FGL for a limiting settlement of 25mm.

### 5.3.3. RECOMMENDATION:

With reference to the above and considering the subsoil condition around each bore hole, the following bearing capacity values may be used.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Secondary Crushing	BH-02 (FGL = 920.000M)	1.00	1 < B ≤ 3	1.00 - 2.00	29.01	--	22	28
			3 < B ≤ 6	1.00 - 2.00	28.28	--	13	20
			B ≥ 6	1.00 - 2.00	28.10	--	18	28
		2.00	1 < B ≤ 3	1.00 - 2.00	30.85	--	25	30
			3 < B ≤ 6	1.00 - 2.00	29.41	--	14	22
			B ≥ 6	1.00 - 2.00	29.04	--	19	28
		3.00	1 < B ≤ 3	1.00 - 2.00	32.70	--	27	30
			3 < B ≤ 6	1.00 - 2.00	30.53	--	15	24
			B ≥ 6	1.00 - 2.00	29.99	--	20	29
Substation-07	BH-03 (FGL = 920.000M)	0.00 - 3.25	Filling soil. Use a net allowable bearing capacity of 5t/sqm.					
		4.50	1 < B ≤ 3	1.00 - 2.00	77.12	--	30	30
			3 < B ≤ 6	1.00 - 2.00	82.12	--	25	30
			B ≥ 6	1.00 - 2.00	85.90	--	25	30
		5.50	1 < B ≤ 3	1.00 - 2.00	94.37	--	30	30
			3 < B ≤ 6	1.00 - 2.00	96.83	--	30	30
Substation-01	BH-04 (FGL = 928.000M)	0.00 - 4.00	Filling soil. Use a net allowable bearing capacity of 5t/sqm.					
		5.00	1 < B ≤ 3	1.00 - 2.00	40.43	--	30	30
			3 < B ≤ 6	1.00 - 2.00	36.41	--	24	30
			B ≥ 6	1.00 - 2.00	35.44	--	24	30
		6.00	1 < B ≤ 6	1.00 - 2.00	37.92	--	30	30
			B ≥ 6	1.00 - 2.00	36.74	--	30	30
Bauxite Grinding	BH-05 (FGL = 928.000M)	0.00 - 2.20	Filling soil. Use a net allowable bearing capacity of 5t/sqm.					
		4.00	1 < B ≤ 6	1.00 - 2.00	79.14	--	30	30
			B ≥ 6	1.00 - 2.00	79.10	--	30	30
		5.00 - 7.00	1 < B ≤ 6	1.00 - 2.00	141.01	30	--	--
			B ≥ 6	1.00 - 2.00	122.82	30	--	--
	BH-07 (FGL = 928.000M)	1.50 - 3.00	1 < B ≤ 6	1.00 - 2.00	33.00	30	--	--
			B ≥ 6	1.00 - 2.00	63.68	30	--	--
		4.00 - 5.00	1 < B ≤ 6	1.00 - 2.00	236.10	100	--	--
			B ≥ 6	1.00 - 2.00	236.10	100	--	--
	BH-10 (FGL = 930.000M)	1.00 - 3.00	1 < B ≤ 6	1.00 - 2.00	258.05	100	--	--
			B ≥ 6	1.00 - 2.00	258.05	100	--	--
Pipe Rack	BH-06 (FGL = EGL)	1.50 - 3.00	1 < B ≤ 6	1.00 - 2.00	56.95	30	--	--
			B ≥ 6	1.00 - 2.00	63.68	30	--	--
Acid Plant	BH-08 (FGL = 928.000M)	1.00	1 < B ≤ 6	1.00 - 2.00	36.62	--	30	30
			B ≥ 6	1.00 - 2.00	41.62	--	30	30
		3.00	1 < B ≤ 6	1.00 - 2.00	81.60	30	--	--
			B ≥ 6	1.00 - 2.00	87.76	30	--	--
		4.00 - 5.00	1 < B ≤ 6	1.00 - 2.00	98.36	50	--	--
			B ≥ 6	1.00 - 2.00	98.36	50	--	--
		6.00	1 < B ≤ 6	1.00 - 2.00	280.00	100	--	--
			B ≥ 6	1.00 - 2.00	280.00	100	--	--
Predisilication	BH-09 & 11 (FGL = 930.000M)	1.00 - 3.00	1 < B ≤ 6	1.00 - 2.00	258.05	100	--	--
			B > 6	1.00 - 2.00	258.05	100	--	--
Digestion	BH-12 & 13 (FGL = 930.000M)	2.00	1 < B ≤ 6	1.00 - 2.00	48.96	--	30	30
			B ≥ 6	1.00 - 2.00	48.36	--	30	30
		3.00 - 5.00	1 < B ≤ 6	1.00 - 2.00	81.60	30	--	--
			B ≥ 6	1.00 - 2.00	87.76	30	--	--

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)			
						S = 12mm	S = 25mm	S = 40mm	
Pipe Rack	BH-15 (FGL = EGL)	1.00	1 <B ≤3	1.00 - 2.00	29.01	--	22	28	
			3 <B ≤6	1.00 - 2.00	28.28	--	13	20	
			B≥ 6	1.00 - 2.00	28.10	--	18	28	
		2.00	1 <B ≤3	1.00 - 2.00	30.85	--	25	30	
			3 <B ≤6	1.00 - 2.00	29.41	--	14	22	
			B≥ 6	1.00 - 2.00	29.04	--	19	28	
		3.00	1 <B ≤3	1.00 - 2.00	32.70	--	27	30	
			3 <B ≤6	1.00 - 2.00	30.53	--	15	24	
			B≥ 6	1.00 - 2.00	29.99	--	20	29	
Evaporation	BH-16 (FGL = 930.000M)	1.00 - 5.00	1 <B ≤6	1.00 - 2.00	49.24	30	--	--	
			B≥ 6	1.00 - 2.00	56.07	30	--	--	
		6.50	1 <B ≤6	1.00 - 2.00	98.36	50	--	--	
			B≥ 6	1.00 - 2.00	98.36	50	--	--	
		8.00	1 <B ≤6	1.00 - 2.00	258.05	100	--	--	
			B≥ 6	1.00 - 2.00	258.05	100	--	--	
SFL Tank Farm	BH-17 (FGL = 930.00)	0.00 - 4.00	Filling soil. Use a net allowable bearing capacity of 5t/sqm.						
		5.00	1 <B≤3	1.0	36.03	--	30	30	
				1.5	31.34	--	28	30	
				2.0	30.36	--	25	30	
			3 <B ≤6	1.0	32.46	--	18	28	
				1.5	28.23	--	16	25	
				2.0	27.34	--	14	22	
			B≥ 6	1.0	31.57	--	18	28	
				1.5	27.45	--	16	25	
				2.0	26.59	--	15	24	
		6.00	1 <B≤3	1.0	37.88	--	30	30	
				1.5	32.94	--	30	30	
				2.0	31.91	--	28	30	
			3 <B ≤6	1.0	33.60	--	20	30	
				1.5	29.21	--	17	27	
				2.0	28.28	--	16	25	
			B≥ 6	1.0	32.53	--	20	30	
				1.5	28.27	--	18	28	
				2.0	27.38	--	16	25	
		SFL Tank Farm	BH-18 (FGL = 930.00)	0.00 - 5.50	Filling soil. Use a net allowable bearing capacity of 5t/sqm.				
7.00	1 <B ≤3			1.00 - 2.00	40.09	--	30	30	
	3 <B ≤6			1.00 - 2.00	35.02	--	30	30	
	B≥ 6			1.00 - 2.00	33.75	--	30	30	
Settling, Washing	BH-23 (FGL = 933.00)	3.50	1 <B≤3	1.0	30.71	--	30	30	
				1.5	28.93	--	28	28	
				2.0	28.04	--	26	28	
			3 <B ≤6	1.0	28.40	--	20	28	
				1.5	26.75	--	16	25	
				2.0	25.93	--	15	25	
			B≥ 6	1.0	27.83	--	16	26	
				1.5	26.21	--	14	22	
				2.0	25.40	--	13	20	
			4.50	1 <B≤3	1.0	32.43	--	30	30
					1.5	30.53	--	30	30
					2.0	29.59	--	28	28
		3 <B ≤6		1.0	29.46	--	23	29	
				1.5	27.74	--	20	27	
				2.0	26.87	--	18	26	
		B≥ 6		1.0	28.72	--	19	28	
				1.5	27.04	--	16	26	
				2.0	26.19	--	15	24	
		5.50	1 <B≤3	1.0	34.14	--	30	30	
				1.5	32.14	--	30	30	
				2.0	31.13	--	30	30	
			3 <B ≤6	1.0	30.52	--	28	30	
				1.5	28.72	--	25	28	
				2.0	27.81	--	24	27	
			B≥ 6	1.0	29.62	--	24	28	
				1.5	27.86	--	20	27	
				2.0	26.98	--	18	26	
		6.50	1 <B≤3	1.0	53.56	--	30	30	
				1.5	50.45	--	30	30	
				2.0	48.90	--	30	30	
			3 <B ≤6	1.0	47.14	--	30	30	
				1.5	44.39	--	25	30	
				2.0	43.01	--	23	30	
B≥ 6	1.0		45.53	--	26	30			
	1.5		42.87	--	21	30			
	2.0		41.54	--	19	30			

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Settling, Washing	BH-24 (FGL = 933.00)	1.50	$1 < B \leq 3$	1.0	27.27	--	27	27
				1.5	25.72	--	25	25
				2.0	24.95	--	22	24
			$3 < B \leq 6$	1.0	26.28	--	22	26
				1.5	24.79	--	18	24
				2.0	24.05	--	16	22
			$B \geq 6$	1.0	26.03	--	18	26
				1.5	24.56	--	15	22
				2.0	23.82	--	13	20
		2.50	$1 < B \leq 3$	1.0	28.99	--	28	28
				1.5	27.33	--	26	26
				2.0	26.50	--	24	24
			$3 < B \leq 6$	1.0	27.34	--	25	27
				1.5	25.77	--	21	25
				2.0	24.99	--	19	24
			$B \geq 6$	1.0	26.93	--	20	26
				1.5	25.38	--	18	24
				2.0	24.61	--	16	22
		3.50	$1 < B \leq 3$	1.0	30.71	--	30	30
				1.5	28.93	--	28	28
				2.0	28.04	--	26	28
			$3 < B \leq 6$	1.0	28.40	--	26	28
				1.5	26.75	--	23	26
				2.0	25.93	--	21	25
			$B \geq 6$	1.0	27.83	--	23	27
				1.5	26.21	--	19	25
				2.0	25.40	--	18	23
		4.50	$1 < B \leq 3$	1.0	48.47	--	30	30
				1.5	45.69	--	30	30
				2.0	44.30	--	30	30
			$3 < B \leq 6$	1.0	44.03	--	30	30
				1.5	41.49	--	26	30
				2.0	40.23	--	24	30
			$B \geq 6$	1.0	42.92	--	28	30
				1.5	40.44	--	22	30
				2.0	39.21	--	20	30
Settling, Washing	BH-25 (FGL = 933.00)	1.00	$1 < B \leq 3$	1.0	27.74	--	27	27
				1.5	25.73	--	25	25
				2.0	26.74	--	25	25
			$3 < B \leq 6$	1.0	37.60	--	30	30
				1.5	34.76	--	30	30
				2.0	36.62	--	30	30
			$B \geq 6$	1.0	42.59	--	30	30
				1.5	39.34	--	30	30
				2.0	41.62	--	30	30
		2.00	$1 < B \leq 3$	1.0	47.87	--	30	30
				1.5	44.62	--	30	30
				2.0	45.48	--	30	30
			$3 < B \leq 6$	1.0	58.42	--	30	30
				1.5	54.25	--	30	30
				2.0	56.14	--	30	30
			$B \geq 6$	1.0	64.01	--	30	30
				1.5	59.37	--	30	30
				2.0	61.76	--	30	30
		3.00	$1 < B \leq 3$	1.0	65.33	--	30	30
				1.5	61.05	--	30	30
				2.0	61.55	--	30	30
			$3 < B \leq 6$	1.0	74.28	--	30	30
				1.5	69.18	--	30	30
				2.0	70.74	--	30	30
			$B \geq 6$	1.0	79.48	--	30	30
				1.5	73.92	--	30	30
				2.0	76.00	--	30	30

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Settling, Washing	BH-26 (FGL = 933.00)	2.00	$1 < B \leq 3$	1.0	28.13	--	28	28
				1.5	26.53	--	26	26
				2.0	25.72	--	24	25
			$3 < B \leq 6$	1.0	26.81	--	24	26
				1.5	25.28	--	20	25
				2.0	24.52	--	18	24
			$B \geq 6$	1.0	26.48	--	20	26
				1.5	24.97	--	18	24
				2.0	24.22	--	16	22
		3.00	$1 < B \leq 3$	1.0	29.85	--	28	29
				1.5	28.13	--	26	28
				2.0	27.27	--	24	27
			$3 < B \leq 6$	1.0	27.87	--	26	27
				1.5	26.26	--	22	26
				2.0	25.46	--	20	25
			$B \geq 6$	1.0	27.38	--	24	27
				1.5	25.80	--	20	25
				2.0	25.01	--	18	24
		4.00	$1 < B \leq 3$	1.0	31.57	--	30	30
				1.5	29.73	--	29	29
				2.0	28.82	--	28	28
			$3 < B \leq 6$	1.0	28.93	--	28	28
				1.5	27.24	--	25	27
				2.0	26.40	--	23	26
			$B \geq 6$	1.0	28.27	--	26	28
				1.5	26.62	--	23	26
				2.0	25.80	--	21	25
		5.00	$1 < B \leq 3$	1.0	91.73	--	30	30
				1.5	85.98	--	30	30
				2.0	85.59	--	30	30
			$3 < B \leq 6$	1.0	94.94	--	30	30
				1.5	88.73	--	30	30
				2.0	89.38	--	30	30
			$B \geq 6$	1.0	98.28	--	30	30
				1.5	91.74	--	30	30
				2.0	92.86	--	30	30
Settling, Washing	BH-27 (FGL = 933.00)	6.50	$1 < B \leq 3$	1.0	38.81	--	30	30
				1.5	33.74	--	30	30
				2.0	32.68	--	30	30
			$3 < B \leq 6$	1.0	34.17	--	30	30
				1.5	29.70	--	28	29
				2.0	28.76	--	26	28
			$B \geq 6$	1.0	33.02	--	28	30
				1.5	28.69	--	25	28
				2.0	27.77	--	23	27
		7.50	$1 < B \leq 3$	1.0	40.67	--	30	30
				1.5	35.34	--	30	30
				2.0	34.22	--	30	30
			$3 < B \leq 6$	1.0	35.32	--	30	30
				1.5	30.68	--	30	30
				2.0	29.70	--	29	29
			$B \geq 6$	1.0	33.98	--	30	30
				1.5	29.51	--	29	29
				2.0	28.57	--	28	28
		9.00	$1 < B \leq 3$	1.0	177.86	--	30	30
				1.5	167.14	--	30	30
				2.0	164.73	--	30	30
			$3 < B \leq 6$	1.0	165.57	--	30	30
				1.5	155.26	--	30	30
				2.0	154.31	--	30	30
			$B \geq 6$	1.0	165.03	--	30	30
				1.5	154.61	--	30	30
				2.0	154.24	--	30	30

Job No. : 4095

Sheet No.

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Flocculation	BH-29 (FGL = 933.00)	7.00	$1 < B \leq 3$	1.0	43.66	--	30	30
				1.5	37.96	--	30	30
				2.0	36.77	--	30	30
			$3 < B \leq 6$	1.0	38.17	--	22	30
				1.5	33.17	--	18	28
				2.0	32.12	--	16	25
			$B \geq 6$	1.0	36.80	--	17	27
				1.5	31.98	--	14	22
				2.0	30.96	--	13	20
		8.00	$1 < B \leq 3$	1.0	45.70	--	30	30
				1.5	39.72	--	30	30
				2.0	38.47	--	30	30
			$3 < B \leq 6$	1.0	39.42	--	22	30
				1.5	34.25	--	18	28
				2.0	33.16	--	16	25
			$B \geq 6$	1.0	37.85	--	22	30
				1.5	32.88	--	18	28
				2.0	31.83	--	16	25
HCSD Pumps	BH-33 (FGL = 935.150M)	1.00 - 3.00	$1 < B \leq 6$	1.00 - 2.00	280.00	100	--	--
			$B \geq 6$	1.00 - 2.00	280.00	100	--	--
Substation US-504	BH-34 (FGL = 935.150M)	1.00 - 3.00	$1 < B \leq 6$	1.00 - 2.00	258.05	100	--	--
			$B \geq 6$	1.00 - 2.00	258.05	100	--	--
Pipe Rack	BH-31 (FGL = EGL)	1.00	$1 < B \leq 3$	1.00 - 2.00	29.01	--	22	28
			$3 < B \leq 6$	1.00 - 2.00	28.28	--	13	20
			$B \geq 6$	1.00 - 2.00	28.10	--	18	28
		2.00	$1 < B \leq 3$	1.00 - 2.00	30.85	--	25	30
			$3 < B \leq 6$	1.00 - 2.00	29.41	--	14	22
			$B \geq 6$	1.00 - 2.00	29.04	--	19	28
		3.00	$1 < B \leq 3$	1.00 - 2.00	32.70	--	27	30
			$3 < B \leq 6$	1.00 - 2.00	30.53	--	15	24
			$B \geq 6$	1.00 - 2.00	29.99	--	20	29
Substation-02	BH-32 (FGL = 934.000M)	0.00 - 9.50	Filling soil. Use a net allowable bearing capacity of 5t/sqm.					
Assembly Area	BH-35 (FGL = 935.000M)	1.00 - 3.00	$1 < B \leq 6$	1.00 - 2.00	258.05	100	--	--
			$B \geq 6$	1.00 - 2.00	258.05	100	--	--
Canteen	BH-36 (FGL = 935.000M)	1.00 - 3.00	$1 < B \leq 6$	1.00 - 2.00	258.05	100	--	--
			$B \geq 6$	1.00 - 2.00	258.05	100	--	--
Hydrate Filtration	BH-38 (FGL = 935.000M)	1.00	$1 < B \leq 6$	1.00 - 2.00	98.36	50	--	--
			$B \geq 6$	1.00 - 2.00	98.36	50	--	--
		2.00 - 3.00	$1 < B \leq 6$	1.00 - 2.00	280.00	100	--	--
			$B \geq 6$	1.00 - 2.00	280.00	100	--	--
Cooling Towers & Cooling Water Distribution	BH-39 (FGL = 935.000M)	1.00 - 3.00	$1 < B \leq 6$	1.00 - 2.00	98.36	50	--	--
			$B \geq 6$	1.00 - 2.00	98.36	50	--	--
		4.00 - 5.00	$1 < B \leq 6$	1.00 - 2.00	258.05	100	--	--
			$B \geq 6$	1.00 - 2.00	258.05	100	--	--
Pipe Rack	BH-41 & 42 (FGL = EGL)	1.00 - 3.00	$1 < B \leq 6$	1.00 - 2.00	98.36	50	--	--
			$B \geq 6$	1.00 - 2.00	98.36	50	--	--
Substation-04	BH-43 (FGL = 935.000M)	0.00 - 15.00	Filling soil. Use a net allowable bearing capacity of 5t/sqm.					
Precipitation	BH-45 (FGL = 930.000M)	2.00 - 4.00	$1 < B \leq 6$	1.00 - 2.00	98.36	50	--	--
			$B \geq 6$	1.00 - 2.00	98.36	50	--	--

Structure Name	Foundation Location	Depth of Foundation below FGL (m)	Width of Foundation (m)	L/B Ratio	NSBC (t/sqm)	NABC (t/sqm)		
						S = 12mm	S = 25mm	S = 40mm
Precipitation	BH-46 (FGL = 930.000M)	9.50 - 10.50	1 < B ≤ 6	1.00 - 2.00	214.76	30	--	--
			B ≥ 6	1.00 - 2.00	214.06	30	--	--
		11.50	1 < B ≤ 6	1.00 - 2.00	98.36	50	--	--
			B ≥ 6	1.00 - 2.00	98.36	50	--	--
Bauxite Handling Conveyor	BH-126 (FGL = EGL)	1.50	1 < B ≤ 3	1.0	27.27	--	27	27
				1.5	25.72	--	25	25
				2.0	24.95	--	22	24
			3 < B ≤ 6	1.0	26.28	--	22	26
				1.5	24.79	--	18	24
				2.0	24.05	--	16	22
			B ≥ 6	1.0	26.03	--	18	26
				1.5	24.56	--	15	22
				2.0	23.82	--	13	20
		2.50	1 < B ≤ 3	1.0	28.99	--	28	28
				1.5	27.33	--	26	26
				2.0	26.50	--	24	24
			3 < B ≤ 6	1.0	27.34	--	25	27
				1.5	25.77	--	21	25
				2.0	24.99	--	19	24
			B ≥ 6	1.0	26.93	--	20	26
				1.5	25.38	--	18	24
				2.0	24.61	--	16	22
		3.50	1 < B ≤ 3	1.0	30.71	--	30	30
				1.5	28.93	--	28	28
				2.0	28.04	--	26	28
			3 < B ≤ 6	1.0	28.40	--	26	28
				1.5	26.75	--	23	26
				2.0	25.93	--	21	25
			B ≥ 6	1.0	27.83	--	23	27
				1.5	26.21	--	19	25
				2.0	25.40	--	18	23
		4.50	1 < B ≤ 3	1.0	48.47	--	30	30
				1.5	45.69	--	30	30
				2.0	44.30	--	30	30
			3 < B ≤ 6	1.0	44.03	--	30	30
				1.5	41.49	--	26	30
				2.0	40.23	--	24	30
			B ≥ 6	1.0	42.92	--	28	30
				1.5	40.44	--	22	30
				2.0	39.21	--	20	30

**Note:**

1. NSBC = Net Safe Bearing Capacity, NABC = Net Allowable Bearing Capacity, EGL = Existing Ground Level
2. S = Limiting Settlement.
3. However for foundation placed inside rock, permissible settlement is considered as 12mm irrespective of type of foundation.
4. In case any loose pocket is observed at the founding level, then the same should be excavated out and the same shall be filled up with PCC. below EGL / FGL and use a net allowable bearing capacity of 5t/sqm.
6. The Subsoil formation, SBC recommendations of BH-30 are already included in report submitted earlier on 15.10.2018 and hence not repeated here.
7. Recommendation for Foundation at deferent Levels: Where the foundation of the adjacent buildings are to be placed at different levels, the conditions as stated in Cl. 6.6 in IS 13063 shall be followed.
8. Foundation on steeply dipping rock surface: Where the foundation of the adjacent buildings are to be placed on steep rock slopes, the conditions as stated in Cl. 6.5 & 8.3 in IS 13063 shall be followed.

**Sample Calculation Around Bauxite Grinding Area:**

Let us consider BH-10.

Place the foundation at 1.00m below FGL. (FGL = 930.000M)

Founding level falls inside weathered rock layer.

**A) Bearing Capacity Based on RMR Method:**

Calculated RMR = 57 as per IS: 13365(Part1)-1998, Annex B

- a) Unconfined Compressive Strength is taken as 410 kg/sqcm, corresponding rating = 4.
- b) Average RQD value = 95%, corresponding rating = 20.
- c) Spacing of discontinuity taken as close, corresponding rating = 8.
- d) Condition of discontinuity considered as Slightly rough and moderately to highly weathered wall rock surface, separation < 1mm, corresponding rating = 20.
- e) Ground water condition taken as Wet, corresponding rating = 7.
- f) Dip Angle Joint Orientation taken as favourable, corresponding rating = -2.

So,  $RMR = 4 + 20 + 8 + 20 + 7 + (-)2 = 57$

So, from Table-3 of IS: 12070: 1987 (Amendment No. 1, 2008),  $q_{ns} = 258.05 \text{ t/sqm}$

**B) Bearing Capacity Based on Uni-axial Compressive Strength Method:**

The safe bearing pressure,  $q_s = q_c N_j$

Where,  $q_s$  = Safe bearing pressure

$q_c$  = Average uniaxial compressive strength of rock core

$N_j$  = Empirical co-efficient depending on spacing of discontinuities

For spacing of discontinuity, 0.06m i.e. 6cm, corresponding  $N_j = 0.10$

$q_c = 367 \text{ kg/sqcm}$  (lowest value of layer VI)

So, safe bearing pressure,  $q_s = 367 \times 0.10 = 36.70 \text{ kg/sqcm} = 367 \text{ t/sqm}$

A factor of 3/4 is taken considering rock with discontinuous joints with opening less than 1mm wide.

Hence, safe bearing pressure,  $= 367 \times \frac{3}{4} = 275.25 \text{ t/sqm}$

However, let us restrict the bearing capacity to 100t/sqm.



## 5.4. USE OF DEEP FOUNDATION:

Alternatively, due to presence of thick fill layer deposits around some of the boreholes and for higher bearing capacity, deep foundation in form of pile is suggested. Bored cast in-situ piles are preferred due to availability of construction agencies and less noise pollution. The determination of pile capacity is given below.

At first, the design strength parameters are determined. Thereafter, the pile capacity values are calculated. While determining the pile capacity, the following considerations are made.

- Cut off = 2.50 m
- Diameter of pile used = 600, 750 and 1000mm
- Assumed Grade of Concrete = M30

### 5.4.1. Determination of Vertical Pile Capacity:

Bored cast in situ piles are preferred due to typical geological formation, ease of construction, availability of construction agencies and less sound pollution.

The pile capacities are evaluated based on following two approaches. As a sample calculation subsoil condition around BH-24 is used. It is suggested to place the pile at about 14.50m below FGL i.e. 1.50m inside weathered rock layer (Layer V)

#### Approach A:

According to IS 2911 (Part 1/Sec 2): 2010, Annex B, Clause B-4.2

$$Q_a = C_{u1} \cdot N_c \cdot \pi B^2 / 4 F_s + \alpha C_{u2} \cdot \pi B L / F_s$$

Where,

$C_{u1}$  = Shear Strength of rock below the base of the pile in  $\text{KN/m}^2$  (see Fig. 3) =  $200 \text{ t/m}^2 = 2000 \text{ KN/m}^2$

$N_c$  = Bearing capacity factor taken as 9

$\alpha$  = 0.9 (recommended value)

$C_{u2}$  = Average shear strength of rock in the socketed length of pile in  $\text{KN/m}^2$  (see Fig. 3) =  $200 \text{ t/m}^2 = 2000 \text{ KN/m}^2$

$B$  = Minimum width of pile shaft (diameter in case of circular pile) in m =  $750\text{mm} = 0.75\text{m}$

$L$  = Socket length of pile in m considered as 1.50m

$D$  = Diameter of pile in m

$F_s$  = Factor of Safety usually taken as 3

$$Q_a = 200 \times 9 \times \pi \times (0.75)^2 / (4 \times 3) + 0.90 \times 200 \times \pi \times 0.75 \times 1.50 / 3 = 477.13 \text{ T}$$

#### Approach B:

As per IS 14593:1998, Safe load capacity of pile,  $Q_s = q_c N_j N_d A_p + q_c \pi D l_s \alpha \beta$

Where,

$Q_s$  = safe load capacity of pile, in ton

$q_c$  = uni-axial compressive strength of rock,  $\text{t/sqm}$

$N_d$  = depth factor =  $0.8 + 0.2 l_s / D$ , limited to 2

$A_p$  = area of pile toe in  $\text{m}^2$

$D$  = diameter of pile in m

$l_s$  = socket length into the rock in m

$\alpha$  = rock socket side resistance reduction factor (Fig.1 of IS 14593:1998)

$\beta$  = rock socket correction factor (Fig.2 of IS 14593:1998)

$N_j$  = values as per Fig. 2 of IS 12070 or Table 4 of IS 12070.

$D$  = diameter of pile in m = 600mm = 0.60m

$N_d = 0.8 + 0.2l_s/D = 0.8 + 0.2 \times 2D/D = 1.2$

$A_p = \pi D^2/4$

$\alpha = 0.03$  (as per Fig.1 of IS 14593:1998)

Mass factor,  $j = 0.2$  (for 0% to 25% RQD and fracture frequency 15nos./m) (As per M J Tomlinson, Sec.4.7.3 Pg-134)

Corresponding  $\beta = 0.57$  (as per Fig.2 of IS 14593:1998)

$N_j = 0.1$  (as per Table 4 of IS 12070 for spacing of discontinuity 30-100 cm)

Therefore,  $Q_s = q_c N_j N_d A_p + q_c \pi D l_s \alpha \beta$

$$= (3670 \times 0.1 \times 1.2 \times 0.785 D^2 + 3670 \times \pi \times D \times 2D \times 0.03 \times 0.57) T$$

$$= (345.714 D^2 + 394.31 D^2) T = 740.03 D^2 T$$

So, for 750mm dia pile,  $Q_s = 416.36t$

Considering the above two approaches and to be in the safer side, let us restrict the vertical pile capacity to 250T. The recommended uplift capacity = 200T.

#### 5.4.2. Determination of Lateral Pile Capacity:

Refer to IS : 2911 (Part I/Sec 2) - 2010, Appendix - C

Constant Factor,  $k_1 = 3.60$  kg/cucm corresponding to Cohesion = 1.00 kg/sqcm

Now,  $K = (k_1/1.5) \times (30/D)$  which is coming as 0.96 kg/cucm [ $D$  = Pile dia in cm]

Stiffness factor,  $R = [EI/KD]^{1/4}$

Now,  $I = 1.55 \times 10^6 \text{ cm}^4$  [for 750mm dia pile]

$E = 5000 \times (f_{ck})^{0.5} = 5000 \times (30)^{0.5} = 27386 \text{ N/sqmm} = 2.74 \times 10^5 \text{ kg/sqcm}$

Hence,  $R = 277.24 \text{ cm}$

From Graph (Fig.4),  $L_f = 1.95 \times R = 540.61 \text{ cm}$  [Assuming Fixed Head Piles]

Pile Head deflection,  $Y = H \times L_f^3 / 12EI = 0.3096 \text{ mm}$  for 1T load

So, for 5mm horizontal deflection at cut-off level horizontal force at pile head,  $H = 16.15T$ , say 16T

Now, Moment =  $[H \times L_f/2] = [1 \times 5.41/2] = 2.70t\text{-m}$  per T of thrust

The Reduction Factor for computation of Maximum Moment in Pile,  $m = 0.70$

So, the corrected actual moment,  $M = 2.70 \times 0.70 = 1.89t\text{-m}$  per T of thrust

*Under free head condition* and for 5mm deflection,  $H = 7T$

#### RECOMMENDATION:

Based on the above, recommended pile capacity values for different pile diameters and depths are given below.

Foundation Location	Embedment Inside Weathered rock (m)	Length of pile below cut-off (m)	Pile Diameter (mm)	Recommended Pile Capacity (T)		Lateral Pile Capacity (T)				Length of Fixity L <sub>f</sub> (m)
				Vertical	Uplift	Free Head Cond.		Fixed Head Cond.		
						5mm	10mm	5mm	10mm	
BH-02 (FGL = 920.000M)	1.50	10.50	600	150	130	6.5	13	14.5	29.5	4.13
	1.50	10.50	750	250	200	8.0	16.5	18.5	37	5.16
	2.00	11.00	1000	500	375	11.0	22	24.5	49	6.88
BH-03 (FGL = 920.000M)	1.50	9.25	600	150	130	2.5	5.5	9	18	4.23
	1.50	9.25	750	250	200	4.5	9	13.5	27.5	5.08
	2.00	9.75	1000	500	375	7.5	15	23	46	6.43
BH-14, 28 (FGL = 933.000M)	1.50	22.80	600	150	130	0.75	1.50	2.5	5	3.37
	1.50	22.80	750	250	200	1.35	2.50	4	8.5	4.33
	2.00	23.30	1000	500	375	2.65	5.30	8	16	5.93

Foundation Location	Embedment Inside Weathered rock (m)	Length of pile below cut-off (m)	Pile Diameter (mm)	Recommended Pile Capacity (T)		Lateral Pile Capacity (T)				Length of Fixity L <sub>f</sub> (m)
				Vertical	Uplift	Free Head Cond.		Fixed Head Cond.		
						5mm	10mm	5mm	10mm	
BH-17 (FGL = 930.000M)	1.50	20.75	600	150	130	3	6.5	8.5	17	3.80
	1.50	20.75	750	250	200	4.5	9	11.5	23.5	4.82
	2.00	21.25	1000	500	375	7	14.5	17.5	35	6.53
BH-18 (FGL = 930.000M)	1.50	8.50	600	150	130	1	2	3.5	7	3.49
	1.50	8.50	750	250	200	2	3.5	6	12	4.46
	2.00	9.00	1000	500	375	3.5	7	10.5	21	6.10
BH-23, 24, 26 (FGL = 933.000M)	1.50	15.00	600	150	130	5.5	11	12.5	25	4.32
	1.50	15.00	750	250	200	7.0	14	16.0	32	5.40
	2.00	15.50	1000	500	375	9.5	19	21.5	43	7.20
BH-25 (FGL = 933.000M)	1.50	4.25	600	150	130	6.5	13	17.5	35	3.89
	1.50	4.25	750	250	200	9.5	19	25	50	4.66
	2.00	4.75	1000	500	375	6	12	35	51	--
BH-27 & 29 (FGL = 933.000M)	1.50	21.25	600	150	130	1.0	2.5	4.0	8.0	3.72
	1.50	21.25	750	250	200	2.0	4.0	6.5	13.0	4.74
	2.00	21.75	1000	500	375	3.5	7.5	10.5	21.0	6.49
BH-32 (FGL = 934.000M)	1.50	20.50	600	150	130	0.25	0.50	1.00	2.00	3.19
	1.50	20.50	750	250	200	0.50	1.00	1.50	3.50	4.04
	2.00	21.00	1000	500	375	1.15	2.30	4.00	8.00	5.58
BH-43 (FGL = 935.000M)	1.50	15.00	600	150	130	0.08	0.16	0.30	0.60	--
	1.50	15.00	750	250	200	0.15	0.30	0.65	1.30	--
	2.00	15.50	1000	500	375	0.45	0.90	1.65	3.30	--
BH-45 (FGL = 930.000M)	1.50	1.50	600	150	130	1	1	4	4	--
	1.50	1.50	750	250	200	3	3	7	7	--
	2.00	2.00	1000	500	375	6.5	6.5	18	18	--
BH-46 (FGL = 930.000M)	1.50	7.25	600	150	130	13	15	15	15	--
	1.50	7.25	750	250	200	19	25	25	25	--
	2.00	7.75	1000	500	375	29	40	40	40	--

**Note:**

- 1) The piles are to be placed at 2D c/c
- 2) The overhang length around BH-03, 14, 28, 17, 18, 27, 29, 32, 43 & 46 is taken as 0.62m, 4m, 4m, 1.15m, 3m, 2.58m, 2.44m, 6.94m, 12.50m & 5.80m respectively
- 3) Lateral Pile Capacity around BH- 32, 43, 46: The depth of filling is 9.437m, 14.969m & 8.258m respectively. Due to such large filling depth, the lateral capacity become very less as cut off to EGL portion pile length is considered as unsupported. However, the lateral can be improved if the filling work is done with controlled Engineered Fill taking proper care. The filling soil shall be chosen suitably to conform standard norms (like medium to low plasticity, low to medium swelling index). The soil which is to be used for filling shall be tested for its OMC & MDD by conducting proctor compaction tests at laboratory. The site filling shall be done in layers with thickness not exceeding 150mm and compacted by suitable compactor so as to achieve a field dry density not less than 95% of MDD as revealed from Proctor Compaction Test. Suitable number of field tests (field dry density) to be conducted at every 25m in a square grid, as a part of field quality control and shall be checked with laboratory results. In that case, the lateral capacity can be enhanced and lateral capacity as recommended against BH-23,24,26 can safely be used for these boreholes also.
- 4) The Spacing should be the two times of pile diameter as per clause 6.6.1, IS 2911(part 1/sec2).

**5.5. CHEMICAL TESTS:**

Chemical tests were performed on few soil & water samples for determining the pH value, Sulphate, Chloride content etc. The results are given in a tabular form below:

**CHEMICAL TEST RESULTS ON SOIL SAMPLES:**

BH/Sample No.	Depth (m)	pH value	Sulphate as SO <sub>3</sub> (%)	Chloride as Cl (%)	Organic matter (%)
BH05 / SPT01	1.50	6.38	BDL	0.0040	0.1210
BH15 / SPT01	1.50	5.51	BDL	0.0080	0.6386
BH23 / SPT02	3.00	6.78	BDL	0.0050	0.1215
BH25 / SPT02	3.00	6.57	BDL	0.0040	0.1130
BH31 / SPT02	3.00	5.59	BDL	0.0070	0.3639
BH126 / SPT01	1.50	5.87	BDL	0.0060	0.1575

**B.D.L:** Below Detection Limit (<0.05%).

**CHEMICAL TEST RESULTS ON WATER SAMPLES: -**

BH/Sample No.	Depth (M)	pH value	Sulphate as (mg/litre)	Chloride as (mg/litre)	Organic Matter (mg/litre)
BH-02 / WS01	0.95	5.80	BDL	9	10.50
BH-09 / WS01	1.10	5.72	BDL	9	7.00
BH-13 / WS01	1.80	5.74	BDL	8	7.00
BH-18 / WS01	1.30	5.68	BDL	8	8.75
BH-27 / WS01	0.80	5.90	BDL	10	8.75
BH-31 / WS01	1.10	5.60	BDL	7	5.25
BH-33 / WS01	1.10	5.80	BDL	8	8.75
BH-38 / WS01	0.80	5.70	BDL	11	5.25
BH-43 / WS01	0.40	5.68	BDL	9	8.75
BH-126 / WS01	4.30	5.20	BDL	10	7.00

It is seen that the values are within the permissible limit (as per IS-456: Table 1, 4 and clause 8.2.2.4) and so no precaution will be required for foundation concrete. **Either Ordinary Portland cement or Portland slag cement or Portland Pozzolana cement can be used for the purpose.**

**5.6. POSSIBILITY OF SUBSOIL LIQUEFACTION DUE TO EARTHQUAKE:**

Seed et al. (1983) stated that based on both laboratory testing and field performance, the great majority of cohesive soils will not liquefy during earthquakes. Using criteria originally stated by Seed and Idriss (1982) and subsequently confirmed by Youd and Gilstrap (1999), in order for a cohesive soil to liquefy, it must meet all the following three criteria:

- The soil must have less than 15 percent of the particles, based on dry weight, that are finer than 0.005 mm (i.e., percent finer at 0.005 mm < 15 percent).
- The soil must have a liquid limit (LL) that is less than 35 (that is, LL < 35).

- c) The water content  $w$  of the soil must be greater than 0.9 of the liquid limit [that is,  $w > 0.9 (LL)$ ].

If the cohesive soil does not meet all three criteria, then it is generally considered to be not susceptible to liquefaction. In our present case, we have

- a) The average Liquid Limit layer- I, II & IIA are 38%, 39% and 40% respectively i.e. more than the critical value of  $LL < 35\%$  ----- safe.
- b) The moisture content of layer- IIA is 19% which is less than 90% of LL of a certain layer ----- safe.

From the above discussion, it can be seen that two among the above clauses (b & c) are against the possibility of liquefaction of the subsoil (layer- I, II & IIA).

At few borehole locations, we have dense to very dense silty sand layer. Since the site is located at zone-II, liquefaction of this layer is also not expected.

Hence the subsoil at the present project site is non liquefiable.

## 5.7. DEWATERING:

The standing water level was found from 0.40m to a maximum depth of 4.30m during the time of investigation. So, construction of open foundation, placed at a depth of 1.00m or more, may create a problem. The subsoil being predominantly clayey in nature, seepage is expected to be less. So, ordinary surface operated pump will be able to tackle the situation for dewatering. For excavation more than 4m proper shoring arrangement may be required to protect the side slope.

## 5.8. SUITABILITY OF EXISTING SOIL FOR FILLING AND BACK-FILLING:

*Recommendation for Filling At foundation locations & Backfilling Purposes:* The subsoil at the site consists of silty clay (CI) with fine sand mixtures having low swelling properties. So, the soil can be used for filling and backfilling purposes with necessary compaction as required.

## 5.9. EXCAVATION:

For excavation in virgin soil, a slope of 1(H):2(V) may be used for layer I & II. For layer III, (cohesion less soil) a reduced slope of 2(H):1(V) may be used. For excavation in stratum-IV, V & VI (i.e. rock layer), vertical or almost vertical slope may be used. However, to be in the safer side, a nominal side slope of 0.5(H):1(V) for stratum-IV & V and 0.25(H):1(V) for stratum-VI should be provided.

It is also suggested to provide a Berm of at least 1m wide after each 3m to 4m of excavation.

Excavation in stratum-I, II & III can be made with shovels and pick-axe. At lower reaches, pneumatic / jack hammer will be more efficient. Alternatively controlled blasting may be required.

## 6. SUMMARY & RECOMMENDATIONS

Based on the field and laboratory tests and the foregoing discussion the following are summarised.

1. The subsoil is characterised by a layer of very stiff silty clay followed by a hard silty clay / dense to very dense clayey silty sand / silty sand layer. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes.
2. Considering the subsoil condition and the proposed structure to be constructed at the present site, it is suggested to go for open foundation. The foundation may be placed at 1.00m or more below FGL depending on structural requirement.
3. The recommended bearing capacity values with various depth of foundation are presented in Section 5.3.3.
4. Alternatively, due to presence of thick fill layer deposits around some of the boreholes and for higher bearing capacity, deep foundation in form of pile is suggested. Bored cast in-situ piles are preferred due to availability of construction agencies and less noise pollution as well as ease of construction.
5. The determination and recommendation of vertical, uplift and lateral capacity for different depth and diameter of pile are given in the previous section 5.4.1 & 5.4.2.
6. Geological Logging of the boreholes for the entire zone of investigation is presented in Section -7.
7. Seven (7) nos. Block Vibration Tests were performed at the site and the test results are discussed and presented in Section -8.
8. One(1) no. Electrical Resistivity Test was performed at the site and the test results are discussed and presented in Section -9.

**For C. E. Testing Company Private Limited,**

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## 7. GEOLOGICAL LOGGING

**BH No. 02**

(00.00 – 12.00)m:

Overburden.

(12.00 – 13.00)m

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(13.00 – 19.00)m:

**Rock Description:** Highly to Moderately weathered (up to 16.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are moderately to tightly compacted (up to 01.00m) then tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 16.00m) followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 03**

(00.00 - 07.00)m:

Overburden.

(07.00 – 11.00)m

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(11.00 - 15.00)m:

**Rock Description:** Moderately weathered to almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 12.00m) to widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh and modest to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been



removed by drill water. As a result modest to little amount of core loss occurred.

**BH No. 04**

(00.00 - 06.00)m:

Overburden.

(06.00 - 09.00)m

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(09.00 - 14.00)m:

**Rock Description:** Highly to Moderately weathered (up to 11.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 11.00m) to widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 05**

(00.00 - 02.00)m:

Overburden.

(02.00 - 09.00)m

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(09.00 - 14.00)m:

**Rock Description:** Highly to Moderately weathered (up to 11.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 11.00m) followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little

amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 06**

(00.00 - 01.00)m:

Overburden.

(01.00 - 11.00)m

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(11.00 - 15.00)m:

**Rock Description:** Moderately weathered (up to 12.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Closely (15-8 no's/m; up to 12.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh and modest to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to little amount of core loss occurred.

**BH No. 07**

(00.00 - 03.00)m:

Overburden.

(03.00 - 08.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(08.00 - 12.00)m:

**Rock Description:** Moderately weathered (up to 09.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** closely (15-8 no's/m; up to 09.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh and modest to

little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to little amount of core loss occurred.

**BH No. 08**

(00.00 - 03.00)m:

Overburden.

(03.00 - 04.00)m

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(04.00 - 10.00)m:

**Rock Description:** Highly to Moderately weathered (up to 07.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 07.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 09**

(00.00 - 03.00)m:

Overburden.

(03.00 - 10.00)m:

**Rock Description:** Highly to Moderately weathered (up to 07.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 07.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 07.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little

amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 10**

(00.00 - 01.00)m:

Overburden.

(01.00 - 08.00)m:

**Rock Description:** Highly to moderately weathered (up to 05.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 02.00m) then closely spaced (15-8 no's/m) to medium spaced fractures (8-5 no's/m; up to 05.00m) followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to fair (up to 05.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred

**BH No. 11**

(00.00 - 03.00)m:

Overburden.

(03.00 - 04.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(04.00 - 08.00)m:

**Rock Description:** Highly to moderately weathered (up to 08.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m up to 8.00m) followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 08.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred

**BH No. 12**

(00.00 - 03.00)m:

Overburden.

(03.00 - 06.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(06.00 - 08.00)m:

**Rock Description:** Highly to moderately weathered (up to 08.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 08.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 08.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred

**BH No. 13**

(00.00 – 02.00)m:

Overburden.

(02.00 – 10.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(10.00 – 15.00)m:

**Rock Description:** Highly weathered (up to 12.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 12.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 12.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 14**

(00.00 - 13.00)m:

Overburden.

(13.00 - 16.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(16.00 - 23.00)m:

**Rock Description:** Highly to moderately weathered (up to 20.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 20.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 20.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 15**

(00.00 - 12.00)m:

Overburden.

(12.00 - 16.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(16.00 - 22.00)m:

**Rock Description:** Highly to moderately weathered (up to 19.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 19.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous



framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 19.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 16**

(00.00 - 02.00)m:

Overburden.

(02.00 - 08.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(08.00 - 13.00)m:

**Rock Description:** Highly to moderately weathered (up to 10.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m; up to 10.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 10.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 17**

(00.00 - 18.00)m:

Overburden.

(18.00 - 25.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(25.00 - 30.00)m:

**Rock Description:** Highly to moderately weathered (up to 27.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 27.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar

to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 27.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 18**

(00.00 - 04.00)m:

Overburden.

(04.00 - 13.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(13.00 – 18.00)m:

**Rock Description:** Highly to moderately weathered (up to 15.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration, coarse grains and are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 15.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 15.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 23**

(00.00 - 13.50)m:

Overburden.

(13.50 – 18.50)m:

**Rock Description:** Highly to Moderately weathered (up to 15.50m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 15.50m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly



rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 15.50m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred

#### **BH No. 24**

(00.00 - 12.50)m:

Overburden.

(12.50 - 18.50)m:

**Rock Description:** Highly to Moderately weathered (up to 15.50m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 15.50m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as discontinuous (up to 13.50m) followed by continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 15.50m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred

#### **BH No. 25**

(00.00 – 09.00)m:

Overburden.

(09.00 – 10.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(10.00 - 17.00)m:

**Rock Description:** Highly to Moderately weathered (up to 14.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 14.00m) fractures then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are

non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and 200-300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 14.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 26**

(00.00 – 08.00)m: Overburden.

(08.00 – 09.00)m: Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(09.00 – 14.00)m: **Rock Description:** Highly to Moderately weathered (up to 11.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and strong.

**Structural Condition:** Very closely (>15 no's/m; up to 11.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 11.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred

#### **BH No. 27**

(00.00 – 17.00)m: Overburden.

(17.00 – 22.00)m: **Rock Description:** Highly to Moderately weathered (up to 19.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and strong.

**Structural Condition:** Very closely (>15 no's/m; up to 19.00m) spaced then widely (5-1 no's/m) spaced fractures. Dominantly

horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 19.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 28**

(00.00 - 17.00)m:

Overburden.

(17.00 - 19.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(19.00 - 24.00)m:

**Rock Description:** Highly weathered (up to 21.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m; up to 21.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 21.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 29**

(00.00 – 16.00)m:

Overburden.

(16.00 – 17.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(17.00 – 22.00)m:

**Rock Description:** Highly weathered (up to 19.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 19.00m) fractures then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 19.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 31**

(00.00 - 12.00)m:

Overburden.

(12.00 - 15.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(15.00 - 19.00)m:

**Rock Description:** Moderately weathered to almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 17.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 17.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is moderately weathered to fresh and modest to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result modest to little amount of core loss occurred.

#### **BH No. 32**

(00.00 - 12.00)m:

Overburden.

(12.00 - 16.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(16.00 - 22.00)m:

**Rock Description:** Highly to moderately weathered (up to 19.00m depth) followed by almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly

compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 19.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and alter to slightly alter (up to 19.00m) to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 19.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 33**

(00.00 - 03.00)m:

Overburden.

(03.00 - 05.00)m:

Completely weathered, decomposed and disintegrated rock particles collected as sludge.

(05.00 - 10.00)m:

**Rock Description:** Highly weathered (up to 07.00m depth) to almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m; up to 07.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 07.00m) to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 34**

(00.00 - 01.00)m:

Overburden.

(01.00 - 08.00)m:

**Rock Description:** Highly weathered (up to 05.00m depth) to almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m; up to 05.00m) to widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 05.00m) to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 35**

(00.00 - 01.00)m:

Overburden.

(01.00 - 08.00)m:

**Rock Description:** Highly to moderately weathered (up to 05.00m depth) to almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 05.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 05.00m) to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 36**

(00.00 - 02.00)m:

Overburden.

(02.00 - 08.00)m:

**Rock Description:** Highly weathered (up to 05.00m depth) to almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to to 05.00m) to



widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 05.00m) to excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

### **BH No. 38**

(00.00 - 07.00)m:

**Rock Description:** Highly to Moderately weathered (up to 04.00m) followed by almost fresh, alternating dark and light bands with yellowish colouration and red spots, coarse grains are moderately to tightly compacted (up to 01.00m) then tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong..

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 04.00m) followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and alter to slightly alter.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is fair very poor to poor (up to 04.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

### **BH No. 39**

(00.00 - 01.00)m:

Overburden.

(01.00 - 07.00)m:

**Rock Description:** Highly weathered (up to 04.00m depth) to almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 04.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 04.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 41**

(00.00 - 07.00)m:

**Rock Description:** Highly weathered (up to 04.00m depth) to almost fresh, alternating dark and light bands with yellowish brown coloration and red spots, coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 04.00m) then widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and slightly alter to clean.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-300mm and >300mm, with pockets of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor (up to 04.00m) then excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

#### **BH No. 42**

(00.00 - 08.00)m:

**Rock Description:** Highly to Moderately weathered (up to 05.00m) followed by almost fresh, alternating dark and light bands with yellowish colouration and red spots, foliated (50°– 60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 05.00m) fractures followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and alter to slightly alter.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-200mm and >300mm, with pockets of 30-100mm and 100-300mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 05.00m) followed by excellent quality.



Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 43**

(00.00 - 01.00)m:

Overburden.

(01.00 - 10.00)m:

**Rock Description:** Highly to Moderately weathered (up to 07.00m) followed by almost fresh, alternating dark and light bands with yellowish coloration and red spots, foliated (50°– 60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 05.00m) fractures with pocket of medium spaced (8-5 no's/m) followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and alter to slightly alter.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-200mm and >300mm, with pockets of 30-100mm and 100-300mm.

**Rock Mass Structure:** The rock mass is very poor to fair (up to 07.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 45**

(00.00 - 07.00)m:

**Rock Description:** Highly to Moderately weathered (up to 04.00m) followed by almost fresh, alternating dark and light bands with yellowish coloration and red spots, foliated (50°– 60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m) to closely spaced (15-8 no's/m; up to 04.00m) fractures followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and alter to slightly alter.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 100-200mm and >300mm, with pockets of 30-100mm and 100-300mm.

**Rock Mass Structure:** The rock mass is very poor to poor (up to 05.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the

disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 46**

(00.00 - 07.00)m:

**Rock Description:** Highly to Moderately weathered (up to 04.00m) followed by almost fresh, alternating dark and light bands with yellowish coloration and red spots, foliated (50°– 60°), coarse grains are tightly compacted **Khondalite**.

**Rock Properties:** Hard to very hard and very strong.

**Structural Condition:** Very closely (>15 no's/m; up to 04.000m) followed by widely (5-1 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and alter to slightly alter.

**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm, alternately mixed with 100-200mm and 100-300mm and rarely with >300mm.

**Rock Mass Structure:** The rock mass is very poor (up to 07.00m) followed by excellent quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered to fresh and huge to little amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge to little amount of core loss occurred.

**BH No. 126**

(00.00 - 11.00)m:

Overburden.

(11.00 - 40.00)m:

**Rock Description:** Highly weathered, alternating dark and light bands with yellowish coloration and red spots, coarse grains are moderately to tightly compacted **Khondalite**.

**Rock Properties:** Hard and strong.

Core loss occurred at (11.00–20.00) (21.00–29.00) (30.00–40.00)m

**Structural Condition:** Very closely (>15 no's/m) spaced fractures. Dominantly horizontal fractures. Open fracture surfaces are non-planar to apparently planar, slightly rough to rough and alter to slightly alter.

**Description of Core:** Recovered core occurs as discontinuous framework. Cores are mostly in lengths of 30-100mm.

**Rock Mass Structure:** The rock mass is very poor quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly weathered and huge amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge amount of core loss occurred.

For C. E. Testing Company private Limited,

*Densanku Acharyya*

(D. Acharyya, Geologist)

*Sukha Paramanik*

(S. Paramanik, Geologist)

## 8. BLOCK VIBRATION TEST

## 1. SITE CONDITION:

The soil at the site is reddish brown, moorum with decomposed rock. Total seven (07) nos. BVT were carried out to determine the dynamic properties of the layer for the construction of machine foundations. The RLs & depth of tests are given below in a tabular form.

BVT No.	Block Size	Co-ordinates		R.L. (M)	Depth (M)
		E	N		
BVT-01	1.50 x 1.00 x 1.00	1178.222	1666.248	920.380	2.00
BVT-02	1.50 x 1.00 x 1.00	1562.737	1769.669	927.919	2.00
BVT-03	1.50 x 1.00 x 1.00	1981.769	1843.962	943.651	2.00
BVT-04	1.50 x 1.00 x 1.00	2031.968	1828.799	948.651	2.00
BVT-05	1.50 x 1.00 x 1.00	1102.433	1231.516	301.545	2.00
BVT-06	1.50 x 1.00 x 1.00	1106.428	1071.731	899.556	2.00
BVT-07	1.50 x 1.00 x 1.00	1187.212	1641.795	916.150	2.00

## 2. PURPOSE OF TEST:

The dynamic tests were performed for studying the behavior of sub-soil under vibration and for determining the various dynamic properties of soil as obtained by exciting a concrete block mechanically. The tests were performed according to I.S. 5249-1992.

## 3. EQUIPMENTS USED:

Description of various equipments which were used during the tests are given below:

### 1. Oscillator:

Mechanical Oscillator type SEA-350 (A) was used. Maximum force that can be generated by this oscillator is 1200 Kg, and maximum frequency is 60c.p.s. Eccentricity range is 0° - 140°. The oscillator was mounted on the base plate, which was in turn fitted with the block by holding down bolts. The oscillator can be fitted with the base plate both for vertical vibration and horizontal vibration. The eccentricity is adjusted by adjustor circle on oscillator. One complete clockwise rotation increases the eccentricity by 4°. The tachometer is fixed internally in the equipment having two visible terminals, which were connected to the phase meter. The oscillator, which is filled with standard engine oil SEA-40, is connected by V-belt with the electric D.C. motor.

### 2. D.C. Motor:

Variable Speed Motor Type SEA-351 (A) was used. This 3 H.P. single phase D.C. Motor was fitted on the frame by the side of the oscillator. Supply from main was given through speed control unit, which controls the speed of the motor. The motor was connected to the oscillator by a V-belt.

### **3. Speed Control Unit:**

Speed Control Unit Type SEA-352(A) was used. The maximum voltage for the armature is 250 V and maximum current is 12 Amp. For the fields, the maximum voltage is 28 V and maximum current is 8 Amp. The main function of the speed control unit is to control the speed of the motor as required. Higher speed of the motor gives higher frequency of the oscillator. The main knob of the speed control unit is turned in the anticlockwise direction till the minimum speed indicator light glows with a 'click' sound and then the knob is turned in the clockwise direction for increasing the speed as required. Maximum indicator light indicates the overloading of the motor.

### **4. Three-in-one Phase Meter:**

Phase Meter Type SEA-550 was used for recording the frequency and amplitude. The instrument is powered by two 9 Volt batteries provided in the cabinet body of the units. For vertical vibration test, one acceleration pick up was fitted on top of the block and was connected to the remaining input of the meter. By turning the switch to "AMPLITUDE", the amplitude of the block is recorded. The second knob is meant for choosing properly the multiplier for recording higher amplitudes.

### **5. Acceleration Pick up:**

The acceleration pick-ups are used to record the amplitude of vibration during vertical and horizontal block resonance test.

## **4. DESCRIPTION OF TESTS PERFORMED:**

Forced vibration test was performed on a concrete block of size 1.50M x 1.00M x 1.00M at the location of BVT-01 & BVT-03 to BVT-07 as per IS-5249-1992. The detailed description of the test is given below:

### **Forced Vibration Test:**

**Vertical Vibration Test:** The acceleration pick up is fixed on the top of the concrete block such that it senses vertical motion of the block. The mechanical oscillator is mounted on the block such that it generates purely vertical sinusoidal vibrations and line of action of the vibrating force passes through the center of gravity of the block. After choosing a suitable value of angle of setting of eccentric masses, the oscillator is made to run at a constant frequency. With the help of the speed control unit, the speed of the motor is regulated and the frequency of the oscillator is increased in steps of small values upto the resonant frequency and two or three more readings of amplitude are

taken beyond the resonant frequency. The same procedure is repeated for various values of angle of setting of eccentric masses. At any eccentricity and frequency, the dynamic force should not exceed 20 percent of the total mass of the block and motor-oscillator assembly. The frequency and amplitude are recorded through meter.

## 5. CALCULATION:

### 5.1. COEFFICIENT OF ELASTIC UNIFORM COMPRESSION, $C_u$

The coefficient of elastic uniform compression,  $C_u$ , is calculated from the natural frequency as follows.

$$C_u = 4 \cdot \pi^2 \cdot f_{nz}^2 \cdot M/A$$

Where,  $f_{nz}$  = Natural frequency as obtained from forced vibration tests.

M = Mass of concrete block with Oscillator etc.

A = Base area of block.

Now we have,  $A = 150 \times 100 = 15000 \text{ cm}^2$ .

Weight of block =  $1.50 \times 1.00 \times 1.00 \times 2400 = 3600 \text{ kg}$

Weight of motor + Oscillator = 169 kg.

Total weight = 3769 kg.

$$M = 3769 / 981 = 3.84 \text{ kg} \cdot \text{Sec}^2/\text{cm} : M/A = 2.56 \times 10^{-4} \text{ kg sec}^2\text{cm}^{-3}$$

The natural frequencies are presented in Column-3 of Table-1 for vertical vibration for each level of Dynamic force. For example **for BVT-01, eccentricity = 8°**,  $f_{nz} = 1466 \text{ rpm} = 1640/60 = 24.43 \text{ c.p.s.}$

$$C_u = [4 \times \pi^2 \times 2.56 \times 10^{-4}] f_{nz}^2 = 4 \times \pi^2 \times 2.56 \times 10^{-4} \times 24.43^2 = \mathbf{6.04 \text{ kg/cucm}}$$

### 5.2. DAMPING CONSTANTS:

The damping constants,  $\xi$  is given as  $\xi = ([f_2 \cdot f_1] / [2 \cdot f_{nz}])$

Where,  $f_1$  and  $f_2$  are the frequencies at which the amplitude is 0.707 times the amplitude at natural frequency.

Considering Vertical Vibration test: **For BVT-01 & 8° eccentric angle:**

$f_{nz} = 1466 \text{ rpm}$ ,  $f_1 = 1173 \text{ rpm}$ ,  $f_2 = 1525 \text{ rpm}$  from graph.

Therefore  $\xi = (1525 - 1173) / (2 \times 1466) = 0.120$

**Table- 1 : Summarized Results for Damping Constant**

BVT No.	Type of Test	Eccentric angle (degree)	Natural frequency, $f_{nz}$ (rpm)	Damping constant ( $\xi$ )	Avg. $\xi$
BVT-01	Vertical	8°	1466	0.120	0.130
		16°	1408	0.152	
		24°	1405	0.119	
BVT-02	Vertical	8°	1640	0.145	0.138
		16°	1832	0.119	
		24°	1861	0.150	
BVT-03	Vertical	8°	1536	0.094	0.120
		16°	1576	0.166	
		24°	1579	0.099	
BVT-04	Vertical	8°	1306	0.065	0.142
		16°	1324	0.146	
		24°	1450	0.216	
BVT-05	Vertical	8°	1419	0.203	0.167
		16°	1503	0.148	
		24°	1582	0.150	
BVT-06	Vertical	8°	1372	0.152	0.171
		16°	1462	0.163	
		24°	1381	0.197	
BVT-07	Vertical	8°	1296	0.088	0.118
		16°	1259	0.104	
		24°	1346	0.160	

### 5.3. DYNAMIC SHEAR AND YOUNG'S MODULUS:

#### DYNAMIC YOUNG'S MODULUS: -

The co-efficient of elastic uniform compression,  $C_u$  is related to dynamic Young's Modulus,  $E_d$  as  $C_u = 1.07 E_d / [(1 - \mu^2)\sqrt{A}]$  ..... when  $L/B = 1.5$

Therefore  $E_d = [\sqrt{A} C_u (1 - \mu^2)] / 1.07$

Using  $\mu = 0.25$  (for moorum with decomposed rock layer) and  $A = 150 \times 100 = 15000$  sqcm.

Substituting the values,  $E_d$  is given as  $107.31 C_u$ .

**For  $C_u = 6.04$  kg/cucm,  $E_d = 648$  kg/sqcm**

#### THE SHEAR MODULUS, G: -

Shear modulus is related to Young's Modulus by  $E_d = 2G (1 + \mu) = 2.50 G$

Therefore,  $G = E_d / 2.50$  giving **259.2 kg/sqcm**.

**Table:- 2: Summarised results for 1.50M x 1.00M foundation size.**

Test No.	Eccentricity	Co-efficient Of Uniform compression $C_u$ (kg/cucm)	Dynamic Young's Modulus (kg/sqcm)	Shear Modulus kg/sqcm (G)	Vertical Damping constant ( $\xi$ )
<b>BVT- 01</b>	8°	6.04	648	259.1	0.120
	16°	5.57	598	239.0	0.152
	24°	5.54	595	238.0	0.119
	<b>Average</b>	<b>5.72</b>	<b>613.43</b>	<b>245.37</b>	<b>0.130</b>
<b>BVT- 02</b>	8°	7.55	811	324.3	0.145
	16°	9.43	1012	404.6	0.119
	24°	9.73	1044	417.6	0.150
	<b>Average</b>	<b>8.90</b>	<b>955.38</b>	<b>382.15</b>	<b>0.138</b>
<b>BVT- 03</b>	8°	6.63	711	284.4	0.094
	16°	6.98	749	299.5	0.166
	24°	7.00	751	300.6	0.099
	<b>Average</b>	<b>6.87</b>	<b>737.08</b>	<b>294.83</b>	<b>0.120</b>
<b>BVT- 04</b>	8°	4.79	514	205.6	0.065
	16°	4.92	528	211.3	0.146
	24°	5.91	634	253.5	0.216
	<b>Average</b>	<b>5.21</b>	<b>558.72</b>	<b>223.49</b>	<b>0.142</b>
<b>BVT- 05</b>	8°	5.66	607	242.8	0.203
	16°	6.35	681	272.4	0.148
	24°	7.03	754	301.7	0.150
	<b>Average</b>	<b>6.34</b>	<b>680.71</b>	<b>272.28</b>	<b>0.167</b>
<b>BVT- 06</b>	8°	5.29	567	226.9	0.152
	16°	6.00	644	257.7	0.163
	24°	5.36	575	229.9	0.197
	<b>Average</b>	<b>5.55</b>	<b>595.48</b>	<b>238.19</b>	<b>0.171</b>
<b>BVT- 07</b>	8°	4.72	506	202.5	0.088
	16°	4.45	478	191.1	0.104
	24°	5.09	546	218.4	0.160
	<b>Average</b>	<b>4.75</b>	<b>510.03</b>	<b>204.01</b>	<b>0.118</b>

**Note:** Following relations are to be used to calculate the coefficient of non uniform compression & shear.

Coefficient of elastic uniform shear,  $C_\tau = 0.50C_u$

Co-efficient of elastic non-uniform compression =  $3.46C_\tau$

Coefficient of elastic non-uniform shear =  $1.50C_\tau$



#### 5.4. CORRECTIONS FOR AREA & OVERBURDEN PRESSURE ON VALUES OF $C_u$ & $C_\tau$

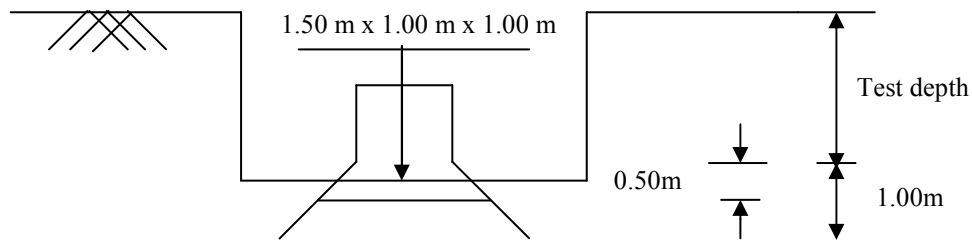
We know that,  $C_u \propto 1/\sqrt{A}$  and  $C_u \propto \sqrt{P_v}$

So, we can write,  $C_u \propto \sqrt{(P_v/A)}$

Hence we can write,  $(C_u)_{\text{block}} / (C_u)_{\text{foundation}} = [\sqrt{(P_v/A)}]_{\text{block}} / [\sqrt{(P_v/A)}]_{\text{foundation}}$

$$(C_u)_{\text{foundation}} = (C_u)_{\text{block}} \times [\sqrt{(A/P_v)}]_{\text{block}} \times [\sqrt{(P_v/A)}]_{\text{foundation}}$$

It is standard practice to deduce the values for 10sqm foundation with vertical stress of 10t/sqm.



#### 5.5. CALCULATION OF $(C_u)_{\text{Foundation}}$ & $(E_d)_{\text{Foundation}}$

Weight of block + machine = 3.769 t

Load at the base of foundation =  $3.769 / (1.50 \times 1.00) = 2.513 \text{ t/sqm}$

Zone of influence =  $B = 1.00 \text{ m}$  below the block.

Hence pressure intensity at  $B/2 = (2.513 \times 1.00 \times 1.50) / ((1.00+0.50) \times (1.50+0.50))$   
 $= 1.256 \text{ t/sqm}$

Overburden of 0.50m (submerged) soil = 0.45 t/sqm

Hence total Pressure =  $(1.256 + 0.45) = 1.706 \text{ t/sqm}$

Area of block =  $1.50 \times 1.00 = 1.50 \text{ sqm}$

Hence  $\sqrt{(A/P_v)_{\text{block}}} = \sqrt{(1.50 / 1.706)} = 0.938$

Let us consider one actual footing of base area = 10 sqm =  $3.162\text{m} \times 3.162\text{m}$

Vertical stress at centre of influence zone = 10 t/sqm (assumed)

Hence  $\sqrt{(P_v/A)_{\text{foundation}}} = \sqrt{(10/10)} = 1$

Therefore,  $(C_u)_{\text{foundation}} = (C_u)_{\text{block}} \times 1 \times 0.938 = 0.938 \times (C_u)_{\text{block}}$

Hence, corrected  $C_u = 5.66 \text{ kg/cm}^3$

The Young's modulus will vary as  $E \propto \sqrt{P_v}$

Hence  $E_{\text{foundation}} = E_{\text{block}} \times \sqrt{(10/1.706)} = 2.421 \times E_{\text{block}}$

The shear modulus will follow the same rule.

On the basis of the above, in Table – 3, the dynamic properties for 10 sqm foundation with vertical pressure intensity of 10 t/sqm are presented.

**TABLE - 3: RECOMMENDED VALUES OF DYNAMIC PROPERTIES:-**

**Foundation size = 10 sqm,  $P_v = 10$  t/sqm**

Test No.	Eccentricity	Corrected $C_u$ (kg/cu cm)	Corrected Modulus of Elasticity (Kg/sqcm) (E)	Corrected Shear Modulus (kg/sqcm) (G)	Vertical Damping constant ( $\xi$ )
<b>BVT- 01</b>	8°	5.66	1568	627.3	0.120
	16°	5.22	1447	578.6	0.152
	24°	5.20	1440	576.2	0.119
	<b>Average</b>	<b>5.36</b>	<b>1485.03</b>	<b>594.01</b>	<b>0.130</b>
<b>BVT- 02</b>	8°	7.08	1963	785.0	0.145
	16°	8.84	2449	979.6	0.119
	24°	9.12	2527	1010.8	0.150
	<b>Average</b>	<b>8.35</b>	<b>2312.83</b>	<b>925.13</b>	<b>0.138</b>
<b>BVT- 03</b>	8°	6.21	1721	688.6	0.094
	16°	6.54	1812	724.9	0.166
	24°	6.57	1819	727.7	0.099
	<b>Average</b>	<b>6.44</b>	<b>1784.35</b>	<b>713.74</b>	<b>0.120</b>
<b>BVT- 04</b>	8°	4.49	1245	497.8	0.065
	16°	4.62	1279	511.6	0.146
	24°	5.54	1534	613.6	0.216
	<b>Average</b>	<b>4.88</b>	<b>1352.59</b>	<b>541.03</b>	<b>0.142</b>
<b>BVT- 05</b>	8°	5.30	1469	587.7	0.203
	16°	5.95	1648	659.3	0.148
	24°	6.59	1826	730.5	0.150
	<b>Average</b>	<b>5.95</b>	<b>1647.90</b>	<b>659.16</b>	<b>0.167</b>
<b>BVT- 06</b>	8°	4.96	1374	549.4	0.152
	16°	5.63	1560	623.8	0.163
	24°	5.02	1392	556.6	0.197
	<b>Average</b>	<b>5.20</b>	<b>1441.57</b>	<b>576.63</b>	<b>0.171</b>
<b>BVT-07</b>	8°	4.42	1226	490.2	0.088
	16°	4.17	1157	462.6	0.104
	24°	4.77	1322	528.8	0.160
	<b>Average</b>	<b>4.46</b>	<b>1234.70</b>	<b>493.88</b>	<b>0.118</b>

## 6. CONCLUDING REMARKS:

- Seven (7) nos. Routine Block Vibration Tests have been conducted on a block of size 1.50M x 1.00M x 1.00M at a depth of 2.00m.
- The observed natural frequencies for the test are already given in the preceding clause.
- The computed  $C_u$  values for the test are already given. However, this is further presented below.

Test No.	Eccentricity	Co-efficient Of Uniform compression $C_u$ (kg/cucm)	Dynamic Young's Modulus (kg/sqcm) $E_d$	Shear Modulus kg/sqcm (G)	Vertical Damping constant ( $\xi$ )
BVT- 01	8°	6.04	648	259.1	0.120
	16°	5.57	598	239.0	0.152
	24°	5.54	595	238.0	0.119
	Average	<b>5.72</b>	<b>613.43</b>	<b>245.37</b>	<b>0.130</b>
BVT- 02	8°	7.55	811	324.3	0.145
	16°	9.43	1012	404.6	0.119
	24°	9.73	1044	417.6	0.150
	Average	<b>8.90</b>	<b>955.38</b>	<b>382.15</b>	<b>0.138</b>
BVT- 03	8°	6.63	711	284.4	0.094
	16°	6.98	749	299.5	0.166
	24°	7.00	751	300.6	0.099
	Average	<b>6.87</b>	<b>737.08</b>	<b>294.83</b>	<b>0.120</b>
BVT- 04	8°	4.79	514	205.6	0.065
	16°	4.92	528	211.3	0.146
	24°	5.91	634	253.5	0.216
	Average	<b>5.21</b>	<b>558.72</b>	<b>223.49</b>	<b>0.142</b>
BVT- 05	8°	5.66	607	242.8	0.203
	16°	6.35	681	272.4	0.148
	24°	7.03	754	301.7	0.150
	Average	<b>6.34</b>	<b>680.71</b>	<b>272.28</b>	<b>0.167</b>
BVT- 06	8°	5.29	567	226.9	0.152
	16°	6.00	644	257.7	0.163
	24°	5.36	575	229.9	0.197
	Average	<b>5.55</b>	<b>595.48</b>	<b>238.19</b>	<b>0.171</b>
BVT- 07	8°	4.72	506	202.5	0.088
	16°	4.45	478	191.1	0.104
	24°	5.09	546	218.4	0.160
	Average	<b>4.75</b>	<b>510.03</b>	<b>204.01</b>	<b>0.118</b>

**Note:** Following relations are to be used to calculate the coefficient of non uniform compression & shear.

Coefficient of elastic uniform shear,  $C_\tau = 0.50C_u$

Co-efficient of elastic non-uniform compression =  $3.46C_\tau$

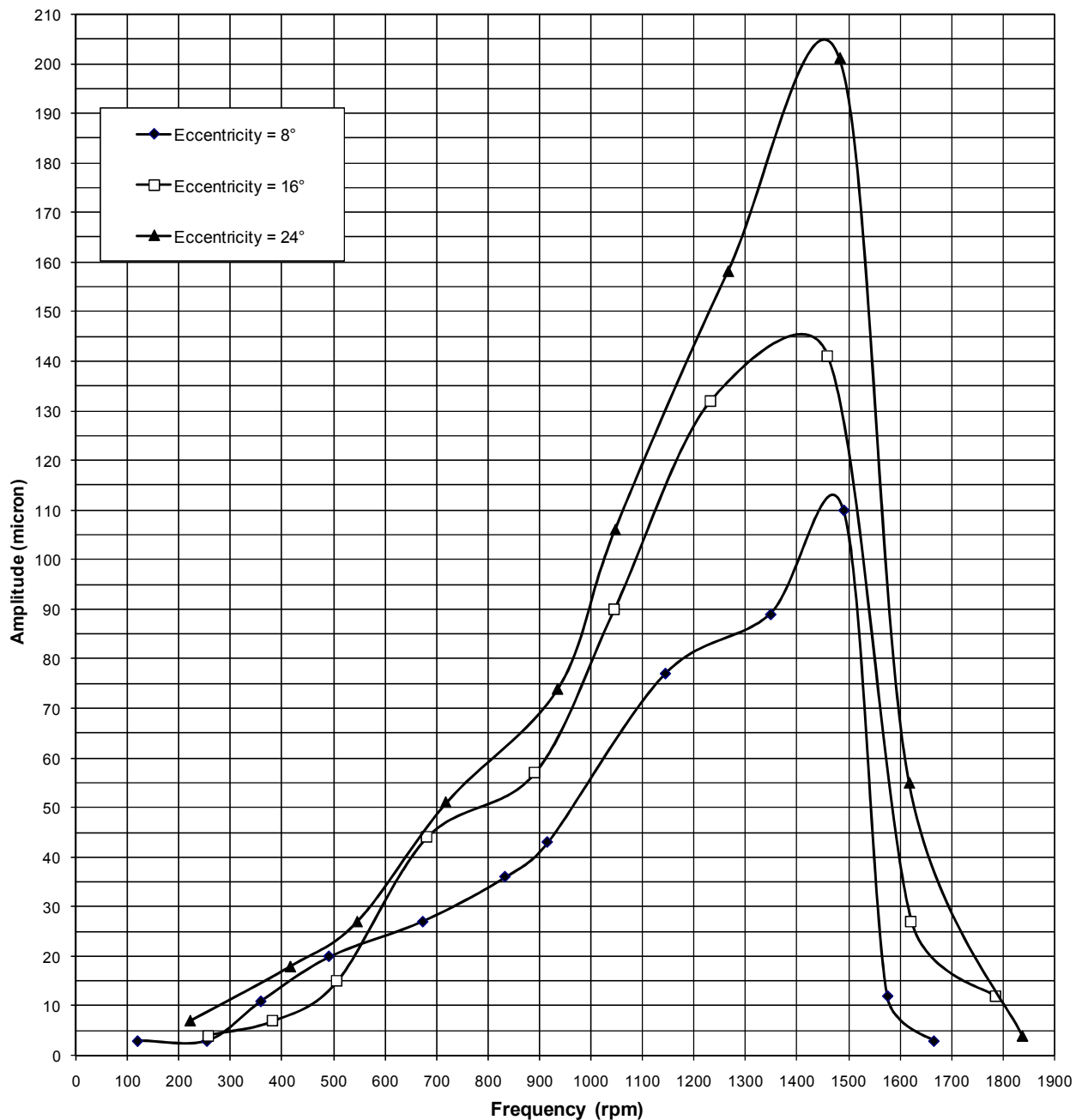
Coefficient of elastic non-uniform shear =  $1.50C_\tau$

4. On the basis of experimental test results, dynamic values are recommended for a **10sqm footing** with an average vertical pressure intensity of **10t/sqm** are calculated and supplied in the previous clause. However, the corrected values are presented below.

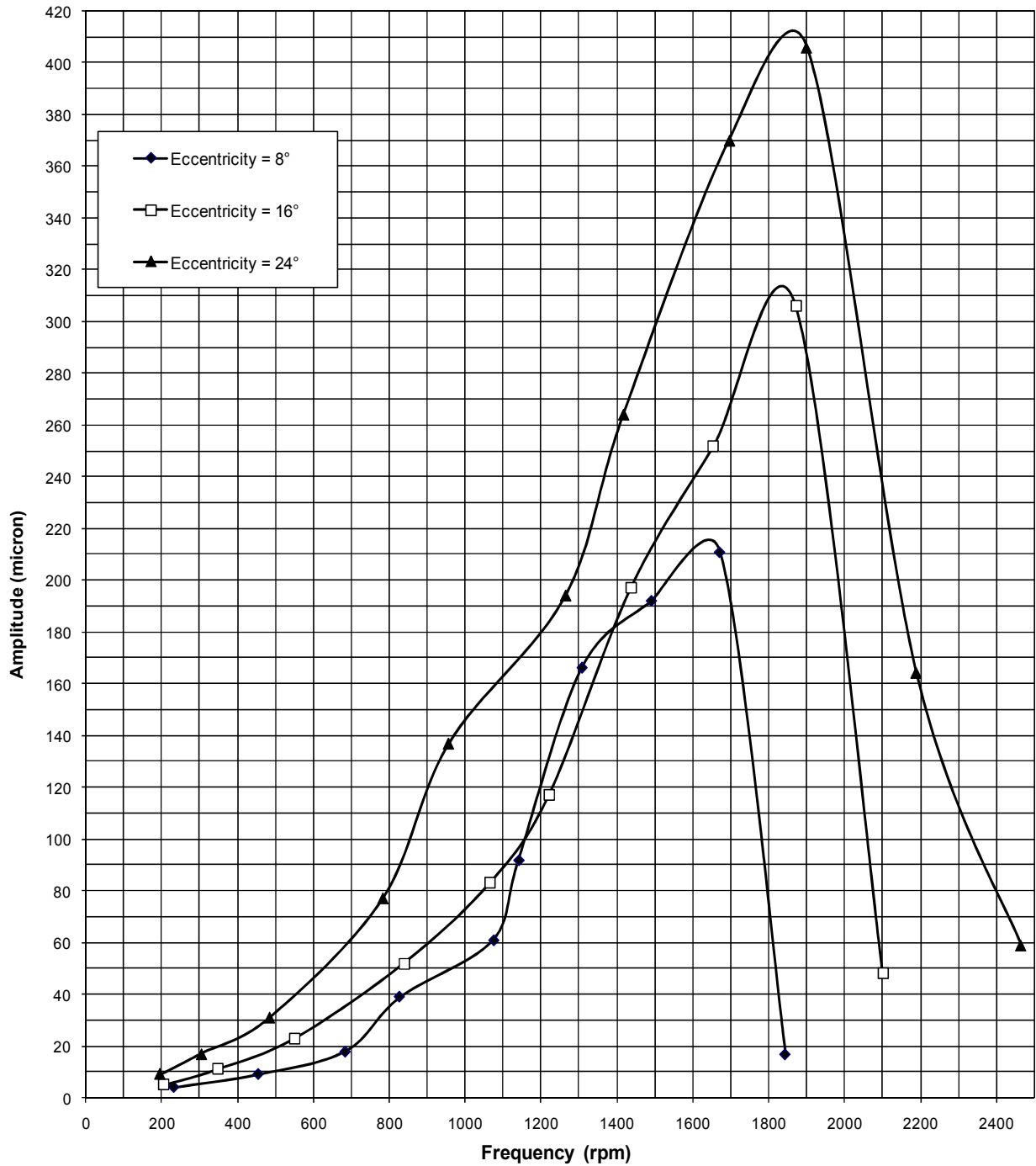
Test No.	Eccentricity	Corrected $C_u$ (kg/cucm)	Corrected Modulus of Elasticity (Kg/sqcm) (E)	Corrected Shear Modulus (kg/sqcm) (G)	Vertical Damping constant ( $\xi$ )
BVT- 01	8°	5.66	1568	627.3	0.120
	16°	5.22	1447	578.6	0.152
	24°	5.20	1440	576.2	0.119
	Average	5.36	1485.03	594.01	0.130
BVT- 02	8°	7.08	1963	785.0	0.145
	16°	8.84	2449	979.6	0.119
	24°	9.12	2527	1010.8	0.150
	Average	8.35	2312.83	925.13	0.138
BVT- 03	8°	6.21	1721	688.6	0.094
	16°	6.54	1812	724.9	0.166
	24°	6.57	1819	727.7	0.099
	Average	6.44	1784.35	713.74	0.120
BVT- 04	8°	4.49	1245	497.8	0.065
	16°	4.62	1279	511.6	0.146
	24°	5.54	1534	613.6	0.216
	Average	4.88	1352.59	541.03	0.142
BVT- 05	8°	5.30	1469	587.7	0.203
	16°	5.95	1648	659.3	0.148
	24°	6.59	1826	730.5	0.150
	Average	5.95	1647.90	659.16	0.167
BVT- 06	8°	4.96	1374	549.4	0.152
	16°	5.63	1560	623.8	0.163
	24°	5.02	1392	556.6	0.197
	Average	5.20	1441.57	576.63	0.171
BVT-07	8°	4.42	1226	490.2	0.088
	16°	4.17	1157	462.6	0.104
	24°	4.77	1322	528.8	0.160
	Average	4.46	1234.70	493.88	0.118

5. For different foundation size & vertical stress, the recommended dynamic properties should be computed by using the principles illustrated.

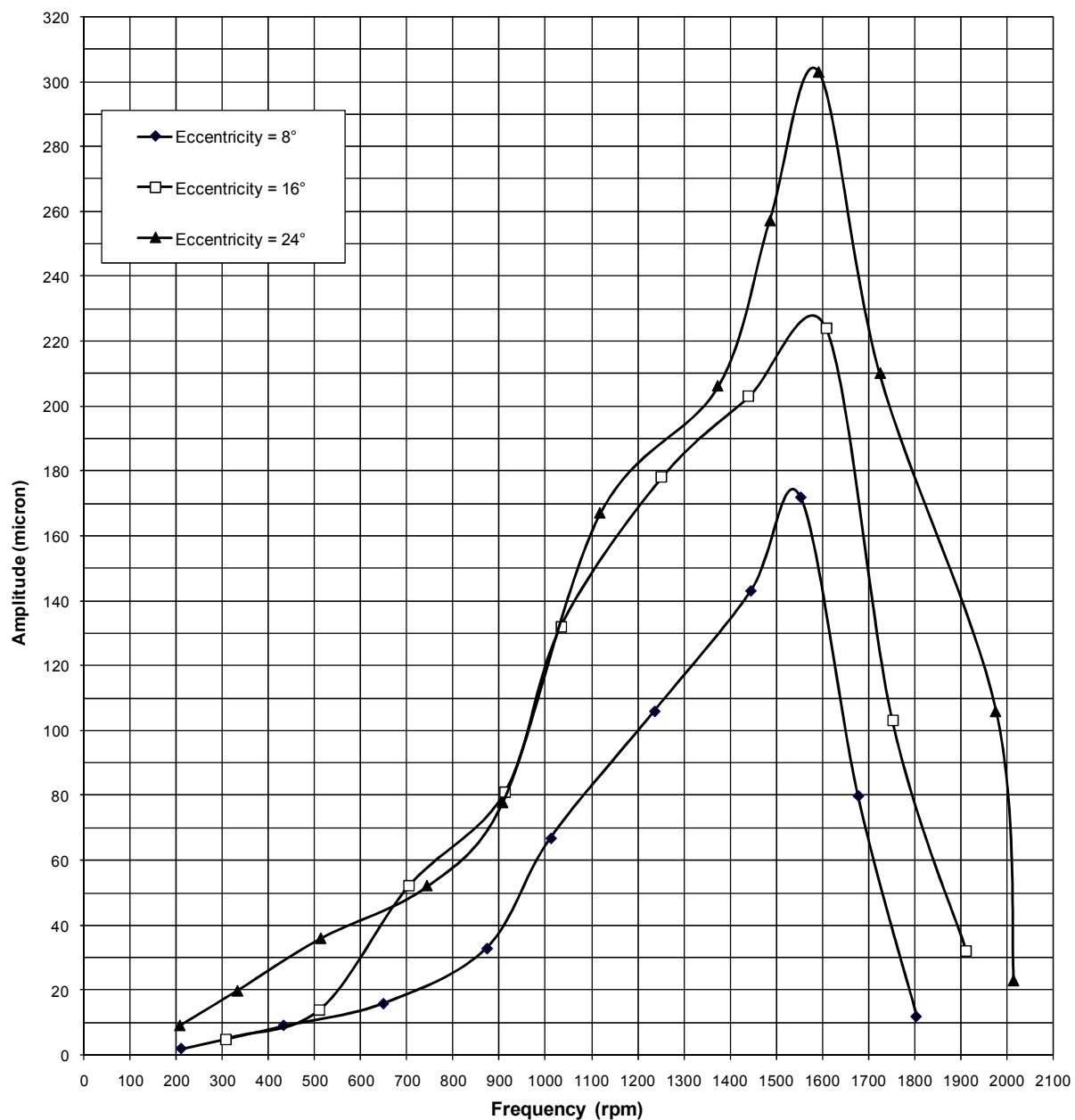
**Vertical Block Vibration Test graphs for BVT-01**



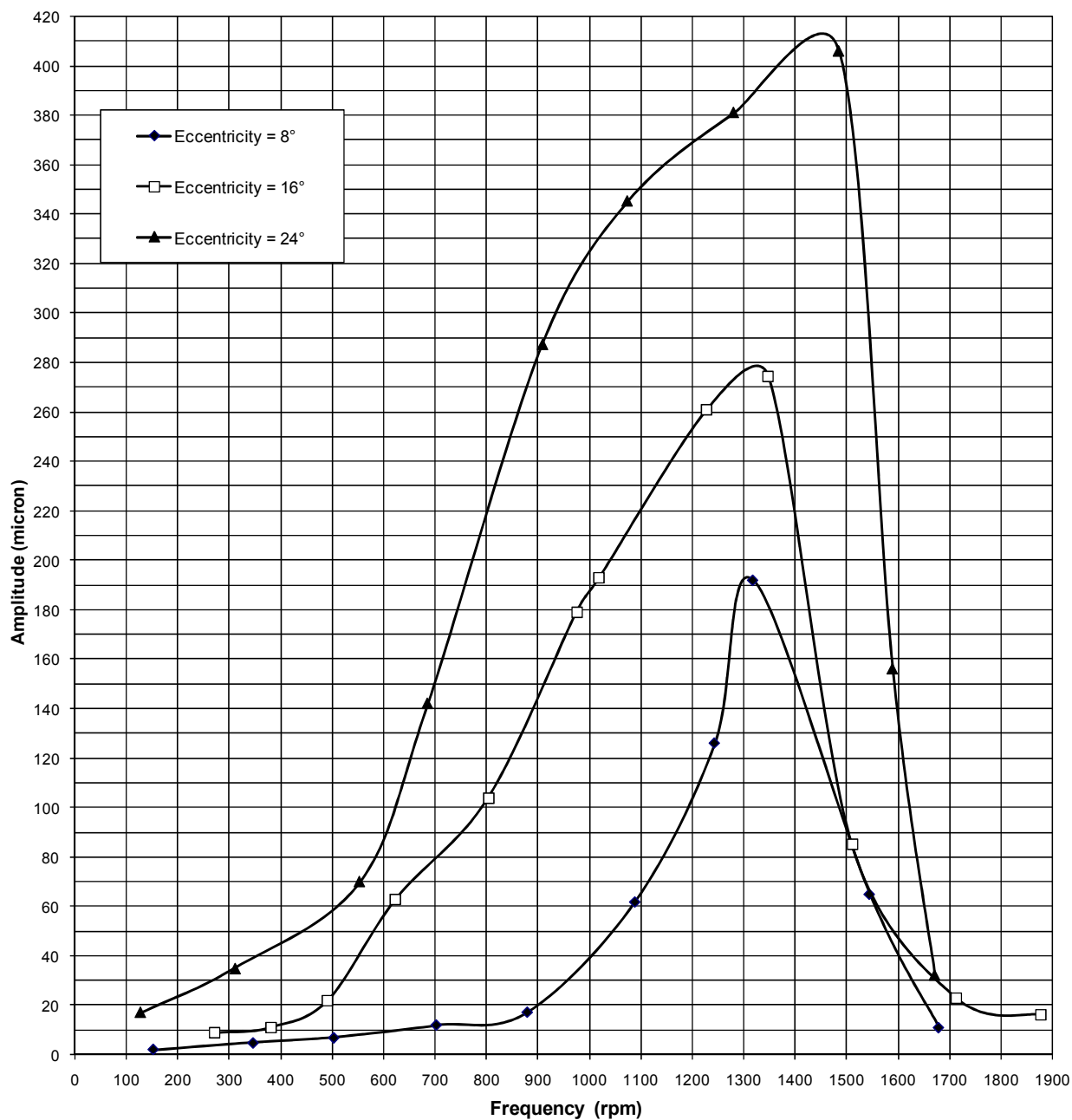
**Vertical Block Vibration Test graphs for BVT-02**



**Vertical Block Vibration Test graphs for BVT-03**

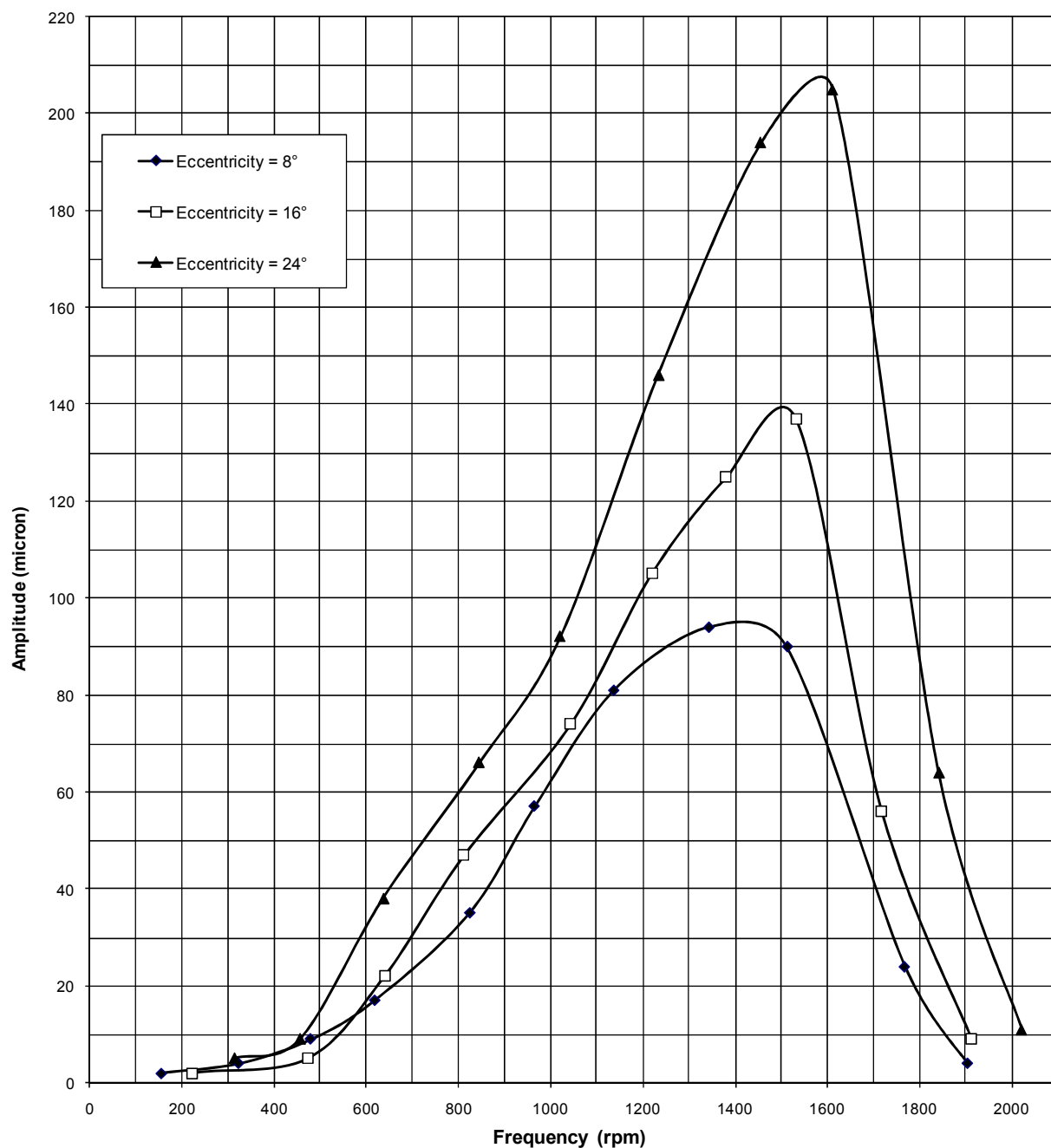


**Vertical Block Vibration Test graphs for BVT-04**

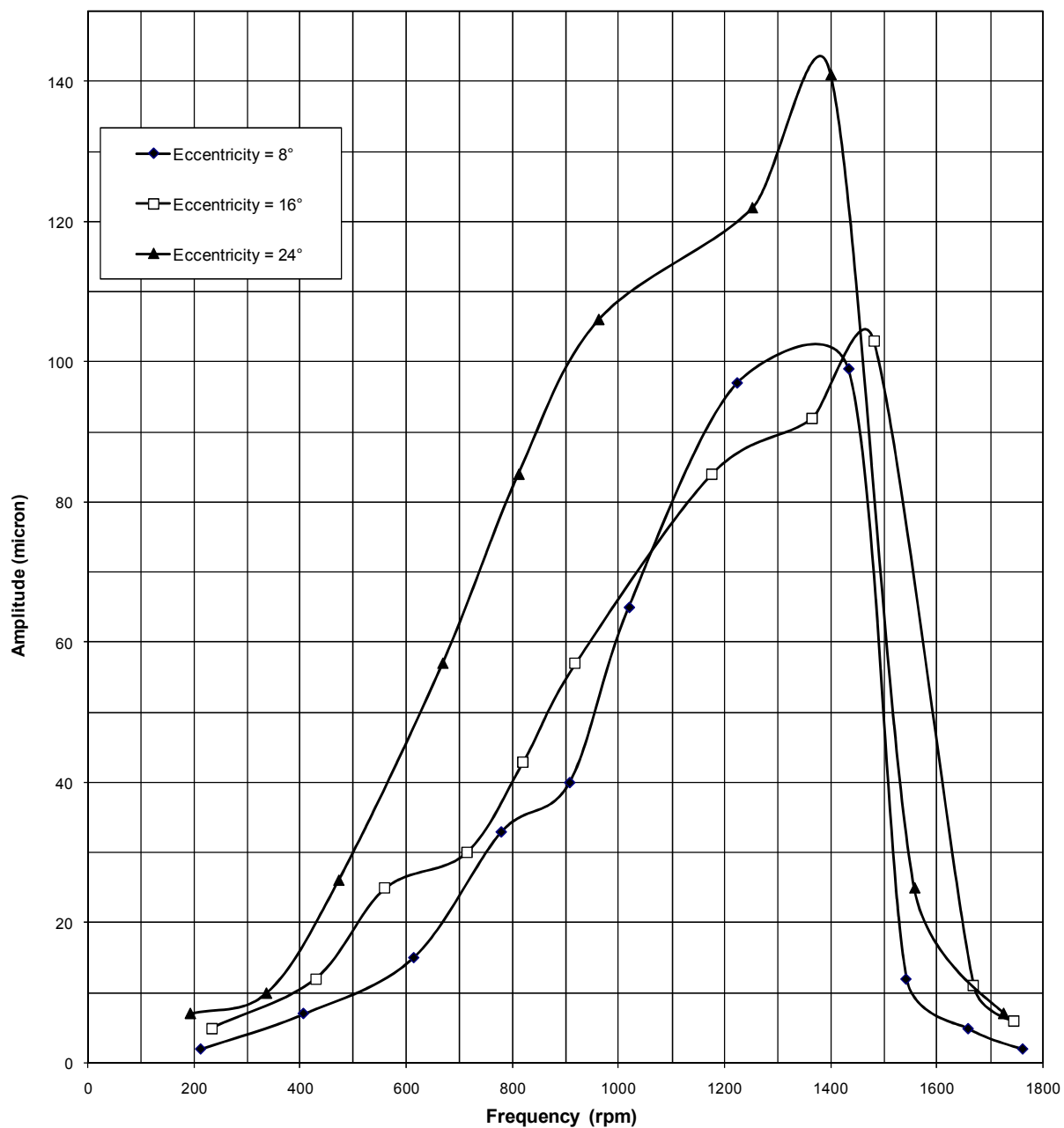




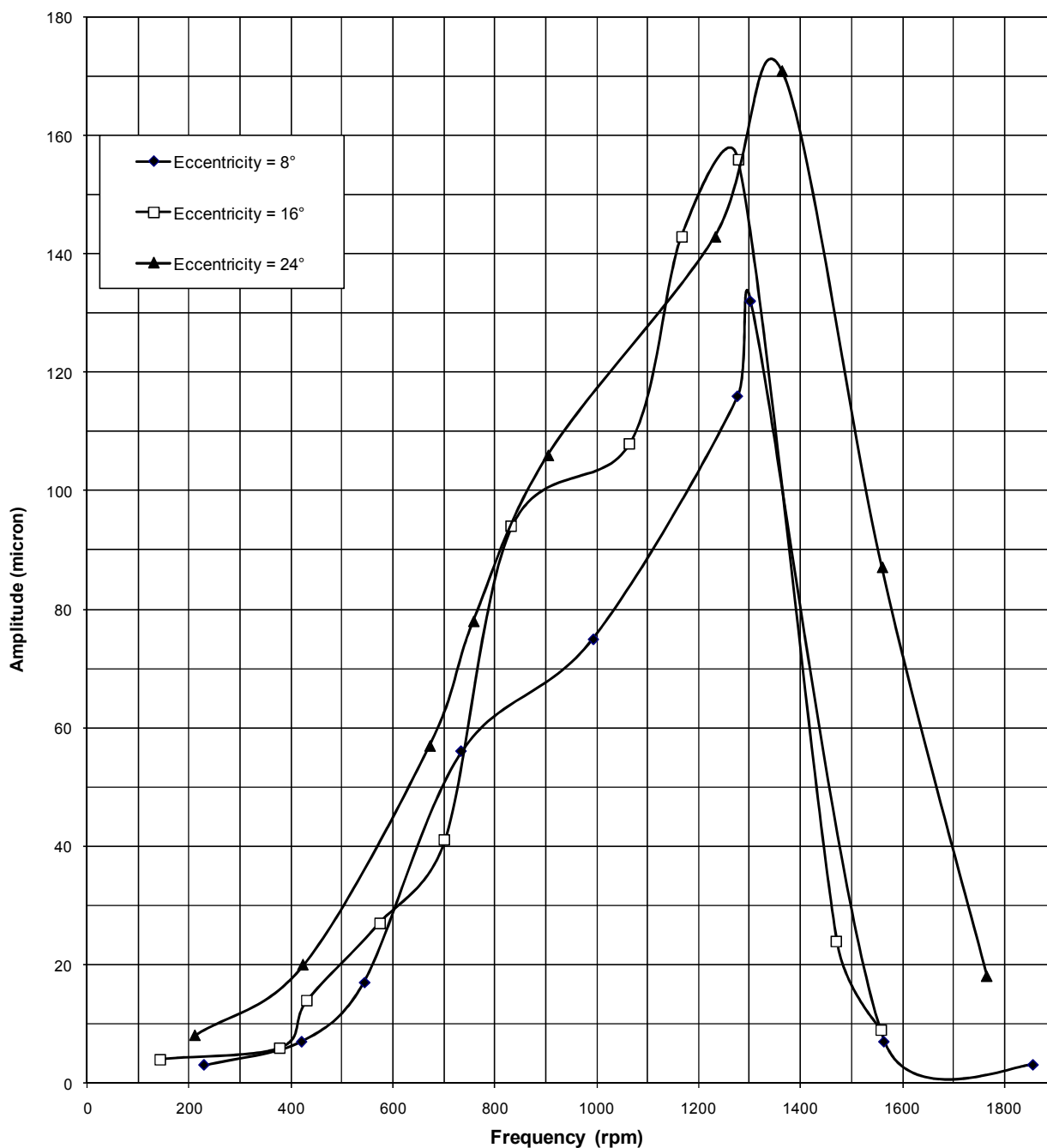
**Vertical Block Vibration Test graphs for BVT-05**



**Vertical Block Vibration Test graphs for BVT-06**



**Vertical Block Vibration Test graphs for BVT-07**



## **9. ELECTRICAL RESISTIVITY TEST**

## REPORT ON ELECTRICAL RESISTIVITY TEST (ERT) FOR 5<sup>th</sup> ALUMINA REFINERY AT DAMANJODI, ODISHA AND PORT FACILITIES AT VISAKHAPATNAM

### INTRODUCTION:

Electrical Resistivity Test was carried out for 5<sup>th</sup> Alumina Refinery at Damanjodi, Odisha and Port facilities at Visakhapatnam using resistivity meter (model DDR2 of IGIS) and following Indian standard Code: IS- 3043 at one location.

### METHODOLOGY:

The Soil Resistivity Survey is a method to find out the Electrical Resistivity (Specific Resistance) of a medium. It is the resistance offered by a unit cube of a particular medium (so called strata below the ground level) when a unit current passes perpendicular to the surface of a cross-sectional area A. The relation is given by Ohm's Law is –

$$\rho = R \times \frac{A}{L} \quad \text{ohm} \times \frac{\text{m}^2}{\text{m}} = \text{ohm} - \text{m} \text{ where}$$

$\rho$  = Resistivity, R = resistance offered by the medium of length L and Cross-sectional area A.

In electrical resistivity survey a known current I (direct current or low frequency alternating current) is sent into the ground through a pair of current electrodes A & B and the potential difference ( $\Delta V$ ) created in the medium is measured between another pair of electrodes M & N. The resistivity of the formation is then given

$$\rho = K \frac{\Delta V}{I} \quad \text{where } \rho \text{ is the apparent resistivity, } K \text{ is the geometric factor.}$$

In the Earth Resistivity Test, the Wenner configuration was followed. In this configuration two potential electrodes M & N are placed in a line with the current electrodes A & B, all four being situated equidistance from one to another and disposed symmetrically with respect to

a central point such that  $AM=MN=NB=a$ . The outer two electrodes A & B were used for sending current (I) and inner two M & N were used for measuring the potential differences ( $\Delta V$ ). The distance between each consecutive electrode (a) was kept constant and was progressively increased to reach the depth at which resistivity information are wanted. Suitable electrode spacing determines the conductivity of the top soil as well as the various subsurface layers occurring in the area under study. At each location, 4 sets of observations were taken for each of the electrode spacing (a) in eight directions (N-S, E-W, NE-SW and NW-SE) and in eight different electrode spacing viz.:  $a = 1.0\text{m}, 2.0\text{m}, 3.0\text{m}, 5.0\text{m}, 8.0\text{m}, 10.0\text{m}, 15.0\text{m}$  and  $25.0\text{m}$  were used to know the nature of change of resistivity.

The apparent resistivity was determined by the formula –

$$\rho = 6.28 a \frac{\Delta V}{I} \text{ where 'a' is the distance between the two consecutive}$$

Electrodes and  $\frac{\Delta V}{I}$  is R which is the observed resistance for measuring resistivity.

The mean value of the resistivity estimated was taken as the representative one.

The depth of investigation in an isotropic and homogeneous formation can be approximated to the distance between the consecutive two electrodes (a).

It may be indicated here that in case of highly resistive formations, current penetrates much deeper into the earth than when the subsurface formations are conducting. Further, in the present investigation only apparent resistivity is measured which may be taken (as a first approximation) as the weighted average of the true resistivity of the subsurface formations in which current lines flow

## TEST RESULT:

The apparent resistivity value at ERT-15 location is presented below.

Sl. No.	Location	ERT No	Easting	Northing	Apparent Resistivity in Ohm-m
1.	Mud settling Area	ERT-15	2017.500	1829.000	1585.88

**APPARENT RESISTIVITY VALUES**

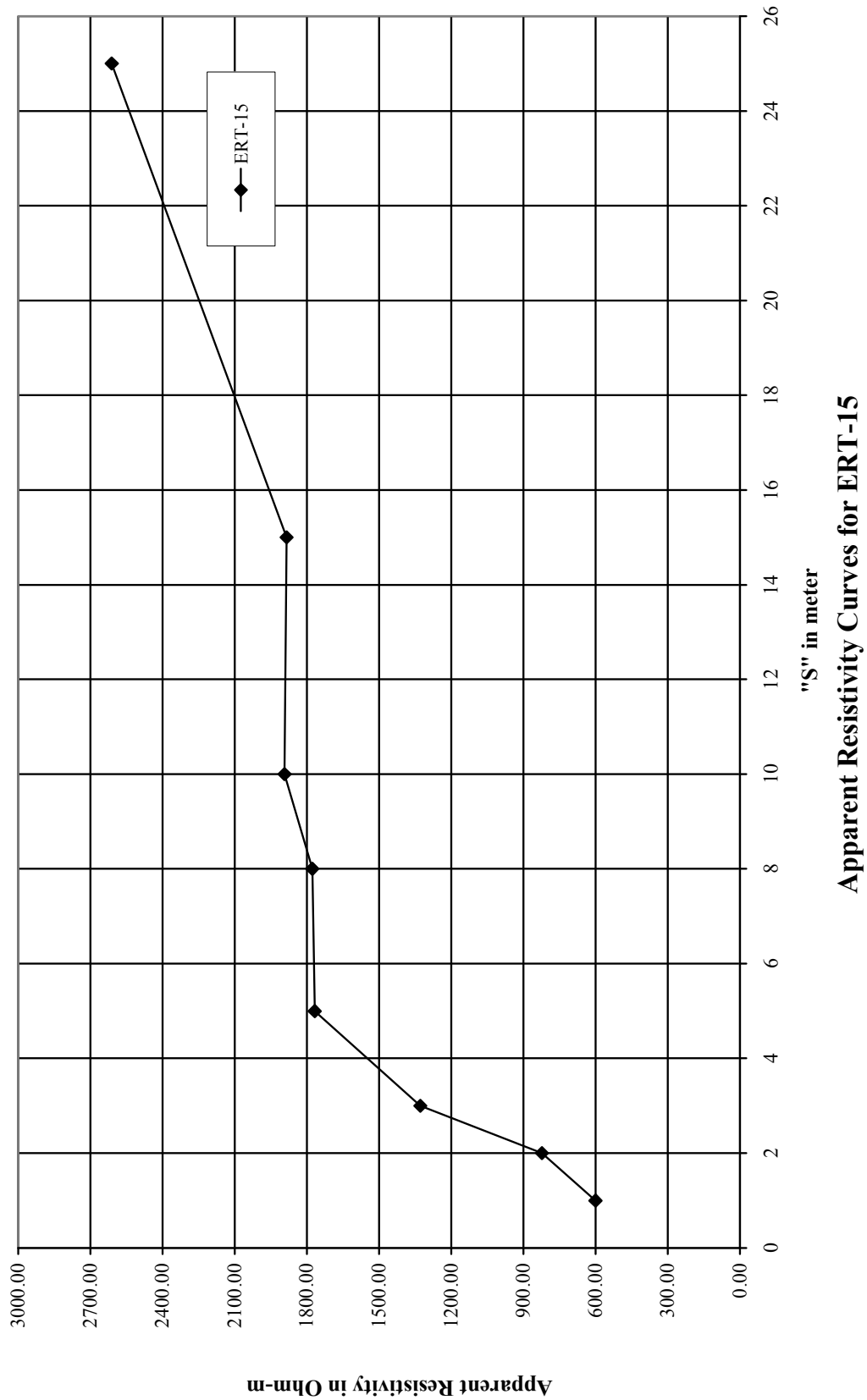
**ERT No. 15**

Sl No.	a ( M )	Apparent Electrical Resistivity (Ohm-m)				Mean
		( N - S )	( E - W )	( NE - SW )	( NW - SE )	
1	1.0	603.168	603.168	603.168	593.743	600.81
2	2.0	810.507	835.639	810.507	835.639	823.07
3	3.0	1338.279	1338.279	1319.154	1319.430	1328.79
4	5.0	1743.532	1790.655	1790.655	1743.532	1767.09
5	8.0	1734.142	1784.407	1784.407	1809.540	1778.12
6	10.0	1822.099	1853.514	1947.761	1947.761	1892.78
7	15.0	1932.063	1790.693	1932.063	1884.940	1884.94
8	25.0	2434.724	2591.803	2670.343	2748.882	2611.44

**Mean Apparent Resistivity - 1585.88 ohm-m**

## **APPARENT RESISTIVITY CURVE**





**APPENDIX**

**SUBJECT**

**SHEET NUMBER**

**PART I: ALL FIELD TESTS RESULTS**

Bore Log Data Sheet  
Pit Log of Trial Pit & CPLT  
Field Density Test Results  
Field CBR Test Results

**A1**  
A2 – A49  
A50 – A64  
A65  
A66 – A71

**PART II: LABORATORY TEST RESULTS**

Laboratory Soil Test Results  
Laboratory Rock Test Results

**A72**  
A74 – A81  
A82 – A88

**PART III: CHARTS & GRAPHS**

Strength Test Results  
Grain Size Distribution Curves

**A89**  
A90  
A91 – A107

**PART I: ALL FIELD TESTS RESULTS**

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.2**Co-ordinates E=1186.379  
N=1676.642

Field Test	Nos	Samples	Nos	Commencement Date : 14/08/2019
Penetrometer (SPT)	10	Undisturbed (UDS)	0	Completion Date : 15/08/2019
Cone (Pc)		Penetrometer (SPT)	10	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	10	Level Of Ground : 920.54 m.
		Water Sample (WS)	1	Water Struck At : Standing Water Level : 0.95 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1 WS-1 DS-2	0.50 0.95 1.00
Hard, reddish brown, silty clay with moorum.		11	12	20				SPT-1	1.45-1.90
								DS-3	2.50
		11	14	23				SPT-2	3.00-3.45
								DS-4	4.00
5.50m		10	16	26				SPT-3	4.50-4.95
								DS-5	5.50
		12	15	32				SPT-4	6.05-6.50
								DS-6	7.00
		15	19	33				SPT-5	7.45-7.90
								DS-7	8.50
		17	23	39				SPT-6	9.10-9.55
								DS-8	10.00
		21	25	47				SPT-7	10.50-10.95
		29	42	55				DS-9	11.30
12.00m		100	4.0	cm	Pentn.			SPT-8	11.50-11.85
								*SPT-9	12.00-12.04
								R1	CR=Nil
								DS-10	RQD=Nil
13.00m		100	3.0	cm	Pentn.			*SPT-10	13.00-13.03
								R2	CR=34%
									RQD=14%
								R3	CR=45%
15.00m									RQD=22%
15.00m									

909 of 1127

BH-200/Sheet-1

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.2**Co-ordinates E=1186.379  
N=1676.642

Field Test	Nos	Samples	Nos	Commencement Date : 14/08/2019
Penetrometer (SPT)	10	Undisturbed (UDS)	0	Completion Date : 15/08/2019
Cone (Pc)		Penetrometer (SPT)	10	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	10	Level Of Ground : 920.54 m.
		Water Sample (WS)	1	Water Struck At : Standing Water Level : 0.95 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
Moderately weathered, whitish grey, fine grained, moderately fractured rock.	15.10m								R4	CR=60% RQD=48%
	16.00m								R5	CR=100% RQD=93%
									R6	CR=100% RQD=93%
Fresh, whitish grey, slightly fractured rock.									R7	CR=100% RQD=95%
	19.00m									

N.B. — '\*' means sample could not be recovered.

910 of 1127

BH-200/Sheet-2

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.3

Co-ordinates E=1321.199  
N=1674.859

Field Test	Nos	Samples	Nos	Commencement Date : 16/08/2019
Penetrometer (SPT)	10	Undisturbed (UDS)	0	Completion Date : 18/08/2019
Cone (Pc)		Penetrometer (SPT)	10	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	8	Level Of Ground : 916.878 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.05 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m								
Dense to very dense, brownish grey, silty sand with decomposed rock fragments & moorum.							DS-1	0.50
							DS-2	1.00
						34	SPT-1	1.50-1.95
							DS-3	2.50
						39	SPT-2	3.00-3.45
							DS-4	4.00
						45	SPT-3	4.50-4.95
							DS-5	5.50
						53	SPT-4	6.00-6.45
						100 10.0 cm Pentn. >100	SPT-5	6.80-6.90
7.00m						100 Refusal	*SPT-6	7.00-7.03 7.00
Completely weathered, light grey, medium grained, decomposed & disintegrated rock particles collected as sludge.						3.0 cm Pentn.	R1	CR=Nil
						Refusal	DS-6	RQD=Nil
						100	*SPT-7	8.00-8.03 8.00
						3.0 cm Pentn.	R2	CR=Nil
						Refusal	DS-7	RQD=Nil
						100	*SPT-8	9.00-9.02 9.00
						2.0 cm Pentn.	R3	CR=Nil
						Refusal	DS-8	RQD=Nil
						100	*SPT-9	10.00-10.03 10.00
						3.0 cm Pentn.	R4	CR=Nil
11.00m						100 Refusal	DS-9	RQD=Nil
Moderately weathered to fresh, whitish grey, fine grained, moderately fractured rock.						2.0 cm Pentn.	*SPT-10	11.00-11.02 11.00
							R5	CR=51% RQD=16%
						NX rotary drilling from 7.00m to 15.00m		12.00
							R6	CR=100% RQD=92%
								13.00
							R7	CR=100% RQD=91%
								14.00
							R8	CR=100% RQD=93%
								15.00
N.B. - '*' means sample could not be recovered.								
15.00m								

Job No : 4095

Created by : SKD

Created on : 06/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.4

Co-ordinates E=1513.967  
N=1776.985

Field Test	Nos	Samples	Nos	Commencement Date : 31/07/2019
Penetrometer (SPT)	8	Undisturbed (UDS)	1	Completion Date : 01/08/2019
Cone (Pc)		Penetrometer (SPT)	8	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	6	Level Of Ground : 924.123 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.50 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Hard, reddish brown, moorum with decomposed rock.								DS-1	0.50
								DS-2	1.00
						36		SPT-1	1.50-1.95
		6	17	19				UDS-1	2.50-2.95
						43		SPT-2	2.95-3.40
		12	19	24				DS-3	4.00
						54		SPT-3	4.50-4.95
		11	23	31				SPT-4	5.40-5.75
		31	43	50		≥100		*SPT-5	6.00-6.04 6.00
		50				5.0 cm Pentn. Refusa.		R1	CR=Nil RQD=Nil
6.00m								DS-4	
Completely weathered, whitish grey, medium grained, decomposed & disintegrated rock particles collected as sludge.						4.0 cm Pentn. Refusa.		*SPT-6	7.00-7.03 7.00
		50						R2	CR=Nil RQD=Nil
						3.0 cm Pentn. Refusa.		DS-5	
		50						*SPT-7	8.00-8.03 8.00
						3.0 cm Pentn. Refusa.		R3	CR=Nil RQD=Nil
		50						DS-6	
9.00m								*SPT-8	9.00-9.04 9.00
Highly weathered, whitish grey, fine grained, fractured rock.						4.0 cm Pentn.		R4	CR=38% RQD=Nil
10.00m									10.00
Moderately weathered, whitish grey, fine grained, fractured rock.								R5	CR=53% RQD=21%
11.00m									11.00
Fresh, whitish grey, fine grained, slightly fractured rock.								R6	CR=100% RQD=93%
									12.00
								R7	CR=100% RQD=96%
									13.00
								R8	CR=100% RQD=95%
									14.00
14.00m									
N.B. - '*' means sample could not be recovered.									





Job No : 4095

Created by : SKD

Created on : 03/08/2019

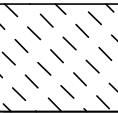
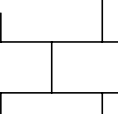
Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.6

Co-ordinates E=1558.875  
N=1726.956

Field Test	Nos	Samples	Nos	Commencement Date : 28/07/2019
Penetrometer (SPT)	12	Undisturbed (UDS)	0	Completion Date : 30/07/2019
Cone (Pc)		Penetrometer (SPT)	12	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	11	Level Of Ground : 926.018 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.7 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m Hard, reddish brown, clayey silt with sand mixture & moorum. Observed decomposed rock fragments.		50	>100				DS-1	0.50
		8.0	Pentn.				SPT-1	0.80-0.88
1.00m		50	Refusa.				*SPT-2	1.00-1.03 1.00
		3.0	Pentn.				R1	CR=Nil
			Refusa.				DS-2	RQD=Nil
		50					*SPT-3	2.00-2.04 2.00
		4.0	Pentn.				R2	CR=Nil
			Refusa.				DS-3	RQD=Nil
		50					*SPT-4	3.00-3.03 3.00
		3.0	Pentn.				R3	CR=Nil
			Refusa.				DS-4	RQD=Nil
		50					*SPT-5	4.00-4.04 4.00
		4.0	Pentn.				R4	CR=Nil
			Refusa.				DS-5	RQD=Nil
		50					*SPT-6	5.00-5.03 5.00
		3.0	Pentn.				R5	CR=Nil
			Refusa.				DS-6	RQD=Nil
		50					*SPT-7	6.00-6.03 6.00
		3.0	Pentn.				R6	CR=Nil
			Refusa.				DS-7	RQD=Nil
		50					*SPT-8	7.00-7.03 7.00
		3.0	Pentn.				R7	CR=Nil
			Refusa.				DS-8	RQD=Nil
		50					*SPT-9	8.00-8.04 8.00
		4.0	Pentn.				R8	CR=Nil
			Refusa.				DS-9	RQD=Nil
		50					*SPT-10	9.00-9.03 9.00
		3.0	Pentn.				R9	CR=Nil
			Refusa.				DS-10	RQD=Nil
		50					*SPT-11	10.00-10.04 10.00
		4.0	Pentn.				R10	CR=Nil
			Refusa.				DS-11	RQD=Nil
11.00m		50					*SPT-12	11.00-11.04 11.00
		4.0	Pentn.				R11	CR=62% RQD=31%
		NX rotary drilling from 1.00m to 15.00m						12.00
							R12	CR=100% RQD=93%
								13.00
							R13	CR=100% RQD=96%
								14.00
							R14	CR=100% RQD=94%
								15.00
Slightly weathered to fresh, whitish grey, fine grained, moderately fractured rock.								
N.B. - '*' means sample could not be recovered.								
15.00m								

Job No : 4095

Created by : SKD

Created on : 06/08/2019


Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.7

Co-ordinates E=1574.412  
N=1783.060

Field Test	Nos	Samples	Nos	Commencement Date : 23/07/2019
Penetrometer (SPT)	8	Undisturbed (UDS)	0	Completion Date : 25/07/2019
Cone (Pc)		Penetrometer (SPT)	8	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	7	Level Of Ground : 932.982 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 1.30 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m									DS-1	0.50
Hard, reddish brown, moorum with decomposed rock.									DS-2	1.00
									SPT-1	1.50-1.95
									SPT-2	2.50-2.75
									*SPT-3	3.00-3.04 3.00
									R1	CR=Nil
									DS-3	RQD=Nil
									*SPT-4	4.00-4.06 4.00
									R2	CR=Nil
									DS-4	RQD=Nil
									*SPT-5	5.00-5.04 5.00
Completely weathered, yellowish grey, medium grained, decomposed & disintegrated rock particles collected as sludge.									R3	CR=Nil
									DS-5	RQD=Nil
									*SPT-6	6.00-6.05 6.00
									R4	CR=Nil
									DS-6	RQD=Nil
									*SPT-7	7.00-7.04 7.00
									R5	CR=Nil
									DS-7	RQD=Nil
									*SPT-8	8.00-8.03 8.00
									R6	CR=65% RQD=15%
Slightly weathered to fresh, whitish grey, fine grained, moderately fractured rock.									R7	CR=100% RQD=96%
										10.00
									R8	CR=100% RQD=94%
										11.00
									R9	CR=100% RQD=95%
										12.00

N.B. - '\*' means sample could not be recovered.

Job No : 4095

Created by : SKD

Created on : 01/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.8

Co-ordinates E=1584.329  
N=1673.462

Field Test	Nos	Samples	Nos	Commencement Date : 21/07/2019
Penetrometer (SPT)	4	Undisturbed (UDS)	0	Completion Date : 22/07/2019
Cone (Pc)		Penetrometer (SPT)	4	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	2	Level Of Ground : 929.150 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.20 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Hard, reddish brown, moorum with decomposed rock fragments.								DS-1	0.50
								DS-2	1.00
		20	31	38	69			SPT-1	1.50-1.95
		38	49	52	>100			SPT-2	2.50-2.85
3.00m		56			5.0 cm Pentn.			*SPT-3	3.00-3.04 3.00
Completely weathered, light grey, medium grained, highly fractured, decomposed & disintegrated rock particles collected sa sludge.		4.0			cm Pentn.			R1	CR=Nil RQD=Nil
4.00m		50			Refusal			*SPT-4	4.00-4.04 4.00
Highly weathered, whitish grey, fine grained, moderately fractured rock.		4.0			cm Pentn.			R2	CR=30% RQD=12%
		NX rotary drilling from 3.00m to 10.00m						R3	CR=33% RQD=25%
									5.00
									6.00
6.00m								R4	CR=56% RQD=14%
Moderately weathered, whitish grey, fine grained, moderately fractured rock.									7.00
7.00m								R5	CR=100% RQD=96%
Fresh, whitish grey, fine grained, slightly fractured rock.									8.00
								R6	CR=100% RQD=95%
									9.00
								R7	CR=100% RQD=92%
N.B. - '*' means sample could not be recovered.									10.00
10.00m									

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095

Created by : SKD

Created on : 01/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.9

Co-ordinates E=1622.310  
N=1812.044

Field Test	Nos	Samples	Nos	Commencement Date : 20/07/2019
Penetrometer (SPT)	3	Undisturbed (UDS)	0	Completion Date : 20/07/2019
Cone (Pc)		Penetrometer (SPT)	3	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	2	Level Of Ground : 935.969 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 1.10 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Hard, reddish brown, moorum with decomposed rock.								DS-1	0.50
								DS-2	1.00
								WS-1	1.10
		20	32	41		73		SPT-1	1.50-1.95
3.00m									
		36	48	53		>100		SPT-2	2.50-2.86
Highly to moderately weathered, whitish grey, fine grained, moderately fractured rock.									
		52				6.0 cm Pentn.		SPT-2	2.50-2.86
6.00m									
		3.0				cm Pentn.		*SPT-3	3.00-3.03 3.00
Slightly weathered, whitish grey, fine grained, moderately fractured rock.									
7.00m									
Fresh, whitish grey, fine grained, moderately fractured rock.									
N.B. - '*' means sample could not be recovered.									
10.00m									

917 of 1127

BH-9/Sheet-1

Job No : 4095

Created by : SKD

Created on : 25/07/2019


Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.10

Co-ordinates E=1650.537  
N=1790.675

Field Test	Nos	Samples	Nos	Commencement Date : 18/07/2019
Penetrometer (SPT)	2	Undisturbed (UDS)	0	Completion Date : 19/07/2019
Cone (Pc)		Penetrometer (SPT)	2	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	1	Level Of Ground : 934.267 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.60 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m Hard, reddish brown, moorum with decomposed rock.		58						DS-1	0.50
		9.0 cm Pentn.						SPT-1	0.70-0.79
1.00m		56						*SPT-2	1.00-1.06 1.00
		6.0 cm Pentn.							
		NX rotary drilling from 1.00m to 8.00m						R1	CR=28% RQD=Nil
									2.00
								R2	CR=45% RQD=32%
									3.00
								R3	CR=43% RQD=40%
									4.00
4.00m								R4	CR=68% RQD=64%
									5.00
5.00m								R5	CR=100% RQD=93%
									6.00
								R6	CR=100% RQD=96%
									7.00
								R7	CR=100% RQD=95%
									8.00
8.00m N.B. - '*' means sample could not be recovered.									

918 of 1127

Job No : 4095

Created by : SKD

Created on : 14/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.11

Co-ordinates E=1625.883  
N=1765.662

Field Test	Nos	Samples	Nos	Commencement Date : 09/08/2019
Penetrometer (SPT)	4	Undisturbed (UDS)	0	Completion Date : 10/08/2019
Cone (Pc)		Penetrometer (SPT)	4	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	4	Level Of Ground : 942.896 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.20 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
								DS-2	1.00
Hard, reddish brown to greyish brown, silty clay with moorum & decomposed rock.		24	35	48	83			SPT-1	1.50-1.95
		32	56		>100			DS-3	2.40
		100	5.0	cm	Pentn.			SPT-2	2.60-2.80
3.00m								*SPT-3	3.00-3.03 3.00
Completely weathered, light grey, medium grained, decomposed & disintegrated rock fragments collected as sludge.								R1	CR=Nil
								DS-4	RQD=Nil
4.00m		100	3.0	cm	Pentn.			*SPT-4	4.00-4.03 4.00
Highly weathered, light brownish grey, fine grained, moderately fractured rock.								R2	CR=24% RQD=Nil
5.00m									5.00
Highly weathered, light brownish grey to whitish grey, fine grained, moderately fractured rock.								R3	CR=32% RQD=32%
									6.00
7.00m								R4	CR=40% RQD=37%
									7.00
Moderately weathered, whitish grey, fine grained, moderately fractured rock.								R5	CR=55% RQD=48%
									8.00
8.00m								R6	CR=100% RQD=94%
									9.00
Fresh, whitish grey to light blackish grey, fine grained, slightly fractured rock.								R7	CR=100% RQD=92%
									10.00
								R8	CR=100% RQD=96%
									11.00
11.00m									
NX rotary drilling from 3.00m to 11.00m									
N.B. - '*' means sample could not be recovered.									

Job No : 4095

Created by : SKD

Created on : 03/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.12

Co-ordinates E=1719.296  
N=1837.678

Field Test	Nos	Samples	Nos	Commencement Date : 23/07/2019
Penetrometer (SPT)	6	Undisturbed (UDS)	0	Completion Date : 24/07/2019
Cone (Pc)		Penetrometer (SPT)	6	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	2	Level Of Ground : 931.492 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.70 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m								
Hard, reddish brown, silty clay / clayey silt with sand mixture & moorum. Observed decomposed rock fragments.							DS-1	0.50
							DS-2	1.00
						54	SPT-1	1.50-1.95
		10	19	35				
3.00m		28	42	52		>100	SPT-2	2.50-2.85
						5.0 cm Pentn.	*SPT-3	3.00-3.03 3.00
		53				Refusal	R1	CR=Nil RQD=Nil
						3.0 cm Pentn.		
						Refusal	*SPT-4	4.00-4.04 4.00
		50					R2	CR=Nil RQD=Nil
						4.0 cm Pentn.		
						Refusal	*SPT-5	5.00-5.03 5.00
		50					R3	CR=Nil RQD=Nil
						3.0 cm Pentn.		
6.00m						Refusal	*SPT-6	6.00-6.03 6.00
		50					R4	CR=32% RQD=Nil
						3.0 cm Pentn.		
8.00m							R5	CR=48% RQD=Nil
							R6	CR=100% RQD=90%
							R7	CR=100% RQD=95%
							R8	CR=100% RQD=95%
11.00m								
NX rotary drilling from 3.00m to 11.00m								
Fresh, whitish grey, fine grained, slightly fractured rock.								
Highly to moderately weathered, whitish grey, medium grained, moderately fractured rock.								
Completely weathered, light grey, medium grained, decomposed & disintegrated rock fragments collected as sludge.								
Hard, reddish brown, silty clay / clayey silt with sand mixture & moorum. Observed decomposed rock fragments.								

N.B. - '\*' means sample could not be recovered.

Job No : 4095

Created by : SKD

Created on : 03/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.13

Co-ordinates E=1718.192  
N=1773.698

Field Test	Nos	Samples	Nos	Commencement Date : 25/07/2019
Penetrometer (SPT)	10	Undisturbed (UDS)	0	Completion Date : 27/07/2019
Cone (Pc)		Penetrometer (SPT)	10	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	10	Level Of Ground : 929.710 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 1.80 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m Hard, reddish brown, clayey silt with sand mixture & moorum. Observed decomposed rock fragments.		21	48	52	>100	cm Pentn.	DS-1	0.50
					5.0	Refusa.	DS-2	1.00
		53				4.0 cm Pentn.	WS-1	1.80
						Refusa.	SPT-1	1.50-1.85
2.00m							*SPT-2	2.00-2.04 2.00
		50				3.0 cm Pentn.	R1	CR=Nil
						Refusa.	DS-3	RQD=Nil
		50				3.0 cm Pentn.	*SPT-3	3.00-3.03 3.00
						Refusa.	R2	CR=Nil
		50				3.0 cm Pentn.	DS-4	RQD=Nil
						Refusa.	*SPT-4	4.00-4.03 4.00
		50				3.0 cm Pentn.	R3	CR=Nil
						Refusa.	DS-5	RQD=Nil
		50				4.0 cm Pentn.	*SPT-5	5.00-5.04 5.00
						Refusa.	R4	CR=Nil
		50				4.0 cm Pentn.	DS-6	RQD=Nil
						Refusa.	*SPT-6	6.00-6.04 6.00
		50				3.0 cm Pentn.	R5	CR=Nil
						Refusa.	DS-7	RQD=Nil
		50				3.0 cm Pentn.	*SPT-7	7.00-7.03 7.00
						Refusa.	R6	CR=Nil
		50				4.0 cm Pentn.	DS-8	RQD=Nil
						Refusa.	*SPT-8	8.00-8.04 8.00
		50				3.0 cm Pentn.	R7	CR=Nil
						Refusa.	DS-9	RQD=Nil
		50				4.0 cm Pentn.	*SPT-9	9.00-9.03 9.00
						Refusa.	R8	CR=Nil
		50				4.0 cm Pentn.	DS-10	RQD=Nil
						Refusa.	*SPT-10	10.00-10.04 10.00
10.00m Highly weathered, whitish grey, fine grained, moderately fractured rock.							R9	CR=35% RQD=Nil
11.00m Moderately weathered, whitish grey, fine grained, moderately fractured rock.							R10	CR=51% RQD=15%
12.00m							R11	CR=100% RQD=94%
							R12	CR=100% RQD=96%
							R13	CR=100% RQD=94%
Fresh, whitish grey, fine grained, slightly fractured rock.								
N.B. - '*' means sample could not be recovered.								
15.00m								

921 of 1127

BH-13/Sheet-1



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.14**Co-ordinates E=1773.145  
N=1749.587

Field Test	Nos	Samples	Nos	Commencement Date : 12/08/2019
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 13/08/2019
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	13	Level Of Ground : 926.641 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 0.90 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
								DS-2	1.00
						32		SPT-1	1.50-1.95
		9	14	18				DS-3	2.50
						36		SPT-2	2.95-3.40
		10	15	21				DS-4	4.00
						36		SPT-3	4.50-4.95
		8	13	23				DS-5	5.50
						37		SPT-4	6.00-6.45
		10	14	23				DS-6	7.00
						44		SPT-5	7.50-7.95
		10	16	28				DS-7	8.50
						40		SPT-6	9.10-9.55
		11	15	25				DS-8	10.00
						50		SPT-7	10.50-10.95
		13	19	31				DS-9	11.40
						69		SPT-8	11.80-12.25
		11	27	42				DS-10	12.50
						>100		SPT-9	12.70-12.90
		38	54	5.0 cm Pentn.				*SPT-10	13.00-13.03 13.00
		100		Refusal				R1	CR=Nil
				3.0 cm Pentn.				DS-11	RQD=Nil
				NX rotary drilling from 13.00m to 23.00m				*SPT-11	14.00-14.04 14.00
				Refusal				R2	CR=Nil
				100				DS-12	RQD=Nil
				4.0 cm Pentn.				*SPT-12	15.00-15.03 15.00
				Refusal					
				100					
				13.0 cm Pentn.					
15.10m									

Hard, reddish brown, silty clay with moorum.

Hard, greyish brown, silty clay with moorum & decomposed rock.

Completely weathered, light grey, medium grained, fully decomposed & disintegrated rock fragments collected as sludge.

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.14

Co-ordinates E=1773.145  
N=1749.587

Field Test	Nos	Samples	Nos	Commencement Date : 12/08/2019
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 13/08/2019
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	13	Level Of Ground : 926.641 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.90 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
15.10m Completely weathered, light grey, medium grained, fully decomposed & disintegrated rock fragments collected as sludge.							R3 DS-13	CR=Nil RQD=Nil
16.00m		100					*SPT-13	16.00-16.03 16.00
		3.0	cm	Pentn.			R4	CR=26% RQD=Nil
Highly weathered, light blackish grey, fine grained, completely fractured rock.							R5	CR=30% RQD=12%
							R6	CR=39% RQD=18%
19.00m Moderately weathered, light blackish grey, fine grained, fractured rock.							R7	CR=58% RQD=55%
20.00m							R8	CR=100% RQD=93%
							R9	CR=100% RQD=94%
Fresh, light blackish grey, fine grained, slightly fractured rock.							R10	CR=100% RQD=96%
23.00m								

N.B. - '\*' means sample could not be recovered.

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 14/08/2019

Sheet No:

# BORE LOG DATA SHEET

# BORE HOLE NO.15

Co-ordinates E=1689.950  
N=1728.028

Field Test	Nos	Samples	Nos	Commencement Date : 10/08/2019
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 11/08/2019
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	13	Level Of Ground : 930.859 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 1.40 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m								DS-1	0.50
								DS-2	1.00
						32		SPT-1	1.50-1.95
		6	13	19				DS-3	2.50
						37		SPT-2	3.00-3.45
Hard, reddish brown, clayey moorum & kankar.		12	16	21				DS-4	4.00
						35		SPT-3	4.45-4.90
		10	17	18				DS-5	5.50
						47		SPT-4	6.05-6.50
6.50m		12	19	28				DS-6	7.00
						48		SPT-5	7.50-7.95
		12	16	32				DS-7	8.50
						68		SPT-6	9.00-9.45
Hard, reddish brown, clayey moorum. Observed decomposed rock fragments.		17	31	37				DS-8	10.00
						81		SPT-7	10.45-10.90
		22	34	47				DS-9	11.30
		29	38		>100			SPT-8	11.60-11.80
12.00m		100			5.0 cm Pentn.			*SPT-9	12.00-12.04 12.00
					Refusa.			R1	CR=Nil
					4.0 cm Pentn.			DS-10	RQD=Nil
					NX rotary drilling from 12.00m to 22.00m			*SPT-10	13.00-13.03 13.00
		100			Refusa.			R2	CR=Nil
					3.0 cm Pentn.			DS-11	RQD=Nil
					Refusa.			*SPT-11	14.00-14.04 14.00
		100			4.0 cm Pentn.			R3	CR=Nil
					Refusa.			DS-12	RQD=Nil
15.10m		100			5.0 cm Pentn.			*SPT-12	15.00-15.03 15.00

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 14/08/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.15**Co-ordinates E=1689.950  
N=1728.028

Field Test	Nos	Samples	Nos	Commencement Date : 10/08/2019
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 11/08/2019
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	13	Level Of Ground : 930.859 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 1.4 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
15.10m Completely weathered, light grey, medium grained, fully decomposed & disintegrated rock fragments collected as sludge.								R4 DS-13	CR=Nil RQD=Nil
16.00m		100						*SPT-13	16.00-16.03 16.00
17.00m Highly weathered, whitish grey, fine grained, moderately fractured rock.		3.0	cm	Pentn.				R5	CR=24% RQD=Nil
18.00m Highly weathered, whitish grey, fine grained, moderately fractured rock.								R6	CR=32% RQD=15%
19.00m Moderately weathered, whitish grey, fine grained, moderately fractured rock.								R7	CR=56% RQD=48%
20.00m								R8	CR=100% RQD=93%
21.00m								R9	CR=100% RQD=96%
22.00m Fresh, light blackish grey, fine grained, slightly fractured rock.								R10	CR=100% RQD=94%

N.B. - '\*' means sample could not be recovered.

925 of 1127

BH-15/Sheet-2

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.16

Co-ordinates E=1652.733  
N=1679.321

Field Test	Nos	Samples	Nos	Commencement Date : 13/08/2019
Penetrometer (SPT)	8	Undisturbed (UDS)	0	Completion Date : 14/08/2019
Cone (Pc)		Penetrometer (SPT)	8	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	8	Level Of Ground : 932.205 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.05 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m							DS-1	0.50
Hard, reddish brown, clayey silt with sand mixture, moorum & decomposed rock.							DS-2	1.00
							SPT-1	1.55-1.90
							*SPT-2	2.00-2.04 2.00
2.00m							R1	CR=Nil
							DS-3	RQD=Nil
							*SPT-3	3.00-3.03 3.00
							R2	CR=Nil
							DS-4	RQD=Nil
							*SPT-4	4.00-4.04 4.00
							R3	CR=Nil
Completely weathered, light grey, medium grained, decomposed & disintegrated rock fragments collected as sludge.							DS-5	RQD=Nil
							*SPT-5	5.00-5.04 5.00
							R4	CR=Nil
							DS-6	RQD=Nil
							*SPT-6	6.00-6.04 6.00
							R5	CR=Nil
							DS-7	RQD=Nil
							*SPT-7	7.00-7.04 7.00
							R6	CR=Nil
							DS-8	RQD=Nil
8.00m							*SPT-8	8.00-8.03 8.00
Highly weathered, light grey, fine grained, highly fractured rock.							R7	CR=31% RQD=Nil
9.00m							R8	CR=56% RQD=18%
Moderately weathered, light grey, fine grained, highly fractured rock.							R9	CR=100% RQD=93%
10.00m							R10	CR=100% RQD=94%
Fresh, whitish grey, fine grained, moderately fractured rock.							R11	CR=100% RQD=96%
13.00m								
N.B. - '*' means sample could not be recovered.								

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha. **CETEST**

Job No : 4095 Created by : SKD Created on : 23/08/2019 Sheet No:

**BORE LOG DATA SHEET** **BORE HOLE NO.17** Co-ordinates E=1724.933 N=1673.462

Field Test	Nos	Samples	Nos	Commencement Date : 15/08/2019
Penetrometer (SPT)	20	Undisturbed (UDS)	0	Completion Date : 17/08/2019
Cone (Pc)		Penetrometer (SPT)	20	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	20	Level Of Ground : 926.346 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.95 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m										
Very stiff, reddish brown, silty clay with moorum.									DS-1	0.50
									DS-2	1.00
								28	SPT-1	1.55-2.00
		7	10	18					DS-3	2.50
									SPT-2	3.00-3.45
								30	DS-4	4.00
4.45m										
Hard, reddish brown, silty clay with moorum.									SPT-3	4.45-4.90
									DS-5	5.50
									SPT-4	6.00-6.45
		8	13	20				36	DS-6	7.00
									SPT-5	7.55-8.00
								35	DS-7	8.50
8.00m										
Hard, greyish brown, silty clay with moorum & decomposed rock.									SPT-6	9.00-9.45
									DS-8	10.00
									SPT-7	10.60-11.05
		11	17	26				43	DS-9	11.50
									SPT-8	12.10-12.55
								53	DS-10	13.00
									SPT-9	13.45-13.90
									DS-11	14.50
15.10m										

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.17

Co-ordinates E=1724.933  
N=1673.462

Field Test	Nos	Samples	Nos	Commencement Date : 15/08/2019
Penetrometer (SPT)	20	Undisturbed (UDS)	0	Completion Date : 17/08/2019
Cone (Pc)		Penetrometer (SPT)	20	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	20	Level Of Ground : 926.346 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.95 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
15.10m		17	32	39	71		SPT-10	15.00-15.45
Hard, greyish brown, silty clay with moorum & decomposed rock.					78		DS-12	16.00
		15	33	45			SPT-11	16.45-16.90
		34	58		>100		DS-13	17.30
					5.0 cm Pentn.		SPT-12	17.60-17.80
18.00m		100			Refusa.		*SPT-13	18.00-18.04 18.00
Completely weathered, light grey, medium grained, fully decomposed & disintegrated rock fragments collected as sludge.		4.0			cm Pentn.		R1	CR=Nil
					Refusa.		DS-14	RQD=Nil
		100					*SPT-14	19.00-19.03 19.00
		3.0			cm Pentn.		R2	CR=Nil
					Refusa.		DS-15	RQD=Nil
		100					*SPT-15	20.00-20.03 20.00
		3.0			cm Pentn.		R3	CR=Nil
					Refusa.		DS-16	RQD=Nil
		100					*SPT-16	21.00-21.03 21.00
		3.0			cm Pentn.		R4	CR=Nil
					Refusa.		DS-17	RQD=Nil
		100					*SPT-17	22.00-22.03 22.00
Highly weathered, whitish grey, fine grained, moderately fractured rock.		3.0			cm Pentn.		R5	CR=Nil
					Refusa.		DS-18	RQD=Nil
		100					*SPT-18	23.00-23.03 23.00
		3.0			cm Pentn.		R6	CR=Nil
Moderately weathered, whitish grey, fine grained, moderately fractured rock.					Refusa.		DS-19	RQD=Nil
		100					*SPT-19	24.00-24.04 24.00
		4.0			cm Pentn.		R7	CR=Nil
					Refusa.		DS-20	RQD=Nil
25.00m		100					*SPT-20	25.00-25.03 25.00
Fresh, whitish grey, fine grained, slightly fractured rock.		3.0			cm Pentn.		R8	CR=29% RQD=Nil
							R9	CR=58% RQD=42%
N.B. - '*' means sample could not be recovered.							R10	CR=100% RQD=92%
							R11	CR=100% RQD=98%
							R12	CR=100% RQD=96%
30.00m								30.00

928 of 1127

BH-17/Sheet-2

Job No : 4095

Created by : SKD

Created on : 31/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.18

Co-ordinates E=1759.683  
N=1673.462

Field Test	Nos	Samples	Nos	Commencement Date : 18/08/2019
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 20/08/2019
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 924.555 m.
		Water Sample (WS)	1	Water Struck At : Standing Water Level : 1.30 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m								
Hard, reddish brown, silty clay with moorum & decomposed rock.		13	16	19	35		DS-1	0.50
							DS-2	1.00
							WS-1	1.30
							SPT-1	1.45-1.90
							DS-3	2.50
		27	45	50	>100		SPT-2	3.10-3.45
		42	56	5.0	cm Pentn.	>100	SPT-3	3.60-3.80
		100			Refusa.		*SPT-4	4.00-4.04 4.00
		4.0			cm Pentn.		R1	CR=Nil
					Refusa.		DS-4	RQD=Nil
Completely weathered, light grey, medium grained, decomposed & disintegrated rock particles collected as sludge.		100					*SPT-5	5.00-5.03 5.00
		3.0			cm Pentn.		R2	CR=Nil
					Refusa.		DS-5	RQD=Nil
		100					*SPT-6	6.00-6.03 6.00
		3.0			cm Pentn.		R3	CR=Nil
					Refusa.		DS-6	RQD=Nil
		100					*SPT-7	7.00-7.04 7.00
		4.0			cm Pentn.		R4	CR=Nil
					Refusa.		DS-7	RQD=Nil
		100					*SPT-8	8.00-8.03 8.00
Highly weathered, whitish grey, fine grained, highly fractured rock.		3.0			cm Pentn.		R5	CR=Nil
					Refusa.		DS-8	RQD=Nil
		100					*SPT-9	9.00-9.02 9.00
		2.0			cm Pentn.		R6	CR=Nil
					Refusa.		DS-9	RQD=Nil
		100					*SPT-10	10.00-10.03 10.00
		3.0			cm Pentn.		R7	CR=Nil
					Refusa.		DS-10	RQD=Nil
		100					*SPT-11	11.00-11.03 11.00
		3.0			cm Pentn.		R8	CR=Nil
Moderately weathered, whitish grey, fine grained, highly fractured rock.					Refusa.		DS-11	RQD=Nil
		100					*SPT-12	12.00-12.03 12.00
		3.0			cm Pentn.		R9	CR=Nil
					Refusa.		DS-12	RQD=Nil
		100					*SPT-13	13.00-13.02 13.00
		2.0			cm Pentn.		R10	CR=36% RQD=Nil
								14.00
							R11	CR=52% RQD=23%
								15.00
							R12	CR=100% RQD=93%
Fresh, whitish grey, fine grained, moderately fractured rock.								16.00
							R13	CR=100% RQD=92%
								17.00
							R14	CR=100% RQD=94%
								18.00
N.B. - '*' means sample could not be recovered.								
18.00m								

929 of 1127

BH-18/Sheet-1



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 09/08/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.23**Co-ordinates E=1816.806  
N=1845.589

Field Test	Nos	Samples	Nos	Commencement Date : 01/08/2019
Penetrometer (SPT)	10	Undisturbed (UDS)	0	Completion Date : 03/08/2019
Cone (Pc)		Penetrometer (SPT)	10	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	10	Level Of Ground : 930.580 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 0.80 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Very stiff, reddish brown, silty clay with kankar.								DS-1	0.50
								DS-2	1.00
		8	10	18				SPT-1	1.45-1.90
								DS-3	2.50
3.00m									
Hard, reddish brown, silty clay with kankar.								SPT-2	3.00-3.45
		10	13	22				DS-4	4.00
		10	15	23				SPT-3	4.45-4.90
								DS-5	5.50
7.00m									
Hard, reddish brown, silty clay with moorum & decomposed rock.		8	13	24				SPT-4	6.05-6.50
								DS-6	7.00
		12	15	28				SPT-5	7.50-7.95
								DS-7	8.50
		16	25	32				SPT-6	9.00-9.45
								DS-8	10.00
		15	28	35				SPT-7	10.50-10.95
		16	32	47				DS-9	11.50
13.50m									
Highly weathered, whitish grey, fine grained, moderately fractured rock.								SPT-8	11.80-12.25
								DS-10	12.60
14.50m									
Moderately weathered, whitish grey, fine grained, moderately fractured rock.								SPT-9	13.00-13.20
								*SPT-10	13.50-13.54 13.50
15.50m									
Fresh, whitish grey, fine grained, slightly fractured rock.								R1	CR=34% RQD=Nil
								R2	CR=56% RQD=22%
								R3	CR=100% RQD=92%
								R4	CR=100% RQD=93%
								R5	CR=100% RQD=96%
N.B. - '*' means sample could not be recovered.									
18.50m									

930 of 1127

BH-23/Sheet-1

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha. **CETEST**

Job No : 4095      Created by : SKD      Created on : 09/08/2019      Sheet No:

**BORE LOG DATA SHEET**      **BORE HOLE NO.24**      Co-ordinates E=1852.521  
N=1837.440

Field Test	Nos	Samples	Nos	Commencement Date : 04/08/2019
Penetrometer (SPT)	9	Undisturbed (UDS)	0	Completion Date : 05/08/2019
Cone (Pc)		Penetrometer (SPT)	9	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	9	Level Of Ground : 932.530 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.85 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Very stiff, reddish brown, silty clay with moorum.								DS-1	0.50
								DS-2	1.00
						29		SPT-1	1.55-2.00
		8	11	18				DS-3	2.50
3.00m									
Hard, reddish brown, silty clay with moorum.								SPT-2	3.00-3.45
						35		DS-4	4.00
								SPT-3	4.50-4.95
		9	14	21				DS-5	5.50
5.50m									
Hard, greyish brown, silty clay with moorum & decomposed rock.								SPT-4	6.10-6.55
						47		DS-6	7.00
								SPT-5	7.50-7.95
						55		DS-7	8.50
								SPT-6	9.10-9.55
						68		DS-8	10.20
								SPT-7	10.65-11.10
						80		DS-9	11.50
								SPT-8	11.90-12.25
						>100		*SPT-9	12.50-12.54 12.50
12.50m									
Highly weathered, whitish grey, fine grained, moderately fractured rock.								R1	CR=25% RQD=Nil
13.50m									
Highly weathered, whitish grey, fine grained, moderately fractured rock.								R2	CR=34% RQD=Nil
14.50m									
Moderately weathered, whitish grey, fine grained, moderately fractured rock.								R3	CR=58% RQD=22%
15.50m									
Fresh, whitish grey, fine grained, moderately fractured rock.								R4	CR=100% RQD=92%
								R5	CR=100% RQD=96%
								R6	CR=100% RQD=94%
N.B. - '*' means sample could not be recovered.									
18.50m									

Job No : 4095

Created by : SKD

Created on : 09/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.25

Co-ordinates E=1902.511  
N=1837.440

Field Test	Nos	Samples	Nos	Commencement Date : 04/08/2019
Penetrometer (SPT)	8	Undisturbed (UDS)	0	Completion Date : 08/08/2019
Cone (Pc)		Penetrometer (SPT)	8	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	8	Level Of Ground : 936.764 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.10 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m Medium dense, brownish grey, silty sand with moorum, kankar.							DS-1 DS-2 SPT-1	0.50 1.00 1.50-1.95
3.00m Dense, brownish grey, silty sand with rock dust, kankar.							DS-3 SPT-2	2.50 3.00-3.45
5.00m Dense to very dense, brownish grey, silty sand with rock dust & kankar.							DS-4 SPT-3 DS-5 SPT-4	4.00 4.50-4.95 5.50 6.00-6.45
9.00m Completely weathered, light grey, medium grained, decomposed & disintegrated rock fragments collected as sludge							DS-6 SPT-5 DS-7 SPT-6 *SPT-7 R1 DS-8 *SPT-8	7.00 7.50-7.95 8.50 8.70-8.90 9.00-9.04 CR=Nil RQD=Nil 10.00-10.03
10.00m Highly weathered, light blackish grey, fine grained, moderately fractured rock.							R2	10.00 CR=28% RQD=Nil
12.00m Moderately weathered, light blackish grey, fine grained, moderately fractured rock.							R3	11.00 CR=32% RQD=18%
13.00m Slightly weathered to fresh, whitish grey, fine grained, slightly fractured rock.							R4	12.00 CR=53% RQD=42%
17.00m							R5	13.00 CR=68% RQD=44%
							R6	14.00 CR=100% RQD=93%
							R7	15.00 CR=100% RQD=93%
							R8	16.00 CR=100% RQD=93%
								17.00

N.B. - '\*' means sample could not be recovered.

932 of 1127

BH-25/Sheet-1

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095

Created by : SKD

Created on : 09/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.26

Co-ordinates E=1876.164  
N=1805.964

Field Test	Nos	Samples	Nos	Commencement Date : 06/08/2019
Penetrometer (SPT)	7	Undisturbed (UDS)	0	Completion Date : 08/08/2019
Cone (Pc)		Penetrometer (SPT)	7	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	7	Level Of Ground : 932.111 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 0.95 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m Very stiff, reddish brown, silty clay with moorum.		8	13	17	30		DS-1 DS-2 SPT-1 DS-3	0.50 1.00 1.50-1.95 2.50
3.00m Dense, brownish grey, clayey silty sand with rock dust & kankar.		10	13	19	32		SPT-2 DS-4	3.00-3.45 4.00
4.50m Dense to very dense, brownish grey, clayey silty sand with traces of moorum.		11	14	29	43		SPT-3 DS-5	4.50-4.95 5.50
		19	25	37	62		SPT-4 DS-6	6.00-6.45 7.00
8.00m Completely weathered, light grey, medium grained, decomposed & disintegrated rock fragments collected as sludge.		37	52		>100	5.0 cm Pentn.	SPT-5	7.50-7.70
9.00m Highly weathered, light blackish grey, fine grained, fractured rock.		100			Refusal	3.0 cm Pentn.	*SPT-6 R1 DS-7	8.00-8.03 8.00 CR=Nil RQD=Nil
10.00m Moderately weathered, light blackish grey, fine grained, moderately fractured rock.		100			Refusal	3.0 cm Pentn.	*SPT-7 R2 R3	9.00-9.03 9.00 CR=38% RQD=21% CR=53% RQD=23%
11.00m Fresh, whitish grey, fine grained, slightly fractured rock.							R4 R5	CR=100% RQD=93% CR=100% RQD=92%
N.B. - '*' means sample could not be recovered.							R6	CR=100% RQD=94%
14.00m								14.00

933 of 1127

BH-26/Sheet-1

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 09/08/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.27**Co-ordinates E=1799.504  
N=1794.233

Field Test	Nos	Samples	Nos	Commencement Date : 02/08/2019
Penetrometer (SPT)	12	Undisturbed (UDS)	0	Completion Date : 04/08/2019
Cone (Pc)		Penetrometer (SPT)	12	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 927.920 m.
		Water Sample (WS)	1	Water Struck At : Standing Water Level : 0.80 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m										
Very stiff, reddish brown, silty clay with moorum.									DS-1	0.50
									WS-1	0.80
									DS-2	1.00
		9	13	16					SPT-1	1.50-1.95
									DS-3	2.50
3.00m										
Dense, brownish grey, clayey silty sand with rock dust, rock pcs. & kankar.		7	12	19					SPT-2	3.00-3.45
									DS-4	4.00
		12	16	21					SPT-3	4.50-4.95
									DS-5	5.50
		10	15	19					SPT-4	6.00-6.45
6.50m										
Dense to very dense, brownish grey, clayey silty sand with rock dust & kankar.									DS-6	7.00
		11	17	28					SPT-5	7.55-8.00
									DS-7	8.50
		13	18	30					SPT-6	9.00-9.45
									DS-8	10.00
		13	16	35					SPT-7	10.45-10.90
11.10m										

934 of 1127

BH-27/Sheet-1

## BORE LOG DATA SHEET

## BORE HOLE NO.27

Co-ordinates	E=1799.504 N=1794.233
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Field Test	Nos	Samples	Nos	Commencement Date :	02/08/2019
Penetrometer (SPT)	12	Undisturbed (UDS)	0	Completion Date :	04/08/2019
Cone (Pc)		Penetrometer (SPT)	12	Bore Hole Diameter :	150mm / NX.
		Disturbed (DS)	12	Level Of Ground :	927.920 m.
Vane (V)		Water Sample (WS)	1	Water Struck At :	
				Standing Water Level :	0.80 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH	DIVN.	=	15cm	Ref. No	Depth (m)	
11.10m							DS-9	11.50
		14	19	37	56		SPT-8	12.00-12.45
							DS-10	13.00
Dense to very dense, brownish grey, clayey silty sand with rock dust & kankar.		16	18	41	59		SPT-9	13.55-14.00
							DS-11	14.50
		15	26	49	75		SPT-10	15.10-15.55
							DS-12	16.00
		22	38	62	>100		SPT-11	16.40-16.74
					4.0 cm Pentn. Refusal			
17.00m		100	3.0	cm Pentn.			*SPT-12	17.00-17.03 17.00
Highly weathered, whitish grey, fine grained, moderately fractured rock.							R1	CR=31% RQD=Nil
18.00m								18.00
Moderately weathered, whitish grey, fine grained, moderately fractured rock.							R2	CR=55% RQD=18%
19.00m								19.00
							R3	CR=100% RQD=94%
								20.00
Fresh, whitish grey, fine grained, slightly fractured rock.							R4	CR=100% RQD=96%
								21.00
							R5	CR=100% RQD=95%
								22.00
N.B. - '*' means sample could not be recovered.								
22.00m								

935 of 1127

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

Job No : 4095

Created by : SKD

Created on : 14/08/2019

Sheet No:

CETEST

BORE LOG DATA SHEET

BORE HOLE NO.28

Co-ordinates E=1805.690  
N=1750.719

Field Test	Nos	Samples	Nos	Commencement Date : 09/08/2019	
Penetrometer (SPT)	14	Undisturbed (UDS)	0	Completion Date : 10/08/2019	
Cone (Pc)		Penetrometer (SPT)	14	Bore Hole Diameter : 150mm / NX.	
Vane (V)		Disturbed (DS)	14	Level Of Ground : 926.222 m.	
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.90 m.	

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES		
		EACH DIVN. = 15cm						Ref. No	Depth (m)	
<div>0.00m</div> <div>Hard, reddish brown, silty clay with moorum.</div> <div>7.50m</div>									DS-1	0.50
									DS-2	1.00
		8	12	18			30		SPT-1	1.45-1.90
									DS-3	2.50
		6	15	21			36		SPT-2	3.05-3.50
									DS-4	4.00
		9	15	22			37		SPT-3	4.50-4.95
									DS-5	5.50
		11	13	25			38		SPT-4	6.10-6.55
									DS-6	7.00
		8	20	32			52		SPT-5	7.50-7.95
									DS-7	8.50
<div>Hard, greyish brown, silty clay with moorum &amp; decomposed rock.</div> <div>12.10m</div>		12	19	29			48	SPT-6	9.00-9.45	
								DS-8	10.00	
		15	19	39			58	SPT-7	10.50-10.95	
								DS-9	11.50	

936 of 1127

BH-28/Sheet-1

Job No : 4095

Created by : SKD

Created on : 14/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.28

Co-ordinates E=1805.690  
N=1750.719

Field Test	Nos	Samples	Nos	Commencement Date : 09/08/2019
Penetrometer (SPT)	14	Undisturbed (UDS)	0	Completion Date : 10/08/2019
Cone (Pc)		Penetrometer (SPT)	14	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	14	Level Of Ground : 926.222 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 0.90 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
12.10m		16	23	39	62		SPT-8	12.05-12.50
							DS-10	13.00
		15	25	41	66		SPT-9	13.55-14.00
							DS-11	14.50
		18	28	48	76		SPT-10	15.00-15.45
							DS-12	16.00
		25	42	58	>100		SPT-11	16.50-16.83
					3.0 cm Pentn.		*SPT-12	17.00-17.03 17.00
17.00m		100			Refusal		R1	CR=Nil
					3.0 cm Pentn.		DS-13	RQD=Nil
		100			Refusal		*SPT-13	18.00-18.03 18.00
					3.0 cm Pentn.		R2	CR=Nil
					Refusal		DS-14	RQD=Nil
19.00m		100			Refusal		*SPT-14	19.00-19.04 19.00
					4.0 cm Pentn.		R3	CR=34%
					NX rotary drilling from 17.00m to 22.00m			RQD=Nil
								20.00
							R4	CR=48%
								RQD=22%
								21.00
21.00m							R5	CR=100%
								RQD=92%
								22.00
							R6	CR=100%
								RQD=94%
								23.00
							R7	CR=100%
								RQD=96%
								24.00
24.00m								

937 of 1127

BH-28/Sheet-2



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

CETEST

BORE LOG DATA SHEET

BORE HOLE NO.29

Co-ordinates E=1844.816  
N=1749.977

Field Test	Nos	Samples	Nos	Commencement Date : 11/08/2019	
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 12/08/2019	
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.	
Vane (V)		Disturbed (DS)	13	Level Of Ground : 928.062 m.	
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.95 m.	

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
<div>0.00m</div> <div>Hard, reddish brown, silty clay with moorum.</div> <div>9.00m</div> <div>Hard, greyish brown, silty clay with moorum &amp; decomposed rock.</div> <div>11.10m</div>										
									DS-1	0.50
									DS-2	1.00
		7	11	19				30	SPT-1	1.45-1.90
									DS-3	2.50
								31	SPT-2	3.05-3.50
		7	12	19						
								36	DS-4	4.00
		9	15	21					SPT-3	4.45-4.90
									DS-5	5.50
								37	SPT-4	6.00-6.45
		8	14	23						
								40	DS-6	7.00
		11	15	25					SPT-5	7.50-7.95
							DS-7	8.50		
						42	SPT-6	9.10-9.55		
	13	15	27							
						52	DS-8	10.00		
	11	18	34				SPT-7	10.50-10.95		

938 of 1127

BH-29/Sheet-1

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.29

Co-ordinates E=1844.816  
N=1749.977

Field Test	Nos	Samples	Nos	Commencement Date : 11/08/2019
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 12/08/2019
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	13	Level Of Ground : 928.062 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.95 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
11.10m Hard, greyish brown, silty clay with moorum & decomposed rock.							DS-9	11.50
		12	19	37	56		SPT-8	12.05-12.50
							DS-10	13.00
		17	22	37	59		SPT-9	13.45-13.90
							DS-11	14.40
		17	25	43	68		SPT-10	14.80-15.25
		32	62		>100		DS-12	15.50
					5.0 cm Pentn.		SPT-11	15.70-15.90
16.00m Completely weathered, light grey, medium grained, fully decomposed & disintegrated rock fragments collected as sludge.		100			Refusal		*SPT-12	16.00-16.03 16.00
					3.0 cm Pentn.		R1	CR=Nil RQD=Nil
17.00m Highly weathered, light blackish grey, fine grained, moderately fractured rock.		100			Refusal		DS-13	
					4.0 cm Pentn.		*SPT-13	17.00-17.04 17.00
18.00m Moderately weathered, light blackish grey, fine grained, moderately fractured rock.							R2	CR=25% RQD=11%
19.00m Fresh, light blackish grey, fine grained, slightly fractured rock.							R3	CR=45% RQD=29%
							R4	CR=100% RQD=92%
							R5	CR=100% RQD=96%
							R6	CR=100% RQD=94%
22.00m N.B. - '*' means sample could not be recovered.								22.00

939 of 1127

BH-29/Sheet-2

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.31**Co-ordinates E=1828.029  
N=1727.370

Field Test	Nos	Samples	Nos	Commencement Date : 17/08/2019
Penetrometer (SPT)	12	Undisturbed (UDS)	0	Completion Date : 18/08/2019
Cone (Pc)		Penetrometer (SPT)	12	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 926.214 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 1.10 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Hard, reddish brown, clayey silt with sand mixture & traces of decomposed rock fragments.								DS-1	0.50
								DS-2	1.00
								WS-1	1.10
							34		
		9	12	22				SPT-1	1.50-1.95
								DS-3	2.50
							39		
		11	16	23				SPT-2	3.00-3.45
								DS-4	4.00
							40		
		10	17	23				SPT-3	4.50-4.95
								DS-5	5.50
							47		
		12	21	26				SPT-4	6.00-6.45
								DS-6	7.00
							51		
		13	23	28				SPT-5	7.50-7.95
8.00m									
Hard, reddish brown, clayey moorum. Observed decomposed rock fragments.								DS-7	8.50
							56		
		15	26	30				SPT-6	9.00-9.45
								DS-8	10.00
							59		
		17	27	32				SPT-7	10.50-10.95
11.10m									

940 of 1127

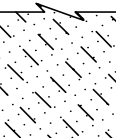
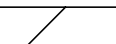
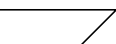
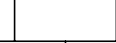
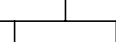

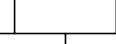
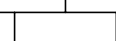

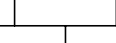
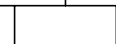
BH-31/Sheet-1

## BORE LOG DATA SHEET

## BORE HOLE NO.31

Co-ordinates	E=1828.029 N=1727.370
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Field Test	Nos	Samples	Nos	Commencement Date :	17/08/2019
Penetrometer (SPT)	12	Undisturbed (UDS)	0	Completion Date :	18/08/2019
Cone (Pc)		Penetrometer (SPT)	12	Bore Hole Diameter :	150mm / NX.
		Disturbed (DS)	12	Level Of Ground :	926.214 m.
Vane (V)		Water Sample (WS)	1	Water Struck At :	
				Standing Water Level :	1.10 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES		
		EACH DIVN. = 15cm				Ref. No	Depth (m)	
11.10m Hard, reddish brown, clayey moorum. Observed decomposed rock fragments.		41	59	>100		DS-9	11.50	
12.00m		100		5.0 cm Pentn.		SPT-8	11.70-11.90	
Completely weathered, light grey, medium grained, decomposed & disintegrated rock particles collected as sludge.				4.0 cm Pentn.		*SPT-9	12.00-12.04 12.00	
				Refusal		R1	CR=Nil RQD=Nil	
				Refusal		DS-10	↓	
		100		3.0 cm Pentn.		*SPT-10	13.00-13.03 13.00	
				Refusal		R2	CR=Nil RQD=Nil	
		100		3.0 cm Pentn.		DS-11	↓	
				Refusal		*SPT-11	14.00-14.03 14.00	
				3.0 cm Pentn.		R3	CR=Nil RQD=Nil	
					Refusal		DS-12	↓
	15.00m		100		3.0 cm Pentn.		*SPT-12	15.00-15.03 15.00
Moderately weathered to fresh, whitish grey, fine grained, moderately fractured rock.						R4	CR=52% RQD=18%	
							↓	
							16.00	
						R5	CR=100% RQD=32%	
							↓	
							17.00	
						R6	CR=100% RQD=93%	
							↓	
							18.00	
						R7	CR=100% RQD=91%	
							↓	
	19.00m							19.00

N.B. – '\*' means sample could not be recovered.

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha. **CETEST**

Job No : 4095 Created by : SKD Created on : 23/08/2019 Sheet No:

BORE LOG DATA SHEET BORE HOLE NO.32 Co-ordinates E=1822.464 N=1676.936

Field Test	Nos	Samples	Nos	Commencement Date : 14/08/2019
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 16/08/2019
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	13	Level Of Ground : 924.563 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.10 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m										
Very stiff, reddish brown, silty clay with moorum.									DS-1	0.50
									DS-2	1.00
		8	11	18				29	SPT-1	1.50-1.95
									DS-3	2.50
3.00m										
Hard, reddish brown, silty clay with moorum.		10	12	20				32	SPT-2	3.00-3.45
									DS-4	4.00
		8	14	23				37	SPT-3	4.55-5.00
									DS-5	5.50
7.00m										
Hard, greyish brown, silty clay with moorum & decomposed rock.		10	15	21				36	SPT-4	6.10-6.55
									DS-6	7.00
		13	19	29				48	SPT-5	7.45-7.90
									DS-7	8.50
11.10m										
		14	20	32				52	SPT-6	9.00-9.45
									DS-8	10.00
		15	25	39				64	SPT-7	10.40-10.85
11.10m										

Job No : 4095

Created by : SKD

Created on : 23/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.32

Co-ordinates E=1822.464  
N=1676.936

Field Test	Nos	Samples	Nos	Commencement Date : 14/08/2019
Penetrometer (SPT)	13	Undisturbed (UDS)	0	Completion Date : 16/08/2019
Cone (Pc)		Penetrometer (SPT)	13	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	13	Level Of Ground : 924.563 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.10 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
11.10m Hard, greyish brown, silty clay with moorum & decomposed rock.		37	55	>100			DS-9	11.25
12.00m		100	5.0 cm	Pentn.			SPT-8	11.70-11.90
		4.0 cm	Refusal				*SPT-9	12.00-12.04 12.00
							R1	CR=Nil
							DS-10	RQD=Nil
		100		Refusal			*SPT-10	13.00-13.03 13.00
		3.0 cm	Pentn.				R2	CR=Nil
							DS-11	RQD=Nil
		100		Refusal			*SPT-11	14.00-14.04 14.00
		4.0 cm	Pentn.				R3	CR=Nil
							DS-12	RQD=Nil
		100		Refusal			*SPT-12	15.00-15.03 15.00
		3.0 cm	Pentn.				R4	CR=Nil
							DS-13	RQD=Nil
16.00m Highly weathered, light grey, fine grained, moderately fractured rock.		100	3.0 cm	Pentn.			*SPT-13	16.00-16.03 16.00
							R5	CR=24% RQD=Nil
17.00m Highly weathered, light grey, fine grained, moderately fractured rock.								17.00
							R6	CR=28% RQD=Nil
18.00m Moderately weathered, light grey, fine grained, moderately fractured rock.								18.00
							R7	CR=56% RQD=45%
19.00m Fresh, whitish grey, fine grained, slightly fractured rock.								19.00
							R8	CR=100% RQD=96%
								20.00
							R9	CR=100% RQD=95%
								21.00
							R10	CR=100% RQD=96%
								22.00
N.B. - '*' means sample could not be recovered.								
22.00m								

943 of 1127

BH-32/Sheet-2

Job No : 4095

Created by : SKD

Created on : 03/08/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.33

Co-ordinates E=1972.733  
N=1845.819

Field Test	Nos	Samples	Nos	Commencement Date : 22/07/2019
Penetrometer (SPT)	5	Undisturbed (UDS)	0	Completion Date : 23/07/2019
Cone (Pc)		Penetrometer (SPT)	5	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	4	Level Of Ground : 942.775 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 1.10 m.


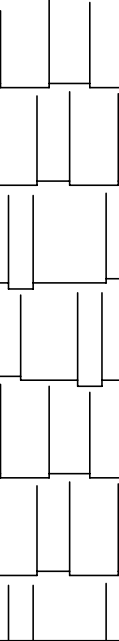
DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Hard, reddish brown, moorum with decomposed rock.								DS-1	0.50
								DS-2	1.00
								WS-1	1.10
		10	18	33	51			SPT-1	1.50-1.95
3.00m		36	48	52	>100			Pentn. SPT-2	2.50-2.90
					10.0 cm			*SPT-3	3.00-3.04 3.00
		58			Refusal			R1 DS-3	CR=Nil RQD=Nil
		4.0	cm	Pentn.					
5.00m					Refusal			*SPT-4	4.00-4.04 4.00
		50						R2 DS-4	CR=Nil RQD=Nil
		4.0	cm	Pentn.					
					Refusal			*SPT-5	5.00-5.04 5.00
7.00m		50						R3	CR=31% RQD=Nil
		4.0	cm	Pentn.					
					NX rotary drilling from 3.00m to 10.00m			R4	CR=48% RQD=11%
10.00m								R5	CR=100% RQD=96%
								R6	CR=100% RQD=98%
N.B. - '*' means sample could not be recovered.								R7	CR=100% RQD=94%

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha. CETEST

Job No : 4095 Created by : SKD Created on : 03/08/2019 Sheet No:

BORE LOG DATA SHEET BORE HOLE NO.34 Co-ordinates E=2022.207 N=1841.331

Field Test	Nos	Samples	Nos	Commencement Date : 20/07/2019
Penetrometer (SPT)	2	Undisturbed (UDS)	0	Completion Date : 21/07/2019
Cone (Pc)		Penetrometer (SPT)	2	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	1	Level Of Ground : 948.899 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 1.10 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m Hard, reddish brown, moorum with decomposed rock.		56	8.0	cm	Pentn.	>100	DS-1	0.50
1.00m		54	4.0	cm	Refusal		SPT-1 *SPT-2	0.80-0.88 1.00-1.04 1.00
		NX rotary drilling from 1.00m to 8.00m					R1	CR=34% RQD=Nil ↓ 2.00
							R2	CR=37% RQD=Nil ↓ 3.00
							R3	CR=41% RQD=Nil ↓ 4.00
							R4	CR=48% RQD=11% ↓ 5.00
5.00m							R5	CR=100% RQD=91% ↓ 6.00
							R6	CR=100% RQD=93% ↓ 7.00
							R7	CR=100% RQD=96% ↓ 8.00
8.00m								
N.B. - '*' means sample could not be recovered.								



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095


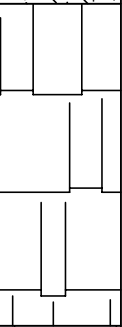
Created by : SKD

Created on : 25/07/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.35**Co-ordinates E=2106.648  
N=1838.335

Field Test	Nos	Samples	Nos	Commencement Date : 14/07/2019
Penetrometer (SPT)	2	Undisturbed (UDS)	0	Completion Date : 19/07/2019
Cone (Pc)		Penetrometer (SPT)	2	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	1	Level Of Ground : 955.696 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.10 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m Hard, reddish brown, moorum with decomposed rock.		58	10.0	cm	Pentn.	>100	DS-1	0.50
1.00m		56	5.0	cm	Pentn.	Refusal	SPT-1 *SPT-2	0.80-0.90 1.00-1.05 1.00
Highly weathered, whitish grey, fine grained, moderately fractured rock.		NX rotary drilling from 1.00m to 8.00m					R1	CR=28% RQD=Nil
3.00m							R2	CR=34% RQD=Nil
Moderately weathered, whitish grey, fine grained, moderately fractured rock.							R3	CR=51% RQD=Nil
5.00m							R4	CR=59% RQD=28%
Fresh, whitish grey, fine grained, moderately fractured rock.							R5	CR=100% RQD=90%
8.00m							R6	CR=100% RQD=92%
							R7	CR=100% RQD=96%

N.B. - '\*' means sample could not be recovered.

946 of 1127

BH-35/Sheet-1

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha. CETEST

Job No : 4095 Created by : SKD Created on : 25/07/2019 Sheet No:

BORE LOG DATA SHEET BORE HOLE NO.36 Co-ordinates E=2150.363 N=1834.306

Field Test	Nos	Samples	Nos	Commencement Date : 17/07/2019
Penetrometer (SPT)	2	Undisturbed (UDS)	0	Completion Date : 20/07/2019
Cone (Pc)		Penetrometer (SPT)	2	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	2	Level Of Ground : 947.193 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.80 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Hard, reddish brown, moorum with decomposed rock.								DS-1	0.50
								DS-2	1.00
								SPT-1	1.50-1.84
								*SPT-2	2.00-2.03 2.00
2.00m									
Highly to moderately weathered, whitish grey, fine grained, moderately fractured rock.								R1	CR=30% RQD=Nil
								R2	CR=30% RQD=Nil
								R3	CR=44% RQD=11%
								R4	CR=100% RQD=93%
5.00m									
Fresh, whitish grey, fine grained, moderately fractured rock.								R5	CR=100% RQD=95%
								R6	CR=100% RQD=93%
8.00m									
N.B. - '*' means sample could not be recovered.									

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.										CETEST	
Job No : 4095			Created by : SKD			Created on : 23/08/2019			Sheet No:		
BORE LOG DATA SHEET				BORE HOLE NO.38				Co-ordinates E=2030.281 N=1744.105			
Field Test		Nos	Samples		Nos	Commencement Date : 11/08/2019		Completion Date : 13/08/2019 Bore Hole Diameter : 150mm / NX. Level Of Ground : 936.867 m. Water Struck At : Standing Water Level : 0.80 m.			
Penetrometer (SPT)		0	Undisturbed (UDS)		0						
Cone (Pc)			Penetrometer (SPT)		0						
Vane (V)			Disturbed (DS)		0						
			Water Sample (WS)		1						
DESCRIPTION				SYMBOL	N-VALUE			SAMPLES			
								Ref. No	Depth (m)		
0.00m					NX rotary drilling from 0.00m to 7.00m				0.00		
Highly weathered, whitish grey, fine grained, moderately fractured rock.								R1	CR=25% RQD=Nil	↓	
1.00m								WS-1	0.80	1.00	
Highly weathered, whitish grey, fine grained, moderately fractured rock.								R2	CR=34% RQD=12%	↓	
3.00m								R3	CR=39% RQD=23%	↓	
Moderately weathered, whitish grey, fine grained, moderately fractured rock.								R4	CR=60% RQD=35%	↓	
4.00m								R5	CR=100% RQD=94%	↓	
Fresh, whitish grey, fine grained, slightly fractured rock.								R6	CR=100% RQD=92%	↓	
7.00m								R7	CR=100% RQD=97%	↓	

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095


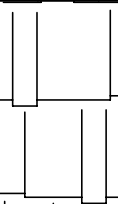
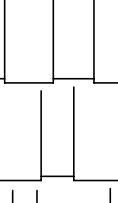
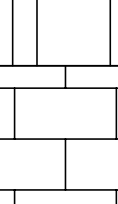
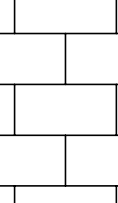
Created by : SKD

Created on : 25/07/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.39**Co-ordinates E=2129.297  
N=1767.147

Field Test	Nos	Samples	Nos	Commencement Date : 15/07/2019
Penetrometer (SPT)	2	Undisturbed (UDS)	0	Completion Date : 16/07/2019
Cone (Pc)		Penetrometer (SPT)	2	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	1	Level Of Ground : 935.629 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 0.80 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m Hard, reddish brown, moorum with sand mixture & decomposed rock fragments.		50	8.0	cm	>100		DS-1	0.50
1.00m		50	4.0	cm	Pentn. Refusal		SPT-1 *SPT-2	0.80-0.88 1.00-1.04 1.00
Highly to moderately weathered, whitish grey, fine grained, moderately fractured rock.		NX rotary drilling from 1.00m to 7.00m					R1	CR=31% RQD=Nil
								2.00
							R2	CR=39% RQD=35%
								3.00
4.00m Fresh, whitish grey, fine grained, slightly fractured rock.							R3	CR=43% RQD=40%
								4.00
							R4	CR=100% RQD=97%
								5.00
							R5	CR=100% RQD=95%
								6.00
7.00m							R6	CR=100% RQD=96%
								7.00

N.B. - '\*' means sample could not be recovered.

949 of 1127

BH-39/Sheet-1

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha. **CETEST**

Job No : 4095 Created by : SKD Created on : 03/08/2019 Sheet No:

**BORE LOG DATA SHEET** **BORE HOLE NO.41** Co-ordinates E=2058.380 N=1727.668

Field Test	Nos	Samples	Nos	Commencement Date : 21/07/2019
Penetrometer (SPT)	0	Undisturbed (UDS)	0	Completion Date : 23/07/2019
Cone (Pc)		Penetrometer (SPT)	0	Bore Hole Diameter : NX.
Vane (V)		Disturbed (DS)	0	Level Of Ground : 938.612 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 0.80 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
							Ref. No	Depth (m)
0.00m		NX rotary drilling from 0.00m to 7.00m						0.00
Highly to moderately weathered, whitish grey, fine grained, moderately fractured rock.							R1	CR=31% RQD=Nil
								1.00
							R2	CR=33% RQD=Nil
								2.00
							R3	CR=35% RQD=Nil
								3.00
							R4	CR=48% RQD=Nil
								4.00
4.00m							R5	CR=100% RQD=90%
Fresh, whitish grey, fine grained, moderately fractured rock.								5.00
							R6	CR=100% RQD=94%
								6.00
							R7	CR=100% RQD=95%
7.00m								7.00

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha. **CETEST**

Job No : 4095 Created by : SKD Created on : 25/07/2019 Sheet No:

BORE LOG DATA SHEET

BORE HOLE NO.42

Co-ordinates E=2135.611  
N=1727.667

Field Test	Nos	Samples	Nos	Commencement Date : 11/07/2019
Penetrometer (SPT)	0	Undisturbed (UDS)	0	Completion Date : 14/07/2019
Cone (Pc)		Penetrometer (SPT)	0	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	0	Level Of Ground : 927.451 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 0.60 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
0.00m		NX rotary drilling from 0.00m to 8.00m						0.00
Highly to moderately weathered, whitish grey, fine grained rock.							R1	CR=28% RQD=Nil
								1.00
							R2	CR=37% RQD=Nil
								2.00
							R3	CR=42% RQD=13%
								3.00
							R4	CR=44% RQD=34%
								4.00
4.00m							R5	CR=60% RQD=30%
Moderately weathered, whitish grey, fine grained rock.								5.00
							R6	CR=100% RQD=96%
								6.00
							R7	CR=100% RQD=96%
5.00m								7.00
Fresh, whitish grey, fine grained, slightly fractured rock.							R8	CR=100% RQD=95%
								8.00
8.00m								

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

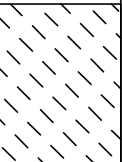





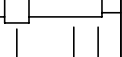
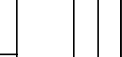



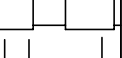

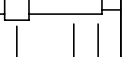


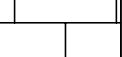
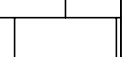
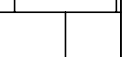
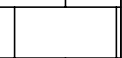
Created by : SKD

Created on : 25/07/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.43**Co-ordinates E=2176.876  
N=1708.679

Field Test	Nos	Samples	Nos	Commencement Date : 08/07/2019
Penetrometer (SPT)	2	Undisturbed (UDS)	0	Completion Date : 11/07/2019
Cone (Pc)		Penetrometer (SPT)	2	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	1	Level Of Ground : 920.031 m.
		Water Sample (WS)	1	Water Struck At : Standing Water Level : 0.40 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m Hard, reddish brown, clayey silt with traces of sand mixture & moorum. Observed decomposed rock fragments.		58	10.0	cm	Pentn.	>100		WS-1 DS-1	0.40 0.50
1.00m		54	4.0	cm	Pentn.	Refusal		SPT-1 *SPT-2	0.80-0.90 1.00-1.04 1.00
Highly/moderately weathered, whitish grey, fine grained, moderately fractured rock.		NX rotary drilling from 1.00m to 10.00m						R1	CR=43% RQD=15%
									2.00
								R2	CR=52% RQD=18%
									3.00
								R3	CR=41% RQD=29%
									4.00
								R4	CR=44% RQD=40%
									5.00
								R5	CR=37% RQD=25%
									6.00
6.00m								R6	CR=65% RQD=61%
Slightly weathered to fresh, whitish grey, fine grained, slightly fractured rock.									7.00
								R7	CR=100% RQD=95%
									8.00
								R8	CR=100% RQD=93%
									9.00
N.B. - '*' means sample could not be recovered.								R9	CR=100% RQD=95%
10.00m									10.00

952 of 1127

BH-43/Sheet-1

Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

CETEST

Job No : 4095 Created by : SKD Created on : 02/09/2019 Sheet No:

BORE LOG DATA SHEET BORE HOLE NO.45 Co-ordinates E=2033.526 N=1673.948

Field Test	Nos	Samples	Nos	Commencement Date : 21/08/2019
Penetrometer (SPT)	0	Undisturbed (UDS)	0	Completion Date : 23/08/2019
Cone (Pc)		Penetrometer (SPT)	0	Bore Hole Diameter : NX.
Vane (V)		Disturbed (DS)	0	Level Of Ground : 929.139 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 1.45 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
								Ref. No	Depth (m)
0.00m Highly weathered, whitish grey, fine grained rock.								R1	0.00 CR=21% RQD=Nil
1.00m Highly weathered, whitish grey, fine grained rock.								R2	1.00 CR=27% RQD=Nil
2.00m Highly weathered, whitish grey, fine grained rock.								R3	2.00 CR=36% RQD=Nil
3.00m Moderately weathered, whitish grey, fine grained rock.								R4	3.00 CR=58% RQD=28%
4.00m Fresh, whitish grey, fine grained rock.								R5	4.00 CR=100% RQD=92%
5.00m Fresh, whitish grey, fine grained rock.								R6	5.00 CR=100% RQD=94%
6.00m Fresh, whitish grey, fine grained rock.								R7	6.00 CR=100% RQD=94%
7.00m Fresh, whitish grey, fine grained rock.									7.00



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4095

Created by : SKD

Created on : 02/09/2019

Sheet No:

**BORE LOG DATA SHEET****BORE HOLE NO.46**Co-ordinates E=2122.851  
N=1672.078

Field Test	Nos	Samples	Nos	Commencement Date : 20/08/2019
Penetrometer (SPT)	0	Undisturbed (UDS)	0	Completion Date : 21/08/2019
Cone (Pc)		Penetrometer (SPT)	0	Bore Hole Diameter : NX.
Vane (V)		Disturbed (DS)	0	Level Of Ground : 921.742 m.
		Water Sample (WS)	0	Water Struck At : Standing Water Level : 1.35 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
								Ref. No	Depth (m)
0.00m									0.00
Completely to highly weathered, whitish grey, fine grained, highly fractured rock.								R1	CR=20% RQD=Nil
									1.00
								R2	CR=21% RQD=Nil
									2.00
2.00m									
Highly weathered, whitish grey, fine grained, highly fractured rock.								R3	CR=34% RQD=Nil
									3.00
3.00m									
Moderately weathered, whitish grey, fine grained, highly fractured rock.								R4	CR=52% RQD=18%
									4.00
4.00m									
Fresh, whitish grey, fine grained, moderately fractured rock.								R5	CR=100% RQD=93%
									5.00
								R6	CR=100% RQD=96%
									6.00
								R7	CR=100% RQD=92%
									7.00
7.00m									

954 of 1127

BH-46/Sheet-1

Job No : 4095

Created by : SKD

Created on : 02/09/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.126

Co-ordinates E=487.339  
N=398.579

Field Test	Nos	Samples	Nos	Commencement Date : 21/08/2019
Penetrometer (SPT)	37	Undisturbed (UDS)	0	Completion Date : 22/08/2019
Cone (Pc)		Penetrometer (SPT)	37	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	35	Level Of Ground : 902.607 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 4.30 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m									
Very stiff, reddish grey, silty clay with sand mixture & moorum.								DS-1	0.50
								DS-2	1.00
						24		SPT-1	1.50-1.95
		6	8	16				DS-3	2.50
3.00m									
Hard, reddish grey, silty clay with sand mixture & moorum.						40		SPT-2	3.00-3.45
		10	17	23				DS-4	4.00
						46		WS-1	4.30
		11	20	26				SPT-3	4.50-4.95
7.00m									
Hard, yellowish grey, clayey silt with sand mixture & moorum. Observed decomposed rock.						59		DS-5	5.50
		17	27	32				SPT-4	6.00-6.45
						63		DS-6	7.00
		21	30	33				SPT-5	7.50-7.95
11.00m									
						79		DS-7	8.50
		23	37	42				SPT-6	9.00-9.45
						>100		DS-8	10.00
		22	48	52		5.0 cm Pentn.		SPT-7	10.50-10.85
11.00m						Refusal		*SPT-8	11.00-11.04 11.00
Completely weathered, brownish grey, medium grained, decomposed & disintegrated rock particles collectes as sludge.		50				4.0 cm Pentn.		R1	CR=Nil
		50				Refusal		DS-9	RQD=Nil
		50				3.0 cm Pentn.		*SPT-9	12.00-12.03 12.00
						NX rotary drilling from 11.00m to 40.00m		R2	CR=Nil
						Refusal		DS-10	RQD=Nil
		50				Refusal		*SPT-10	13.00-13.03 13.00
						3.0 cm Pentn.		R3	CR=Nil
						Refusal		DS-11	RQD=Nil
		50				Refusal		*SPT-11	14.00-14.03 14.00
						3.0 cm Pentn.		R4	CR=Nil
						Refusal		DS-12	RQD=Nil
		50				Refusal		*SPT-12	15.00-15.03 15.00
						3.0 cm Pentn.		R5	CR=Nil
						Refusal		DS-13	RQD=Nil
		50				Refusal		*SPT-13	16.00-16.04 16.00
						4.0 cm Pentn.		R6	CR=Nil
						Refusal		DS-14	RQD=Nil
		50				Refusal		*SPT-14	17.00-17.03 17.00
						3.0 cm Pentn.		R7	CR=Nil
						Refusal		DS-15	RQD=Nil
		50				Refusal		*SPT-15	18.00-18.02 18.00
						2.0 cm Pentn.		R8	CR=Nil
						Refusal		DS-16	RQD=Nil
		50				Refusal		*SPT-16	19.00-19.04 19.00
						4.0 cm Pentn.		R9	CR=Nil
						Refusal		DS-17	RQD=Nil
20.00m						50 cm Pentn.		*SPT-17	20.00-20.03 20.00

Job No : 4095

Created by : SKD

Created on : 02/09/2019

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.126

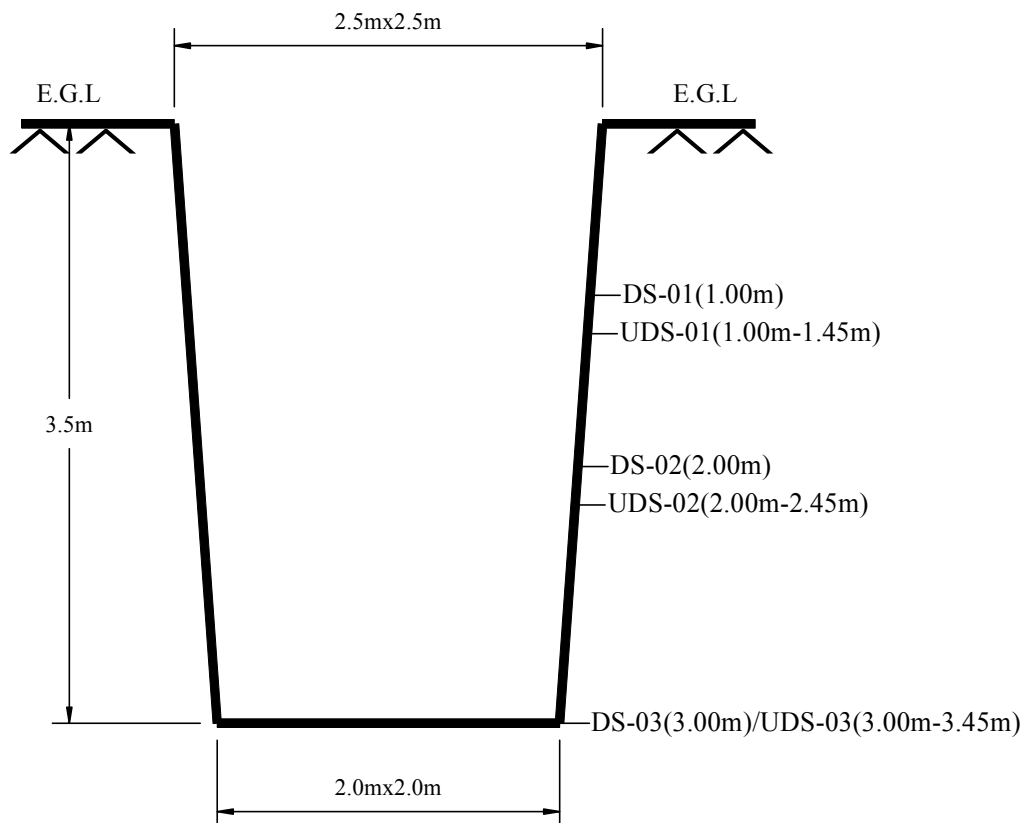
Co-ordinates E=487.339  
N=398.579

Field Test	Nos	Samples	Nos	Commencement Date : 21/08/2019
Penetrometer (SPT)	37	Undisturbed (UDS)	0	Completion Date : 22/08/2019
Cone (Pc)		Penetrometer (SPT)	37	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	35	Level Of Ground : 902.607 m.
		Water Sample (WS)	1	Water Struck At : Standing Water Level : 4.30 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
20.10m Completely weathered, light grey, medium grained, highly fractured rock.								R10	CR=13% RQD=Nil
21.00m		50						*SPT-18	21.00-21.03 21.00
		3.0	cm	Pentn.				R11	CR=Nil
		50						DS-18	RQD=Nil
		50						*SPT-19	22.00-22.04 22.00
		4.0	cm	Pentn.				R12	CR=Nil
		50						DS-19	RQD=Nil
		50						*SPT-20	23.00-23.03 23.00
		3.0	cm	Pentn.				R13	CR=Nil
		50						DS-20	RQD=Nil
		50						*SPT-21	24.00-24.03 24.00
		3.0	cm	Pentn.				R14	CR=Nil
		50						DS-21	RQD=Nil
		50						*SPT-22	25.00-25.04 25.00
		4.0	cm	Pentn.				R15	CR=Nil
		50						DS-22	RQD=Nil
		50						*SPT-23	26.00-26.03 26.00
		3.0	cm	Pentn.				R16	CR=Nil
		50						DS-23	RQD=Nil
		50						*SPT-24	27.00-27.03 27.00
		3.0	cm	Pentn.				R17	CR=Nil
		50						DS-24	RQD=Nil
		50						*SPT-25	28.00-28.04 28.00
		4.0	cm	Pentn.				R18	CR=Nil
		50						DS-25	RQD=Nil
		50						*SPT-26	29.00-29.03 29.00
29.00m Completely weathered, brownish grey, medium grained, highly fractured rock.								R19	CR=16% RQD=Nil
30.00m		50						*SPT-27	30.00-30.03 30.00
		3.0	cm	Pentn.				R20	CR=Nil
		50						DS-26	RQD=Nil
		50						*SPT-28	31.00-31.03 31.00
		3.0	cm	Pentn.				R21	CR=Nil
		50						DS-27	RQD=Nil
		50						*SPT-29	32.00-32.03 32.00
		3.0	cm	Pentn.				R22	CR=Nil
		50						DS-28	RQD=Nil
		50						*SPT-30	33.00-33.04 33.00
		4.0	cm	Pentn.				R23	CR=Nil
		50						DS-29	RQD=Nil
		50						*SPT-31	34.00-34.03 34.00
		3.0	cm	Pentn.				R24	CR=Nil
		50						DS-30	RQD=Nil
		50						*SPT-32	35.00-35.03 35.00
		3.0	cm	Pentn.				R25	CR=Nil
		50						DS-31	RQD=Nil
		50						*SPT-33	36.00-36.03 36.00
		3.0	cm	Pentn.				R26	CR=Nil
		50						DS-32	RQD=Nil
		50						*SPT-34	37.00-37.04 37.00
		4.0	cm	Pentn.				R27	CR=Nil
		50						DS-33	RQD=Nil
		50						*SPT-35	38.00-38.03 38.00
		3.0	cm	Pentn.				R28	CR=Nil
		50						DS-34	RQD=Nil
		50						*SPT-36	39.00-39.03 39.00
		3.0	cm	Pentn.				R29	CR=Nil
		50						DS-35	RQD=Nil
		50						*SPT-37	40.00-40.03 40.00
40.00m N.B. - '*' means sample could not be recovered.		50							

Co-ordinates:  
E = 1701.164  
N = 1799.250  
RL = 932.490M

SWL = Not Found



EGL-3.50m:- Reddish brown, silty clay with moorum.

## PIT LOG OF TP-1



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4 0 9 5

Created by : S K D

Created on : 30/08/2019

Sheet No:

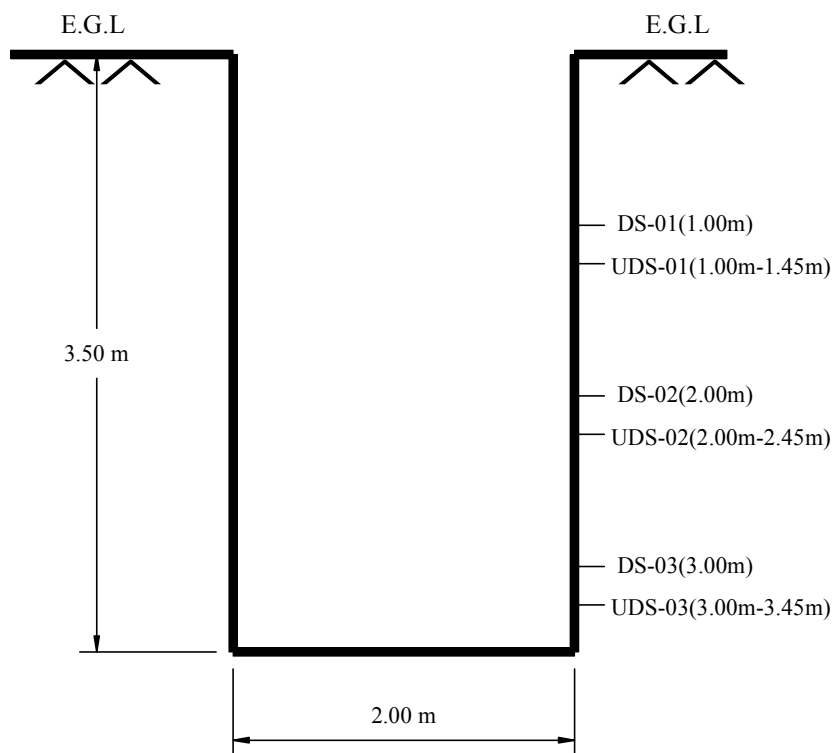
Co-ordinates:

E = 1900.524

N = 1805.292

RL = 934.111M

SWL = Not Found



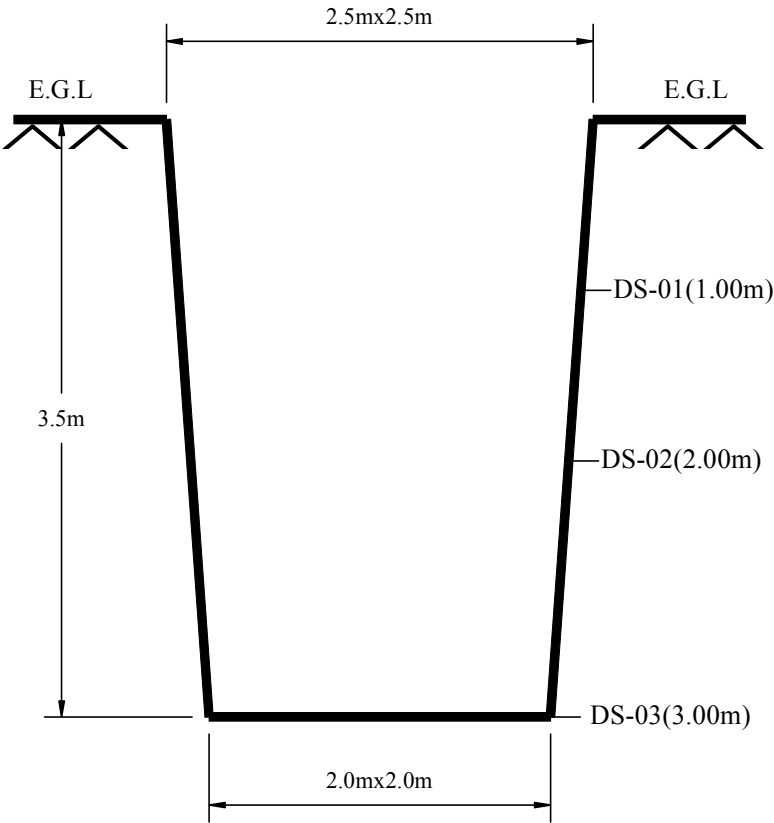
EGL-3.50m:- Reddish brown, silty clay with moorum.

PIT LOG OF TP-2



Co-ordinates:  
E = 2012.097  
N = 1852.526  
RL = 948.749M

SWL = Not Found



EGL-3.50m:- Brownish grey, decomposed rock with rock pcs.

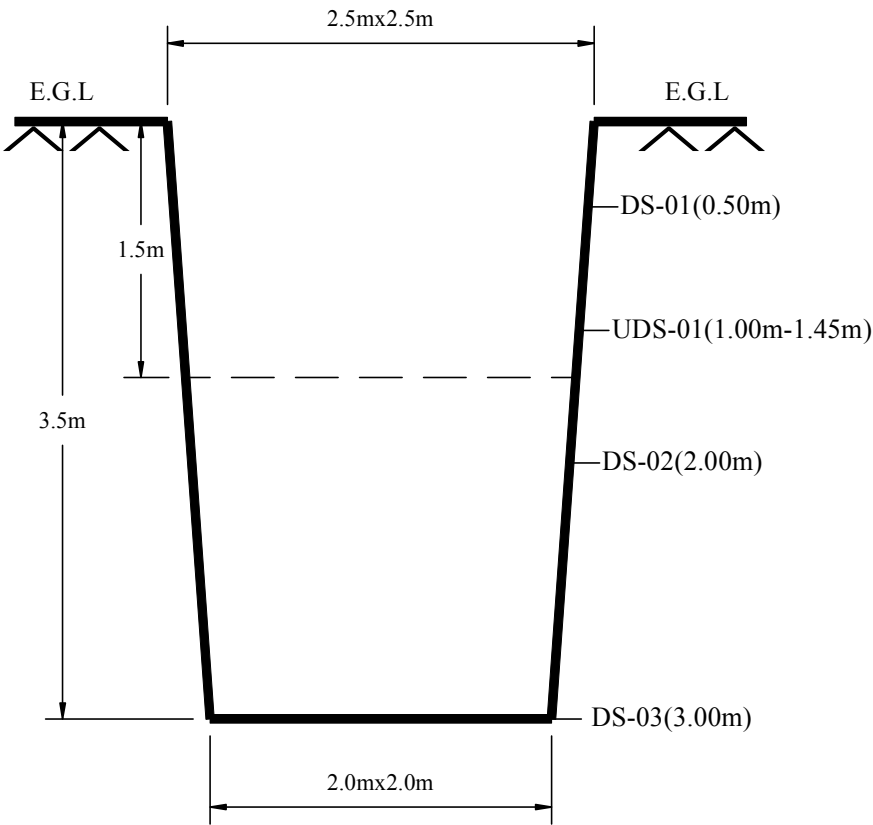
PIT LOG OF TP-3





Co-ordinates:  
E = 2324.897  
N = 1860.384  
RL = 939.500M

SWL = Not found.



EGL-1.50m:- Reddish brown, clayey silt with moorum.  
1.50m-3.50m:- Whitish grey, silty sand with weathered rock.

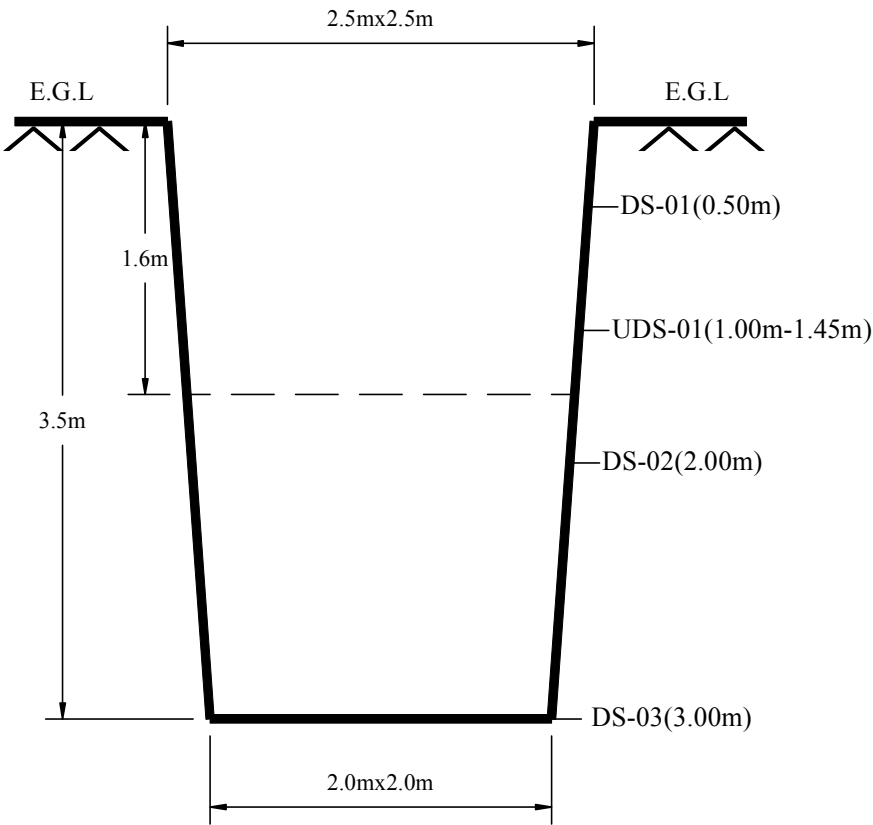
PIT LOG OF TP-17





Co-ordinates:  
E = 2451.973  
N = 2039.380  
RL = 943.957M

SWL = Not found.



EGL-1.60m:- Reddish brown, clayey silt with moorum.  
1.60m-3.50m:- Whitish grey, silty sand with weathered rock.

PIT LOG OF TP-18

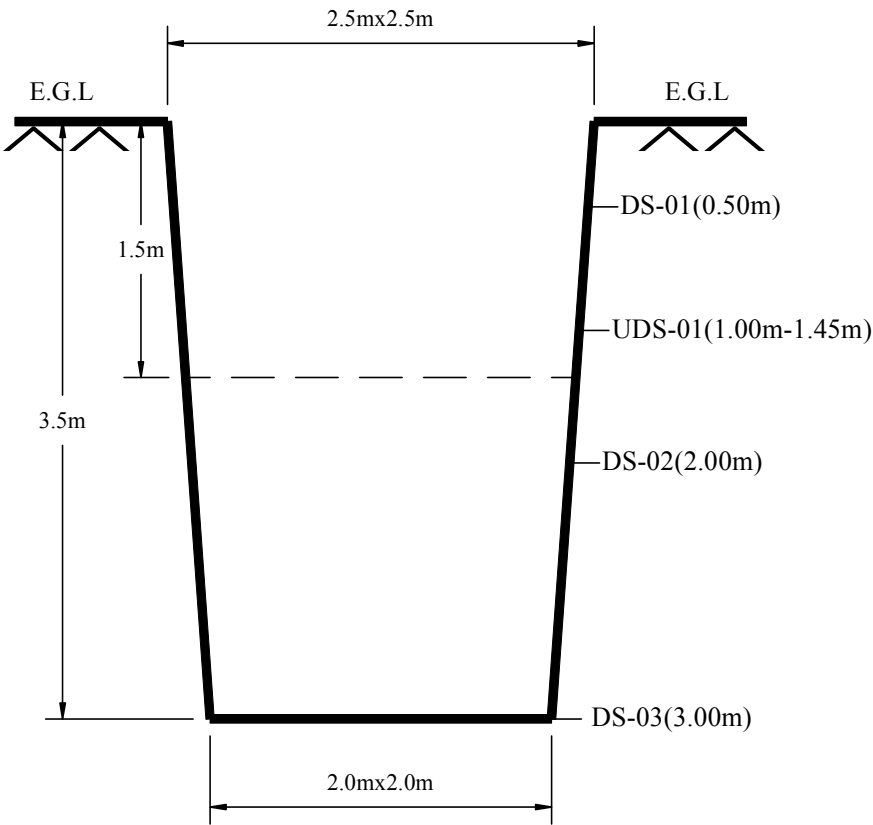






Co-ordinates:  
E = 2737.221  
N = 1939.843  
RL = 966.095M

SWL = Not found.



EGL-1.50m:- Reddish brown, clayey silt with moorum.  
1.50m-3.50m:- Whitish grey, silty sand with weathered rock.

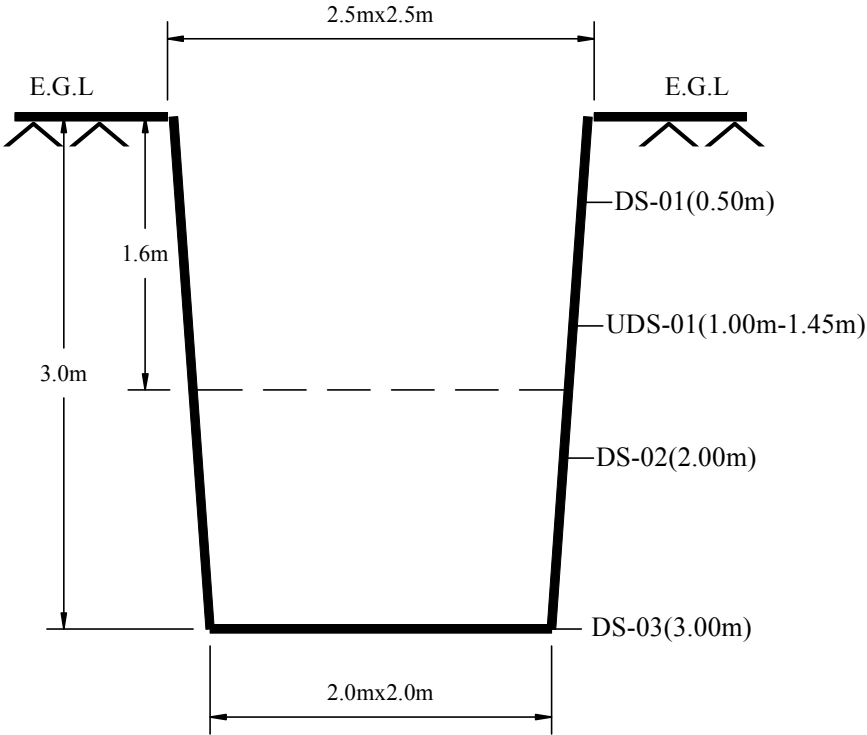
PIT LOG OF TP-19





Co-ordinates:  
E = 2815.519  
N = 1622.555  
RL = 963.586M

SWL = Not found.



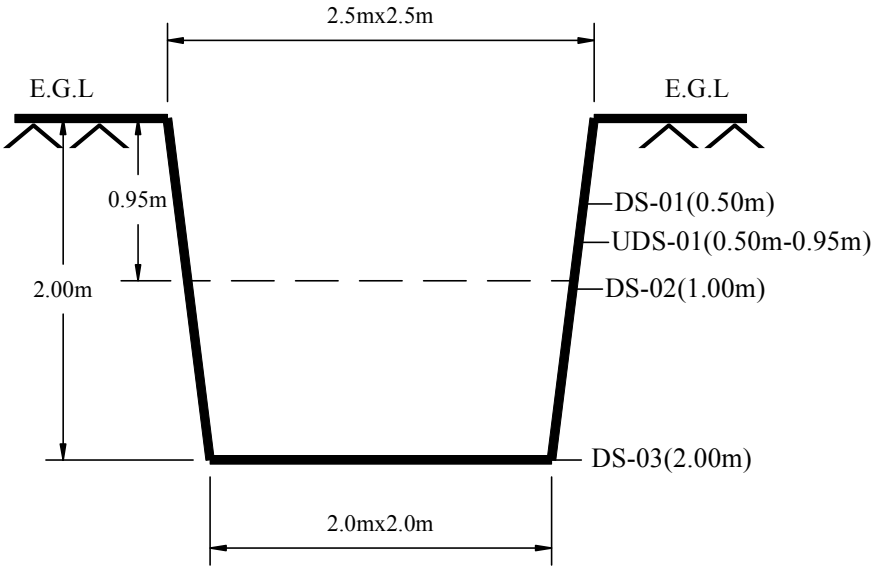
EGL-1.60m:- Reddish brown, clayey silt with moorum.  
1.60m-3.00m:- Whitish grey, silty sand with weathered rock.

PIT LOG OF TP-20



Co-ordinates:  
E = 2809.932  
N = 1581.381  
RL = 964.853M

SWL = Not found.



EGL-0.95m:- Reddish brown, clayey silt with moorum.  
0.95m-2.00m:- Whitish grey, silty sand with weathered rock.

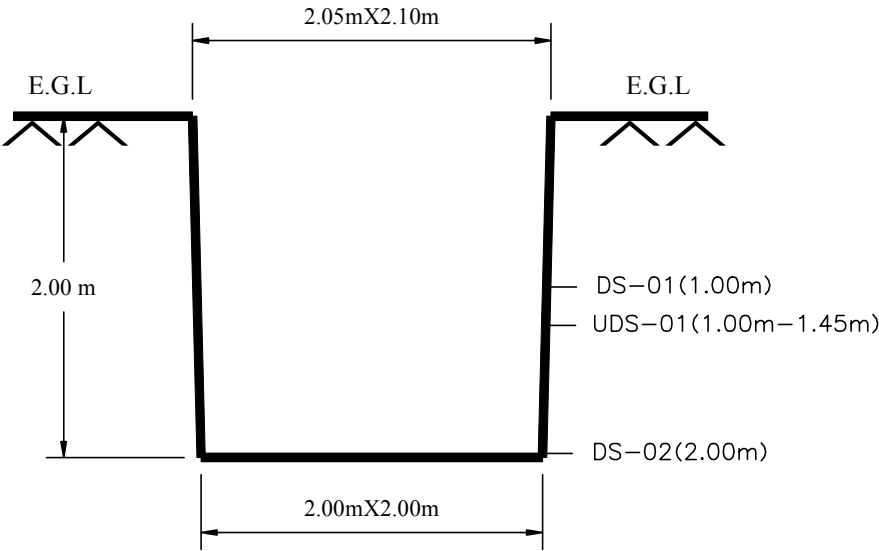
PIT LOG OF TP-21



Commenced on: 28/08/2019  
Completed on: 29/08/2019  
Pit size: 2.00mX2.00mX2.00m(depth)  
Load on pr.guage/divn.=10kg/sq.cm  
Load on jack/divn. =1.65ton  
Plate size: 0.60mX0.60m  
Load on plate/divn.=4.58t/sq.m  
**Test Type: Routine CPLT**

**Co-ordinates:**  
**E = 1190.917**  
**N = 1665.692**  
**RL = 920.131M**

SWL = NOT FOUND



EGL-2.00m:- Reddish brown, silty clay with moorum.

PIT LOG OF CPLT-1

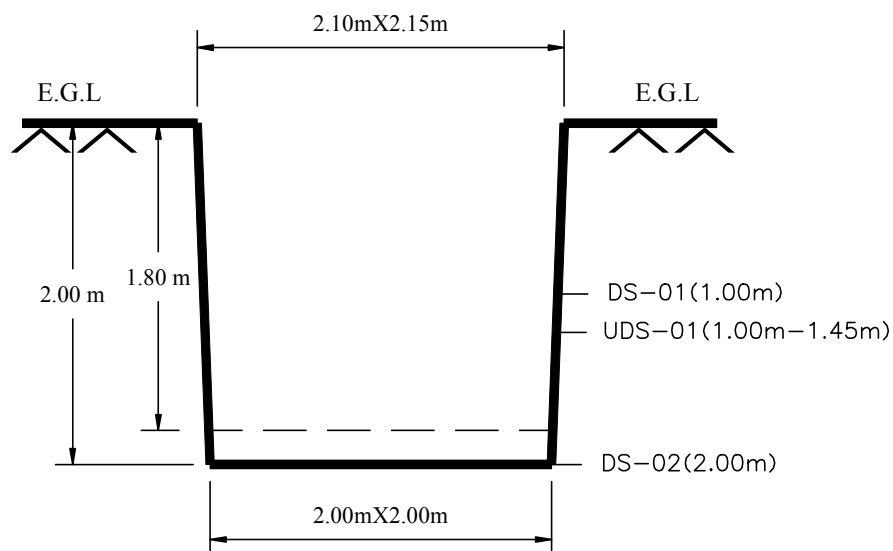




Commenced on: 26/08/2019  
Completed on: 27/08/2019  
Pit size: 2.00mX2.00mX2.00m(depth)  
Load on pr.guage/divn.=10kg/sq.cm  
Load on jack/divn. =1.65ton  
Plate size: 0.60mX0.60m  
Load on plate/divn.=4.58t/sq.m  
**Test Type: Routine CPLT**

**Co-ordinates:**  
**E = 1547.885**  
**N = 1781.661**  
**RL = 926.888M**

SWL = NOT FOUND



EGL-1.80m:- Reddish brown, silty clay with moorum.  
1.80m-2.00m:- Reddish brown, silty clay with moorum & decomposed rock.

## PIT LOG OF CPLT-2





Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4 0 9 5

Created by : S K D

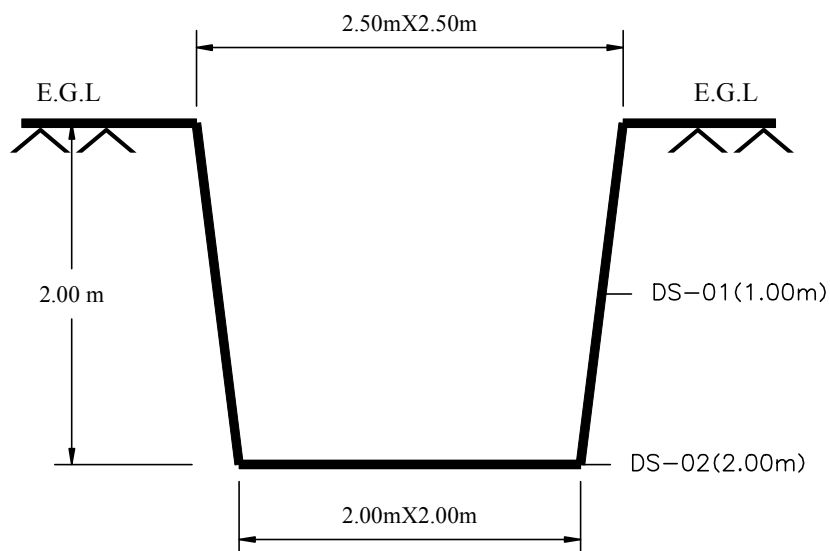
Created on : 05/09/2019

Sheet No:

Commenced on: 30/08/2019  
Completed on: 31/08/2019  
Pit size: 2.00mX2.00mX2.00m(depth)  
Load on pr.guage/divn.=10kg/sq.cm  
Load on jack/divn. =1.65ton  
Plate size: 0.60mX0.60m  
Load on plate/divn.=4.58t/sq.m  
**Test Type: Routine CPLT**

**Co-ordinates:**  
**E = 1973.875**  
**N = 1824.754**  
**RL = 940.732M**

SWL = Not Found



EGL-2.00m:- Brownish grey, decomposed rock with rock pcs.

## PIT LOG OF CPLT-3



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4 0 9 5

Created by : S K D

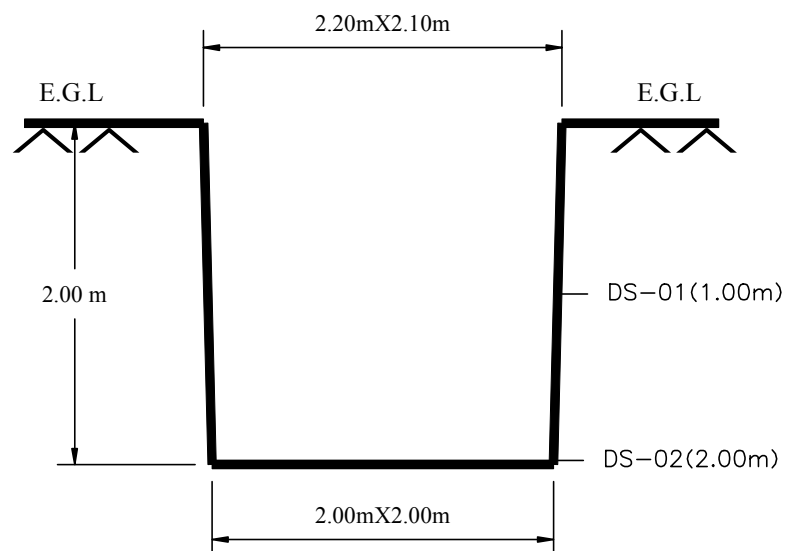
Created on : 12/09/2019

Sheet No:

Commenced on: 01/09/2019  
Completed on: 02/09/2019  
Pit size: 2.00mX2.00mX2.00m(depth)  
Load on pr.guage/divn.=10kg/sq.cm  
Load on jack/divn. =1.65ton  
Plate size: 0.60mX0.60m  
Load on plate/divn.=4.58t/sq.m  
**Test Type: Routine CPLT**

**Co-ordinates:**  
**E = 2016.635**  
**N = 1866.429**  
**RL = 949.381M**

SWL = NOT FOUND



EGL-2.00m:- Brownish grey, silty sand with decomposed rock.

## PIT LOG OF CPLT-4



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4 0 9 5

Created by : S K D

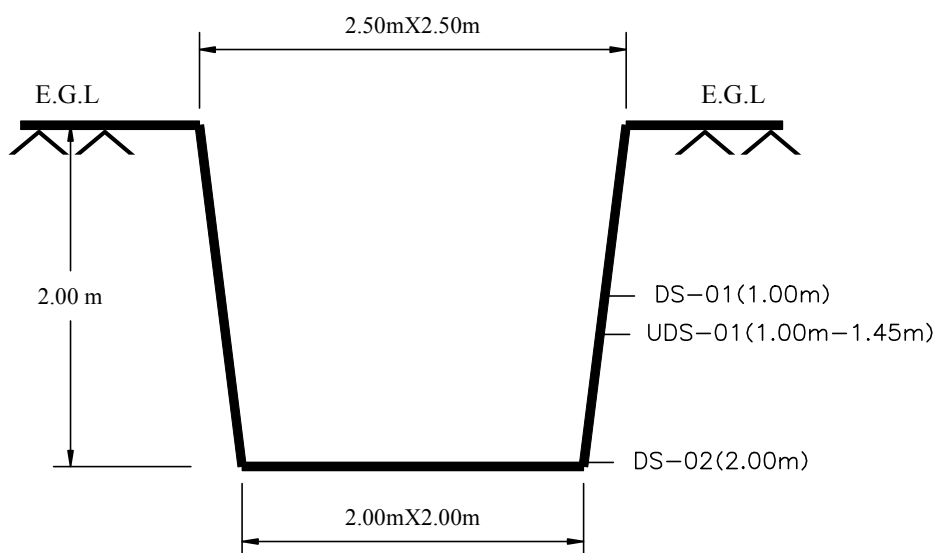
Created on : 12/09/2019

Sheet No:

Commenced on: 04/09/2019  
Completed on: 04/09/2019  
Pit size: 2.00mX2.00mX2.00m(depth)  
Load on pr.guage/divn.=10kg/sq.cm  
Load on jack/divn. =1.65ton  
Plate size: 0.60mX0.60m  
Load on plate/divn.=4.58t/sq.m  
**Test Type: Routine CPLT**

**Co-ordinates:**  
**E = 1107.509**  
**N = 1067.493**  
**RL = 899.797M**

SWL = NOT FOUND



EGL-2.00m:- Reddish brown, silty clay. Obs. moorum.

## PIT LOG OF CPLT-5

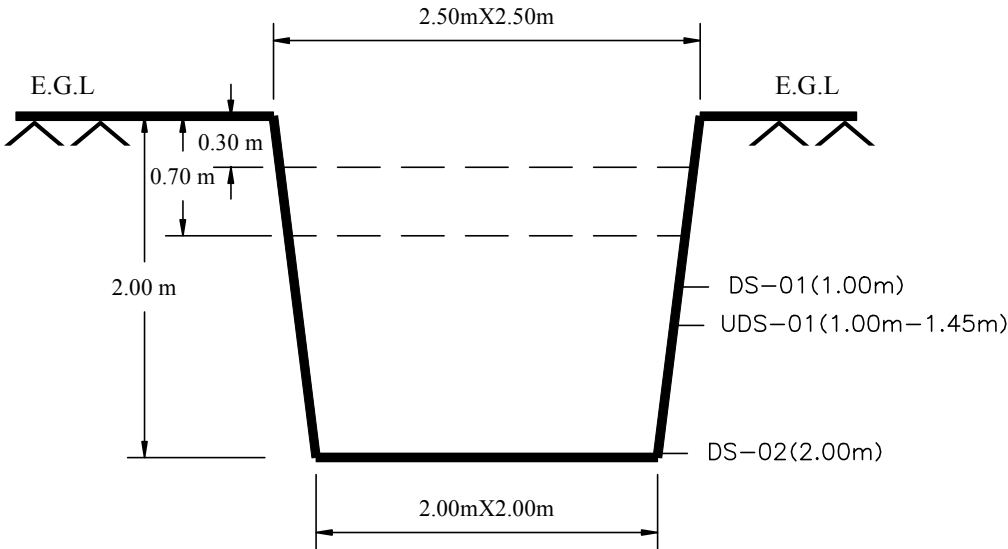




Commenced on: 06/09/2019  
Completed on: 06/09/2019  
Pit size: 2.00mX2.00mX2.00m(depth)  
Load on pr.guage/divn.=10kg/sq.cm  
Load on jack/divn. =1.65ton  
Plate size: 0.60mX0.60m  
Load on plate/divn.=4.58t/sq.m  
**Test Type: Routine CPLT**

**Co-ordinates:**  
**E = 1102.575**  
**N = 1239.259**  
**RL = 901.643M**

SWL = NOT FOUND



EGL-0.30m:- Whitish grey, lime.  
0.30m-0.70m:- Reddish brown, clayey silt with brick bats.  
0.70m-2.00m:- Reddish brown, silty clay. Obs. moorum.

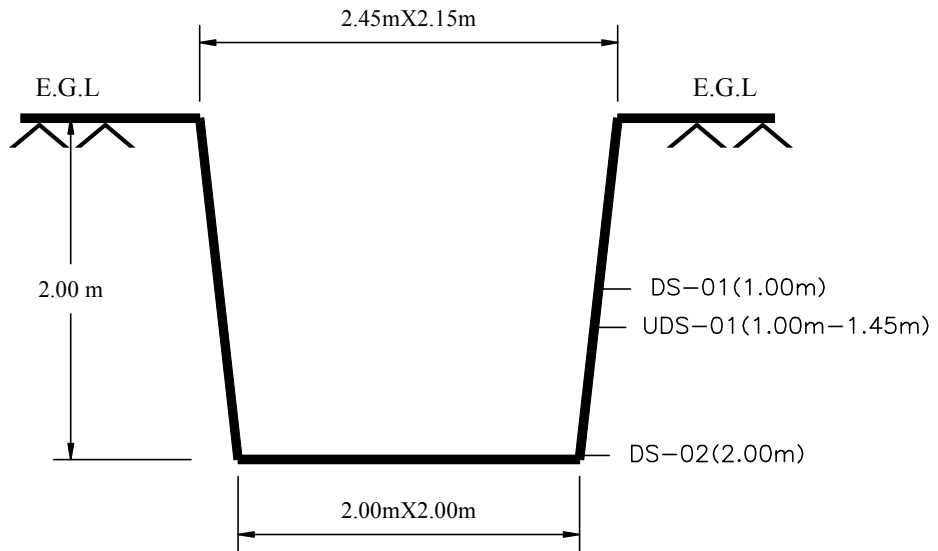
## PIT LOG OF CPLT-6



Commenced on: 08/09/2019  
Completed on: 09/09/2019  
Pit size: 2.00mX2.00mX2.00m(depth)  
Load on pr.guage/divn.=10kg/sq.cm  
Load on jack/divn. =1.65ton  
Plate size: 0.60mX0.60m  
Load on plate/divn.=4.58t/sq.m  
**Test Type: Routine CPLT**

**Co-ordinates:**  
**E = 1191.039**  
**N = 1644.314**  
**RL = 916.153M**

SWL = NOT FOUND



EGL-2.00m:- Reddish brown, silty clay with moorum.

PIT LOG OF CPLT-7



**Summarised Field Dry Density Test Results**

Test Location	Depth of Test (M)	Bulk Density (gm/cc)	Water Content (%)	Dry Density (gm/cc)
TP-01	1.00	1.90	14.00	1.67
	3.00	1.69	11.00	1.52
TP-02	1.00	1.88	14.00	1.65
	3.00	1.64	7.00	1.53

**Summarised Field CBR Test Results**

Test Location	Depth of Test (M)	Field CBR (%)					
		Unsokaed			Soaked		
		For 2.5mm Pentn.	For 5.0mm Pentn.	Recommended FCBR	For 2.5mm Pentn.	For 5.0mm Pentn.	Recommended FCBR
CBR-01	1.00	18.61	14.64	18.00	13.78	10.53	13.00
		18.46	14.71		12.46	9.50	
		18.44	14.42		12.84	9.87	
CBR-03	1.00	18.20	14.19	18.00	12.48	9.17	11.00
		18.10	14.02		11.34	8.05	
		17.75	13.57		11.83	8.50	
CBR-05	1.00	17.91	13.59	18.00	12.35	8.61	12.00
		18.42	13.62		12.26	8.69	
		17.77	13.63		12.09	9.10	
CBR-06	1.00	16.70	13.03	17.00	12.67	9.65	13.00
		17.44	13.70		13.74	10.56	
		18.28	13.97		13.03	9.91	
CBR-07	1.00	20.94	16.13	21.00	18.72	14.36	19.00
		21.17	16.38		20.02	15.44	
		21.76	16.82		19.49	15.04	

**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-01 (Unsoaked)****Test - 1**

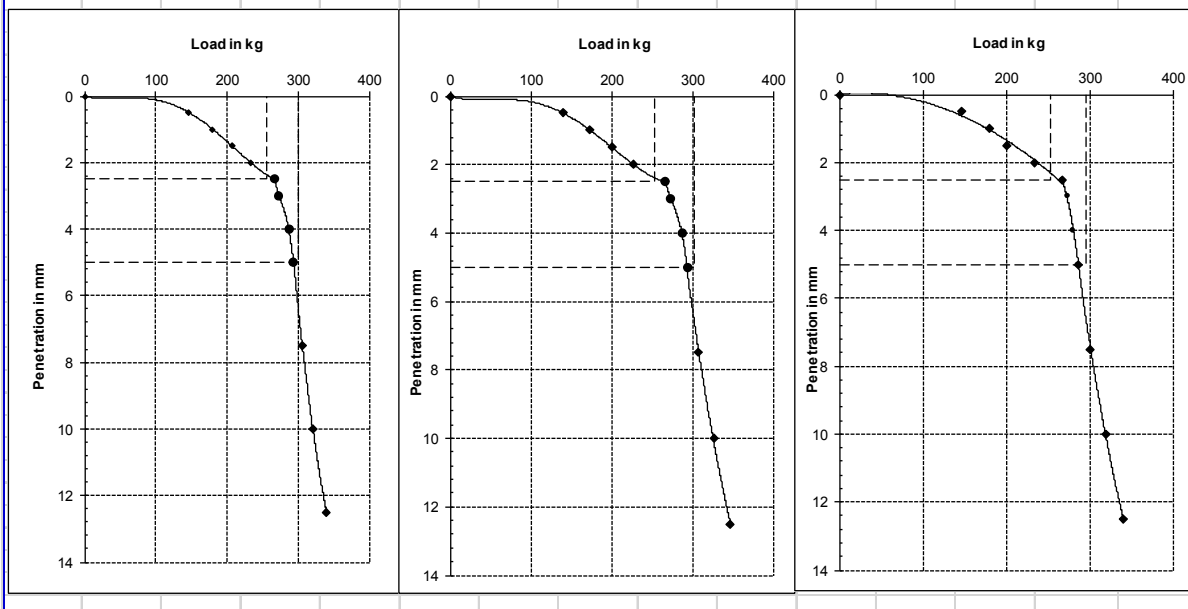
Penetration (mm)	CBR (%)
2.5	18.61
5.0	14.64

**Test - 2**

Penetration (mm)	CBR (%)
2.5	18.46
5.0	14.71

**Test - 3**

Penetration (mm)	CBR (%)
2.5	18.44
5.0	14.42

**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-01 (Soaked)****Test - 1**

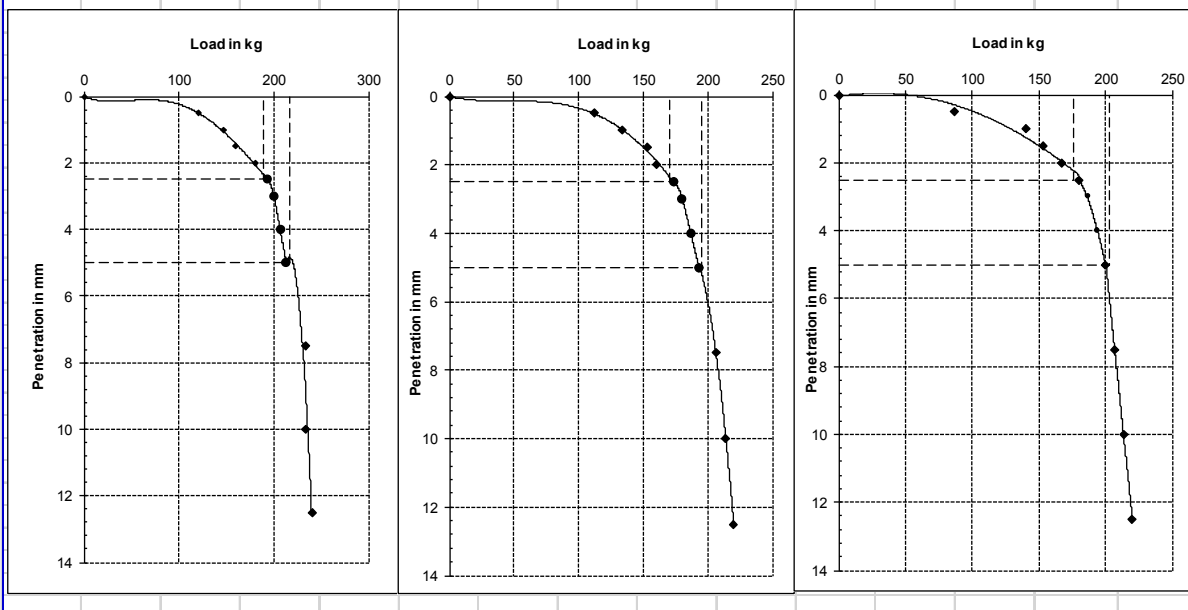
Penetration (mm)	CBR (%)
2.5	13.78
5.0	10.53

**Test - 2**

Penetration (mm)	CBR (%)
2.5	12.46
5.0	9.50

**Test - 3**

Penetration (mm)	CBR (%)
2.5	12.84
5.0	9.87



**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-03 (Unsoaked)****Test - 1**

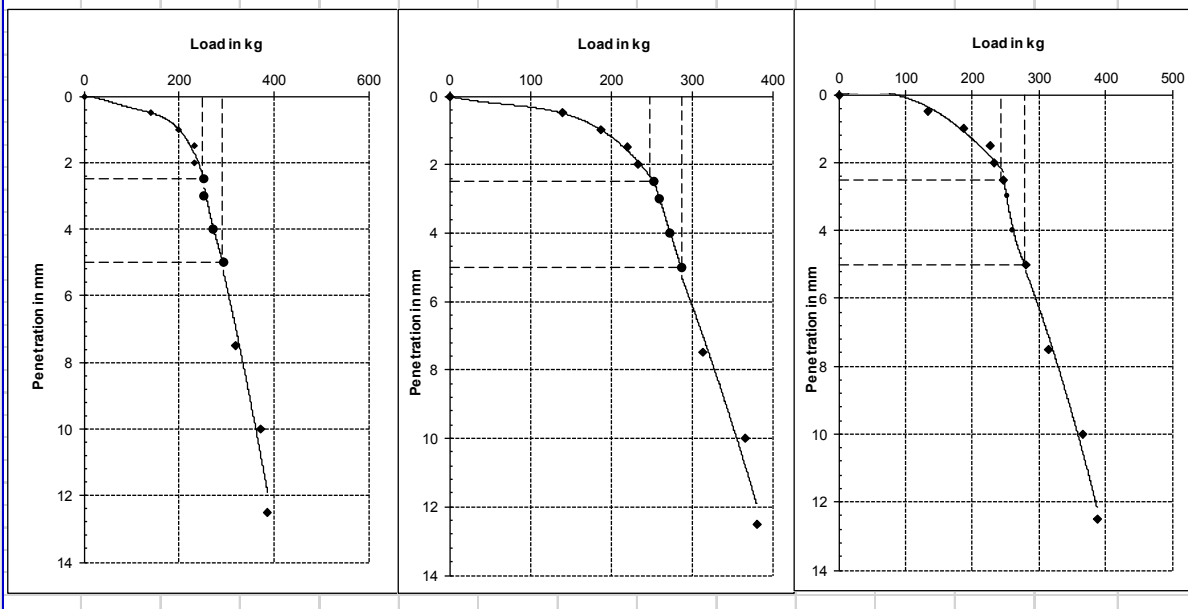
Penetration (mm)	CBR (%)
2.5	18.20
5.0	14.19

**Test - 2**

Penetration (mm)	CBR (%)
2.5	18.10
5.0	14.02

**Test - 3**

Penetration (mm)	CBR (%)
2.5	17.75
5.0	13.57

**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-03 (Soaked)****Test - 1**

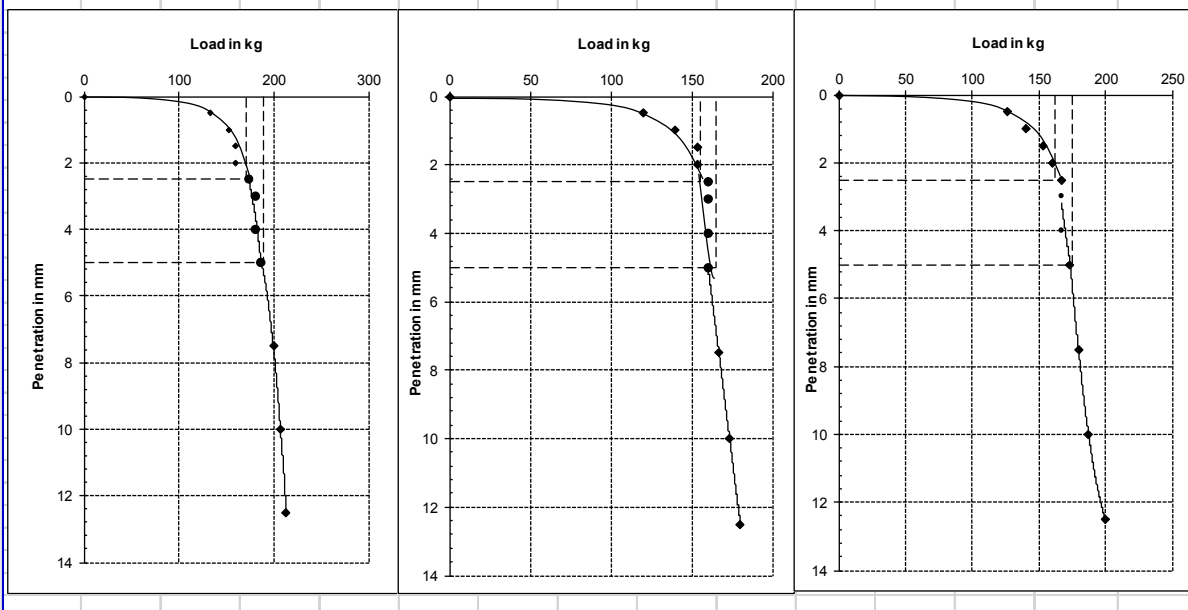
Penetration (mm)	CBR (%)
2.5	12.48
5.0	9.17

**Test - 2**

Penetration (mm)	CBR (%)
2.5	11.34
5.0	8.05

**Test - 3**

Penetration (mm)	CBR (%)
2.5	11.83
5.0	8.50



**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-05 (Unsoaked)****Test - 1**

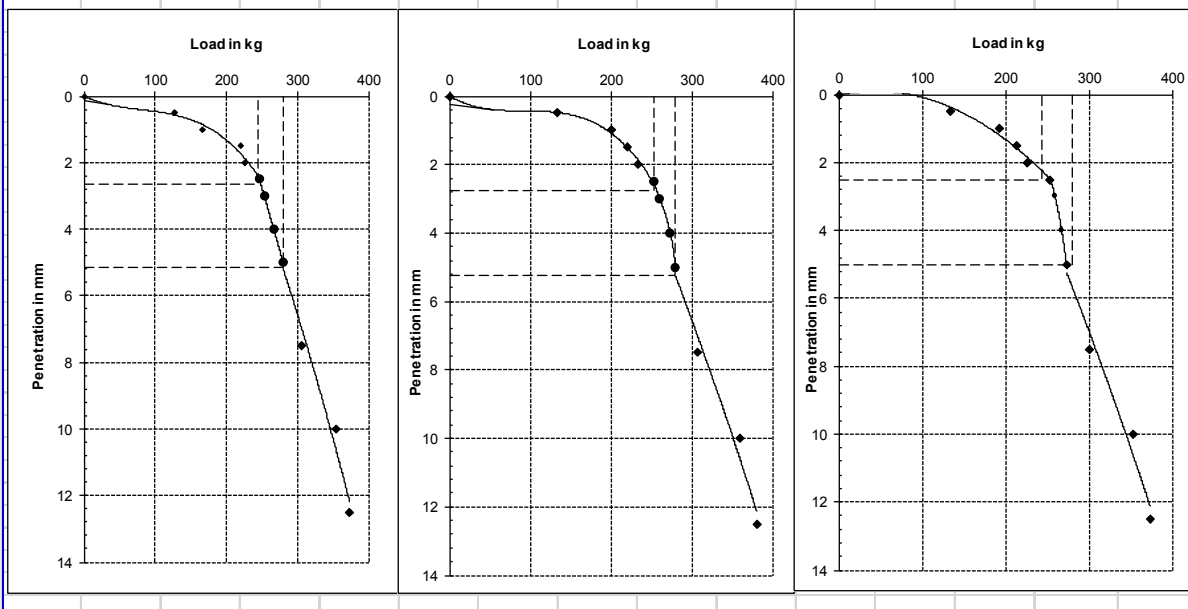
Penetration (mm)	CBR (%)
2.5	17.91
5.0	13.59

**Test - 2**

Penetration (mm)	CBR (%)
2.5	18.42
5.0	13.62

**Test - 3**

Penetration (mm)	CBR (%)
2.5	17.77
5.0	13.63

**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-05 (Soaked)****Test - 1**

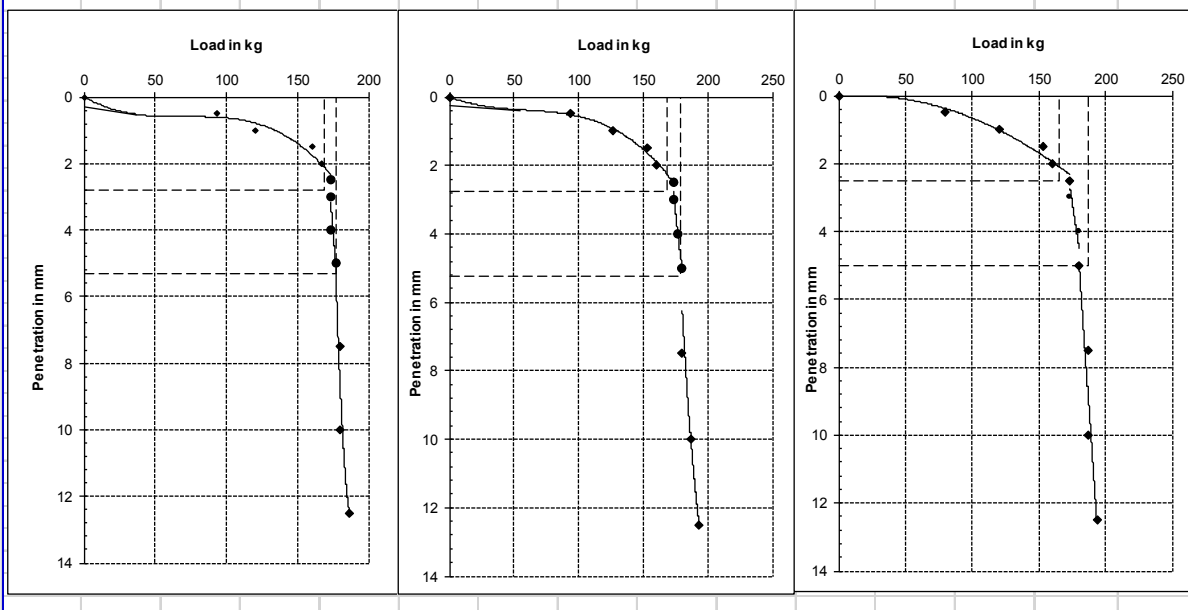
Penetration (mm)	CBR (%)
2.5	12.35
5.0	8.61

**Test - 2**

Penetration (mm)	CBR (%)
2.5	12.26
5.0	8.69

**Test - 3**

Penetration (mm)	CBR (%)
2.5	12.09
5.0	9.10



**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-06 (Unsoaked)****Test - 1**

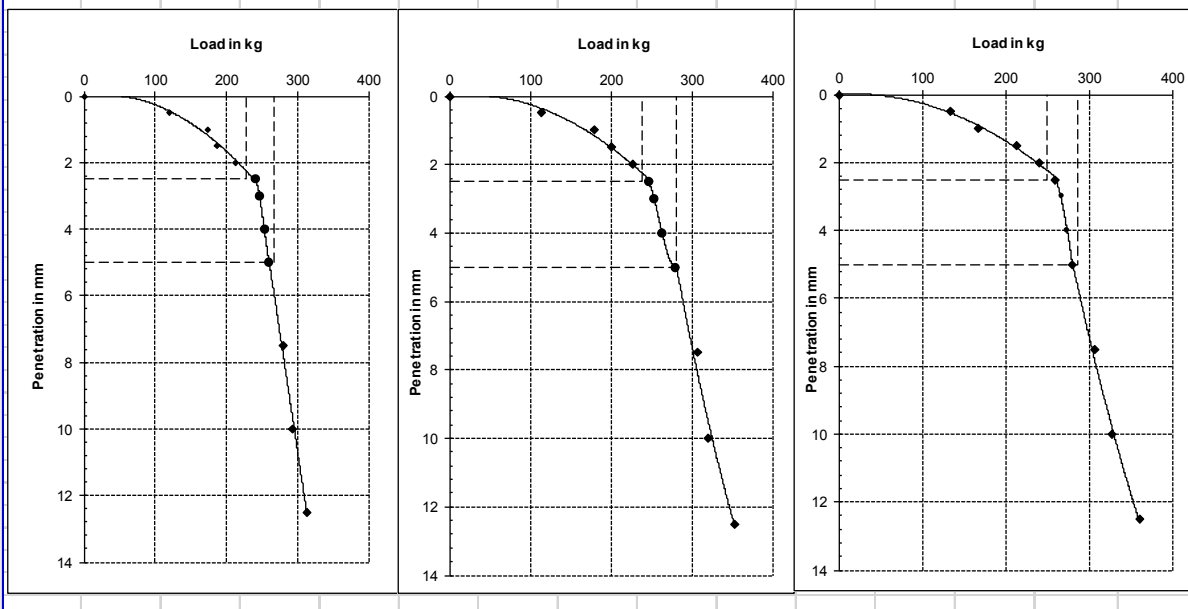
Penetration (mm)	CBR (%)
2.5	16.70
5.0	13.03

**Test - 2**

Penetration (mm)	CBR (%)
2.5	17.44
5.0	13.70

**Test - 3**

Penetration (mm)	CBR (%)
2.5	18.28
5.0	13.97

**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-06 (Soaked)****Test - 1**

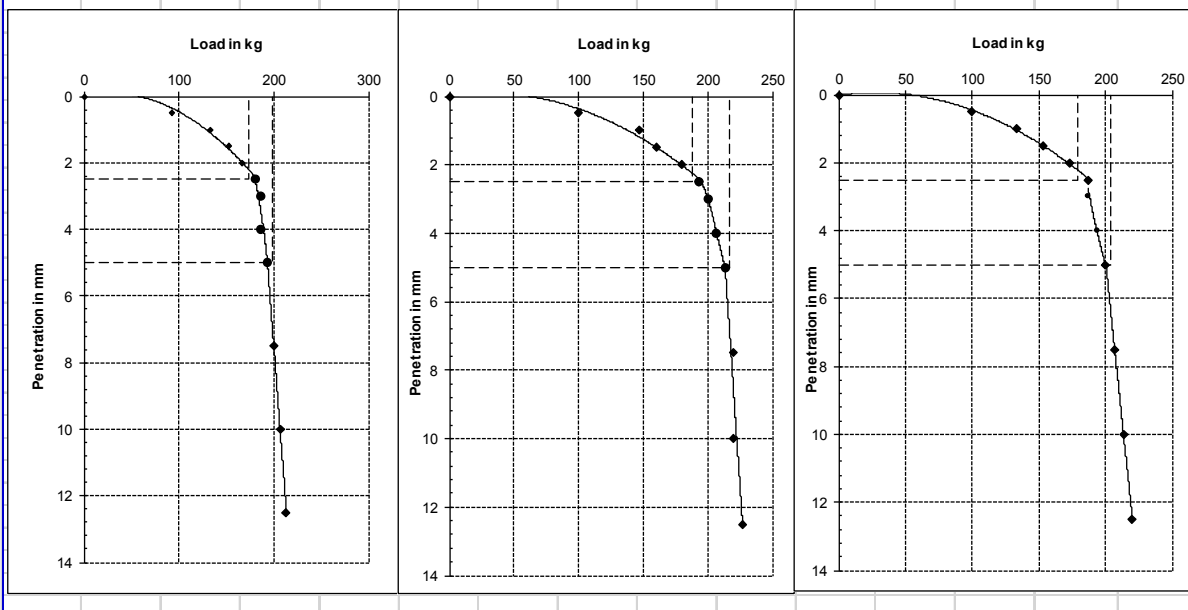
Penetration (mm)	CBR (%)
2.5	12.67
5.0	9.65

**Test - 2**

Penetration (mm)	CBR (%)
2.5	13.74
5.0	10.56

**Test - 3**

Penetration (mm)	CBR (%)
2.5	13.03
5.0	9.91





**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-07 (Unsoaked)****Test - 1**

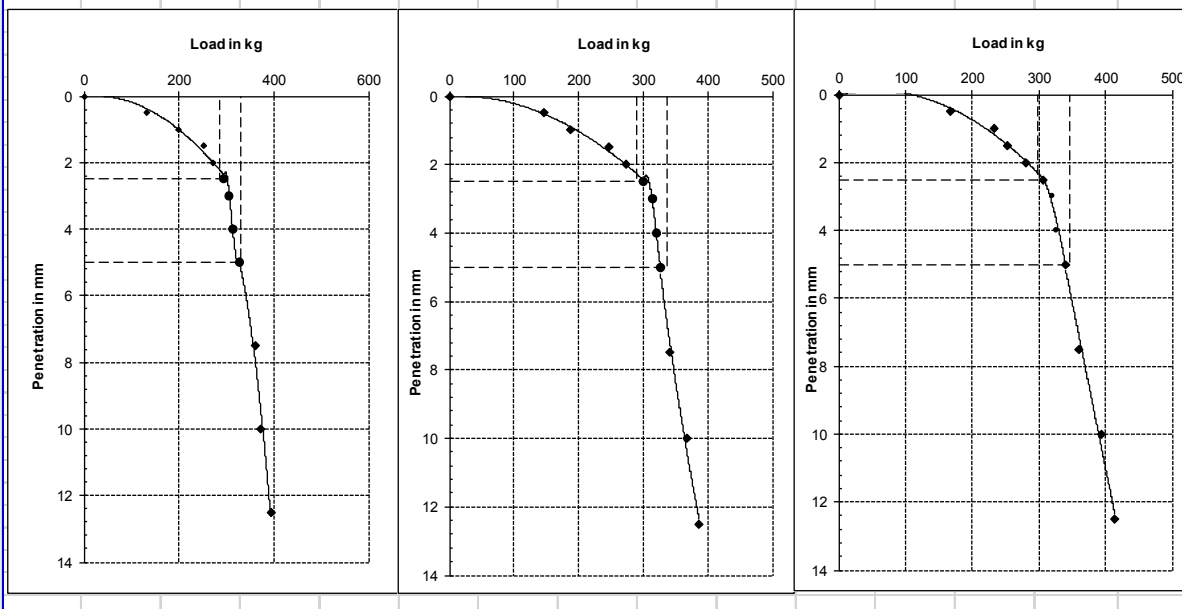
Penetration (mm)	CBR (%)
2.5	20.94
5.0	16.13

**Test - 2**

Penetration (mm)	CBR (%)
2.5	21.17
5.0	16.38

**Test - 3**

Penetration (mm)	CBR (%)
2.5	21.76
5.0	16.82

**Load Penetration Curve of Field C.B.R. Test****Field CBR NO.-07 (Soaked)****Test - 1**

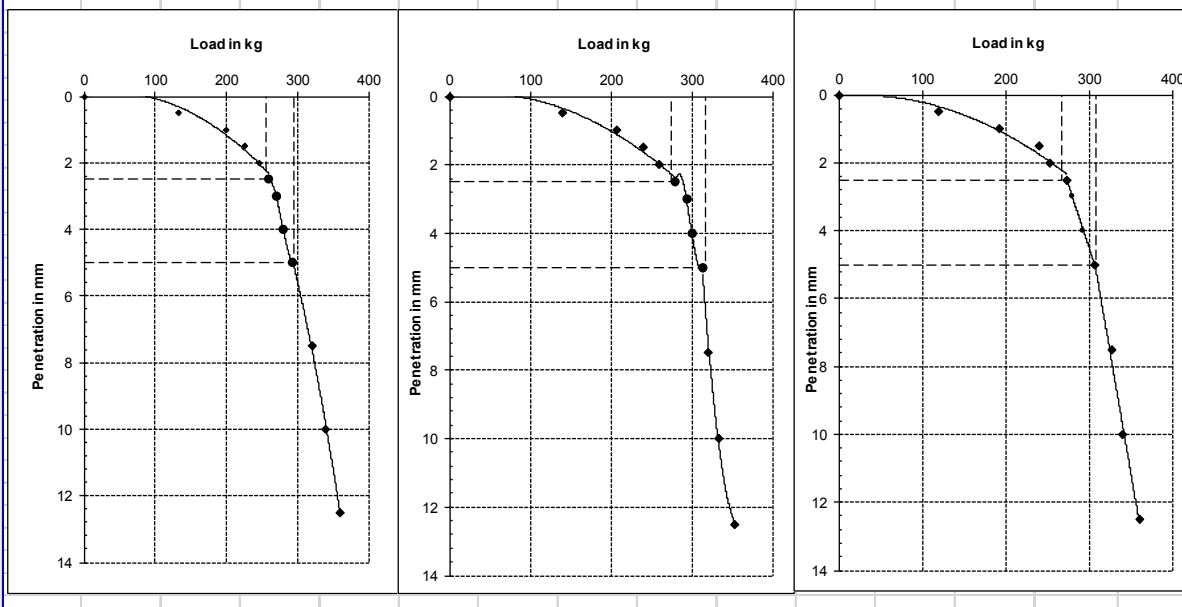
Penetration (mm)	CBR (%)
2.5	18.72
5.0	14.36

**Test - 2**

Penetration (mm)	CBR (%)
2.5	20.02
5.0	15.44

**Test - 3**

Penetration (mm)	CBR (%)
2.5	19.49
5.0	15.04



## **PART II: LABORATORY TEST RESULTS**

**Format No: CET/FM/42**

## **TEST REPORT**

TEST REPORT NO : 4095 DATE: 23/09/2019  
ULR : TC684019000000025P  
Name and Address of Customer : M/s. National Aluminium Company Limited  
Nalco Bhawan, Nayapalli,  
Bhubaneswar – 751 013  
  
Customer Reference No : 4095  
  
Customer Reference Date : 03/08/2019  
  
Date of Sample Received at Lab : 07/08/2019  
  
Date of Starting of Test : 07/08/2019  
  
Date of Completion of Test : 23/09/2019  
  
Sample ID Nos : 4095/BH-02/SPT01 to 4095/BH-126/RUN-19

Please refer the page no. A74 of A107 to A88 of A107 of the Report for the following:

1. Sample Description
2. Test methods used
3. Test results

Further to note that the test parameters are mentioned at the header of test result table.

- \* The report related to the particular sample(s) tested under stated condition.
- \* All tests are based as per IS specifications and/or SOPs.
- \* Any discrepancy in this report should be brought to the notice within 15 (fifteen) days from the date of certificate
- \* Full/Partial use of this test results should not be done without the written permission of authorized signatory and are to be considered as confidential.
- \* This laboratory is not responsible for the sampling processes.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			Grain Size				Test Method
				Dens. gms/cc						Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %	Sand %	Silt %	Clay %	
BH02	SPT01	1.45	Reddish brown clayey silt with decomposed rock fragments.											38	20			49	51 (Silt+Clay)	**See the Note	
BH02	SPT03	4.50	Reddish brown clayey silt. Obs. moorum & high percentage of decomposed rock fragments.														6	67	27 (Silt+Clay)	Do	
BH02	SPT05	7.45	Greyish brown clayey silt. Obs. moorum & high percentage of decomposed rock fragments.														6	59	35 (Silt+Clay)	Do	
BH02	SPT07	10.50	Reddish brown clayey silt. Obs. moorum & high percentage of decomposed rock fragments.														6	66	28 (Silt+Clay)	Do	
BH03	SPT01	1.50	Brownish grey silty sand with decomposed rock fragments. Obs. moorum.											*N.P.				69	31 (Silt+Clay)	Do	
BH03	DS05	5.50	Reddish brown silty sand. Obs. decomposed rock fragments.														7	64	29 (Silt+Clay)	Do	
BH04	SPT01	1.50	Reddish brown clayey silt with traces of sand mixture.											43	23					Do	
BH04	UDS01	2.50	Reddish brown clayey silt with sand mixture & traces of kanakrs.									TRSH-UU	1.44	15	36	18	5	44	35	16	Do
												3.0	2.944								
												2.0	2.571								
												1.0	2.216								
BH04	SPT03	4.50	Reddish brown clayey silt with sand mixture & moorum.														4	54	42 (Silt+Clay)	Do	

Res-4095 / Page 2

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits				Grain Size			Test Method
				Dens. gms/cc						Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %	Sand %	Silt %	Clay %	
BH06	SPT01	0.80	Reddish brown clayey silt with sand mixture & traces of decomposed rock fragments.											40	22			35	65 (Silt+Clay)	Do	
BH07	SPT01	1.50	Greyish brown decomposed rock dust & rock pieces.														25	64	11 (Silt+Clay)	Do	
BH08	SPT02	2.50	Brownish grey silty clay with high percentage of moorum. Obs. decomposed rock fragments.														16	71	13 (Silt+Clay)	Do	
BH09	SPT01	1.50	Reddish brown moorum with decomposed rock fragments & rock pices.											*N.P.			39	52	9 (Silt+Clay)	Do	
BH10	SPT01	0.70	Greyish brown decomposed rock dust with sand mixture.														13	80	7 (Silt+Clay)	Do	
BH11	DS02	1.00	Reddish brown clayey silt with sand mixture. Obs. moorum.											36	18		14	41	45 (Silt+Clay)	Do	
BH11	SPT01	1.55	Brownish grey clayey silt. Obs. moorum & high percentage of decomposed rock fragments.														9	69	22 (Silt+Clay)	Do	
BH12	SPT02	2.50	Reddish brown clayey silt with sand mixture & moorum. Obs. decomposed rock fragments.															41	59 (Silt+Clay)	Do	

Job No. : 4095

Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			Grain Size				Test Method
				Dens. gms/cc						Pc/Ph kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %	Sand %	Silt %	Clay %	
BH13	SPT01	1.50	Reddish brown clayey silt with sand mixture & moorum. Obs. decomposed rock fragments.															63	37	(Silt+Clay)	Do
BH14	SPT01	1.50	Reddish brown clayey silt with sand mixture & decomposed rock fragments.											40	21			42	58	(Silt+Clay)	Do
BH14	SPT03	4.50	Brownish grey clayey silt with sand mixture. Obs. traces of moorum & decomposed rock fragments.														8	62	30	(Silt+Clay)	Do
BH14	SPT07	10.50	Brownish grey clayey silt with sand mixture. Obs. traces of moorum & decomposed rock fragments.														3	68	29	(Silt+Clay)	Do
BH15	SPT01	1.50	Reddish brown clayey moorum & kankars.														23	42	35	(Silt+Clay)	Do
BH15	SPT03	4.45	Reddish brown clayey moorum with kankars & sand mixture.														5	60	35	(Silt+Clay)	Do
BH15	SPT07	10.45	Reddish brown clayey moorum. Obs. decomposed rock fragments.														4	67	29	(Silt+Clay)	Do
BH16	SPT01	1.55	Reddish brown clayey silt with sand mixture & decomposed rock fragments.															41	59	(Silt+Clay)	Do
BH17	SPT02	3.00	Reddish brown clayey silt with sand mixture.											40	21			45	55	(Silt+Clay)	Do

Job No. : 4095

Sheet No.

Res-4095 / Page 4

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			Grain Size				Test Method
				Dens. gms/cc						Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %	Sand %	Silt %	Clay %	
BH17	SPT04	6.00	Reddish brown clayey silt with sand mixture & traces of rock fragments.															46	54	(Silt+Clay)	Do
BH17	SPT06	9.00	Reddish brown clayey silt with sand mixture. Obs. moorum & high percentage of decomposed rock fragments.														10	73	17	(Silt+Clay)	Do
BH17	SPT10	15.00	Reddish brown clayey silt with sand mixture. Obs. moorum & high percentage of decomposed rock fragments.														16	65	19	(Silt+Clay)	Do
BH18	SPT01	2.50	Reddish brown clayey silt with sand mixture & decomposed rock fragments.											37	19			44	56	(Silt+Clay)	Do
BH23	SPT01	1.45	Reddish brown clayey silt with sand mixture, moorum & rock fragments.														11	45	44	(Silt+Clay)	Do
BH23	SPT03	4.45	Reddish brown clayey silt with traces of rock fragments.											37	20						Do
BH23	SPT05	7.50	Reddish brown clayey silt with sand mixture, moorum, kankars, rock fragments & rock pices.														29	39	32	(Silt+Clay)	Do
BH24	SPT01	1.55	Reddish brown clayey silt with traces of rock fragments.											37	20						Do
BH24	SPT02	3.00	Reddish brown clayey silt with sand mixture, traces of moorum & gravels.														13	45	42	(Silt+Clay)	Do

Job No. : 4095

Sheet No.

Res-4095 / Page 5

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			Grain Size					Test Method
									Pc/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %	Sand %	Silt %	Clay %		
BH24	SPT05	7.50	Reddish brown clayey silt with sand mixture, traces of moorum, rock fragments.													12	50	38	(Silt+Clay)	Do	
BH24	SPT07	10.65	Reddish brown clayey silt with sand mixture, moorum, kankars, rock fragments etc.													18	42	40	(Silt+Clay)	Do	
BH25	SPT01	1.50	Brownish grey silty sand with decomposed rock fragments.											*N.P.		6	65	29	(Silt+Clay)	Do	
BH25	SPT03	4.50	Brownish grey silty sand with rock fragments & kankars.											*N.P.		13	65	22	(Silt+Clay)	Do	
BH25	SPT05	7.50	Brownish grey silty sand with rock fragments & kankars.											*N.P.		13	60	27	(Silt+Clay)	Do	
BH26	SPT02	3.00	Brownish grey clayey silty sand with rock fragments & kankars.											*N.P.		13	55	32	(Silt+Clay)	Do	
BH26	SPT04	6.00	Brownish grey clayey silty sand with traces of moorum.											*N.P.		9	56	35	(Silt+Clay)	Do	
BH27	SPT01	1.50	Reddish brown clayey silt with traces of sand mixture & rock fragments.														37	63	(Silt+Clay)	Do	
BH27	SPT03	4.50	Brownish grey silty sand with rock fragments, rock pices & kankars.											*N.P.		13	61	26	(Silt+Clay)	Do	
BH27	SPT06	9.00	Brownish grey silty sand with rock fragments & kankars.											*N.P.		8	61	31	(Silt+Clay)	Do	



Job No. : 4095

Sheet No.

Res-4095 / Page 6

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			Grain Size				Test Method	
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %	Sand %	Silt %	Clay %		
BH27	SPT09	13.55	Brownish grey silty sand with rock fragments & kankars.														5	60	35 (Silt+Clay)	Do	
BH28	SPT01	1.45	Reddish brown clayey silt with sand mixture & decomposed rock fragments.															47	53 (Silt+Clay)	Do	
BH28	SPT05	7.50	Reddish brown clayey silt with sand mixture. Obs. high percentage of decomposed rock fragments & traces of moorum.															76	24 (Silt+Clay)	Do	
BH28	SPT07	10.50	Reddish brown clayey silt with sand mixture. Obs. moorum & high percentage of decomposed rock fragments.														7	71	22 (Silt+Clay)	Do	
BH28	SPT10	15.00	Reddish brown clayey silt with sand mixture. Obs. moorum & high percentage of decomposed rock fragments.														12	67	21 (Silt+Clay)	Do	
BH29	SPT01	1.45	Reddish brown, silty clay with traces of sand mixture & kankars.			2.65												10	62	28	Do
BH29	SPT04	6.00	Reddish brown, silty clay.											40	22						Do
BH29	SPT07	10.50	Greyish brown, silty clay with decomposed rock fragments & kankars.			2.67											4	32	49	15	Do
BH29	SPT09	13.45	Greyish brown, silty clay with decomposed rock fragments & kankars.			2.69											5	35	48	12	Do

Job No. : 4095

Sheet No.

Res-4095 / Page 7

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens. gms/cc	Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			Grain Size				Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %	Sand %	Silt %	Clay %	
BH31	SPT02	3.00	Reddish brown clayey silt with sand mixture & decomposed rock fragments.										40	22			47	53	(Silt+Clay)	Do
BH31	SPT05	7.50	Reddish brown clayey silt with sand mixture & decomposed rock fragments.														60	40	(Silt+Clay)	Do
BH31	SPT07	10.50	Reddish brown clayey moorum. Obs. decomposed rock fragments.													11	69	20	(Silt+Clay)	Do
BH32	SPT01	1.50	Reddish brown clayey silt with sand mixture.										38	18			44	56	(Silt+Clay)	Do
BH32	SPT03	4.55	Reddish brown clayey silt with sand mixture.														48	52	(Silt+Clay)	Do
BH32	SPT06	9.00	Reddish brown clayey silt with sand mixture / clayey silty sand.													9	69	22	(Silt+Clay)	Do
BH33	SPT02	2.50	Brownish grey, clayey moorum with decomposed rock fragments.										*N.P.			1	98	1	(Silt+Clay)	Do
BH34	SPT01	0.80	Brownish grey, clayey moorum with decomposed rock fragments & rock pieces.										*N.P.			50	47	3	(Silt+Clay)	Do
BH35	SPT01	0.80	Reddish brown moorum with decomposed rock fragments..													6	59	35	(Silt+Clay)	Do
BH39	SPT01	0.80	Brownish grey, moorum with sand mixture & decomposed rock fragments.													6	78	16	(Silt+Clay)	Do

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			Grain Size				Test Method
				Dens. gms/cc						Pc/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %	Sand %	Silt %	Clay %	
BH43	SPT01	0.80	Reddish brown clayey silt with traces of fine sand mixture.											44	27					Do	
BH126	SPT01	1.50	Brownish grey clayey silt with sand mixture. Obs. traces of moorum & decomposed rock fragments.														41	59 (Silt+Clay)		Do	
BH126	SPT02	3.00	Reddish brown clayey silt with sand mixture. Obs. traces of moorum & decomposed rock fragments.											42	20		45	55 (Silt+Clay)		Do	
BH126	SPT05	7.50	Brownish grey clayey silt with sand mixture. Obs. traces of moorum & decomposed rock fragments.														2	40	58 (Silt+Clay)	Do	
*N.P. - Non Plastic																					
**Note: Test Methods																					
Bulk Density & Dry Density: Ref. CET/SOP/01, Issue No. 01-(Page 27 & 39 of 40)										Shrinkage Limit: IS 2720 (Part 6)											
Natural Moisture Content: IS 2720 (Part 2)										Triaxial Test (TRSH-UU): IS 2720 (Part 11)											
Specific Gravity: IS 2720 (Part 3).										Consolidation Properties (Void Ratio): IS 2720 (Part 15)											
Grain size analysis: IS 2720 (Part 4)										Liquid Limit & Plastic Limit: IS 2720 (Part 5)											

\*N.P. - Non Plastic

\*\*Note: Test Methods

Bulk Density &amp; Dry Density: Ref. CET/SOP/01, Issue No. 01-(Page 27 &amp; 39 of 40)

Natural Moisture Content: IS 2720 (Part 2)

Specific Gravity: IS 2720 (Part 3).

Grain size analysis: IS 2720 (Part 4)

Shrinkage Limit: IS 2720 (Part 6)

Triaxial Test (TRSH-UU): IS 2720 (Part 11)

Consolidation Properties (Void Ratio): IS 2720 (Part 15)

Liquid Limit &amp; Plastic Limit: IS 2720 (Part 5)

## LABORATORY ROCK TEST RESULTS

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Test Method
				Bulk	Dry				Dry	Saturated			
2	4	15.00-16.00	Moderately weathered, whitish grey, fine grained, moderately fractured rock.	2.918	2.915	0.092	0.538	2.931	--	594	--	--	*See the Note
2	7	18.00-19.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.850	2.848	0.077	0.378	2.859	--	498	--	--	Do
3	6	12.00-13.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.804	2.800	0.122	0.690	2.820	--	--	--	35.09	Do
3	8	14.00-15.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.817	2.814	0.116	0.645	2.832	431	370	0.858	--	Do
4	4	9.00 - 10.00	Highly weathered, whitish grey, fine grained fractured rock.	2.759	2.756	0.127	0.423	2.768	--	--	--	29.23	Do
4	8	13.00 - 14.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.842	2.839	0.118	0.401	2.850	--	519	--	--	Do
5	8	9.00-10.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.756	2.751	0.206	0.639	2.768	--	--	--	26.18	Do
5	12	13.00-14.0	Fresh, whitish grey, fine grained, slightly fractured rock.	2.814	2.809	0.183	0.552	2.825	--	410	--	--	Do
6	12	12.00 - 13.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.866	2.862	0.133	0.511	0.741	--	458	--	39.20	Do
6	14	14.00 - 15.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.859	2.856	0.098	0.321	2.861	576	379	0.658	--	Do
7	6	8.00-9.00	Slightly weathered, whitish grey, fine grained, moderately fractured rock.	2.818	2.814	0.148	0.681	2.833	--	--	--	48.11	Do

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)		Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Test Method
				Bulk	Dry		(%)			Dry	Saturated			
7	9	11.00-12.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.907	2.903	0.128	0.432	0.432	2.916	--	436	--	--	Do
8	3	5.00 - 6.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	3.105	3.101	0.123	0.428	0.428	3.206	--	419	--	24.95	Do
8	6	8.00 - 9.00	Fresh, whitish grey, fine grained, slightly fractured rock.	3.609	3.605	0.095	0.307	0.307	3.619	690	655	0.949	--	Do
9	2	4.00 - 5.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	3.836	3.830	0.162	0.849	0.849	3.863	--	--	--	28.51	Do
9	4	6.00 - 7.00	Slightly weathered, whitish grey, fine grained, moderately fractured rock.	3.915	3.912	0.082	0.355	0.355	3.926	--	445	--	--	Do
9	6	8.00 - 9.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.792	2.788	0.148	0.589	0.589	2.805	--	537	--	--	Do
10	2	2.00-3.00	Moderately weathered, whitish grey, fine grained, moderately fractured rock.	2.809	2.804	0.188	0.703	0.703	2.824	--	245	--	--	Do
10	7	7.00-8.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.846	2.840	0.216	0.554	0.554	2.864	--	440	--	57.02	Do
11	3	5.00-6.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.775	2.770	0.180	0.760	0.760	2.791	--	263	--	--	Do
11	8	10.00-11.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.978	2.975	0.102	0.600	0.600	2.993	422	372	0.881	--	Do
12	7	9.00 - 10.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.900	2.897	0.104	0.477	0.477	2.911	--	--	--	26.73	Do
12	8	10.00 - 11.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.786	2.780	0.217	0.522	0.522	2.791	--	492	--	30.07	Do

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Test Method
				Bulk	Dry				Dry	Saturated			
13	9	10.00 - 11.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.802	2.798	0.148	0.535	2.813	--	--	--	26.73	Do
13	13	14.00 - 15.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.845	2.842	0.107	0.452	2.856	--	510	--	46.33	Do
14	6	18.00 - 19.00	Highly weathered, light blackish grey, fine grained, completely fractured rock.	2.893	2.891	0.058	0.285	2.899	--	432	--	--	Do
14	10	22.00 - 23.00	Fresh, light blackish grey, fine grained, slightly fractured rock.	2.924	2.923	0.058	0.318	2.932	--	507	--	--	Do
15	6	17.00 - 18.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.774	2.770	0.137	0.667	2.789	--	297	--	--	Do
15	8	19.00 - 20.00	Fresh, light blackish grey, fine grained, slightly fractured rock.	2.839	2.835	0.118	0.569	2.851	629	405	0.643	--	Do
16	8	9.00 - 10.00	Moderately weathered, light grey, fine grained, highly fractured rock.	2.892	2.889	0.106	0.461	2.902	--	371	--	--	Do
16	11	12.00 - 13.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.925	2.922	0.105	0.504	2.936	--	449	--	--	Do
17	8	25.00 - 26.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.742	2.737	0.208	0.921	2.762	--	--	--	11.82	Do
17	12	29.00 - 30.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.872	2.869	0.109	0.446	2.882	--	453	--	--	Do
18	12	15.00 - 16.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.966	2.963	0.081	0.328	2.973	422	378	0.895	--	Do
18	14	17.00 - 18.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.955	2.952	0.081	0.513	2.967	--	506	--	66.30	Do

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)		Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Test Method
				Bulk	Dry		(%)			Dry	Saturated			
23	2	14.50 - 15.50	Moderately weathered, whitish grey, fine grained, moderately fractured rock.	3.130	3.129		0.059	0.311	3.138	--	528	--	--	Do
23	5	16.50 - 17.50	Fresh, whitish grey, fine grained, slightly fractured rock.	2.831	2.827		0.133	0.682	2.846	--	367	--	--	Do
24	2	13.50 - 14.50	Highly weathered, whitish grey, fine grained, moderately fractured rock.	3.047	3.044		0.099	0.519	3.163	--	--	--	21.68	Do
24	4	15.50 - 16.50	Fresh, whitish grey, fine grained, slightly fractured rock.	2.912	2.909		0.089	0.430	2.922	--	756	--	--	Do
25	2	10.00 - 11.00	Highly weathered, light blackish grey, fine grained, moderately fractured rock.	2.995	2.993		0.065	0.263	3.001	--	--	--	18.09	Do
25	6	14.00 - 15.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.870	2.866		0.146	0.766	2.888	--	507	--	--	Do
26	3	10.00 - 11.00	Moderately weathered, light blackish grey, fine grained, moderately fractured rock.	3.902	3.898		0.098	0.699	3.926	--	--	--	45.64	Do
26	6	13.00 - 14.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.886	2.884		0.075	0.323	2.893	--	507	--	--	Do
27	2	18.00 - 19.00	Moderately weathered, whitish grey, fine grained, moderately fractured rock.	3.468	3.463		0.145	0.839	3.492	--	454	--	--	Do
27	5	21.00 - 22.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.817	2.815		0.077	0.380	2.826	--	541	--	--	Do
28	4	20.00 - 21.00	Moderately weathered, whitish grey, fine grained, moderately fractured rock.	2.825	2.822		0.112	0.480	2.835	--	--	--	24.05	Do

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)		Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Test Method
				Bulk	Dry		(%)			Dry	Saturated			
28	7	23.00-24.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.885	2.881	0.118		0.541	2.897	--	495	--	36.24	Do
29	3	18.00-19.00	Moderately weathered, light blackish grey, fine grained, moderately fractured rock.	2.861	2.858	0.105		0.565	2.872	--	--	--	20.11	Do
29	6	21.00-22.00	Fresh, light blackish grey, fine grained, slightly fractured rock.	3.215	3.210	0.156		0.361	3.234	--	522	--	--	Do
31	5	16.00-17.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.800	2.794	0.203		0.913	2.820	--	385	--	--	Do
31	7	18.00-19.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.871	2.868	0.113		0.453	2.881	--	--	--	33.29	Do
32	6	17.00-18.00	Highly weathered, light grey, fine grained, moderately fractured rock.	2.835	2.832	0.106		0.472	2.843	--	--	--	26.42	Do
32	10	21.00-22.00	Fresh, whitish grey, fine grained, slightly fractured rock.	3.069	3.060	0.278		1.964	3.122	--	498	--	--	Do
33	3	5.00-6.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.801	2.797	0.149		0.613	2.814	--	--	--	30.29	Do
33	7	9.00-10.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.759	2.752	0.230		1.279	2.788	--	576	--	--	Do
34	2	2.00-3.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.810	2.807	0.130		0.644	2.825	--	--	--	37.71	Do
34	7	7.00-8.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.827	2.822	0.152		0.608	2.840	--	419	--	--	Do
35	2	2.00-3.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.797	2.792	0.169		0.988	2.820	--	--	--	21.29	Do



**Job No. : 4095**
**Sheet No.**

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Test Method
				Bulk	Dry				Dry	Saturated			
35	5	5.00 - 6.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.990	2.987	0.099	0.387	2.999	--	484	--	--	Do
36	2	3.00 - 4.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.804	2.797	0.238	1.043	2.827	--	--	--	22.99	Do
36	6	7.00 - 8.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.889	2.885	0.139	0.744	2.897	--	452	--	46.33	Do
38	4	3.00 - 4.00	Moderately weathered, whitish grey, fine grained, moderately fractured rock.	2.811	2.808	0.109	0.444	2.821	--	--	--	27.49	Do
38	6	5.00 - 6.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.851	2.848	0.105	0.425	2.861	--	475	--	--	Do
39	2	2.00 - 3.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.968	2.965	0.078	0.298	2.974	--	315	--	--	Do
39	6	6.00 - 7.00	Fresh, whitish grey, fine grained, slightly fractured rock.	3.002	2.997	0.185	0.673	3.017	--	472	--	--	Do
41	1	0.00 - 1.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.687	2.681	0.230	0.925	2.706	--	--	--	25.64	Do
41	6	5.00 - 6.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.837	2.832	0.161	0.640	2.851	--	629	--	--	Do
42	3	2.00 - 3.00	Moderately weathered, whitish grey, fine grained, fractured rock.	2.829	2.825	0.174	0.942	2.851	--	--	--	24.95	Do
42	7	6.00 - 7.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.936	2.933	0.095	0.349	2.944	--	576	--	55.24	Do
43	1	1.00 - 2.00	Moderately weathered, whitish grey, fine grained, moderately fractured rock.	2.805	2.801	0.149	0.788	2.823	--	402	--	--	Do

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)		Porosity %	Specific Gravity	Unconfined Compressive strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Test Method
				Bulk	Dry					Dry	Saturated			
43	5	5.00 - 6.00	Highly weathered, whitish grey, fine grained, moderately fractured rock.	2.796	2.791	0.167		0.907	2.817	--	388	--	--	Do
43	9	9.00 - 10.00	Fresh, whitish grey, fine grained, slightly fractured rock.	2.836	2.833	0.110		0.369	2.843	--	576	--	30.29	Do
45	3	2.00- 3.00	Highly weathered, whitish grey, fine grained rock.	2.975	2.972	0.106		0.661	2.992	--	--	--	28.38	Do
45	7	6.00- 7.00	Fresh, whitish grey, fine grained, slightly fractured rock.	3.101	3.099	0.077		0.383	3.111	494	381	--	--	Do
46	3	2.00- 3.00	Highly weathered, whitish grey, fine grained, highly fractured rock.	2.745	2.741	0.152		0.570	2.756	--	--	--	18.25	Do
46	5	4.00- 5.00	Fresh, whitish grey, fine grained, moderately fractured rock.	2.855	2.852	0.102		0.398	2.864	--	454	--	--	Do
126	10	20.00- 21.00	Completely weathered, light grey, medium grained, highly fractured rock.	2.473	2.466	0.301		2.917	2.540	--	--	--	--	Do
126	19	29.00- 30.00	Completely weathered, brownish grey, medium grained, highly fractured rock.	2.776	2.772	0.133		0.507	2.786	--	--	--	13.01	Do

**\*Note: Test Methods**

Point Load Index: IS 8764.

Water Content, Bulk & Dry Density and Porosity: IS 13030

Specific Gravity: IS 2720 (Part 3).

Unconfined Compressive Strength: IS 9143.

**C.E. Testing Company Pvt. Ltd.**

Prepared By

*Indranil Chowdhury*

(Indranil Chowdhury)

Deputy Technical Manager

Checked & Approved By

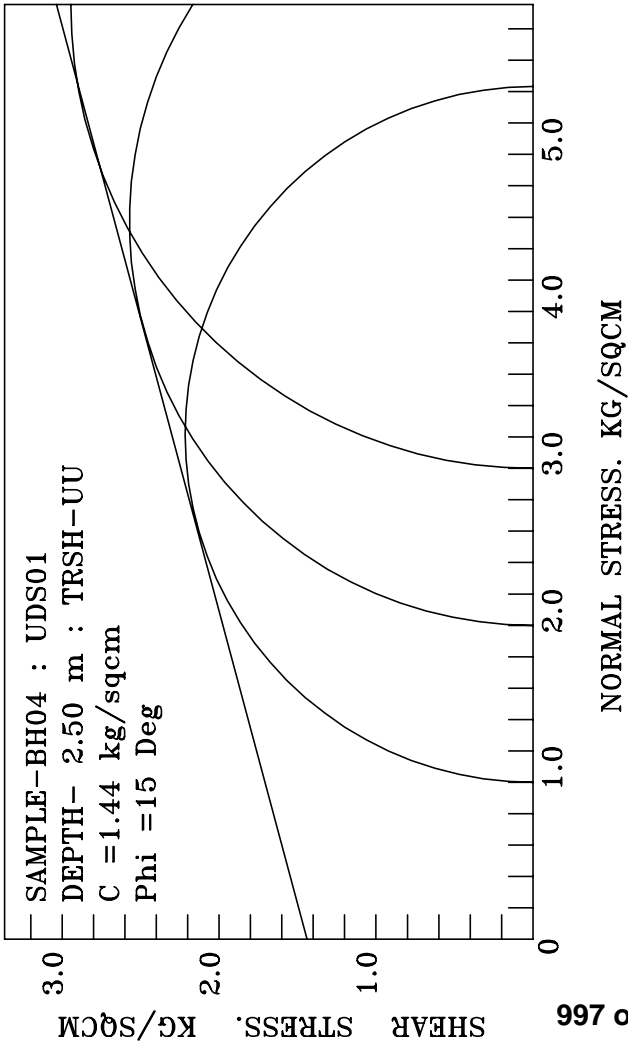
*Sudip Nath*

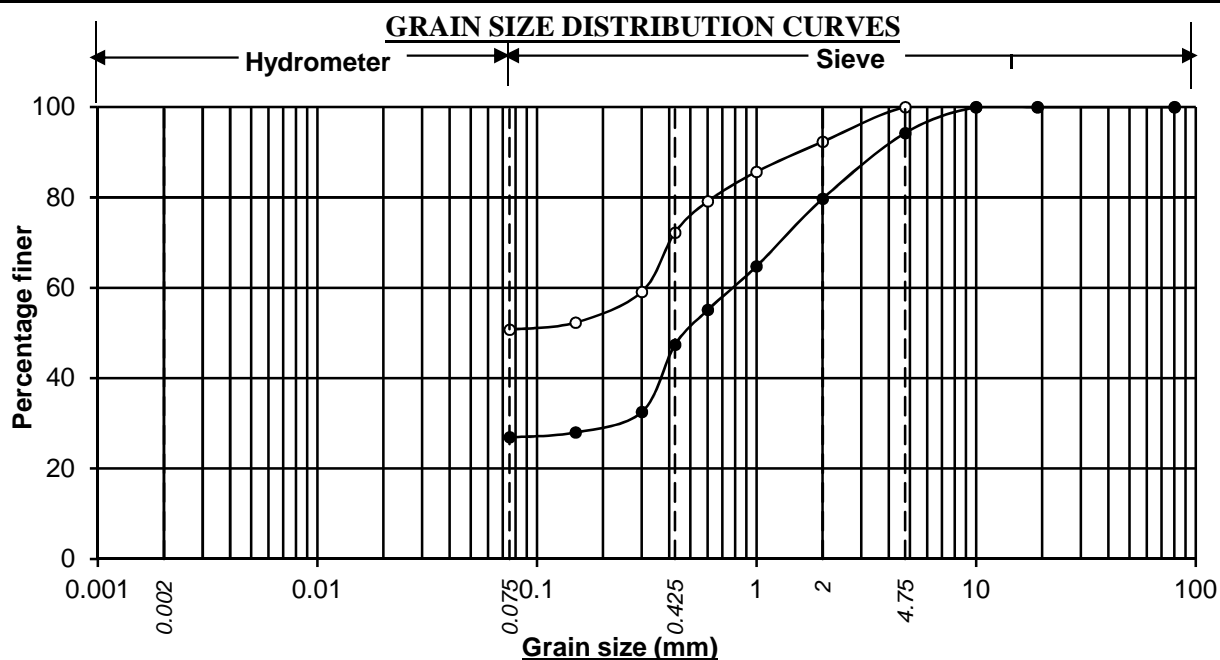
(Sudip Nath)

Technical Manager

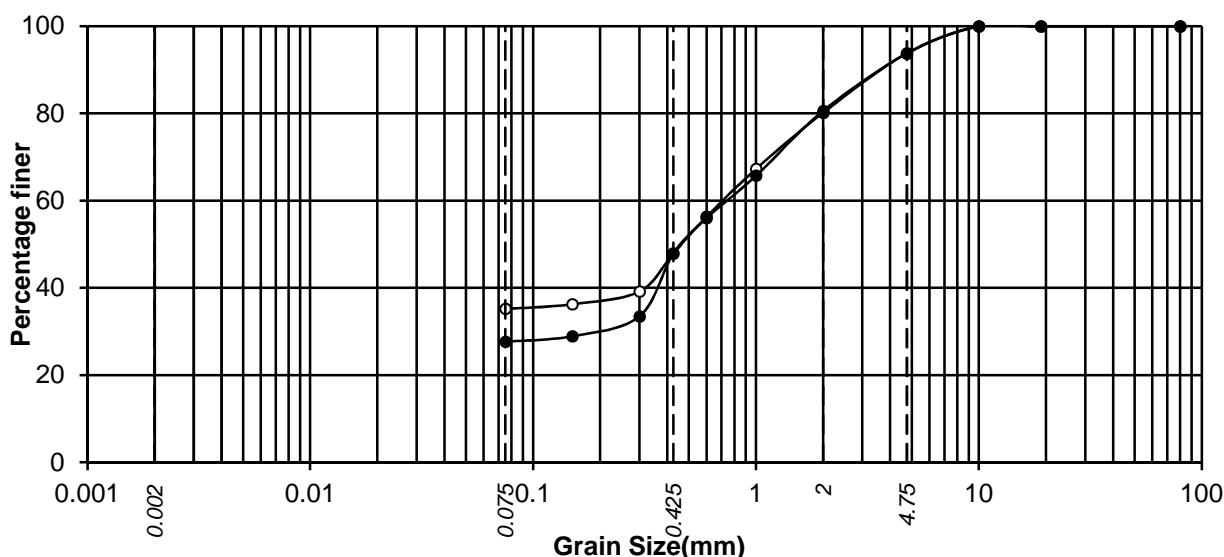
**\*\*End of Report\*\***

### **PART III: CHARTS & GRAPHS**





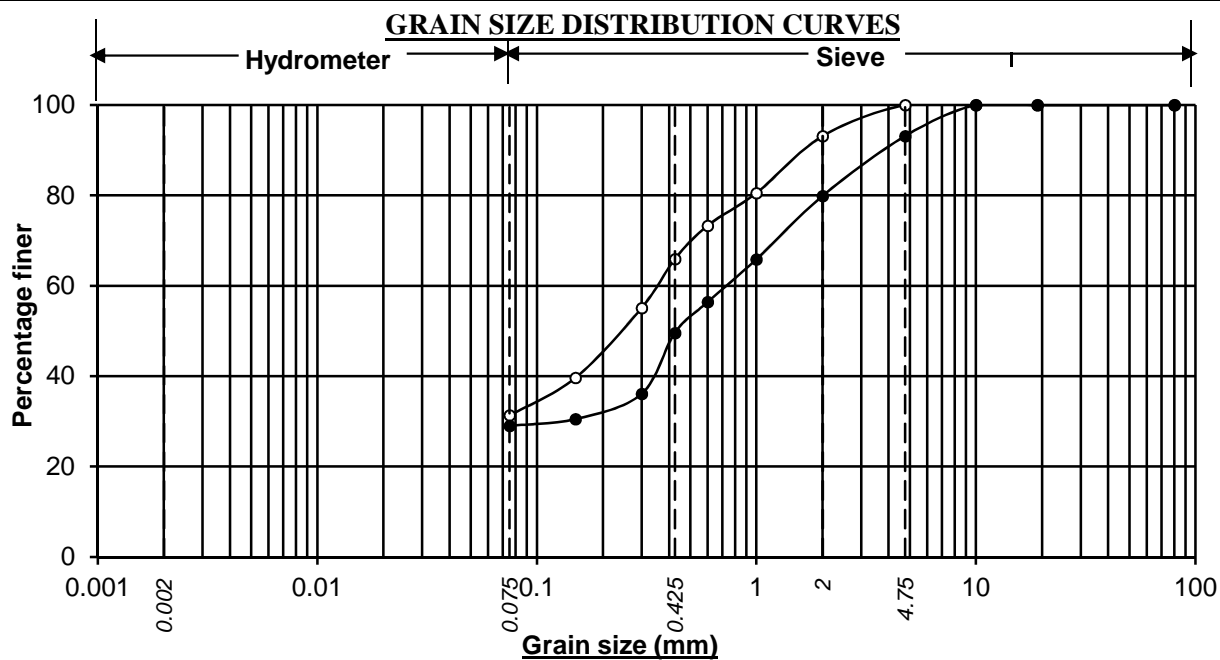
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-02,SPT-01, 1.45M		50.8	21.4	20.1	7.7	49.2		0.0
BH-02,SPT-03, 4.50M		26.9	20.6	32.3	14.5	67.4		5.7



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-02,SPT-05, 7.45M		35.2	12.7	32.3	13.6	58.6		6.2
BH-02,SPT-07, 10.50M		27.7	20.2	32.7	13.2	66.1		6.2

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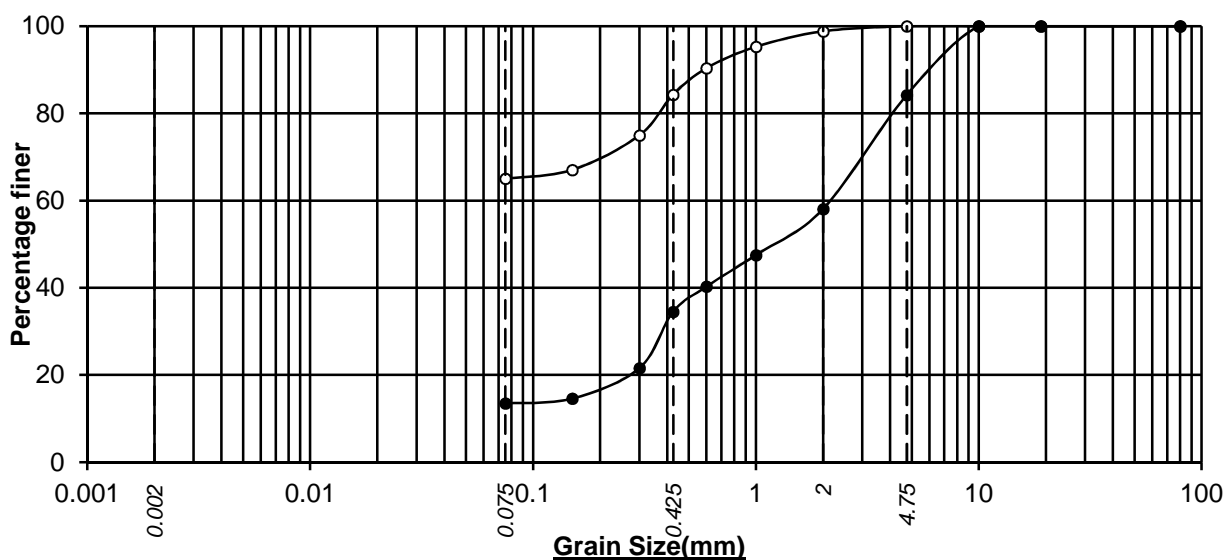
**Job No.**  
**4095**



—○— BH-03,SPT-01, 1.50M

—●— BH-03,DS-04, 5.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-03,SPT-01, 1.50M		31.3	34.6	27.2	6.9	68.7		0.0
BH-03,DS-04, 5.50M		29.0	20.6	30.3	13.2	64.1		6.9



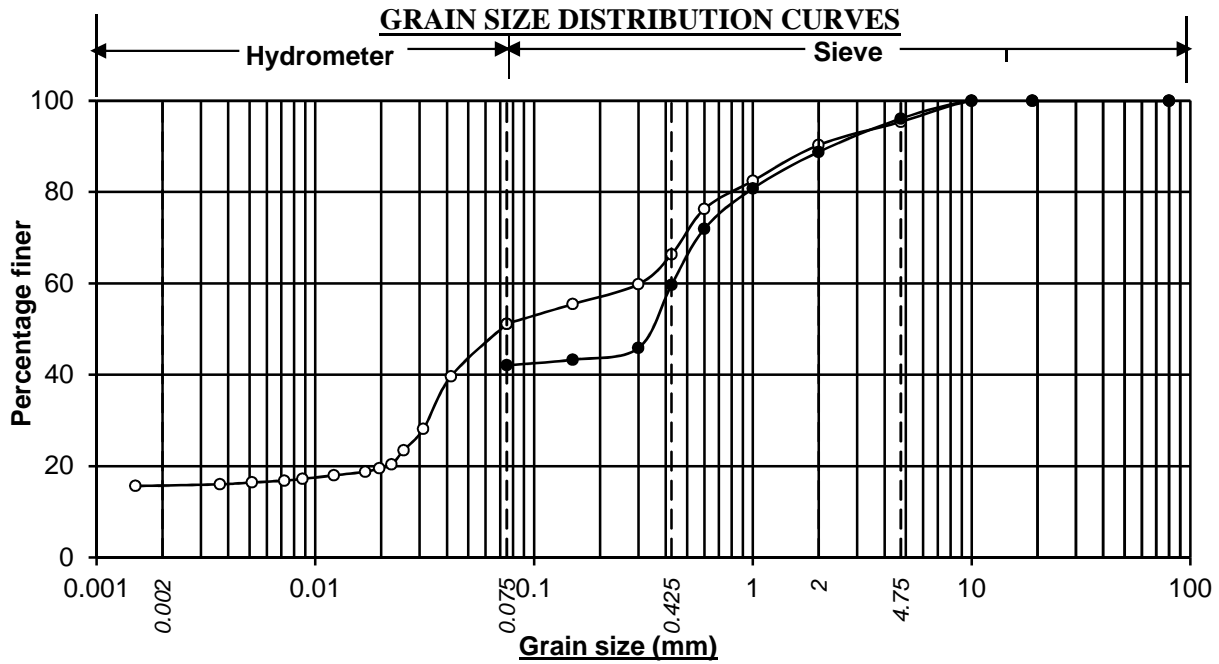
—○— BH-06,SPT-01, 0.80M

—●— BH-08,SPT-02, 2.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-06,SPT-01, 0.80M		65.0	19.3	14.5	1.2	35.0		0.0
BH-08,SPT-02, 2.50M		13.5	21.0	23.6	26.1	70.7		15.8

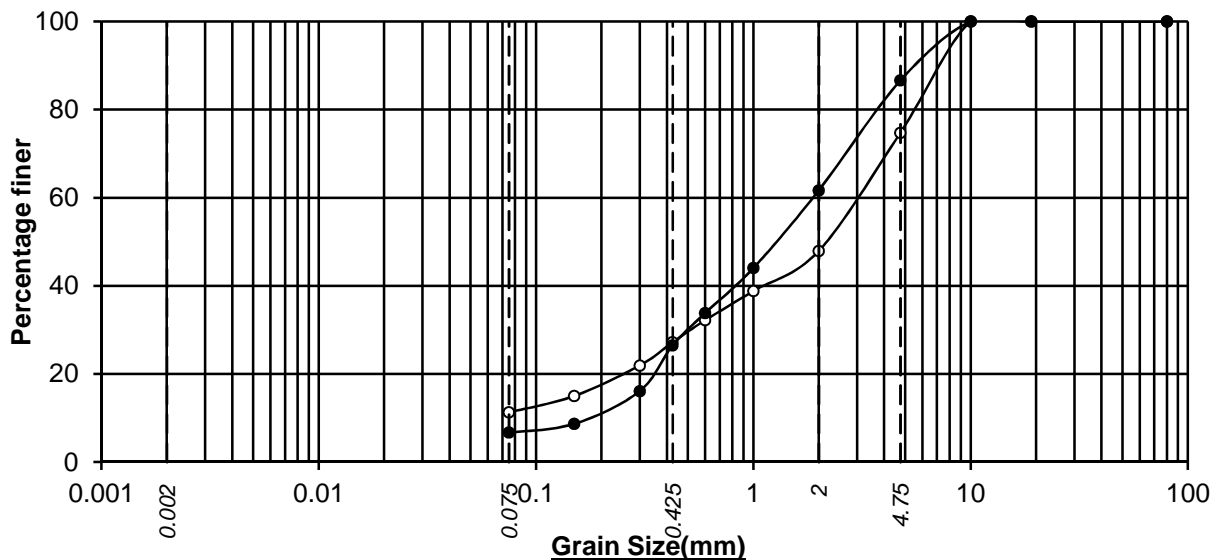
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Odisha.

Job No.  
4095



—○— BH-04,UDS-01, 2.50M      —●— BH-04,SPT-03, 4.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-04,UDS-01, 2.50M	15.8	35.4	15.1	24.0	5.1	44.2		4.6
BH-04,SPT-03, 4.50M		42.1	17.6	29.1	7.3	54.0		3.9

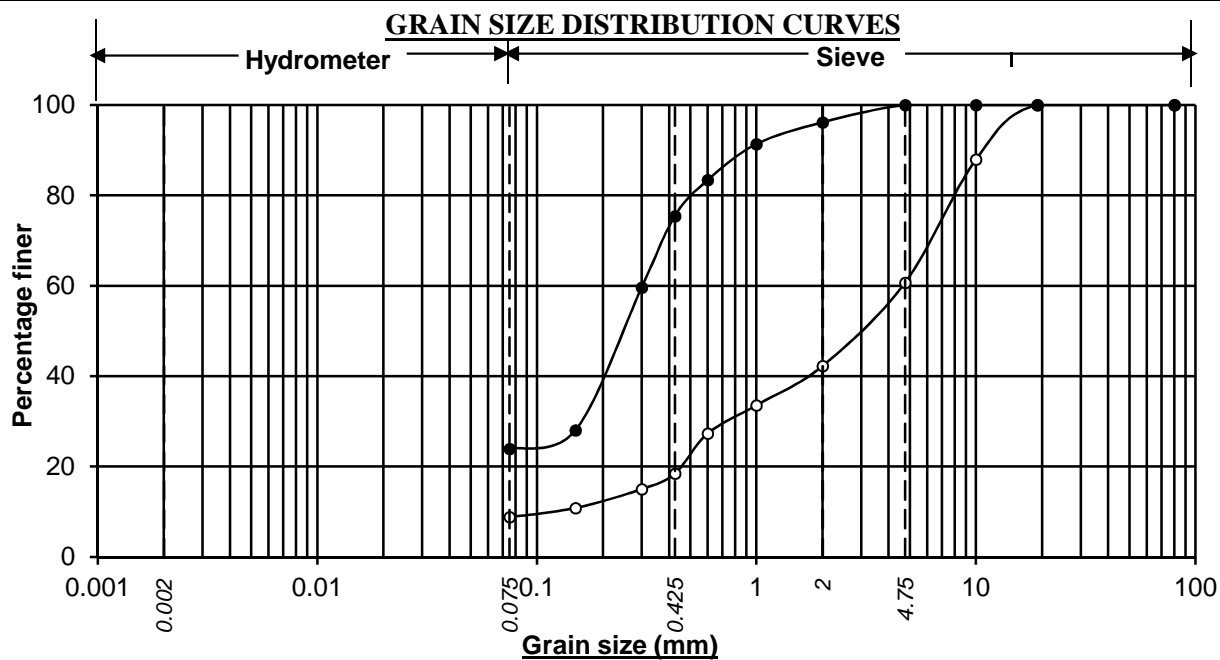


—○— BH-07,SPT-01, 1.50M      —●— BH-10,SPT-01, 0.70M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-07,SPT-01, 1.50M		11.3	15.9	20.7	26.8	63.4	2.365	25.3
BH-10,SPT-01, 0.70M		6.7	19.8	35.2	24.9	79.9	1.922	13.4

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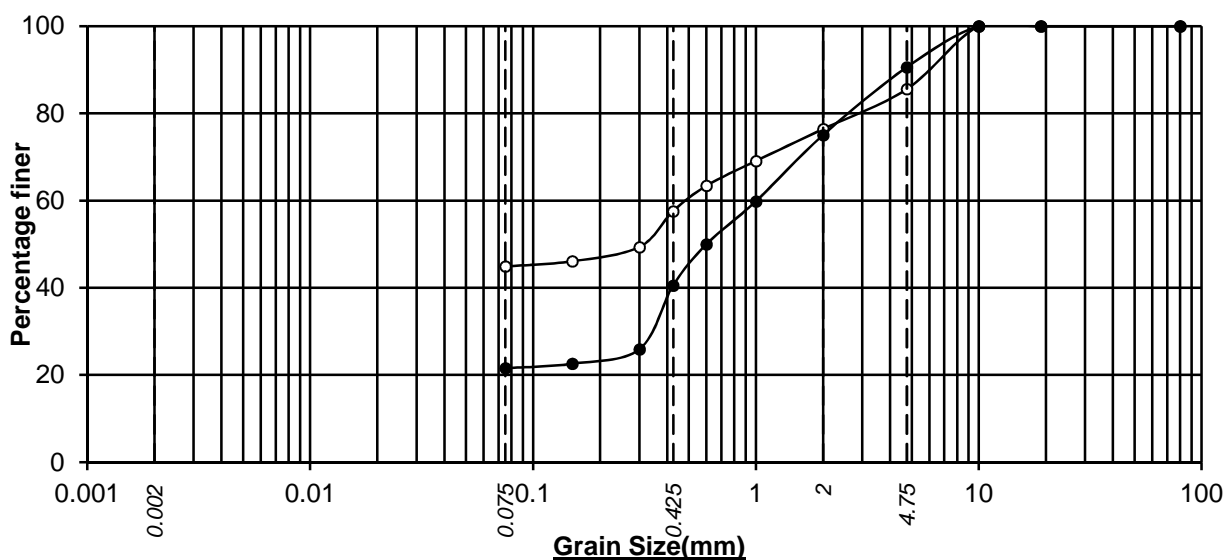
Job No.  
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—○— BH-09, SPT-01, 1.50M

—●— BH-10, SPT-05, 7.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-09, SPT-01, 1.50M		8.8	9.7	23.8	18.4	51.9		39.3
BH-10, SPT-05, 7.50M		23.9	51.5	20.7	3.9	76.1		0.0



—○— BH-11, DS-02, 1.00M

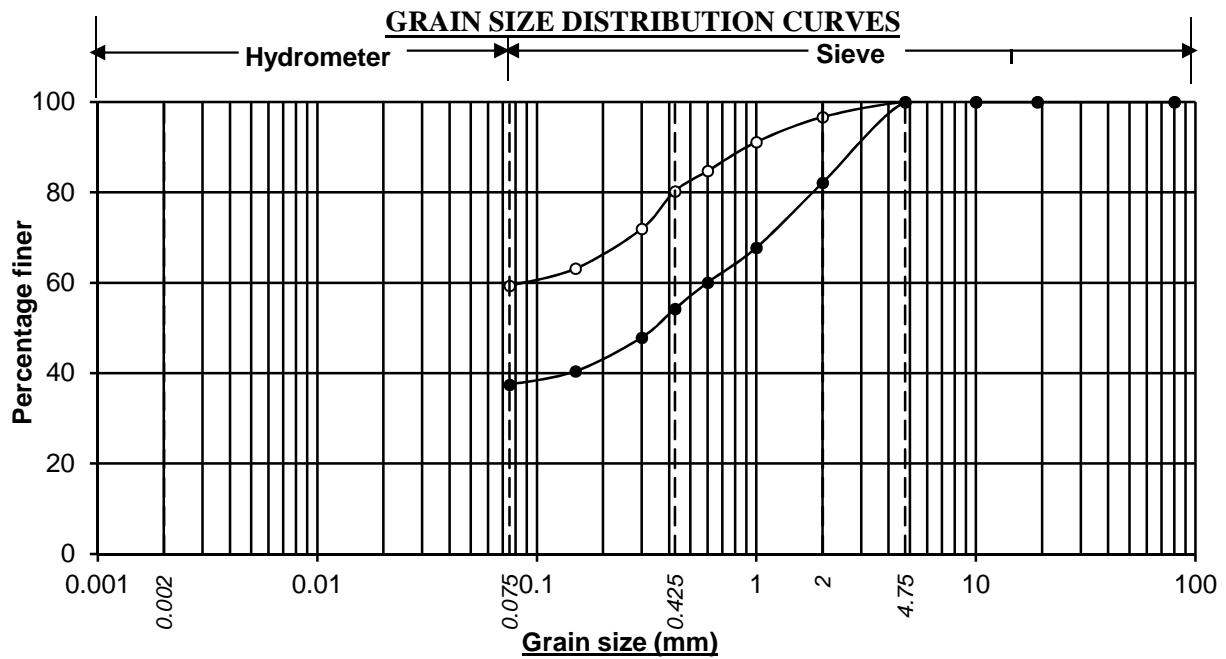
—●— BH-11, SPT-01, 1.55M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-11, DS-02, 1.00M		44.9	12.7	18.8	9.2	40.7		14.4
BH-11, SPT-01, 1.55M		21.6	19.0	34.5	15.5	69.0		9.4

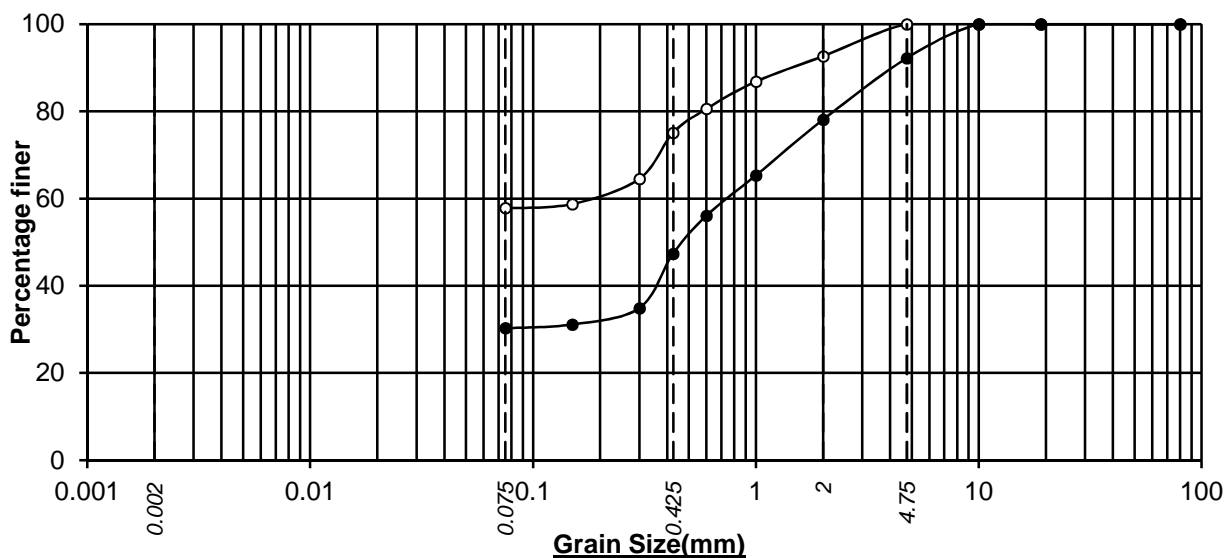
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Job No.  
4095





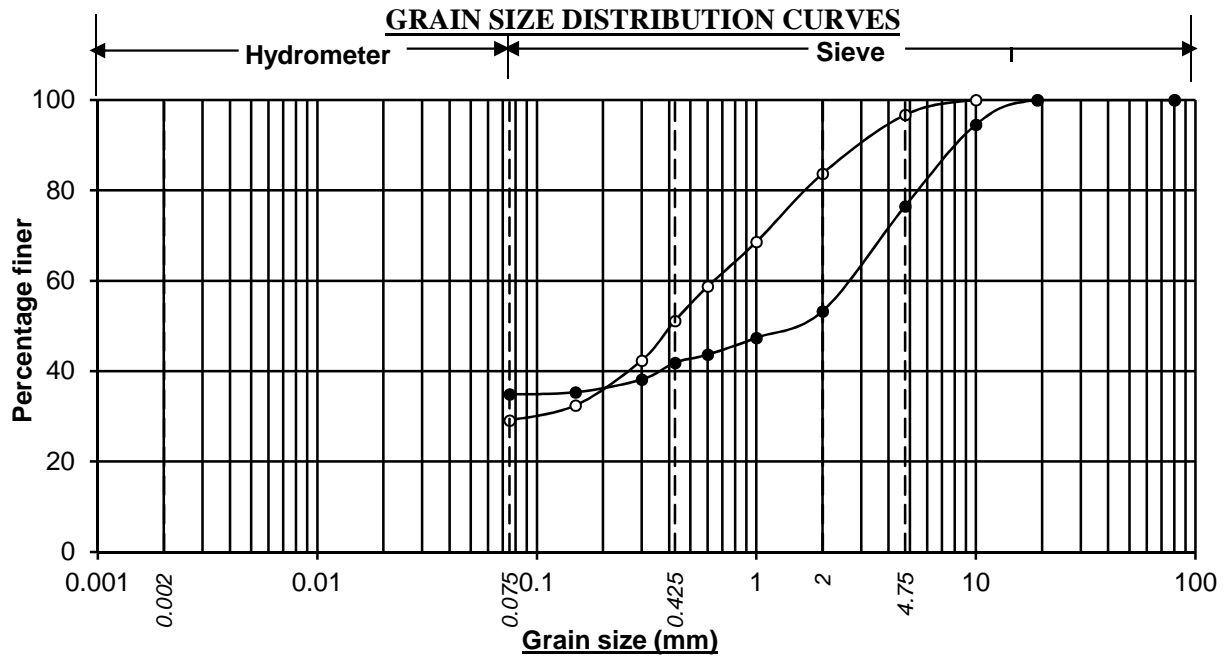
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-12, SPT-02, 2.50M		59.4	20.8	16.4	3.4	40.6		0.0
BH-13, SPT-01, 1.50M		37.5	16.7	27.9	17.9	62.5		0.0



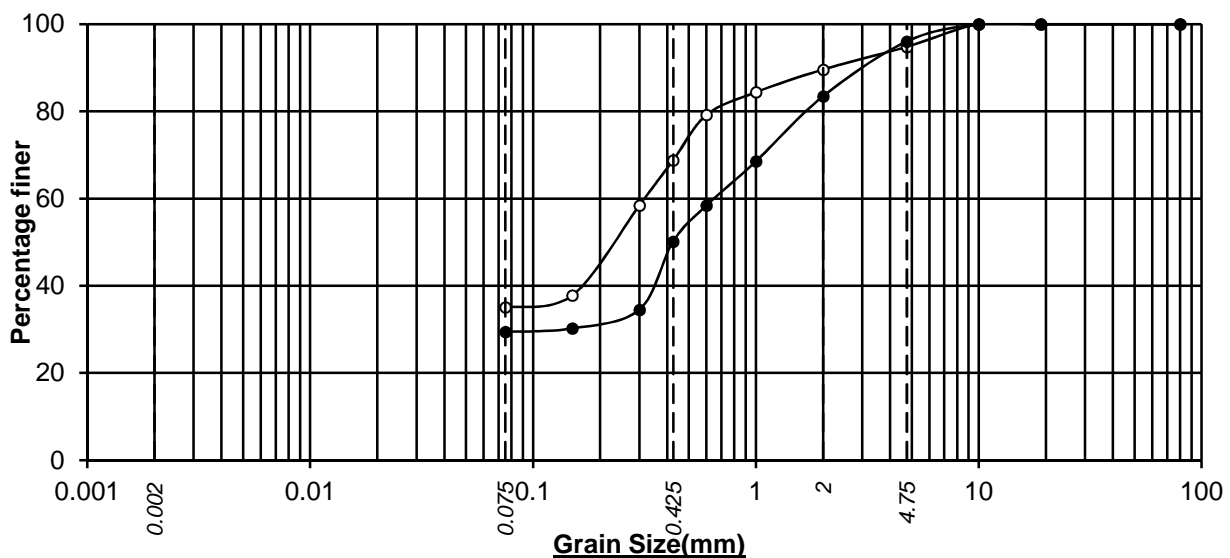
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-14, SPT-01, 1.50M		57.8	17.3	17.5	7.4	42.2		0.0
BH-14, SPT-03, 4.50M		30.3	17.1	30.7	14.1	61.9		7.8

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Job No.  
4095



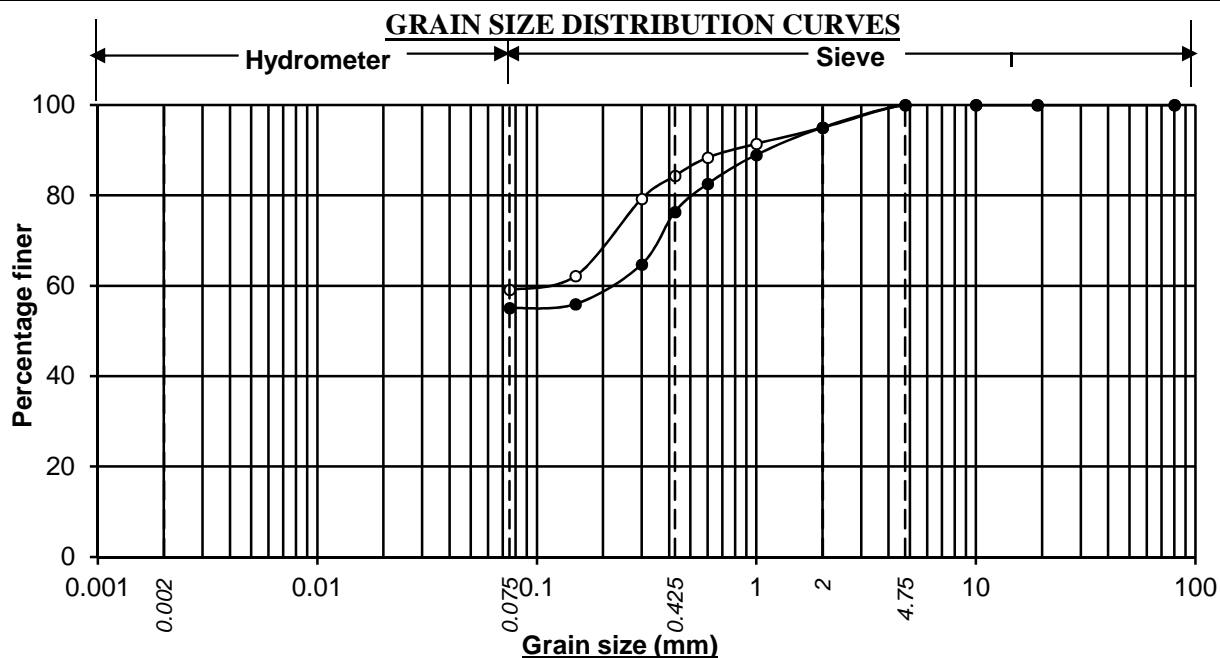
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-14, SPT-07, 10.50M		29.1	22.0	32.6	13.0	67.6		3.3
BH-15, SPT-01, 1.50M		34.9	7.0	11.4	23.2	41.6		23.5



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-15, SPT-03, 4.45M		35.1	33.7	20.8	5.2	59.7		5.2
BH-15, SPT-07, 10.45M		29.4	20.7	33.3	12.6	66.6		4.0

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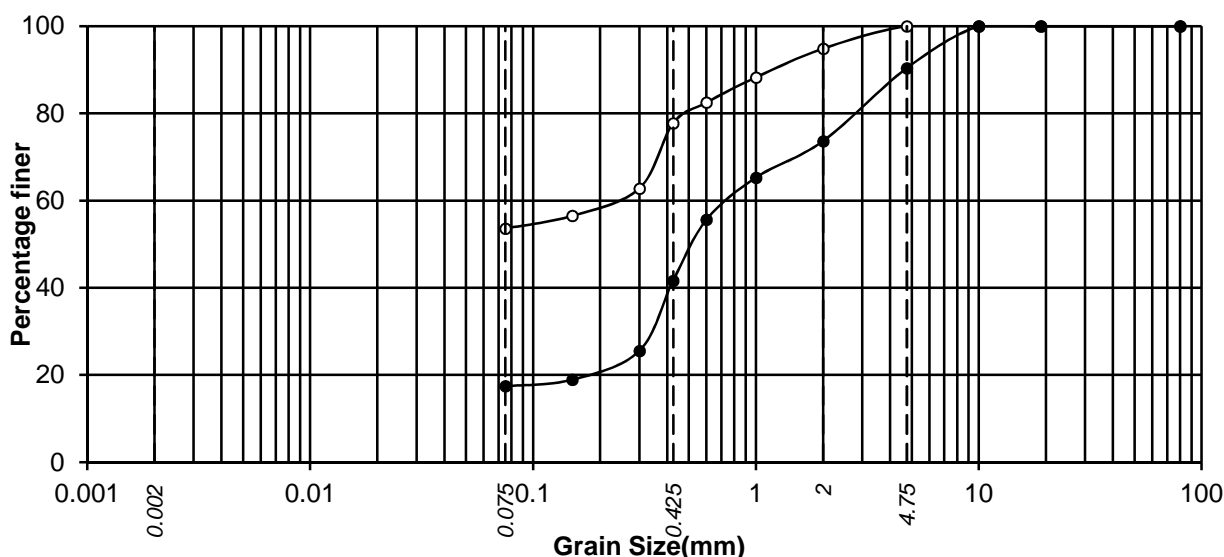
**Job No.**  
**4095**



—○— BH-16, SPT-01, 1.55M

—●— BH-17, SPT-02, 3.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-16, SPT-01, 1.55M		59.1	25.2	10.7	5.0	40.9		0.0
BH-17, SPT-02, 3.00M		55.1	21.2	18.7	5.0	44.9		0.0



—○— BH-17, SPT-04, 6.00M

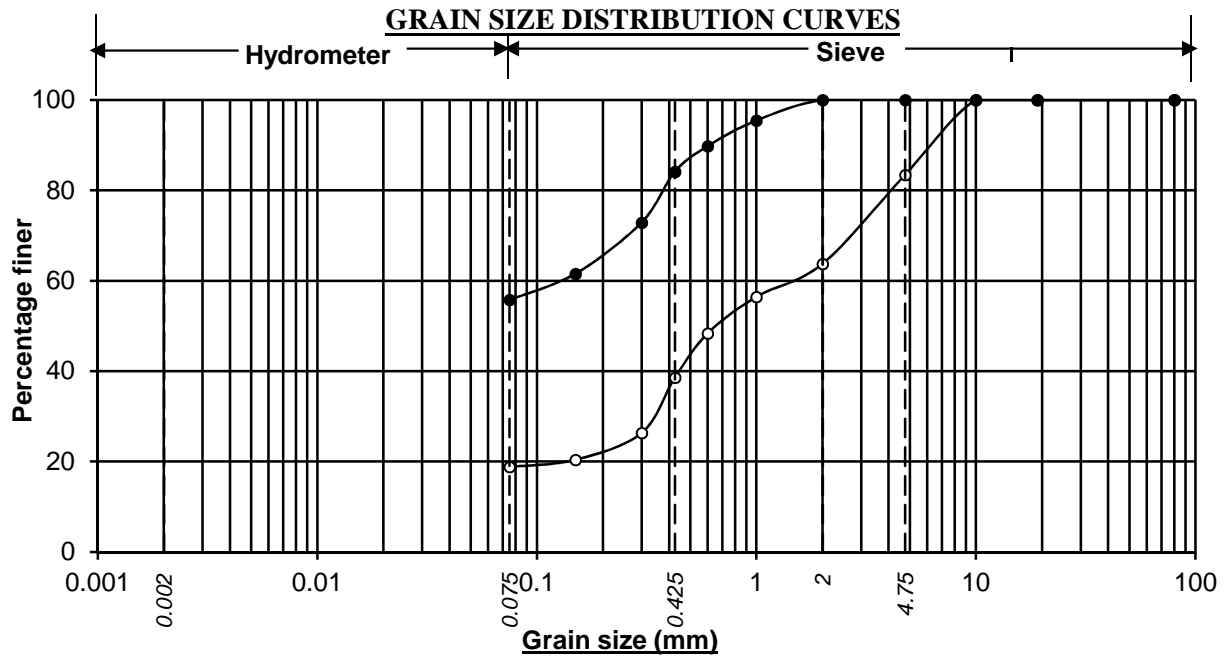
—●— BH-17, SPT-06, 9.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-17, SPT-04, 6.00M		53.6	24.1	17.1	5.2	46.4		0.0
BH-17, SPT-06, 9.00M		17.5	24.2	32.0	16.7	72.9		9.6

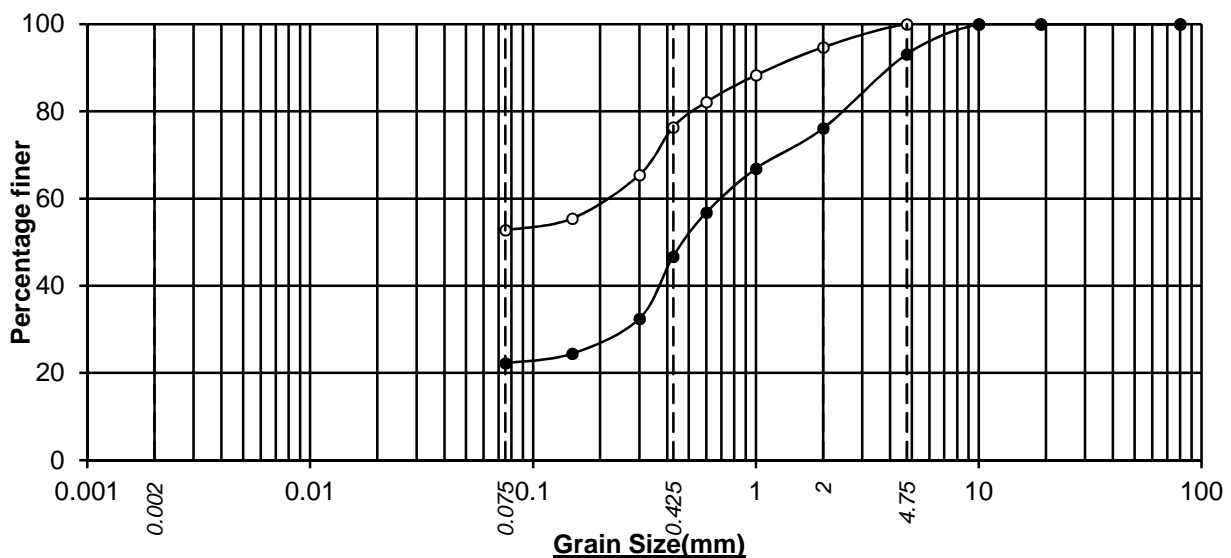
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Odisha.

Job No.  
4095

1004 of 1127



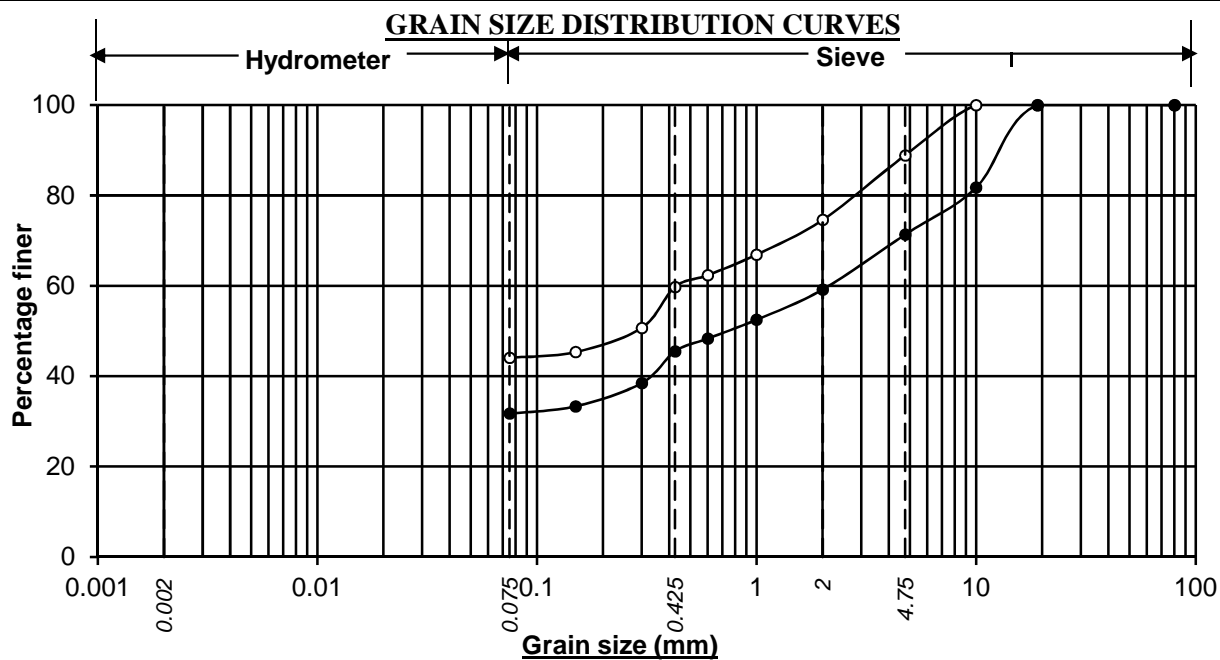
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-17, SPT-10, 15.00M		18.8	19.7	25.2	19.7	64.6		16.6
BH-18, SPT-01, 2.50M		55.8	28.3	15.9	0.0	44.2		0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-28, SPT-01, 1.45M		52.8	23.6	18.3	5.3	47.2		0.0
BH-28, SPT-07, 10.50M		22.3	24.4	29.4	17.0	70.8		6.9

Project:- Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

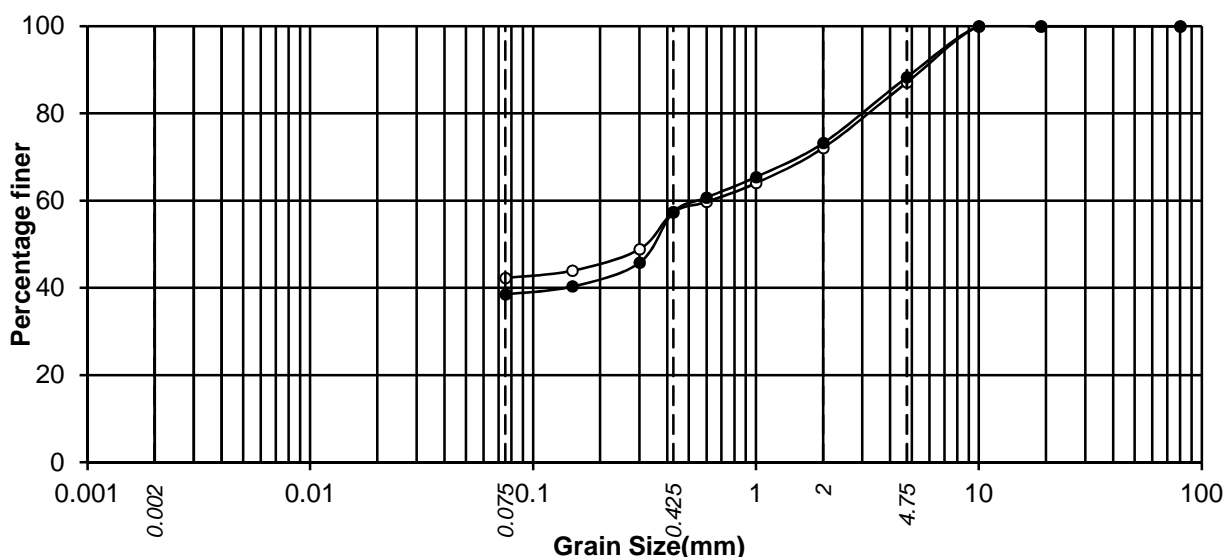
Job No.  
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—○— BH-23,SPT-01, 1.45M

—●— BH-23,SPT-05, 7.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-23,SPT-01, 1.45M		44.1	15.7	14.8	14.3	44.8		11.1
BH-23,SPT-05, 7.50M		31.8	13.6	13.7	12.2	39.5		28.7



—○— BH-24,SPT-02, 3.00M

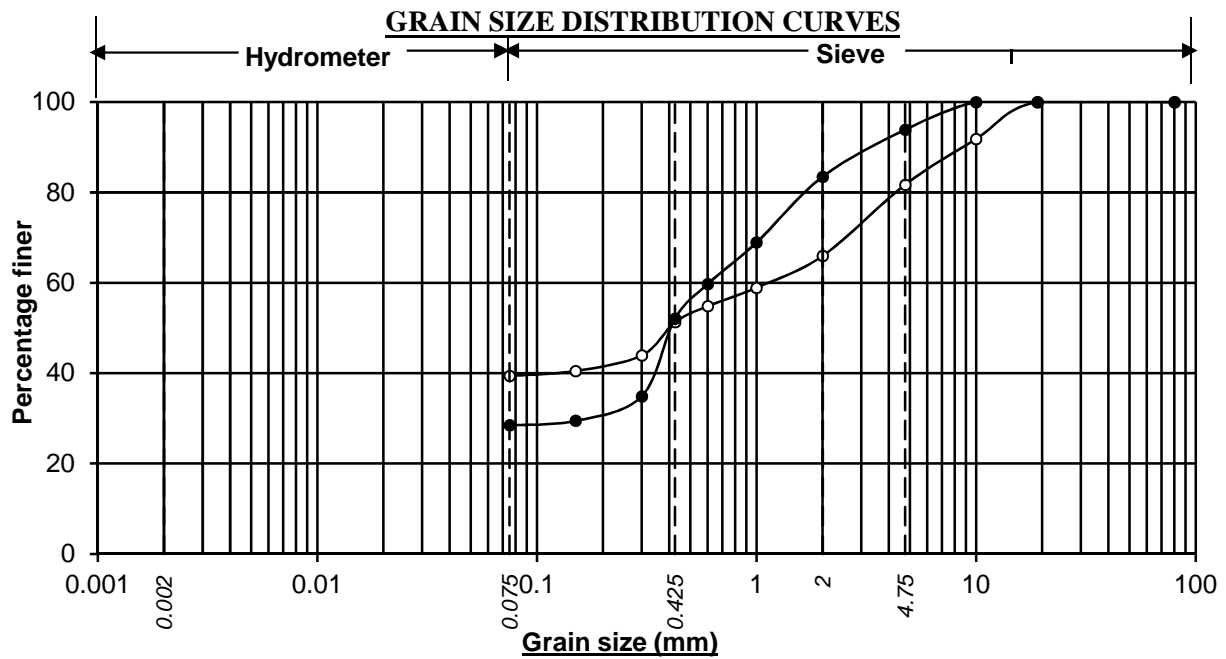
—●— BH-24,SPT-05, 7.50M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-24,SPT-02, 3.00M		42.3	15.0	14.8	15.0	44.8		12.9
BH-24,SPT-05, 7.50M		38.5	18.9	15.8	15.1	49.8		11.7

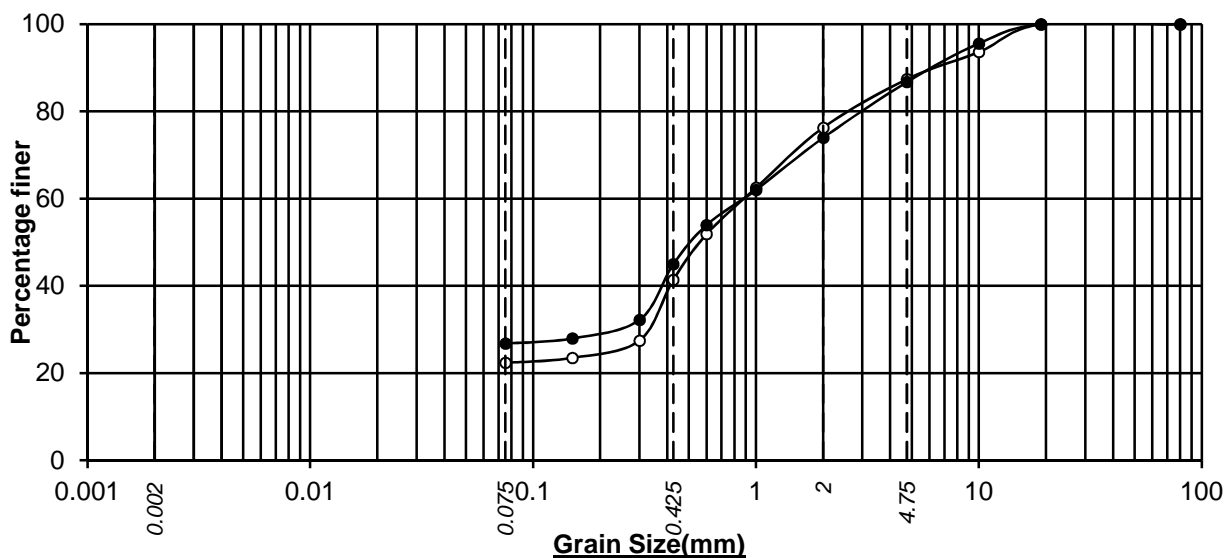
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Odisha.

1006 of 1127

Job No.  
4095



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-24, SPT-07, 10.65M		39.4	11.9	14.7	15.7	42.3		18.3
BH-25, SPT-01, 1.50M		28.5	23.6	31.4	10.4	65.4		6.1

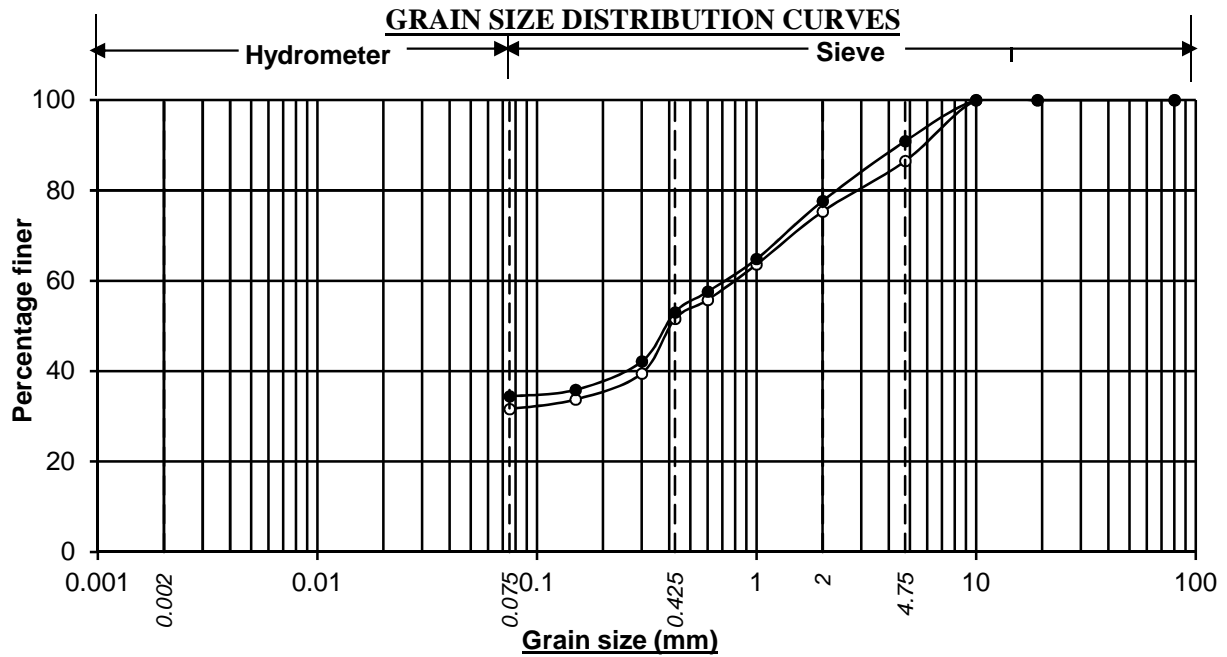


Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-25, SPT-03, 4.50M		22.4	19.0	34.9	11.1	65.0		12.6
BH-25, SPT-05, 7.50M		26.8	18.1	29.0	12.8	59.9		13.3

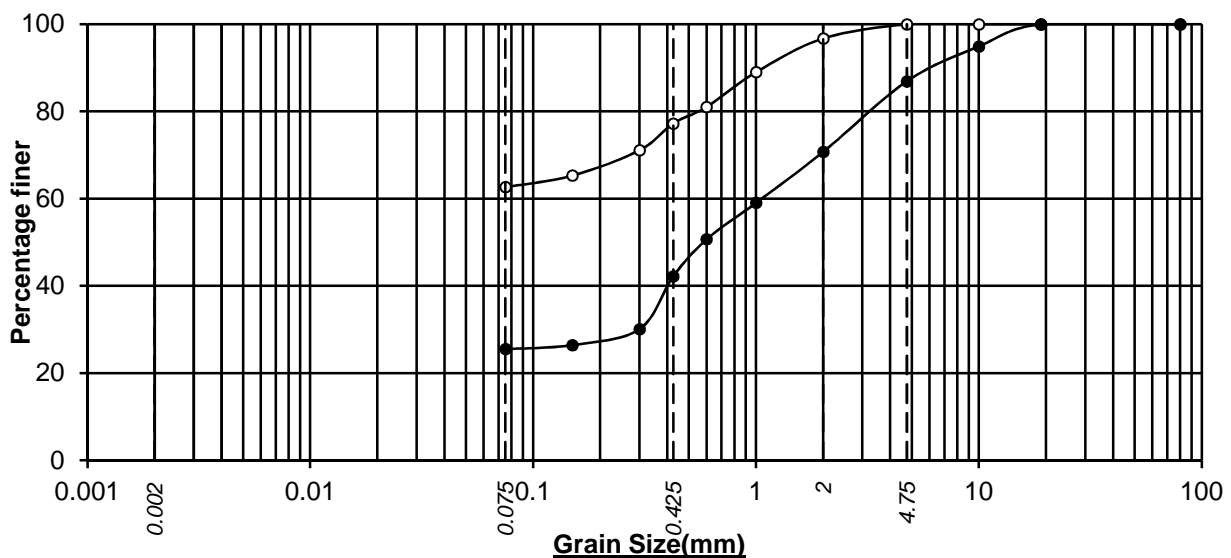
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**Job No.**  
**4095**

1007 of 1127



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-26, SPT-02, 3.00M		31.6	19.9	23.8	11.2	54.9		13.5
BH-26, SPT-04, 6.00M		34.5	18.6	24.6	13.2	56.4		9.1

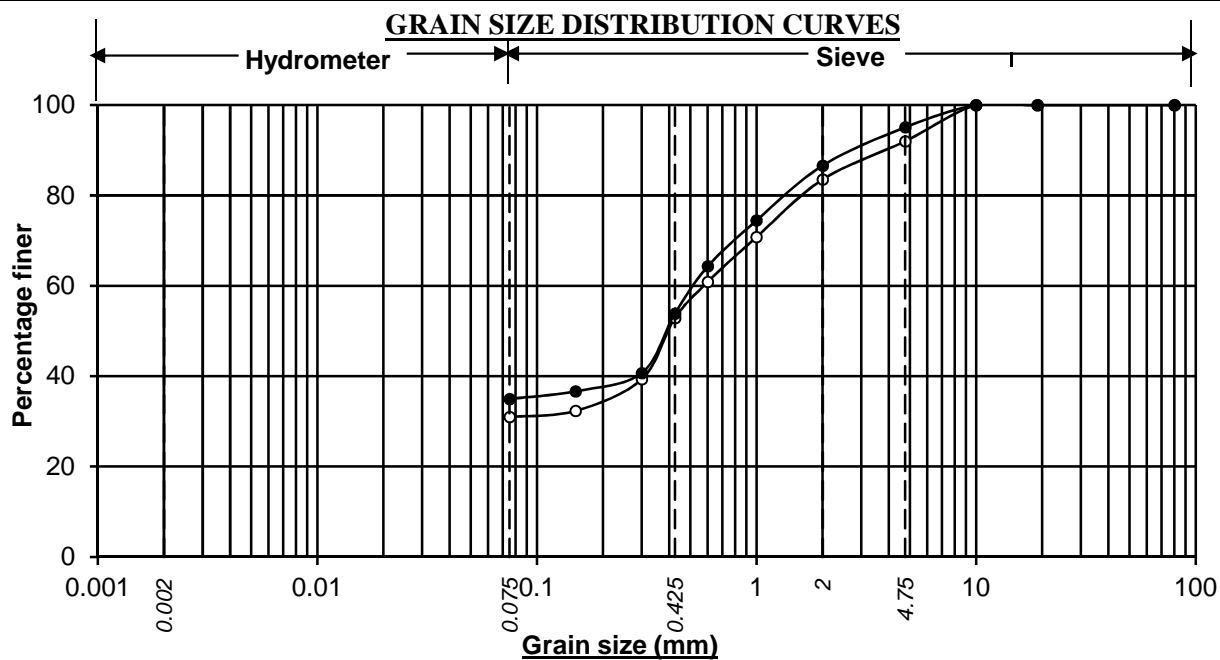


Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-27, SPT-01, 1.50M		62.7	14.5	19.5	3.3	37.3		0.0
BH-27, SPT-03, 4.50M		25.5	16.7	28.5	16.2	61.4		13.1

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**Job No.**  
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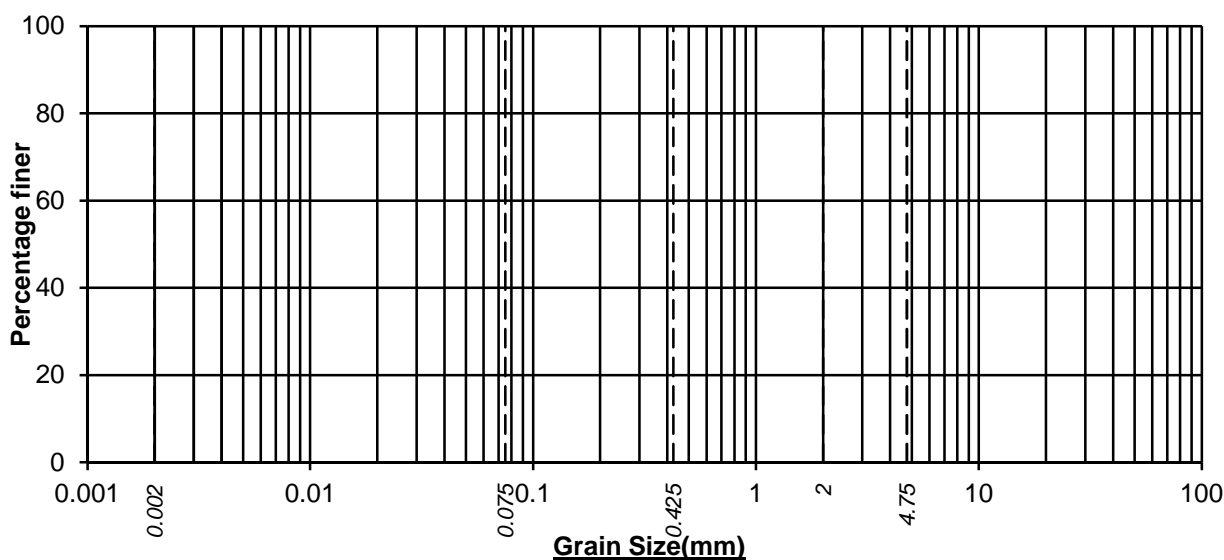
1008 of 1127



—○— BH-27,SPT-06, 9.00M

—●— BH-27,SPT-09, 13.55M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-27,SPT-06, 9.00M		31.0	21.9	30.6	8.5	61.0		8.0
BH-27,SPT-09, 13.55M		35.0	19.0	32.7	8.4	60.1		4.9



—○— #N/A

—●— #N/A

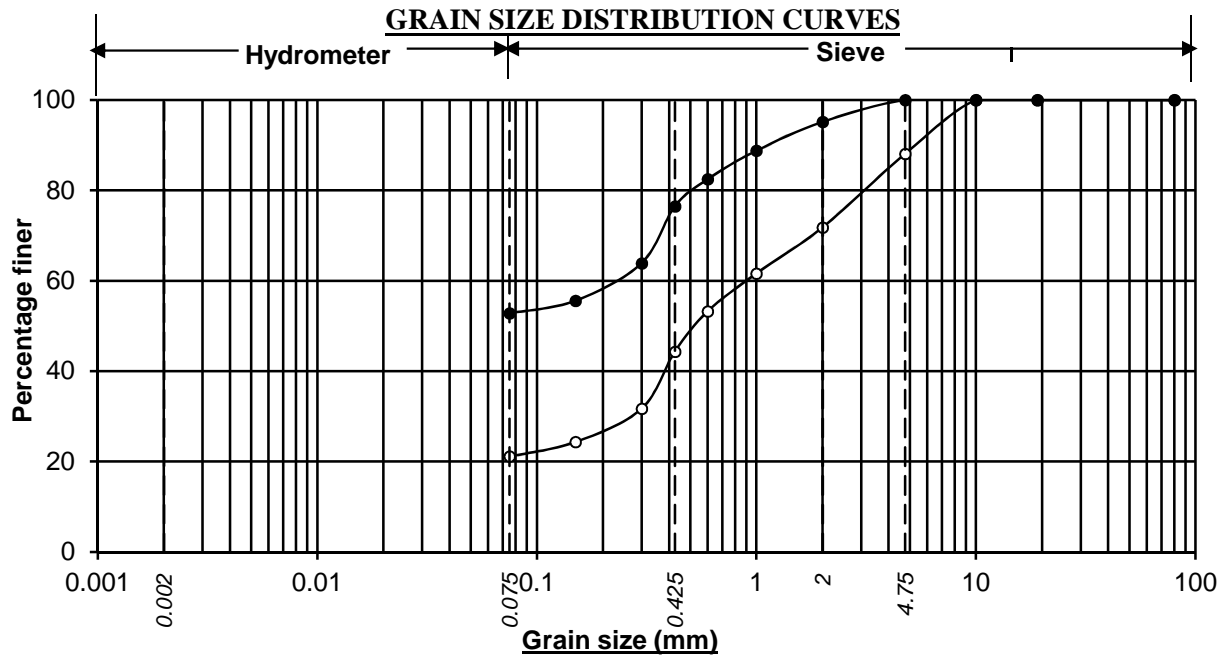
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)

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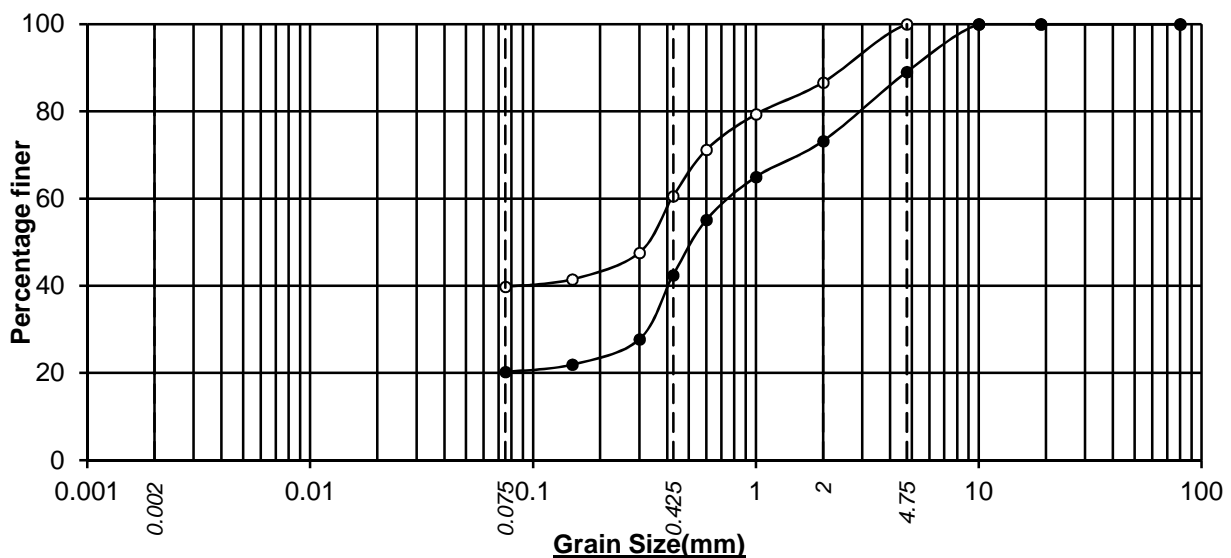
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1000 of 1127





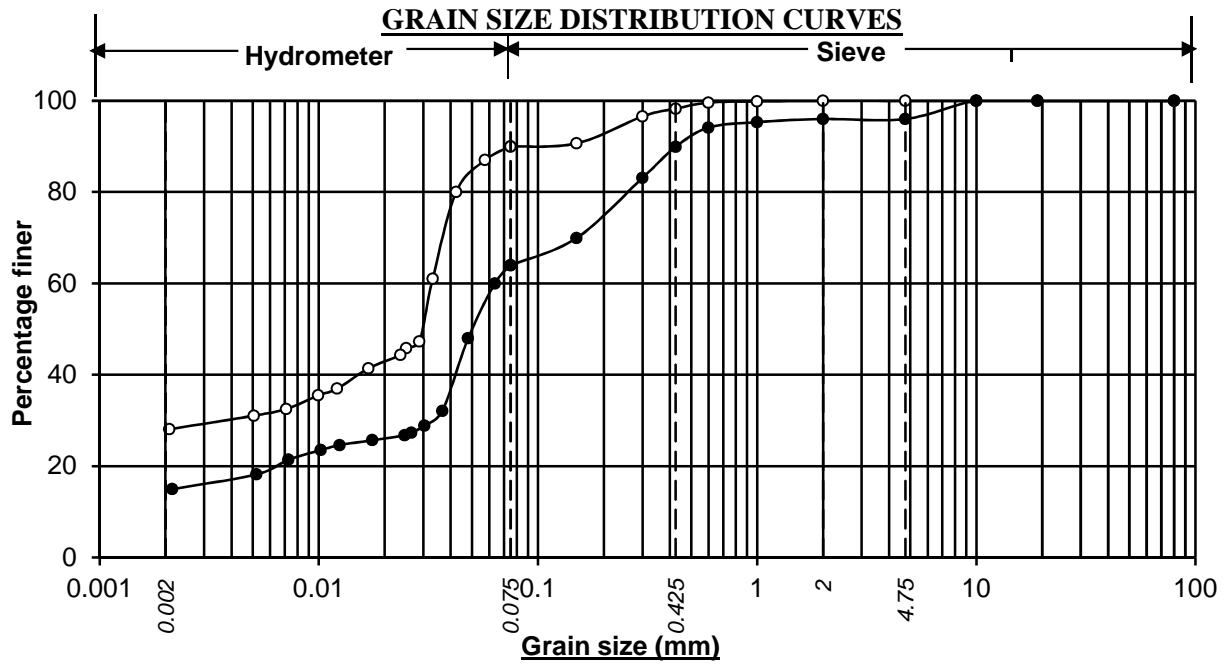
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-28, SPT-10, 15.00M		21.1	23.2	27.5	16.3	67.0		11.9
BH-31, SPT-02, 3.00M		52.8	23.6	18.7	4.9	47.2		0.0



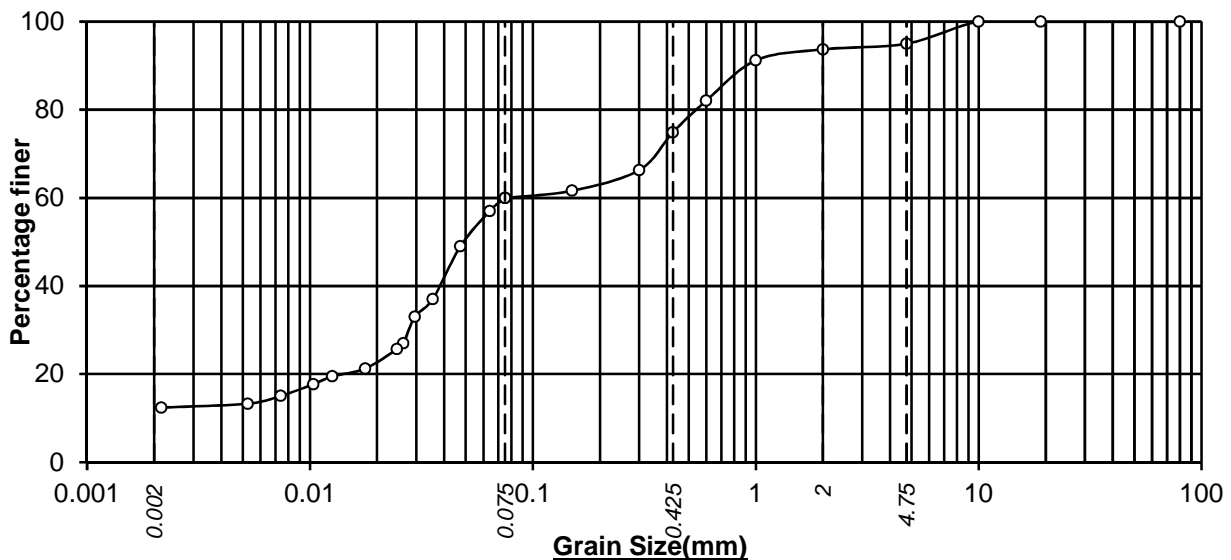
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-31, SPT-05, 7.50M		39.8	20.7	26.1	13.4	60.2		0.0
BH-31, SPT-07, 10.50M		20.3	22.0	30.8	15.9	68.7		11.0

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**Job No. 4095**



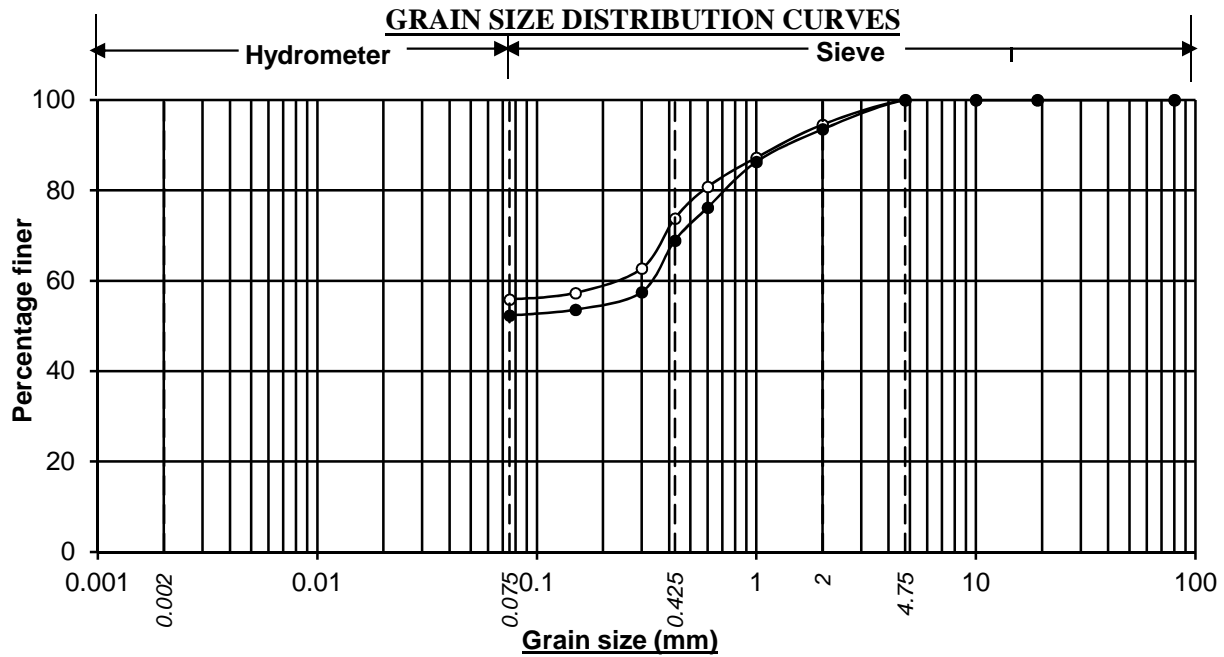
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-29,SPT-01, 1.45M	28.0	62.0	8.3	1.7	0.0	10.0		0.0
BH-29,SPT-07, 10.50M	14.7	49.3	25.9	6.1	0.0	32.0		4.0



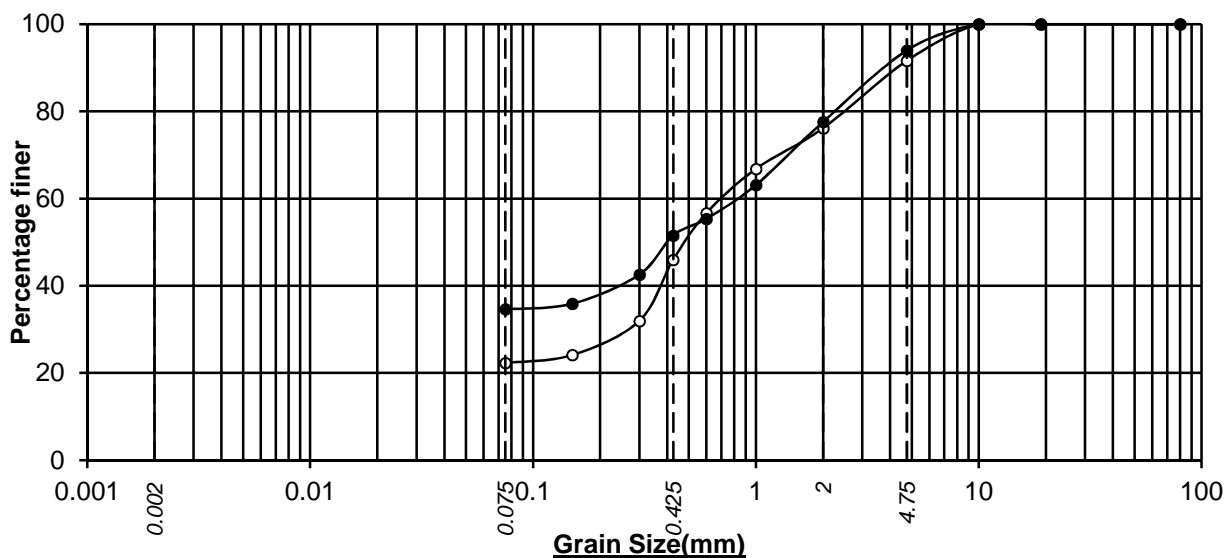
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-29,SPT-09, 13.45M	12.3	47.7	14.9	18.8	1.3	35.0		5.0

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Odisha.

Job No.  
4095



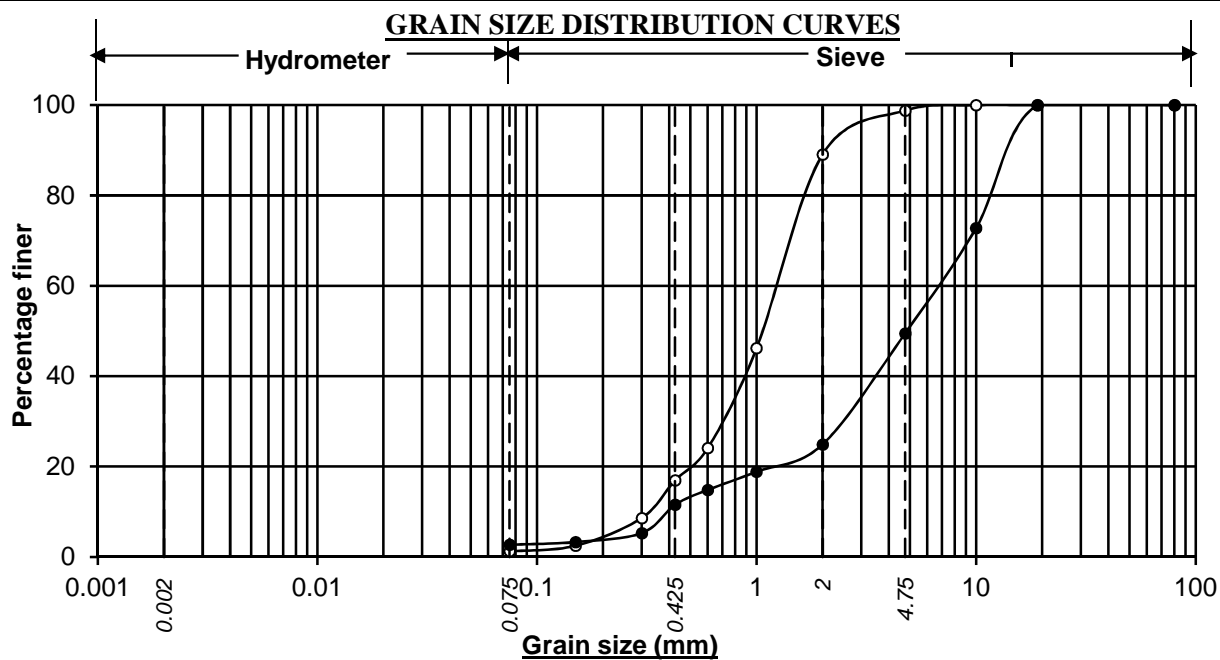
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-32,SPT-01, 1.50M		55.8	17.9	20.8	5.5	44.2		0.0
BH-32,SPT-03, 4.55M		52.3	16.6	24.6	6.5	47.7		0.0



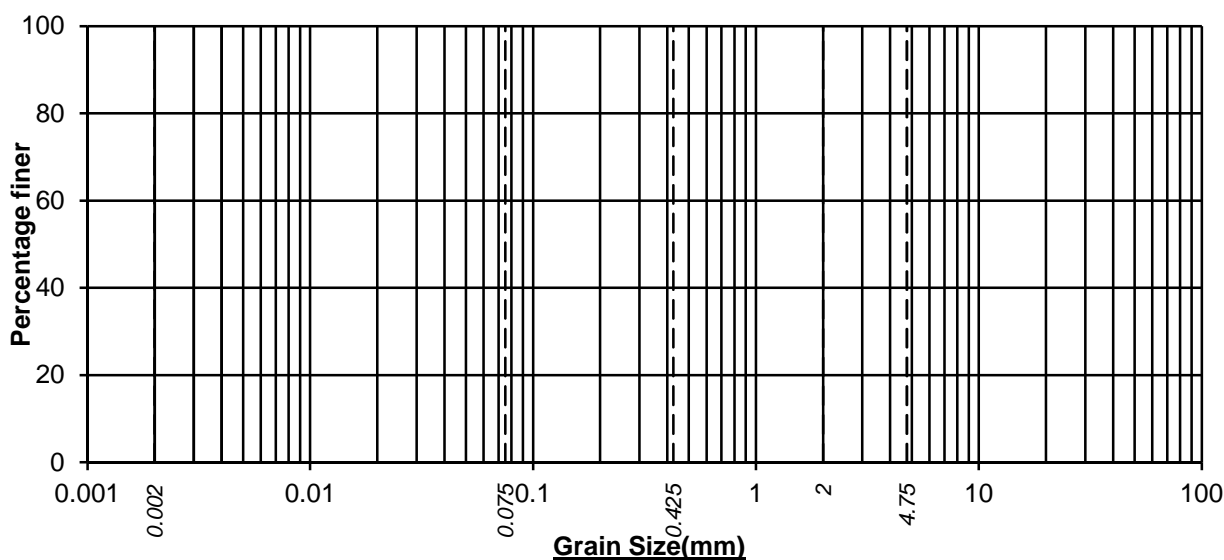
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-32,SPT-06, 9.00M		22.3	23.6	30.2	15.5	69.3		8.4
BH-35,SPT-01, 0.80M		34.6	16.8	26.1	16.4	59.3		6.1

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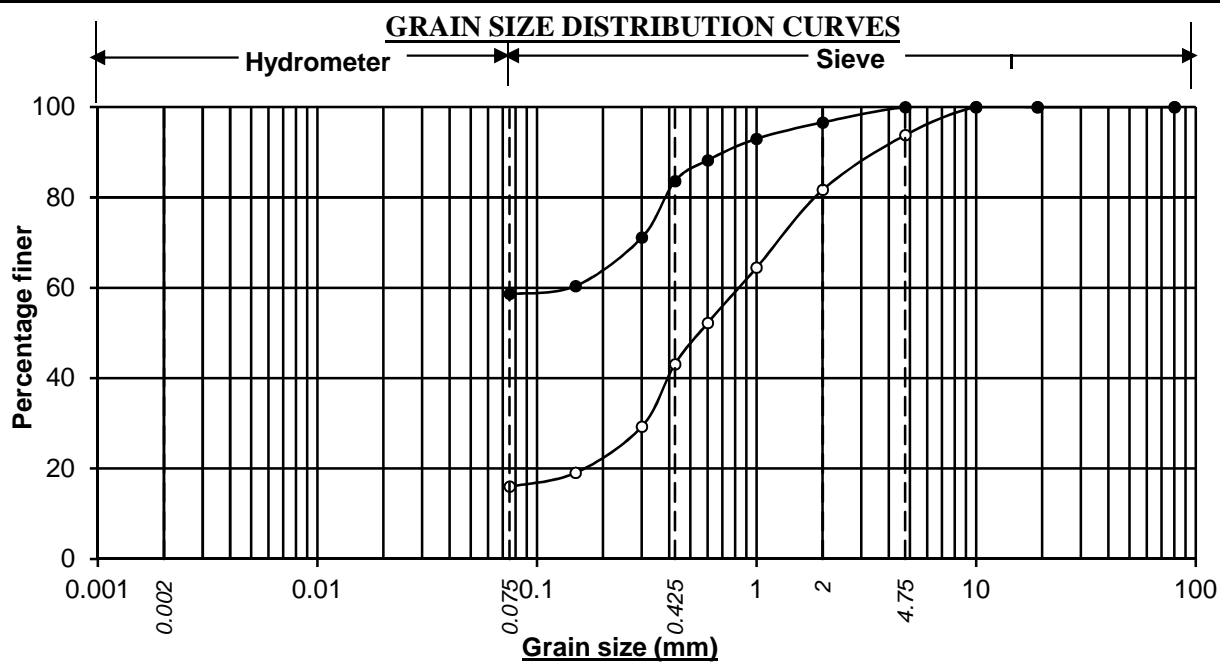
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-33, SPT-02, 2.50M		1.3	15.6	72.2	9.7	97.5		1.2
BH-34, SPT-01, 0.80M		2.7	8.8	13.4	24.6	46.8		50.5



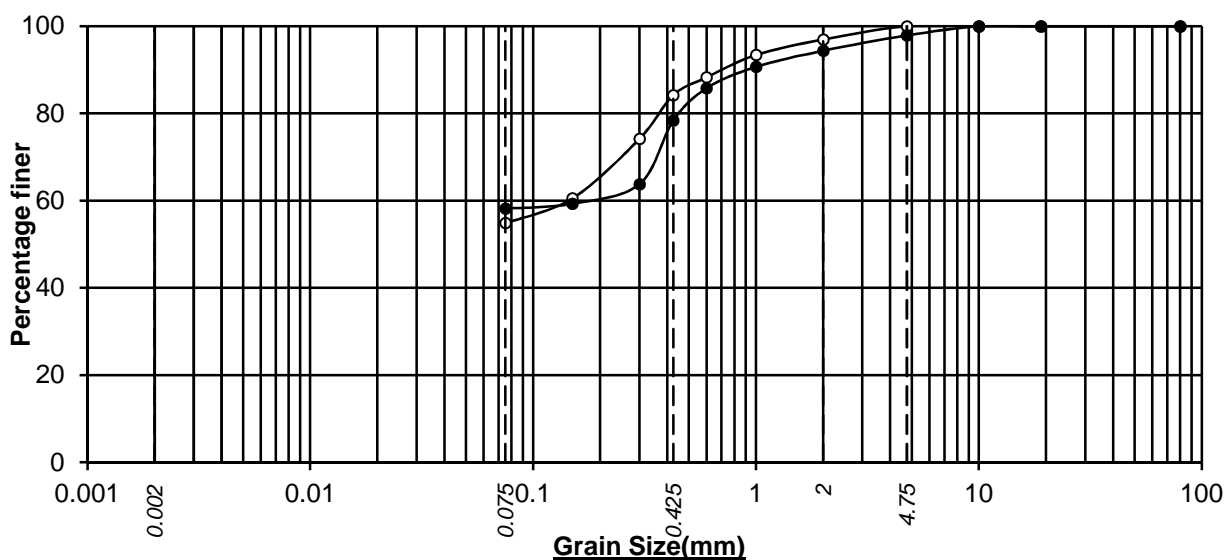
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)

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Job No.  
4095



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-39, SPT-01, 0.80M		16.1	27.1	38.5	12.1	77.7		6.2
BH-126, SPT-01, 1.50M		58.7	24.9	13.0	3.4	41.3		0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
BH-126, SPT-02, 3.00M		54.9	29.3	12.8	3.0	45.1		0.0
BH-126, SPT-05, 7.50M		58.2	20.2	16.0	3.5	39.7		2.1

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**Job No.**  
**4095**

## Relation between SPT "N" &amp; E.

Penetration Testing 1988, ISOPT-1, De Ruiter (ed.)  
© 1988 Balkema, Rotterdam, ISBN 90 6191 801 4

## History of soil penetration testing

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Nils Flodin

*Royal Institute of Technology, Stockholm, Sweden*

**ABSTRACT:** The development of dynamic and static penetration testing methods has been reviewed. A large number of different tools are now used for the investigation in-situ of the shear strength and the deformation properties of both soils and rocks as described in the paper.

## 1 INTRODUCTION

## 1.1 Penetration Testing Methods

A large number of different static and dynamic penetration tests are used today as described by Sanglerat (1972). The most common are :

- o Standard penetration test (SPT)
- o Cone penetration test (CPT)
- o Weight sounding test (WST)
- o Ram sounding test (DPA and DPB)

European reference standards have been adopted by ISSMFE in 1977 for these methods.

Penetrometers are generally used in Europe during the exploratory phase of a soil investigation to determine the soil conditions in general such as the depth, thickness and lateral extent of the various strata so that an evaluation of different possible foundation methods can be made such as spread footings, rafts, piles or caissons or if it is possible to improve the soil conditions e.g. by preloading, with excavation and replacement, stone columns, pressure berms, lime or cement columns or with embankment piles. In the Scandinavian countries and Finland the weight penetrometer (WST) is common. This method is very fast and inexpensive and a large number of soundings can be carried out within a short time. In Holland, the Dutch Cone Penetrometer (CPT) is used for the same purpose while in U.K., Germany, Spain, Portugal, France, Italy and Greece different types of dynamic penetrometers are often utilized (SPT and DP) because

of the limited penetration depth of CPT in dense or hard soils.

Penetration tests are also very valuable during the detailed exploration phase especially in silt, sand and gravel so that the compressibility of the soil in the different strata can be estimated. It is also possible to get an indication of the shear strength so that the ultimate bearing capacity of footings and piles can be assessed. In most cases the settlements will govern the design rather than the ultimate bearing capacity of the soil.

Electrical cone penetrometers and pore pressure probes (piezocones) are mainly used during the detailed exploration phase. These penetrometers are relatively delicate and can easily be damaged by stones or boulders in the soil. The maximum capacity and the maximum depth of the electrical cone penetrometers are limited. It is difficult or not possible in most cases to penetrate very dense or cemented layers. Predrilling or precoring may be required.

## 1.2 Design Values

Dynamic penetrometers are generally used to estimate the ultimate bearing capacity of piles and of caissons. With CPT or WST it is often not possible to reach the required depth. Therefore Standard penetration tests (SPT) or ram soundings (DPA or DPB) are used.

Design parameters cannot as a rule be determined from the penetration

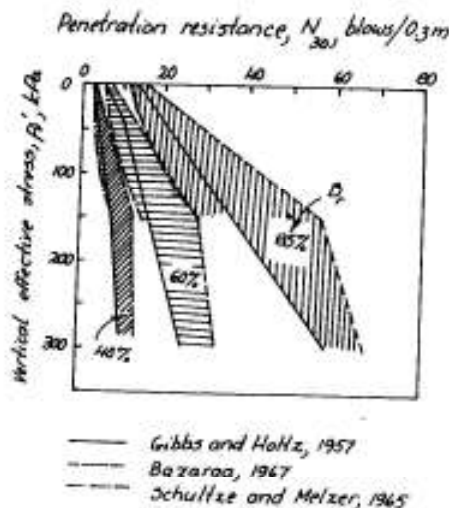


Fig 29 Relationship between  $N_{30}$ ,  $P'_{vo}$  and  $D_r$  (after Marcuson and Bieganousky, 1977)

Meyerhof proposed in 1965 that the allowable load as calculated from the equations given above could be increased by 50% without exceeding a maximum settlement of 25 mm.

Meyerhof (1965) suggested also the following relationship between the coefficient of subgrade reaction  $k_s$  and  $N_{30}$  for a 0.3 m wide plate

$$k_s = q/s = 0.75 N_{30} \text{ (MN/m}^3\text{)} \quad (6)$$

where  $q$  is the applied load (MPa) and  $s$  is the settlement (m). The relationship  $[B/(B + 0.3)]^2$  has been used by Meyerhof to estimate the settlement of a footing with the width  $B$  as proposed by Peck et al (1953). At e.g.  $N_{30} = 10$  and

$q = 0.1$  MPa then  $s = 0.075$  m or 7.5 mm.

Schultze and Menzenbach (1961) found for sands that the compression modulus  $[M]$  could be correlated with the penetration resistance  $N_{30}$

$$M = 7.1 + 0.49 N_{30} \text{ (MPa)} \quad (7)$$

Stroud and Butler (1975) proposed the relationship

$$M = f N_{30} \text{ (MPa)} \quad (8)$$

The coefficient  $f$  was reported to vary between about 0.45 MPa for materials with medium plasticity to about 0.60 MPa at  $I_p < 20$ . Stroud (1974) proposed a

constant value of 0.44 MPa on  $f$ .

SPT has also been used to estimate the settlements of footings in sand as well as in overconsolidated clays as summarized by Sutherland (1977).

Simons and Menzies (1977) have suggested for granular soils the following simple relationship

$$s = 3qB/N_{30} \quad (9)$$

for a footing with the width  $B$ .

In USSR (Trofimenkov, 1974) an equivalent modulus of elasticity  $E_s = (35$

to 50)  $\log N_{30}$  is used to estimate the settlements of footings on sand based on the results from SPT. Parry (1971) proposed the relationship  $E_s = 5 N_{30}$

while Webb (1969) suggested the expression

$$E_s = 0.537 (N_{30} + 15) \text{ (MPa)} \quad (10)$$

for saturated fine to medium sand and

$$E_s = 0.358 (N_{30} + 5) \text{ (MPa)} \quad (11)$$

for a saturated clayey fine sand.

Correlations have been published for granular soils by e.g. Meyerhof (1956) Peck et al (1974), Muromachi et al (1974), Tassios and Anagnostopoulou (1974), Mitchell et al (1978) and by others between the penetration resistance ( $N_{30}$ ) and the effective angle of internal friction ( $\phi'$ ). Muromachi et al. (1974) proposed the following relationship

$$\phi' = 20^\circ + 3.5 \sqrt{N_{30}} \quad (12)$$

where  $N_{30}$  (blows/0.3 m) is the measured penetration resistance. The accuracy of this equation is reported to be about  $\pm 5^\circ$ . The correlation with  $\phi'$  is in general more constant than with the relative density (de Mello, 1971).

The relationship proposed by Mitchell et al (1978) is shown in Fig 30. It can be seen that the effective overburden pressure has a large effect on the interpretation of the results. It should be noted that the scatter of the results is relatively large. It is, therefore, often preferable to evaluate the bearing capacity of e.g. footings and piles directly from the measured penetration resistance ( $N_{30}$ ) without using the angle of internal friction. The results may otherwise be misleading.

Meyerhof showed in 1956 that SPT can also be used to evaluate the bearing capacity of piles. The undrained shear

## Annexure-2

**ABBREVIATION USED IN THIS REPORT AND IT'S FULL FORM**

BH		:	Bore Hole
UDS		:	Undisturbed Sample
DS		:	Disturbed Sample
SPT		:	Standard Penetration Test
ERT		:	Electrical Resistivity Test
CPLT		:	Cyclic Plate Load Test
TRSH-UU		:	Triaxial Unconsolidated Undrained Tests
UNCONFD		:	Unconfined Compression Test on "UDS"
REMOULD		:	Unconfined Compression Test on Remoulded Sample
DRSH-CQ		:	Consolidated Quick Direct Shear Test
LQ/LL		:	Liquid Limit
PL		:	Plastic Limit Test
SL		:	Shrinkage Limit
PI		:	Plasticity Index
Gravl.		:	Gravel
NMC		:	Natural Moisture Content
	S	:	Moisture Content From Sample
	T	:	Moisture Content From Triaxial Tests
	DR	:	Moisture Content From DRSH-CQ Tests
	C	:	Moisture Content From Consolidation Tests
SP.GR		:	Specific Gravity
CBR		:	California Bearing Ratio
N		:	Blows per 30cm penetration
EGL		:	Existing Ground Level
RL		:	Reduced Level
SWL		:	Standing Water Level
PC/PN		:	Chamber Pressure/Normal Pressure
E <sub>s</sub>		:	Total Soil Modulus
E <sub>u</sub>		:	Undrained Young's modulus
K		:	A constant to be multiplied to Cohesion to get E <sub>u</sub>
E <sub>d</sub>		:	Drained Young's modulus
M <sub>v</sub>		:	Compressibility
M <sub>vc</sub>		:	Compression for consolidation only.
C <sub>v</sub>		:	Co-efficient of volume decrease



# Foundation Design and Construction

Seventh Edition

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M. J. Tomlinson  
CEng, FICE, FIStructE

*with contributions by*  
R. Boorman BSc, MEng, MICE,  
FIStructE

Prentice  
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**Table 2.11** Compressibility of various types of clays

Type	Qualitative description	Coefficient of volume compressibility, $m_v$ ( $\text{m}^2/\text{MN}$ )
Heavily overconsolidated boulder clays (e.g. many Scottish boulder clays) and stiff weathered rocks (e.g. weathered siltstone), hard London Clay, Gault Clay, and Oxford Clay (at depth)	Very low compressibility	Below 0.05
Boulder clays (e.g. Teesside, Cheshire) and very stiff 'blue' London Clay, Oxford Clay, Keuper Marl	Low compressibility	0.05–0.10
Upper 'blue' London Clay, weathered 'brown' London Clay, fluvio-glacial clays, Lake clays, weathered Oxford Clay, weathered Boulder Clay, weathered Keuper Marl, normally consolidated clays (at depth)	Medium compressibility	0.10–0.30
Normally consolidated alluvial clays (e.g. estuarine clays of Thames, Firth of Forth, Bristol Channel, Shatt-al-Arab, Niger Delta, Chicago Clay), Norwegian 'Quick' Clay	High compressibility	0.30–1.50
Very organic alluvial clays and peats	Very high compressibility	Above 1.50

For soft normally-consolidated clays:

$$\text{Immediate settlement} = 0.1\rho_{\text{oed}},$$

$$\text{Consolidation settlement} = \rho_{\text{oed}},$$

$$\text{Final settlement} = 1.1\rho_{\text{oed}}.$$

(e) *Calculation of consolidation settlement ( $\rho_c$ )*. If the variation in compressibility of a soil is known from the result of a number of oedometer tests, the consolidation settlement ( $\rho_c$ ) is calculated preferably from the values of the coefficient of volume compressibility ( $m_v$ ) as determined from the oedometer tests. Some typical values are shown in Table 2.11. Relationships between the undrained shear strength, plasticity index,  $N$ -value and modulus of volume compressibility are shown in Fig. 1.5.

Skempton and Bjerrum<sup>2,32</sup> have shown that the actual consolidation settlement ( $\rho_c$ ) may be less than the calculated values based on oedometer tests. They give the formula

$$\rho_c = \mu_g \rho_{\text{oed}}, \quad (2.45)$$

where

$\mu_g$  = a coefficient (geological factor) which depends on the type of clay,

$\rho_{\text{oed}}$  = settlement as calculated from oedometer tests.

Skempton and Bjerrum have related  $\mu_g$  to the pore pressure coefficient of the soils as determined from undrained triaxial compression tests, and also to the dimensions of the loaded area. However, for most practical purposes it is sufficient to take the following values for  $\mu_g$ :

Type of clay	$\mu_g$
Very sensitive clays (soft alluvial, estuarine, and marine clays)	1.0–1.2
Normally consolidated clays	0.7–1.0
Overconsolidated clays (London Clay, Weald, Kimmeridge, Oxford, and Lias Clays)	0.5–0.7
Heavily overconsolidated clays (glacial till, Keuper Marl)	0.2–0.5

The  $\mu_g$  value for London Clay is generally taken as 0.5.

Although the geological factor has some theoretical basis it is generally regarded as a means whereby the apparently high settlements calculated from oedometer test results can be reconciled with the much smaller settlements as measured in foundations on stiff overconsolidated clays. It is possible that oedometer tests on good samples taken by piston-driven thin-wall tubes will give lower  $m_v$  values than those obtained from conventional hammer-driven thick-wall tube samples and hence the geological factor will no longer be required. However, there is little published evidence at present to justify changing the present practice. EC 7 (Annex D5) permits empirical corrections to be made to settlement calculations based on one-dimensional consolidation of the soil.

The oedometer settlement ( $\rho_{\text{oed}}$ ) of a soil layer is calculated from the formula

$$\rho_{\text{oed}} = m_v \sigma_z H, \quad (2.46)$$

where

$m_v$  = average coefficient of volume compressibility obtained for the effective pressure increment in the particular layer under consideration,

$\sigma_z$  = average effective vertical stress imposed on the particular layer resulting from the net foundation pressure ( $q_n$ ),

$H$  = thickness of the particular layer under consideration.

TABLE 1 VALUES OF  $\lambda$ 

TYPE OF CLAY	$\lambda$
(1)	(2)
Very sensitive clays (soft alluvial, estuarine and marine clays)	1.0 to 1.2
Normally consolidated clays	0.7 to 1.0
Overconsolidated clays	0.5 to 0.7
Heavily overconsolidated clays	0.2 to 0.5

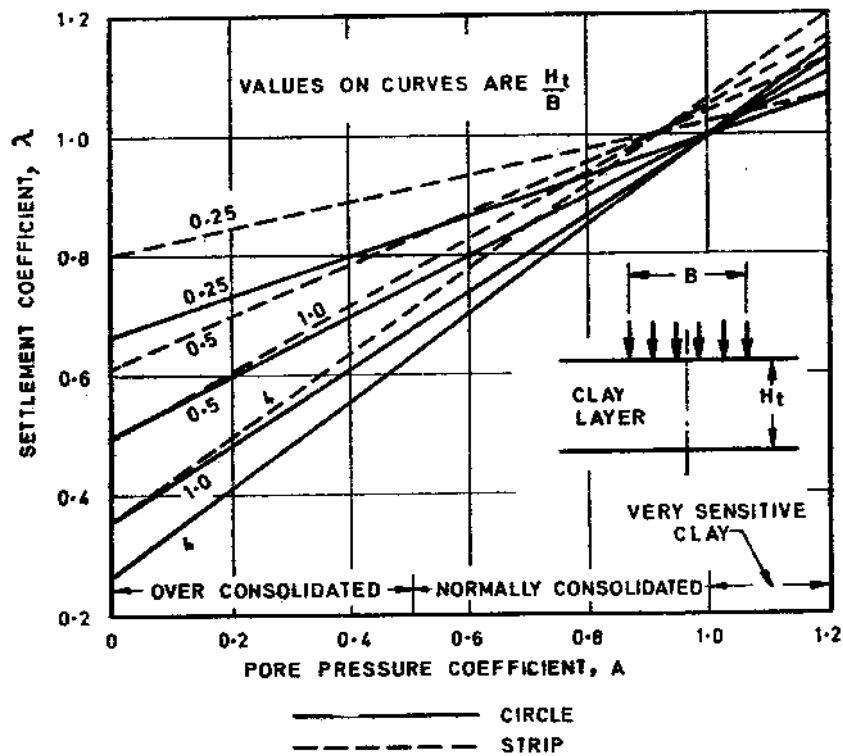
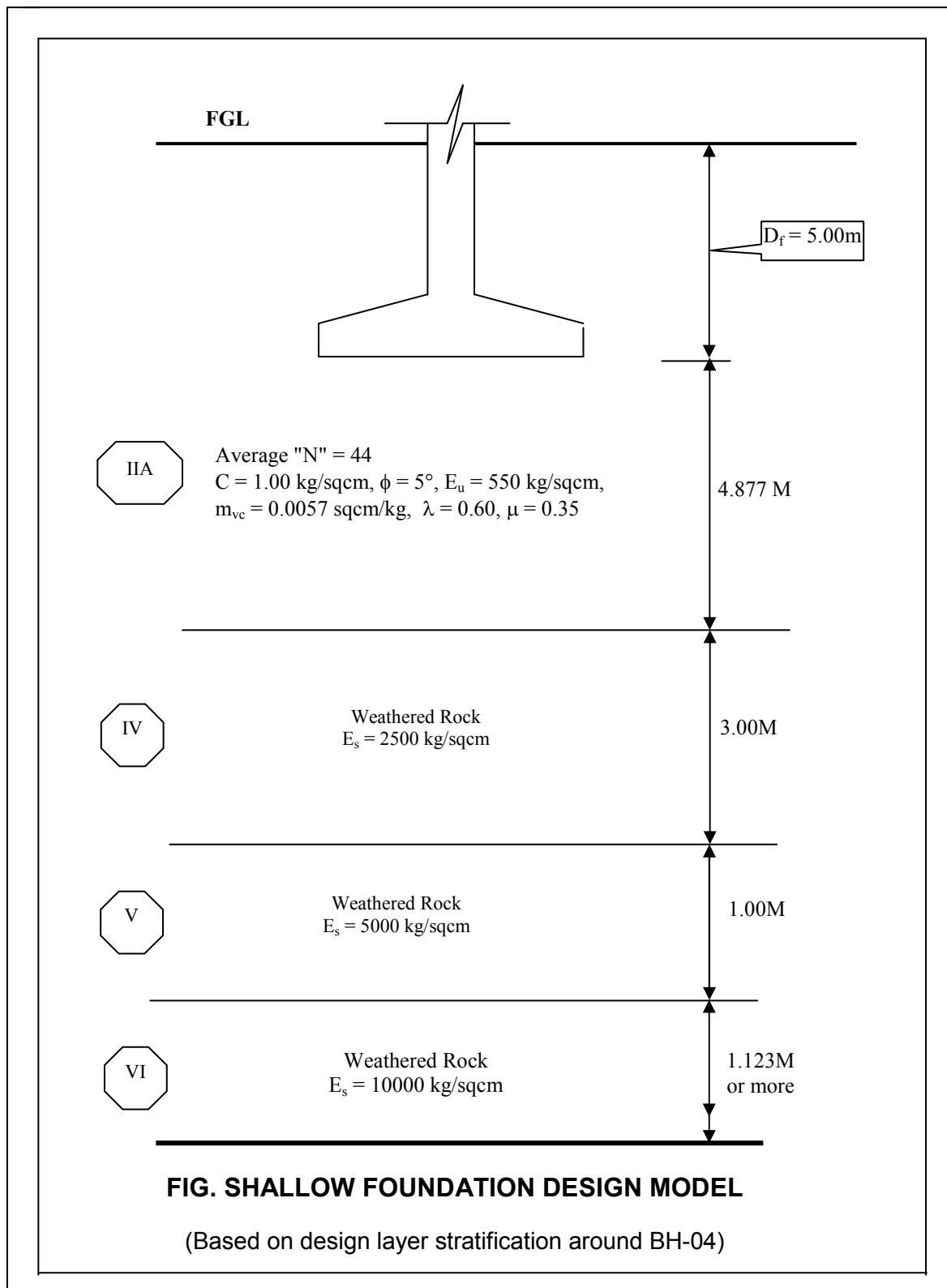


FIG. 10 SETTLEMENT COEFFICIENTS FOR CIRCULAR AND STRIP FOOTINGS

**Annexure-4****Sample Bearing Capacity Calculation Around BH-04 location:**

**Determination of Bearing Capacity:**Cohesion,  $C = 10.00$  t/sqmUsing  $\phi = 5$  degree, the bearing capacity factors are:

$$N_c = 6.49, N_q = 1.57, N_\gamma = 0.45$$

Use, Depth of Foundation =  $D_f = 5$  M (Below Finished Ground level)Width of Foundation =  $B = 3$  MLength of Foundation =  $L = 6$  MOverburden Pressure =  $q = 5.000$  (Depth)  $\times 0.90$  (Submerged density) =  $4.50$  t/sqm (Assuming the ground water table is flushing with the ground level)

The Shape factors are [ IS:6403 - 1981 ]

$$S_c = 1.10 \quad S_q = 1.10 \quad S_\gamma = 0.80$$

The Depth factors are [ IS:6403 - 1981 ]

$$D_c = 1.36 \quad D_q = 1.00 \quad D_\gamma = 1.00$$

Computed Net Ultimate Bearing Capacity =  $101.09$  t/sqm**Using a factor of safety of 2.5, Net Safe Bearing Capacity =  $40.43$  t/sqm**

The above bearing capacity should be checked against settlement criteria. This is shown below.

**Settlement Calculation:****Settlement Analysis****A) General Data:**

Width of foundation =	3.00	m
Length of foundation =	6.00	m
Depth of foundation =	5.0	m below FGL
Net Base Pressure =	3.0	kg/sqcm

**B) Subsoil Properties:****Layer - IIA**

Young's Modulus =	550	kg/sqcm
Poisson Ratio, $\mu =$	0.35	
Top of Stratum =	5.00	m
End of Stratum =	9.877	m
Geological factor, $G =$	0.60	
$m_{vc} =$	0.0057	sqcm/kg

**Layer - IV**

Young's Modulus =	2500	kg/sqcm
Poisson Ratio, $\mu =$	0.25	
Top of Stratum =	9.877	m
End of Stratum =	11.000	m
Geological factor, $G =$	1.00	
$m_{vc} =$	0.0000	sqcm/kg

**C) Calculation of Immediate Settlement:****Settlement at center**

$$M = L' / B' = 2.000$$

$$N = H / B' = 3.251$$

$$I_1 = 0.423$$

$$I_2 = 0.080$$

$$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.460$$

$$\text{Immediate settlement } S_i = 1.321 \text{ cm}$$

$$[q_0 \times B' \times (1-\mu^2) \times m \times I_s] / E_s$$

**Settlement at corner**

$$M = L' / B' = 2.00$$

$$N = H / B' = 1.626$$

$$I_1 = 0.233480$$

$$I_2 = 0.108331$$

$$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.283$$

$$\text{Immediate settlement } S_i = 0.407 \text{ cm}$$

Average  $S_i$  for Stratum IIA =  $8.64$  mmTotal immediate settlement =  $8.76$  mm**Settlement at center**

$$M = L' / B' = 1.381$$

$$N = H / B' = 0.285$$

$$I_1 = 0.015$$

$$I_2 = 0.056$$

$$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.0525$$

$$\text{Immediate settlement } S_i = 0.0195 \text{ cm}$$

$$[q_0 \times B' \times (1-\mu^2) \times m \times I_s] / E_s$$

**Settlement at corner**

$$M = L' / B' = 1.38$$

$$N = H / B' = 0.143$$

$$I_1 = 0.004$$

$$I_2 = 0.032$$

$$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.0251$$

$$\text{Immediate settlement } S_i = 0.0047 \text{ cm}$$

Average  $S_i$  for Stratum IV =  $0.121$  mm

(for all the two layers)

**D) Calculation of Consolidation Settlement:**

Strata	From (M)	To (M)	Thickness (M)	Mid depth (M)	$\Delta P$ (kg/sqcm)	$m_{vc}$ sqcm/kg	G	$S_c$ (cm)
Layer - IIA	5.00	7.44	2.44	1.22	1.77	0.0057	0.60	1.478
	7.44	9.88	2.44	3.66	0.84	0.0057	0.60	0.700
Hence, Total Consolidation Settlement =								21.79 mm

So, Total Settlement =  $30.55$  mmFox's Depth correction Factor =  $0.70$ **Corrected total settlement =  $21.33$  mm**

The calculated settlement is well within permissible limit. So, use a net allowable bearing capacity of  $30$  t/sqm for depth of foundation of  $5.00$  m below FGL for a limiting settlement of  $25$  mm.

**Use depth of foundation = 5.00m below FGL & size of footing = 5m x 10m**

Computed Net Ultimate Bearing Capacity = 91.03 t/sqm

**Using a factor of safety of 2.5, Net Safe Bearing Capacity = 36.41 t/sqm**

The above bearing capacity should be checked against settlement criteria. This is shown below.

**SETTLEMENT CALCULATION:****Settlement Analysis****A) General Data:**

Width of foundation =	5.00	m
Length of foundation =	10.00	m
Depth of foundation =	5.0	m below FGL
Net Base Pressure =	2.4	kg/sqcm

**B) Subsoil Properties:****Layer - IIA**

Young's Modulus =	550	kg/sqcm
Poisson Ratio, $\mu$ =	0.35	
Top of Stratum =	5.00	m
End of Stratum =	9.877	m
Geological factor, G =	0.60	
$m_{vc}$ =	0.0057	sqcm/kg

**Layer - IV**

Young's Modulus =	2500	kg/sqcm
Poisson Ratio, $\mu$ =	0.25	
Top of Stratum =	9.877	m
End of Stratum =	12.877	m
Geological factor, G =	1.00	
$m_{vc}$ =	0.0000	sqcm/kg

**C) Calculation of Immediate Settlement:***Settlement at center*

$$M = L' / B' = 2.000$$

$$N = H / B' = 1.951$$

$$I_1 = 0.282$$

$$I_2 = 0.103$$

$$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.330$$

$$\text{Immediate settlement } S_i = 1.263 \text{ cm}$$

$$[q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s$$

*Settlement at corner*

$$M = L' / B' = 2.00$$

$$N = H / B' = 0.975$$

$$I_1 = 0.120567$$

$$I_2 = 0.108505$$

$$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.171$$

$$\text{Immediate settlement } S_i = 0.327 \text{ cm}$$

Average  $S_i$  for Stratum IIA: 7.95 mm*Settlement at center*

$$M = L' / B' = 1.506$$

$$N = H / B' = 0.607$$

$$I_1 = 0.060$$

$$I_2 = 0.088$$

$$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.1190$$

$$\text{Immediate settlement } S_i = 0.0720 \text{ cm}$$

$$[q_o \times B' \times (1-\mu^2) \times m \times I_s] / E_s$$

*Settlement at corner*

$$M = L' / B' = 1.51$$

$$N = H / B' = 0.304$$

$$I_1 = 0.017$$

$$I_2 = 0.059$$

$$I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.0561$$

$$\text{Immediate settlement } S_i = 0.0170 \text{ cm}$$

Average  $S_i$  for Stratum IV= 0.445 mm



Job No. : 4095

Sheet No.

**Layer - V**

Young's Modulus = 5000 kg/sqcm  
 Poisson Ratio,  $\mu$  = 0.25  
 Top of Stratum = 12.877 m  
 End of Stratum = 13.877 m  
 Geological factor, G = 1.00  
 $m_{vc}$  = 0.0000 sqcm/kg

**Layer - VI**

Young's Modulus = 10000 kg/sqcm  
 Poisson Ratio,  $\mu$  = 0.25  
 Top of Stratum = 13.877 m  
 End of Stratum = 15.00 m  
 Geological factor, G = 1.00  
 $m_{vc}$  = 0.0000 sqcm/kg

**Settlement at center**

$M = L' / B' = 1.388$   
 $N = H / B' = 0.155$   
 $I_1 = 0.005$   
 $I_2 = 0.034$   
 $I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.027$   
 Immediate settlement  $S_i = 0.007$  cm  
 $[q_o \times B \times (1 - \mu^2) \times m \times I_s] / E_s$

**Settlement at center**

$M = L' / B' = 1.360$   
 $N = H / B' = 0.162$   
 $I_1 = 0.005$   
 $I_2 = 0.035$   
 $I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.029$   
 Immediate settlement  $S_i = 0.003$  cm  
 $[q_o \times B \times (1 - \mu^2) \times m \times I_s] / E_s$

**Settlement at corner**

$M = L' / B' = 1.388$   
 $N = H / B' = 0.078$   
 $I_1 = 0.001$   
 $I_2 = 0.018$   
 $I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.013$   
 Immediate settlement  $S_i = 0.002$  cm

**Settlement at corner**

$M = L' / B' = 1.360$   
 $N = H / B' = 0.081$   
 $I_1 = 0.001$   
 $I_2 = 0.019$   
 $I_s = I_1 + \{(1-2\mu) / (1-\mu)\} I_2 = 0.014$   
 Immediate settlement  $S_i = 0.001$  cm

Average  $S_i$  for Stratum V = 0.04 mmAverage  $S_i$  for Stratum VI = 0.02 mm

Total immediate settlement = 8.46 mm (for all the four layers)

**D) Calculation of Consolidation Settlement:**

Strata	From (M)	To (M)	Thickness (M)	Mid depth (M)	$\Delta P$ (kg/sqcm)	$m_{vc}$ sqcm/kg	G	$S_c$ (cm)
Layer - IIA	5.00	7.44	2.44	1.22	1.72	0.0057	0.60	1.434
	7.44	9.88	2.44	3.66	1.01	0.0057	0.60	0.846

Hence, Total Consolidation Settlement = 22.81 mm

So, Total Settlement = 31.26 mm

Fox's Depth correction Factor = 0.79

**Corrected total settlement = 24.64 mm**

The calculated settlement is well within permissible limit. So, use a net allowable bearing capacity of 24t/sqm for a depth of foundation of 5.00m below FGL for a limiting settlement of 25mm.

**Job No: 4095**

**REPORT ON  
GEOTECHNICAL INVESTIGATION WORK FOR  
5<sup>th</sup> ALUMINA REFINERY AT DAMANJODI, ODISHA  
AND PORT FACILITIES AT VISAKHAPATNAM**

***(Port Area)***

***Clients :***

**M/s. National Aluminium Company Limited  
Nalco Bhawan, Nayapalli,  
Bhubaneswar – 751 013**

***Foundation Consultants :***

**C. E. Testing Company Pvt. Limited  
An ISO 9001, 14001& OHSAS 18001 Certified Company  
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**July – 2018  
*(Revised on 12-12-2018)***



**LIST OF CONTENTS**

<b><u>SUBJECT</u></b>	<b><u>SHEET NUMBER</u></b>
<b>1. INTRODUCTION</b>	<b>2</b>
Field Test Location Map	3
<b>2. FIELD INVESTIGATIONS</b>	
General, Boring, Sampling, Standard Penetration Tests, Measurement of Water Table, Rotary Core Drilling, Trial Pits, Electrical Resistivity Tests	<b>5</b>
<b>3. LABORATORY TESTING</b>	<b>8</b>
<b>4. SUB-SOIL CONDITIONS, STRATIFICATION &amp; PROPERTIES</b>	<b>9</b>
Sub-Soil Conditions	9
Sub-Soil Stratifications	9
Generalized Soil Profile	10
Graphical Presentation	15
<b>5. DISCUSSION</b>	<b>16</b>
Details of Structures	16
Choice of Foundation and Founding Level	16
Swelling Characteristics	20
Chemical Tests	20
Standard Proctor Compaction, CBR & Laboratory Permeability Test	21
Possibility of Subsoil Liquefaction Due To Earthquake	21
Suitability of Existing Soil For Filling and Back-filling	22
Suitability of Soil For Construction of Roads & Pavement	22
<b>6. SUMMARY &amp; RECOMMENDATIONS</b>	<b>23</b>
<b>7. GEOLOGICAL LOGGING</b>	<b>25</b>
<b>8. ELECTRICAL RESISTIVITY TESTS</b>	<b>29</b>
<b>APPENDIX</b>	<b>36</b>

# REPORT ON

## GEOTECHNICAL INVESTIGATION WORK FOR

### 5<sup>th</sup> ALUMINA REFINERY AT DAMANJODI, ODISHA

### AND PORT FACILITIES AT VISAKHAPATNAM

## 1. INTRODUCTION

**M/s. National Aluminium Company Limited** has proposed the construction of 5<sup>th</sup> Alumina Refinery at Damanjodi, Odisha and Port facilities at Visakhapatnam. For designing foundation structures coming under this project, it was necessary to conduct a detailed Geotechnical Investigation Work to obtain engineering properties of the underlying soil and **M/s. National Aluminium Company Limited**, in turn, appointed **M/s. C. E. Testing Company Pvt. Ltd., Kolkata** as their Geotechnical Consultant.

The scope of the work comprised of sinking 7 nos. bore holes in **Port Area**. The scope also includes TP (Trial Pit – 2 Nos.) and ERT (Electrical Resistivity Tests – 2 Nos.).

The boreholes of 150 mm diameter were advanced by Shell and Auger method in soil. In rock, rotary core drilling of “NX” size was adopted. The scope also included conducting Standard Penetration Tests, collecting disturbed samples at regular intervals for identification and logging purposes, collecting undisturbed tube samples at suitable intervals or at change of strata whichever is earlier and testing these in the laboratory.

Based on the above, this report presents the Bore Logs, Soil Profile, laboratory and field Test Results.

The subsoil is characterised by filled up soil at top followed by very loose / loose silty sand followed by very soft to soft / medium silty clay. Then dense to very dense silty sand with decomposed rock was observed. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes. However, around BH-04 location, medium dense silty sand & stiff to very stiff silty clay / clayey silt was observed.

Considering the nature of the subsoil as revealed from field tests and laboratory tests most suitable foundation is recommended. However, this is discussed in details later.



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

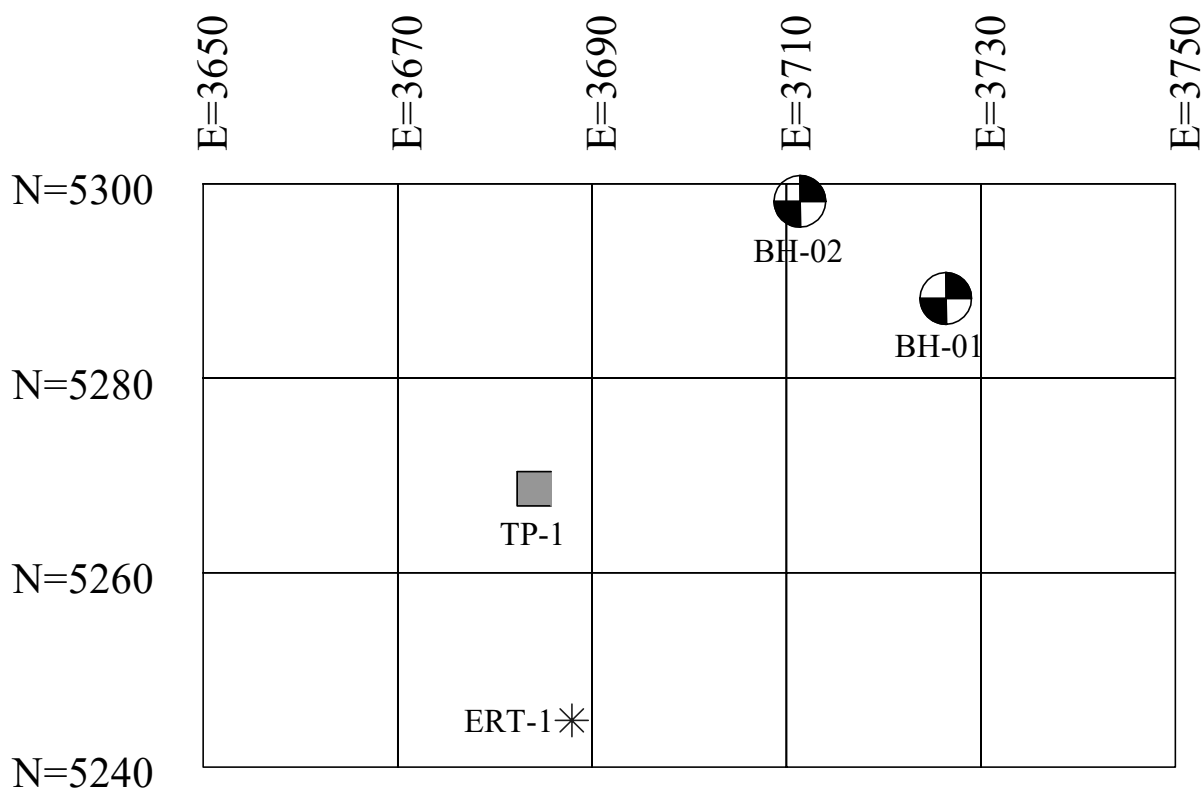
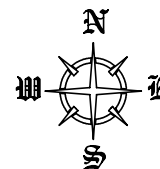
**CETEST**

Job No : 4095

Created by : T.SAHA

Created on : 03/07/2018

Sheet No:



SCALE-N.T.S.

Legend :-

BORE HOLE ( BH )	
TRIAL PITS (TP)	
ELECTRICAL RESISTIVITY TESTS (ERT)	

Bore Hole No.	Co-ordinates(M)		R.L.(M)
	Easting	Northing	
BH-1	3726.412	5288.204	98.406
BH-2	3711.408	5298.197	98.747
TP-1	3684.023	5268.553	98.626
ERT-1	3687.911	5244.801	98.402

FIG. 1.01 : BORE HOLE LOCATION MAP





Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

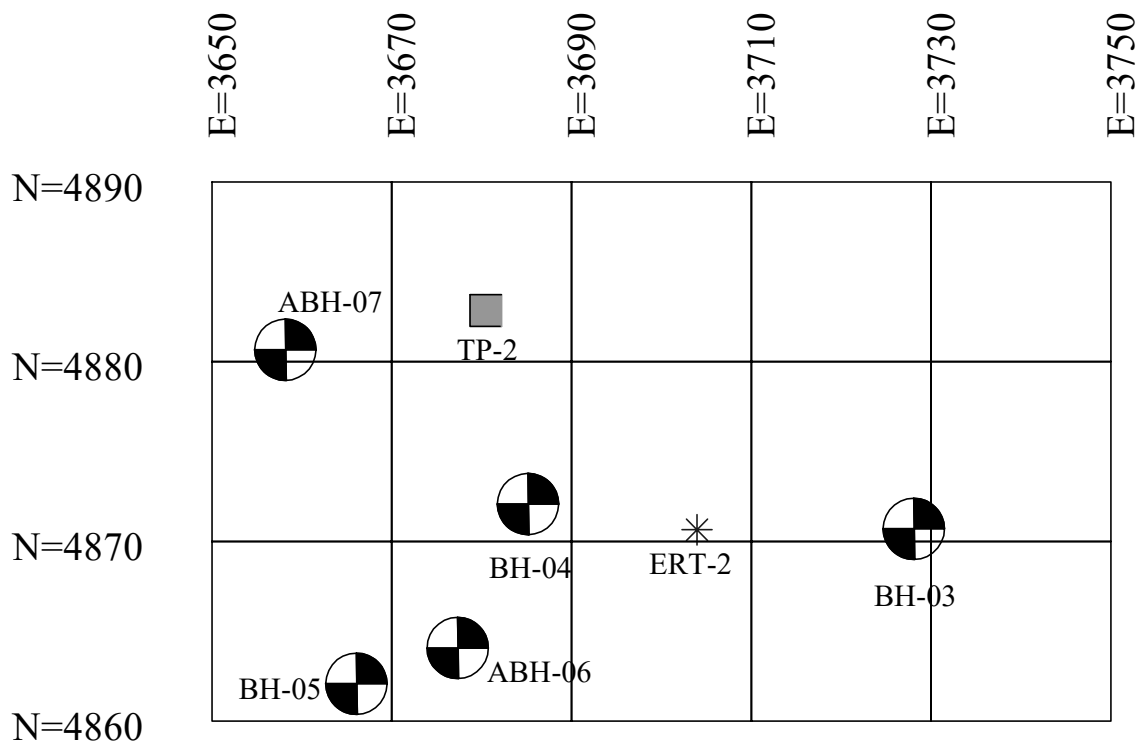
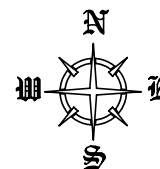
**CETEST**

Job No : 4095

Created by : T.SAHA

Created on : 03/07/2018

Sheet No:



**SCALE-N.T.S.**

**Legend :-**

BORE HOLE ( BH )	
TRIAL PITS (TP)	
ELECTRICAL RESISTIVITY TESTS (ERT)	

Bore Hole No.	Co-ordinates(M)		R.L.(M)
	Easting	Northing	
BH-3	3728.127	4871.401	98.555
BH-4	3685.208	4874.159	98.628
BH-5	3667.113	4864.169	98.973
ABH-6	3677.334	4868.150	98.828
ABH-7	3658.208	4881.319	98.681
TP-2	3680.428	4885.612	98.845
ERT-2	3703.956	4871.298	99.120

FIG. 1.02 : BORE HOLE LOCATION MAP



## 2. FIELD INVESTIGATIONS

### 2.1. GENERAL:

In an attempt for finalisation in the design of foundation for these proposed structures to be constructed at this site, Geotechnical Investigation was envisaged. The entire Investigation programme had been divided mainly into two parts, I) Field works & II) Laboratory tests.

- I) Field works unfold the sub-surface deposit types and their characteristics and
- II) Laboratory tests part would help determining the relevant physical and geotechnical properties of the sub-surface deposits leading to finalisation of foundation depths of the structures and the bearing capacity with particular reference to the sub-surface types and their strength parameters and settlement potentials at the site.

A list of the bore holes with the reduced level and standing water level are presented in a tabular form below.

Structure Name	BH No.	Co-ordinate (M)			Terminating Depth (M)	SWL (M)	Top of rock below EGL(M)
		E	N	R.L.			
Caustic Storage Tank	BH-01	3726.412	5288.204	98.406	40.00	0.50	21.00
Caustic Storage Tank	BH-02	3711.408	5298.197	98.747	40.00	0.53	20.30
Substation	BH-03	3728.127	4871.401	98.555	40.00	1.28	28.50
Alumina Storage & Handling	BH-04	3685.208	4874.159	98.628	40.00	1.20	28.50
	BH-05	3667.113	4864.169	98.973	40.00	1.39	29.10
	ABH-06	3677.334	4868.150	98.828	40.00	1.28	28.00
	ABH-07	3658.208	4881.319	98.681	40.00	1.30	28.10

### 2.2. BORING:

Boring was carried out by Shell and Auger method to sink nominal 150mm diameter bore holes to depths envisaged by using a mechanical winch. Undisturbed soil samples were collected at suitable intervals or at change of strata whichever is earlier by open drive sampling method since it was intended to ascertain the sub-soil characteristics.

### 2.3. SAMPLING:

Nominal 100 mm diameter undisturbed samples were recovered. The sampling equipment used consists of a two-tier assembly of sample tubes 450 mm in length fitted at its lower end. The sampling assembly was driven by means of a jarring link to its full length or as far downs as was found practicable. As the soil is very stiff to hard and contains sand mixtures / calcareous nodules, cutting shoe was used with a area ratio < 20%. After withdrawal the

calcareous nodules, cutting shoe was used with a area ratio < 20%. After withdrawal the ends of the tubes were sealed with wax and capped before onward transmission to the laboratory. At close intervals in depth disturbed samples were collected for identification and logging purpose. These were tagged and packed in polythene packets and transported to the laboratory.

#### **2.4. STANDARD PENETRATION TESTS:**

Standard Penetration Tests were conducted in the bore holes at intervals of 1.5M to 3.0M depth or at change of strata whichever is earlier using a split spoon sampler. The split spoon sampler used is of a Standard design having an outer diameter of 50.8 mm and inner diameter of 35 mm, driven with a monkey weighing 63.5 kgs, falling freely through 75cms. A record of the number of blows required to penetrate every 15cms to a maximum depth of 45cms was made. The first 15cm of drive are considered to be seating drive and are neglected. The total blows required for second & third 15cm of penetration is counted and termed as penetration resistance "N". On completion of a test, the split spoon sampler was opened and soil specimens were preserved in polythene bags for logging purpose.

All the boreholes were sunk with winch. However, raising of hammer for SP Tests were done manually. Hence there will not be any inertia loss and the efficiency of hammer blows should be considered as 100%.

#### **2.5. MEASUREMENT OF WATER TABLE:**

Standing water level after 24 hours of removal of casing was also noted and shown in the profile.

#### **2.6. ROTARY CORE DRILLING:**

This drilling technique is regarded as the most satisfactory method of assessing the character of rock formations, which lie at depth below the ground surface. Specimens of rock in the form of cylindrical cores are recovered from the drill holes by means of a core barrel. Double barrel technique is adopted according to field condition. The core barrel is provided at its lower end with a detachable shoe or core bit, which is of diamond. All rotary core bits were of NX (73mm) size.

**2.7. TRIAL PITS:**

2 nos. Trial Pits were excavated for physical verification of subsoil with depth. The co-ordinates of the Trial Pit locations are presented below.

Trial Pit No.	Co-ordinate (M)			Depth (M)	Standing Water Level(M)
	Easting	Northing	R.L.		
TP – 1	3684.023	5268.553	98.626	3.50	1.50
TP – 2	3680.428	4885.612	98.845	3.20	1.80

**2.8. ELECTRICAL RESISTIVITY TESTS:**

Two (2) nos. Electrical Resistivity Tests were carried out at the following locations. The test procedure and results are presented under Section-8.

ERT	Co-ordinate (M)		R.L. (M)
	E	N	
ERT-1	3687.911	5244.801	98.402
ERT-2	3703.956	4871.298	99.120

### 3. LABORATORY TESTING

For proper identification and classification of the sub-soil deposits and for deriving adequate information regarding its relevant physical and geotechnical properties at the site under investigation, the following laboratory tests were conducted on the soil / rock samples collected from the exploratory bore holes:

#### On Soil Samples:

1. Grain size analysis (Sieve as well as Hydrometer).
2. Determination of Liquid Limit, Plastic Limit and Shrinkage Limit.
3. Determination of Natural Moisture Content.
4. Determination of Specific Gravity.
5. Determination of Bulk & Dry Unit Weight.
6. Strength determination by Triaxial Unconsolidated Undrained Test (UU).
7. Strength Determination of Unconfined Compression Test on "UDS" (UNCONFD).
8. Strength Determination of Unconfined Compression Test on REMOULDED samples.
9. Strength determination by Direct Shear Test (CU).
10. One-dimensional Consolidation Test for determining settlement potentiality.
11. Standard Proctor Compaction Test to determine OMC & MDD.
12. Determination of California Bearing Ratio (4 days soaked) compacted at 95% of MDD.
13. Determination of Permeability on samples compacted at MDD.
14. Determination of Free Swelling Index & Swelling Pressure.
15. Chemical tests on soil samples to determine pH value, Sulphate, Chloride & organic matter content etc.

#### On Rock Samples:

1. Determination of Bulk Density, Water Content, Specific Gravity & Porosity of Rock.
2. Determination of Unconfined Compressive Strength of Rock samples (Saturated & Dry State)
3. Determination of Point Load Strength Index.

Laboratory test results are presented in a tabular form in the Appendix. The results are self explanatory excepting that of consolidation tests. The compressibility for a pressure range has been separated into 2 components through the compression ratio. As a first step dial gauge reading is plotted against square root of time and by extrapolation dial reading at zero time, is obtained. The compression ratio is given as

$$r = (d_i - d_s) / (d_i - d_f), \text{ where}$$

$d_i$  = Initial reading of dial before load application

$d_s$  = Dial reading corresponding to theoretical zero time

$d_f$  = Final dial reading after 24 hrs.

Now we write  $m_{vc} = (1 - r) \times m_v$

All the tests were conducted as per relevant Indian Standard Specifications.



## 4. SUBSOIL CONDITION, STRATIFICATION AND PROPERTIES

### 4.1. SUB-SOIL CONDITIONS:

The boring records showing the various soils met with are enclosed in the Appendix. These are prepared from field logs after proper modifications in the light of the laboratory test results and observation of disturbed and penetrometer soil samples. The results of the Standard Penetration Tests are given as 'N' values in these boring records. The sub-soil profiles (as obtained from field and Laboratory test results) across the bore holes are shown under Figs. 2.01 to 2.03 giving description, consistency and colour of each strata. The "N" values are shown in the profiles as well as presented in the borelogs in the Appendix. The laboratory test results and the back up sheets are also presented there.

### 4.2. SUB-SOIL STRATIFICATIONS:

The subsoil is characterised by filled up soil at top followed by very loose / loose silty sand followed by very soft to soft / medium silty clay. Then dense to very dense silty sand with decomposed rock was observed. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes. However, around BH-04 location, medium dense silty sand & stiff to very stiff silty clay / clayey silt was observed. The description of each layer is presented below.

#### 4.2.1. FILL:

Filled up soil consists of reddish brown / blackish grey silty clay / clayey silt / silty sand with kankar, moorum, concrete pieces, coal dust, stoner, rock pieces etc. The average properties of this layer are presented below, however these properties do not truly represents the properties of whole stratum.

#### GRAIN SIZE

Gravel %	14
Sand %	58
(Silt + Clay) %	28

#### 4.2.2. STRATUM - I:

The soil in this layer consists of very soft to soft / medium, deep grey / steel grey silty clay / clayey silt with sand mixture & organic matter. Conch pieces, calcareous nodules have also been observed in this layer. The average properties of this layer are presented below.

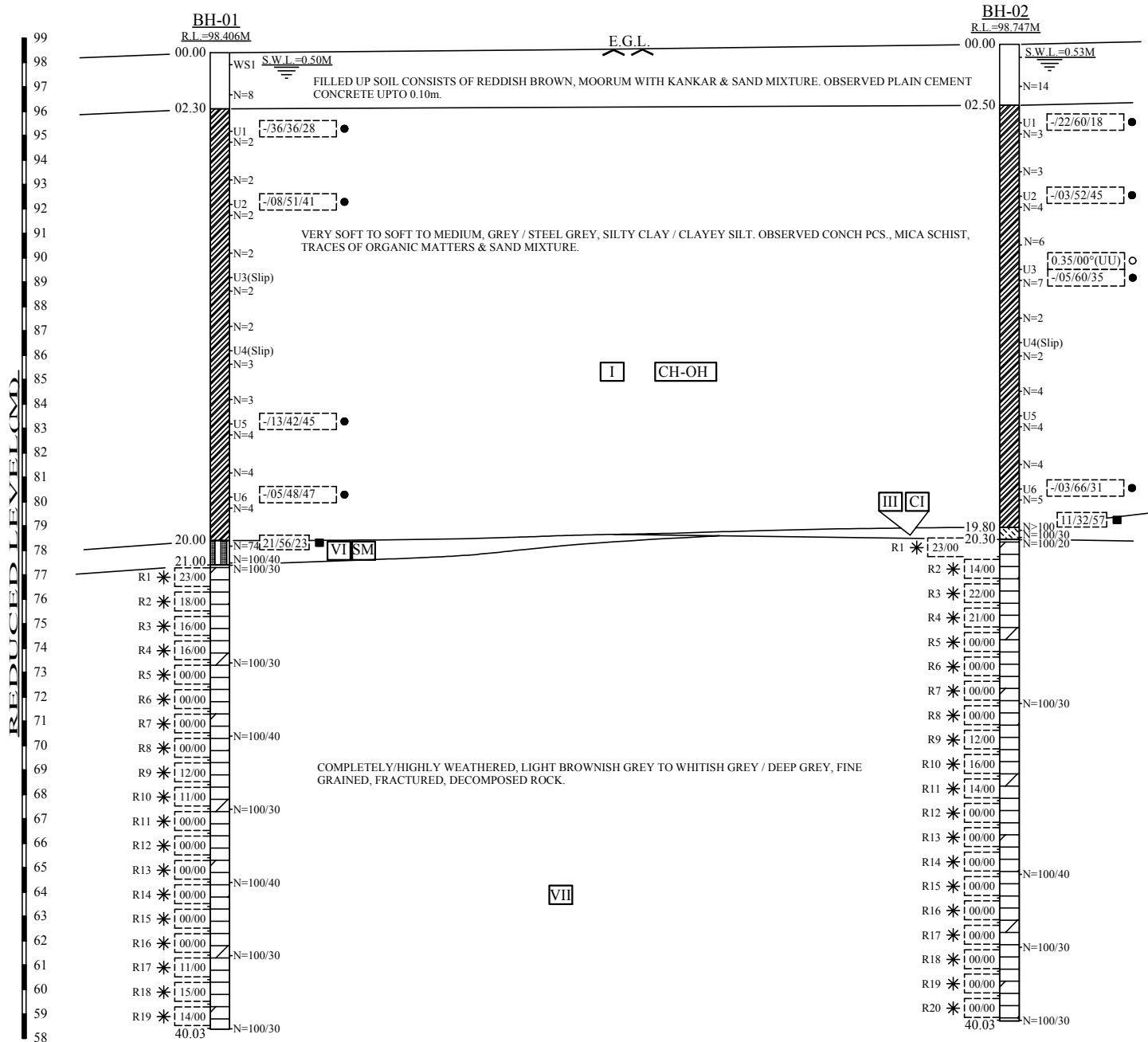


FIG. 2.1 : GENERALISED SOIL PROFILE  
(CAUSTIC TANK)



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CETEST

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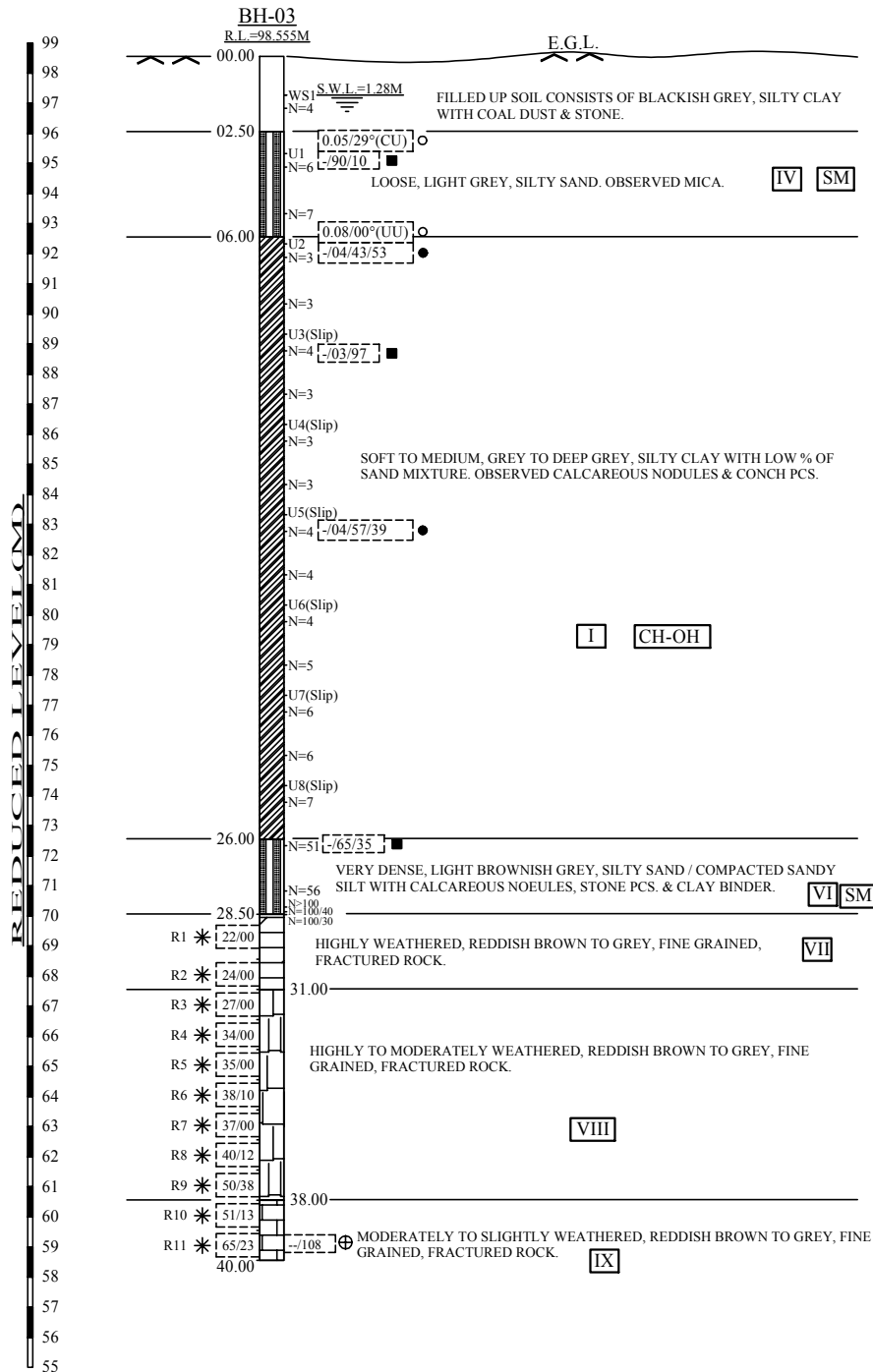


FIG. 2.2 : SUB-SOIL PROFILE

(Sub Station)

U means UDS  
N means 'N' value  
WS means Water Sample  
P means Point Load Strength Index (kg/sqcm)  
N=X/Y means X blows required for Ymm penetration  
\* CR/RQD %  
○ C(kg/sqcm) / Ø(°) values  
● Gravel/Sand/Silt/Clay %  
■ Gravel/Sand/(Silt+Clay) %  
⊕ Dry / Saturated unconfined compressive strength of rock (Kg/sqcm)

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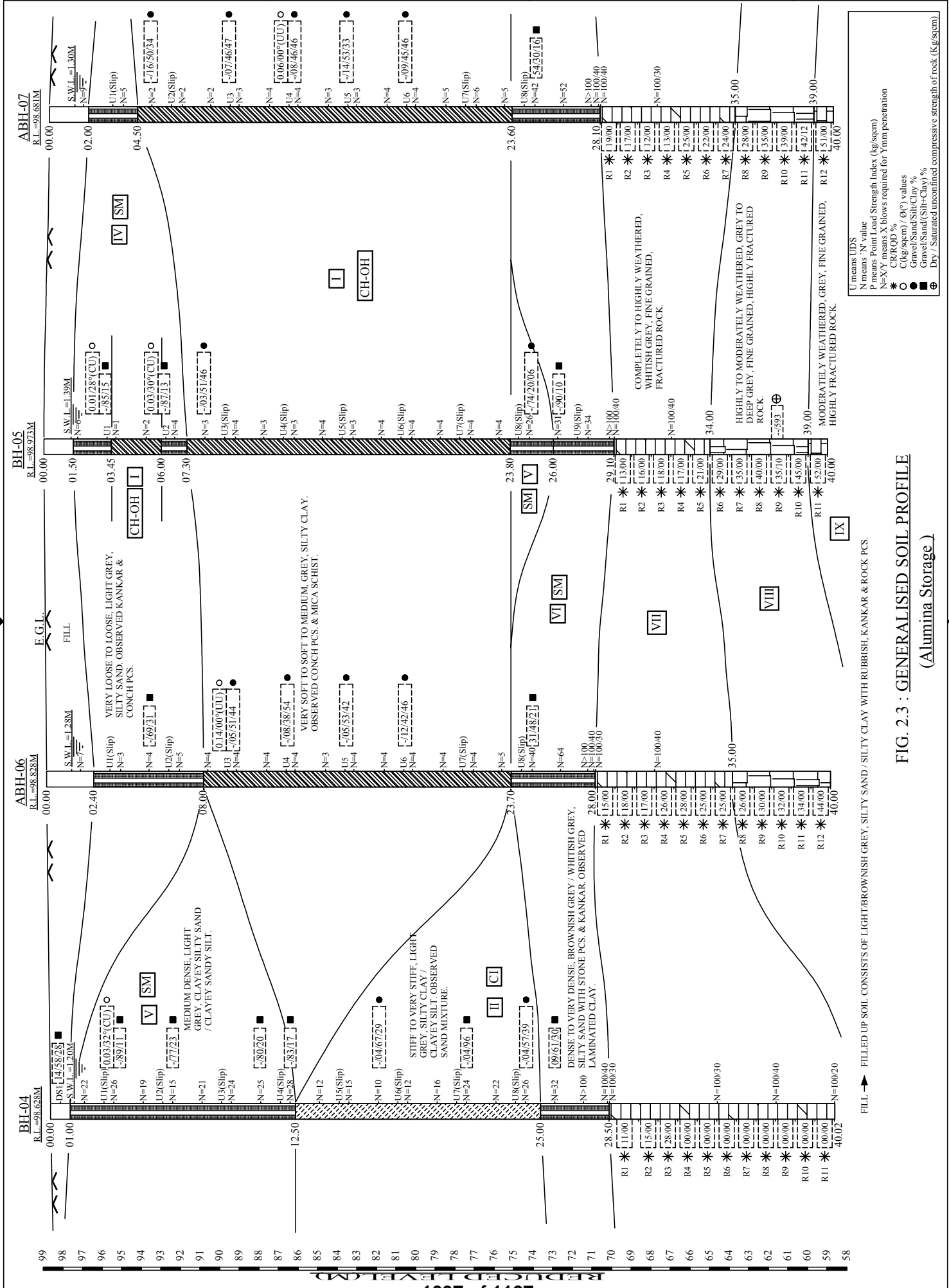


FIG. 2.3 : GENERALISED SOIL PROFILE  
(Alumina Storage)

Bulk Density, gms/cc	1.56	Specific gravity	2.49
Dry Density, gms/cc	0.95	Void Ratio	1.970
Natural Water Content %	65	Liquid limit %	65
<b>TRSH-UU:</b>		Plastic Limit %	26
Cohesion kg/sqcm	0.16	Shrinkage Limit %	13
Friction angle °	0°	<b>GRAIN SIZE</b>	
Unconfined cohesion, kg/sqcm	0.12	Sand %	09
Remoulded cohesion, kg/sqcm	0.08	Silt %	52
<b>SENSITIVITY, S<sub>t</sub></b>	1.52	Clay %	41

**4.2.3. STRATUM - II:**

This layer is present only around BH-04 location and the soil in this layer consists of stiff to very stiff, light grey silty clay / clayey silt with sand mixture. The average properties of this layer are presented below.

Specific gravity	2.62	<b>GRAIN SIZE</b>	
Liquid limit %	42	Sand %	04
Plastic Limit %	21	Silt %	62
Shrinkage Limit %	12	Clay %	34

**4.2.4. STRATUM - III:**

This layer is present only around BH-02 location and the soil in this layer consists of hard, light brownish grey clayey silt with sand mixture. The properties of this layer are presented below.

Liquid limit %	40
Plastic Limit %	22
<b>GRAIN SIZE</b>	
Gravel %	11
Sand %	32
(Silt + Clay) %	57

**4.2.5. STRATUM - IV:**

The soil in this layer consists of very loose to loose light grey silty sand with clay binder, kankar & conch pieces. The average properties of this layer are presented below.

Bulk Density, gms/cc	1.64	Natural Water Content %	18
Dry Density, gms/cc	1.38		
<b>DRSH-CQ:</b>		<b>GRAIN SIZE</b>	
Cohesion kg/sqcm	0.03	Sand %	83
Friction angle °	29°	(Silt + Clay) %	17

**4.2.6. STRATUM - V:**

This layer is present only around BH-04 & 05 locations and the soil in this layer consists of medium dense, reddish brown / light grey, clayey silty sand with kankar. The average

properties of this layer are presented below.

Bulk Density, gms/cc	1.75	Specific gravity	2.67
Dry Density, gms/cc	1.50	Natural Water Content %	17
<b>DRSH-CQ:</b>		<b>GRAIN SIZE</b>	
Cohesion kg/sqcm	0.03	Sand %	81
Friction angle °	32°	(Silt + Clay) %	19

#### 4.2.7. STRATUM - VI:

The soil in this layer consists of dense to very dense, brownish grey / whitish grey, silty sand with clay binder, kankar, moorum, stone pieces etc. The average properties of this layer are presented below.

##### GRAIN SIZE

Gravel %	19
Sand %	58
(Silt + Clay) %	23

#### 4.2.8. STRATUM - VII:

This is rock layer and consists of completely to highly weathered, whitish grey / reddish brown, fine grained, decomposed / highly fractured rock. Core recovery of this layer ranges from 0% to 25% with nil RQD.

Only one type of test was carried out on the rock samples viz.

##### 1. Determination of Point Load Strength Index.

The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.578
Dry Density, gms/cc	2.543
Water Content %	1.347
Specific Gravity	2.684
Porosity %	5.247
Point Load Strength Index, kg/sqcm	25.53

#### 4.2.9. STRATUM - VIII:

This is also rock layer and consists of highly to moderately weathered, reddish brown to grey, fine grained, highly fractured rock. Core recovery of this layer ranges from 26% to 50% and RQD varies from 0% to 38%.

The following tests were carried out on the rock samples viz.

1. Unconfined Compressive Strength determination of the rock samples after 24 hours full submergence and thereafter air drying before testing (i.e. saturated condition).

## 2. Determination of Point Load Strength Index.

The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.702
Dry Density, gms/cc	2.675
Water Content %	1.024
Specific Gravity	2.834
Porosity %	5.112
UCS (saturated), kg/sqcm	593
Point Load Strength Index, kg/sqcm	60.82

**4.2.10. STRATUM - IX:**

This is rock layer and consists of moderately to slightly weathered, reddish brown to grey, fine grained, highly fractured rock. Core recovery of this layer ranges from 51% to 65% and RQD varies from 0% to 23%. The average properties of this layer as revealed from the routine laboratory test are as follows.

Bulk Density, gms/cc	2.853
Dry Density, gms/cc	2.832
Water Content %	0.738
Specific Gravity	2.908
Porosity %	2.569
UCS (saturated), kg/sqcm	108
Point Load Strength Index, kg/sqcm	52.36

**4.3. GRAPHICAL PRESENTATION:**

The detailed Laboratory Test Results in tabular form are given in the Appendix. The back up sheets are also presented there as given in below:

1. *Strength envelopes from Triaxial Tests.*
2. *Normal Stress vs. Shear Stress from Direct Shear Tests.*
3. *Standard Proctor Compaction Curves.*
4. *CBR Curves.*
5. *e-log p curves from consolidation tests.*
6. *Grain size distribution curves for sieve and hydrometer tests.*

The consolidation test results are analysed by numerical methods and only the final output in a tabular form is given. The  $m_{vc}$  indicates the time dependent component of  $m_v$  and  $c_v$  is the co-efficient of consolidation.

## 5. DISCUSSION

### 5.1. DETAILS OF STRUCTURES:

The subsoil quality, thickness of each layer varies widely within the zone of investigation. Again, the type of structures to be constructed is different with different requirement. Considering all these aspect, the entire area is subdivided in to the following.

Sl. No.	Structure Name	Bore Hole Points	Reference Figure No.
1	Caustic Storage Tank	BH-01 & 02	2.01
2	Sub Station	BH-03	2.02
3	Alumina Storage & Handling	BH-04, 05, 06 & 07	2.03

### 5.2. CHOICE OF FOUNDATION AND FOUNDING LEVEL:

Due to presence of very soft to soft silty clay layer upto about 23.00m or more, deep foundation in form of pile is proposed. Bored cast in-situ piles are preferred due to typical geological formation, availability of construction agencies, ease of construction and less noise pollution. The determination of pile capacity is given below.

At first, the design strength parameters are determined. Thereafter, the pile capacity values are calculated. While determining the pile capacity, the following considerations are made.

- Cut off = 2.50 m
- Diameter of pile used = 450, 500 and 750mm
- Assumed Grade of Concrete = M30

#### 5.2.1. DESIGN PARAMETERS

##### Around BH-03, 04, 05, ABH-06 & ABH-07 locations:

Pile capacity is calculated using layer stratification of BH-03 location as this is worst case.

##### Layer – IV:

Average Corrected N = 6

Use C = 0.00 kg/sqcm,  $\Phi = 28^\circ$  &  $K_0 = 1.00$

##### Layer – I:

Average N in this layer = 4, corresponding cohesion from N value = 0.38 kg/sqcm

From laboratory TRSH-UU test results, average C = 0.16 kg/sqcm &  $\Phi = 0^\circ$

Thus average C = 0.27 kg/sqcm &  $\Phi = 0^\circ$

Use C = 0.25 kg/sqcm,  $\Phi = 0^\circ$  & Use Adhesion factor,  $\alpha = 1.00$



**Layer – VI:**

Average Corrected N = 30

The average fine content of the stratum-VI is 23%

So, as per Meyerhof, granular soil with fine content more than 5%,

$$\phi = 25 + 0.15D_r = 25 + 0.15 \times 65 \quad (D_r = 65\% \text{ for corrected "N" } = 23) \approx 35^\circ$$

For bored cast-in-situ piles the soil gets loosened during boring.

Poulos (1980) suggested that  $\Phi = \Phi_1 - 3 = 35 - 3 = 32^\circ$

Use  $C = 0 \text{ kg/sqcm}$  &  $\Phi = 32^\circ$ ,  $K_0 = 1.10$  (as this is bored pile)

**5.2.2. DETERMINATION OF VERTICAL CAPACITY:**

Based on the above, pile capacity has been calculated for different depth and diameter of pile and the recommended pile capacity values are given below. A typical pile capacity calculation is enclosed at the end of the report. (Use cut-off = 2.50m, M30 grade of concrete)

Foundation Location	Pile founding depth below EGL (M)	Pile Diameter (mm)	Recommended Vertical Pile Capacity (T)
BH-01 & 02	28	450	40
		500	50
		750	110
		1000	210
BH-03, 04, 05, ABH-06 & 07	28	450	40
		500	45
		750	90
		1000	160
	32	450	50
		500	65
		750	140
		1000	260

**5.2.3. DETERMINATION OF UPLIFT CAPACITY:**

Safe Uplift Capacity of Pile =  $1/3^{\text{rd}}$  of Shaft Resistance in Vertical Capacity + Self weight of pile (Buoyant)

With reference to the above, the following uplift capacity values are recommended.

Foundation Location	Bottom depth of pile below EGL (M)	Pile Diameter (mm)	Recommended Uplift Pile Capacity (T)
BH-01 & 02	28	450	26
		500	30
		750	48
		1000	72

Foundation Location	Bottom depth of pile below EGL (M)	Pile Diameter (mm)	Recommended Uplift Pile Capacity (T)
BH-03, 04, 05, ABH-06 & 07	28	450	30
		500	34
		750	55
		1000	78
	32	450	36
		500	42
		750	72
		1000	110

**5.2.4. DETERMINATION OF LATERAL CAPACITY:****Around BH-03, 04, 05, ABH-06 & ABH-07 locations**

Use design corrected  $N = 4$  for calculating lateral pile capacity

Refer to IS : 2911 (Part I/Sec 2) - 2010, Appendix - C

Modulus of Subgrade Reaction,  $\eta_h = 0.02$  kg/cucm corresponding to "N" value = 4  
[Assuming Submerged Sand]

$$T = [EI/\eta_h]^{1/5}$$

$$\text{Now, } I = 1.55 \times 10^6 \text{ cm}^4 \text{ [for 750mm dia pile]}$$

$$E = 5000 \times (f_{ck})^{0.5} = 5000 \times (30)^{0.5} = 27386 \text{ N/sqmm} = 2.74 \times 10^5 \text{ kg/sqcm}$$

$$\text{Hence, } T = 452.69 \text{ cm}$$

From Graph (Fig.4),  $L_f = 2.18 \times T = 986.87 \text{ cm}$  [Assuming Fixed Head Piles in Sands]

Pile Head deflection,  $Y = H \times L_f^3 / 12EI = 1.8830\text{mm}$  for 1T load

So, for 5mm horizontal deflection at scour/cut-off level horizontal force at pile head,  $H = 2.66T$ , say  $2.50T$

$$\text{Now, Moment} = [H \times L_f/2] = [1 \times 9.87/2] = 4.93\text{t-m per T of thrust}$$

The Reduction Factor for computation of Maximum Moment in Pile,  $m = 0.82$

So, the corrected actual moment,  $M = 4.93 \times 0.82 = 4.05\text{t-m per T of thrust}$

Similarly, for 450mm, 500mm & 1000mm dia pile  $H = 1.10T$ ,  $1.35T$  &  $4.21T$  respectively and corresponding corrected actual moment,  $M = 2.69 \text{ t-m / t}$ ,  $2.93 \text{ t-m / t}$  &  $2.93 \text{ t-m / t}$  of lateral thrust respectively

Similarly, lateral pile capacities for other boreholes are calculated separately and presented below.

**5.2.5. RECOMMENDATION:**

Foundation Location	Bottom depth of pile below EGL (M)	Pile Dia. (mm)	Recommended Pile Capacity				
			Vertical (T)	Uplift (T)	Lateral (T)	Moment (t-m per T of thrust)	Length of fixity (m)
BH-01 & 02	28	450	40	26	3.00	1.61	4.59
		500	50	30	3.50	1.78	5.10
		750	110	48	5.50	2.68	7.65
		1000	210	72	7.61	3.57	10.19
BH-03, 04, 05, ABH-06 & 07	28	450	40	30	1.10	2.69	6.56
		500	45	34	1.35	2.93	7.13
		750	90	55	2.50	4.05	9.87
		1000	160	78	4.21	5.09	12.42
	32	450	50	36	1.10	2.69	6.56
		500	65	42	1.35	2.93	7.13
		750	140	72	2.50	4.05	9.87
		1000	260	110	4.21	5.09	12.42

**5.3. SWELLING CHARACTERISTICS:**

The swelling pressure and Free Swell Index tests were performed on few samples and the test results are presented in the Appendix. The average swelling pressure and free swell index are 0.19kg/sqcm & 50.27% respectively. Thus, the subsoil has low to medium swelling characteristics. So, no problem with respect to the swelling of the subsoil is anticipated.

**5.4. CHEMICAL TESTS:**

Chemical tests were performed on few soil samples for determining the pH value, Sulphate, Chloride content etc. The results are given in a tabular form below:

**CHEMICAL TEST RESULTS ON SOIL SAMPLES:**

BH/Sample No.	Depth (m)	pH value	Sulphate as SO <sub>3</sub> (%)	Chloride as Cl (%)	Organic matter (%)
BH01 / UDS01	3.00	7.00	0.200	0.690	0.811
BH02 / UDS02	6.00	7.54	0.600	1.550	2.095
BH04 / SPT03	4.50	6.98	0.200	0.410	0.413
BH05 / UDS01	3.00	7.05	0.050	0.136	0.631
ABH06 / UDS03	9.00	7.24	0.250	1.300	2.127
ABH07 / UDS04	12.00	7.30	0.250	1.210	2.479

It is seen that the values are within permissible limits (as per IS:456-2000) with slightly high chloride content.

So, **Ordinary Portland Cement with C<sub>3</sub>A content from 5 to 8 percent shall be desirable to be used in concrete. Alternatively, Portland slag cement conforming to IS 455 having more than 50 percent slag or a blend of ordinary Portland cement and slag may be used.**

### 5.5. STANDARD PROCTOR COMPACTION, CBR & LABORATORY PERMEABILITY TEST:

One (1) no. Standard Proctor Compaction tests were carried out. Thereafter, one CBR test (4 days soaked) was carried out on the samples prepared at 95% of MDD. Additionally, one permeability test was also conducted on samples compacted at MDD. The test results are presented below. The compaction & CBR graphs are presented in the Appendix.

SL No	Sample No	Depth (M)	Description	Standard Proctor Compaction Test		Soaked CBR Value at 95% of MDD (%)		Recommended Soaked CBR (%)	Permeability on samples compacted at MDD/OMC (cm/sec)
				OMC (%)	MDD (gm/cc)	2.50mm Penetration	5.00mm Penetration		
1	TP01/DS01	1.00	Dark grey silty clay with decomposed rock, traces of sand mixture & conch.	16.70	1.766	10.38	8.78	10	$4.44 \times 10^{-06}$

### 5.6. POSSIBILITY OF SUBSOIL LIQUEFACTION DUE TO EARTHQUAKE:

Seed et al. (1983) stated that based on both laboratory testing and field performance, the great majority of cohesive soils will not liquefy during earthquakes. Using criteria originally stated by Seed and Idriss (1982) and subsequently confirmed by Youd and Gilstrap (1999), in order for a cohesive soil to liquefy, it must meet all the following three criteria:

- The soil must have less than 15 percent of the particles, based on dry weight, that are finer than 0.005 mm (i.e., percent finer at 0.005 mm < 15 percent).
- The soil must have a liquid limit (LL) that is less than 35 (that is, LL < 35).
- The water content  $w$  of the soil must be greater than 0.9 of the liquid limit [that is,  $w > 0.9 (LL)$ ].

If the cohesive soil does not meet all three criteria, then it is generally considered to be not susceptible to liquefaction. In our present case, we have

- The average clay % fraction of layer- I & II are 41% and 34% respectively i.e. more than the critical value of 15% ----- safe
- The average Liquid Limit layer- I, II & III are 65%, 42% and 40% respectively i.e. more than the critical value of LL<35% ----- safe.

From the above discussion, it can be seen that all the three clauses (a & 2) are against the possibility of liquefaction of the subsoil.

At lower reaches, we have dense to very dense silty sand layer. Liquefaction of this layer is also not expected.

However around some borehole locations very loose to loose / medium dense sand layer appears. So, the subsoil may have some possibility to liquefy under earthquake.

The liquefaction potential of subsoil is evaluated as per provision laid down in "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF

*Workshops on Evaluation of Liquefaction Resistance of Soils*” by Dr. Gonzalo Castro et al. published in “*Journal of Geotechnical and Geoenvironmental Engineering*”, October’ 2001.

The ratio of  $CRR/CSR \leq 1.0$  indicates that the soil is prone to liquefaction whereas  $CRR/CSR > 1.0$  or corrected  $N_1 > 30$  indicates the soil is non liquefiable.

Based on the SPT values in boreholes, the liquefaction resistance of all the boreholes were evaluated for zone – II as per IS:1893 Part I and presented in a separate sheet.

Bore Hole No.	Avg Depth	Field N	Total OVP (t/sqm)	Effective OVP (t/sqm)	CN	CE	CB	CS	CR	(N1)	FC	$\alpha$	$\beta$	Corr. (N1)	$r_d$	CSR	CRR <sub>7.5</sub>	FOS	
BH-03	3.68	6	5.88	2.21	1.70	1.00	1.05	1.10	0.80	9.4	10	0.87	1.02	10.5	0.97	0.17	0.12	1.224	
	5.23	7	8.36	3.14	1.70	1.00	1.05	1.10	0.85	11.7	10	0.87	1.02	12.8	0.96	0.17	0.14	1.461	
BH-04	1.73	22	2.87	1.14	1.70	1.00	1.05	1.10	0.75	32.4	11	1.21	1.03	34.5	Non-Liquefiable				
	3.23	26	5.49	2.27	1.70	1.00	1.05	1.10	0.80	40.8	11	1.21	1.03	43.1					
	4.73	19	8.12	3.39	1.70	1.00	1.05	1.10	0.85	31.7	11	1.21	1.03	33.8					
	6.23	15	10.74	4.52	1.49	1.00	1.05	1.10	0.95	24.5	23	4.06	1.10	31.0					
BH-05	1.73	6	3.56	1.34	1.70	1.00	1.05	1.10	0.75	8.8	15	2.50	1.05	11.8	0.99	0.17	0.13	1.324	
	3.45 - 6.00						Non-Liquefiable Clay Layer												
	6.68	4	10.58	3.90	1.6	1.00	1.05	1.10	0.95	7.0	13	1.89	1.04	9.2	0.95	0.17	0.11	1.112	
ABH-06	3.78	3	6.04	2.27	1.70	1.00	1.05	1.10	0.80	4.7	17	3.01	1.06	8.0	0.97	0.17	0.10	1.001	
	5.23	4	8.36	3.14	1.70	1.00	1.05	1.10	0.85	6.7	17	3.01	1.06	10.1	0.96	0.17	0.11	1.200	
	6.78	5	10.84	4.07	1.57	1.00	1.05	1.10	0.95	8.6	17	3.01	1.06	12.1	0.95	0.16	0.13	1.414	
ABH-07	3.78	5	6.04	2.27	1.70	1.00	1.05	1.10	0.80	7.9	17	3.01	1.06	11.3	0.97	0.17	0.13	1.304	
1) $C_N$ = Correction for Overburden pressure limited to 1.70																			
$C_N = \sqrt{\frac{P_a}{\sigma}}$ $P_a = 1$ Atmospheric pressure = 10t/sqm $\sigma$ = Vertical effective stress at the depth of SPT																			
Fine content means particles smaller than 75 micron For Fine Content $\leq 5$ , $\alpha = 0$ and $\beta = 1$ For (Fine Content) $> 5$ AND $< 35$ , $\alpha = \text{EXP}((1.76 - (190/FC))$ and $\beta = ((0.99 + (FC^{1.5}/1000))$ For Fine Content $> 35$ , $\alpha = 5$ and $\beta = 1.20$ Corrected (N1) = $\alpha + \beta \cdot (N1)$ $r_d = (1 - 0.4113 \cdot d^{0.75} + 0.04052 \cdot d + 0.001753 \cdot d^{1.5}) / (1 - 0.4177 \cdot d^{0.75} + 0.05729 \cdot d - 0.006205 \cdot d^{1.5} + 0.00121 \cdot d^2)$ $CSR = 0.65 \cdot (a_{msv}/g) \cdot (\text{Total Overburden pressure}) \cdot r_d / (\text{Effective Overburden pressure})$ $CRR_{7.5} = 1 / (34 \cdot \text{Final}(N1)_{60} + \text{Final}(N1)_{60} / 135 + 50 \cdot (10 \cdot \text{Final}(N1)_{60} + 45)^{-1} / 200$ FOS against Liquefaction = $(CRR_{7.5} / CSR) \cdot MSF$ For calculation of CSR & CRR, water level is considered at ground level.																			
2) $C_E$ = Correction for Level of energy delivered by SPT hammer = 1.00. 3) $C_B$ = Correction for Borehole Diameter = 1.05 for 150mm borehole dia. 4) $C_S$ = Correction for SPT sampler use = 1.10 for sampler without liner. 5) $C_R$ = Correction for short length of drill rod.																			
Rod length(m)		$C_R$	Rod length(m)		$C_R$														
<3		0.75	6-10		0.95														
3-4		0.80	10-30		1.00														
4-6		0.85																	
(N1) = $N \cdot C_N \cdot C_E \cdot C_B \cdot C_S \cdot C_R$																			

## 5.7. SUITABILITY OF EXISTING SOIL FOR FILLING AND BACK-FILLING:

*Recommendation for Filling At foundation locations & Backfilling Purposes:* The subsoil at the site consists of silty clay (CI) with fine sand mixtures having low to medium swelling properties. So, the soil can be used for filling and backfilling purposes with necessary compaction as required. The soil can be easily compacted and will easily attain a dry density (by standard proctor) of 1.75 gm/cc and above.

## 5.8. SUITABILITY OF SOIL FOR CONSTRUCTION OF ROADS & PAVEMENT:

The subsoil at the site consists of silty clay / clayey silt with fine sand mixtures having low to medium swelling properties. Thus the soil can be used for the construction of roads and pavement as a fill material.

Laboratory CBR Tests: From standard proctor tests, we have maximum dry density is in the order 1.76 gm/cc with OMC of 16.70%. Thus the soil may be compacted at OMC and the Bulk density in that case will be around 2.05 gm/cc. 4 days soaked CBR test was performed on remoulded soil sample (compacted at MDD). The CBR value obtained from test was 10% for soaked condition.

## 6. SUMMARY & RECOMMENDATIONS

Based on the field and laboratory tests and the foregoing discussion the following are summarised.

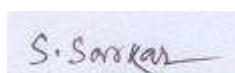
1. The subsoil is characterised by filled up soil followed by very loose / loose silty sand followed by very soft to soft / medium silty clay. Then dense to very dense silty sand clayey silty sand with decomposed rock was observed. After that weathered rock layer was struck and that continued upto the terminating depth of all boreholes. However, around BH-04 location, medium dense silty sand & stiff to very stiff silty clay / clayey silt was observed.
2. Due to presence of very soft to soft silty clay layer upto about 23.00m or more, deep foundation in form of pile is proposed.
3. **Use of Pile Foundation:**
  - a. Bored cast in-situ piles are preferred due to typical geological formation, availability of construction agencies, ease of construction and less noise pollution.
  - b. The determination and recommendation of vertical, uplift and lateral capacity for different depth and diameter of pile are given in the previous section. However, for routine design, this is further given below. (cut-off = 2.50m & grade of concrete – M30).

Foundation Location	Bottom depth of pile below EGL (M)	Pile Dia. (mm)	Recommended Pile Capacity				
			Vertical (T)	Uplift (T)	Lateral (T)	Moment (t-m per T of thrust)	Length of fixity (m)
BH-01 & 02	28	450	40	26	3.00	1.61	4.59
		500	50	30	3.50	1.78	5.10
		750	110	48	5.50	2.68	7.65
		1000	210	72	7.61	3.57	10.19
BH-03, 04, 05, ABH-06 & 07	28	450	40	30	1.10	2.69	6.56
		500	45	34	1.35	2.93	7.13
		750	90	55	2.50	4.05	9.87
		1000	160	78	4.21	5.09	12.42
	32	450	50	36	1.10	2.69	6.56
		500	65	42	1.35	2.93	7.13
		750	140	72	2.50	4.05	9.87
		1000	260	110	4.21	5.09	12.42

4. The discussion on swelling characteristics is given in Section 5.3.
5. Standard Proctor Compaction tests were carried out in the laboratory to determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). Thereafter, CBR (soaked) tests were also carried out on the samples prepared at MDD. The summarised test results and the graphs are presented in Appendix.
6. Chemical tests were carried out on few soil samples so as to detect the **pH value, Sulphate, Chloride etc.** It is seen that the values are on a safe side. So, any cement can be used for foundation concrete. **Either Ordinary Portland cement or Portland slag cement or Portland Pozzolana cement can be used for the purpose.**
7. The possibility of subsoil liquefaction due to earthquake is given in Section 5.6.
8. The suitability of existing soil for filling and back-filling is given in Section 5.7.
9. The suitability of soil for construction of roads & pavement is discussed in Section 5.8.
10. Geological Logging for the zone of investigation is presented in Section -7.
11. 2 (Two) nos. ERT were performed at the site and the test results are discussed and presented in Section - 8.

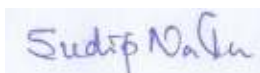
For C. E. Testing Company Private Limited,

Prepared By



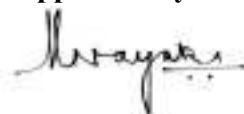
( S. SARKAR )

Checked By



( S. NATH )

Approved By



( DR. M. NAYAK )



## 7. GEOLOGICAL LOGGING

**BH No. 01**

(00.00–21.00)m : Overburden.

(21.00–40.00)m : **Rock Description:** Completely weathered, decomposed and disintegrated, brownish grey, fine to medium grained rock fragments, with remnants of highly weathered, brownish grey, medium grained **Gneiss** at 21.00-31.00m, 37.00-40.00m depth.**Structural Condition:** Very closely spaced (>15 nos./m) fractures. Dominantly randomly oriented fractures. Open fracture surfaces are non-planar, slightly smooth and very altered.**Description of Core:** Recovered core occurs as discontinuous framework. Cores are mostly in lengths of 30-100mm and <30mm.**Rock Mass Structure:** The rock mass is very poor.

Partial drill water loss has been noticed for the entire depth.

The formation rock is completely weathered and huge of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete to huge amount of core loss occurred.

**BH No. 02**

(00.00– 20.30)m : Overburden.

(20.30– 40.00)m : **Rock Description:** Completely weathered, decomposed and disintegrated, brownish grey, fine to medium grained rock fragments, with remnants of highly weathered, brownish grey, medium grained **Gneiss** at 20.30-24.00m, 29.00-31.00m depth.**Structural Condition:** Very closely spaced (>15 nos./m) fractures. Dominantly randomly oriented fractures. Open fracture surfaces are non-planar, slightly smooth and very altered.**Description of Core:** Recovered core occurs as discontinuous framework. Cores are mostly in lengths of 30-100mm and <30mm.**Rock Mass Structure:** The rock mass is very poor.

Partial drill water loss has been noticed for the entire depth.

The formation rock is completely weathered and huge of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete to huge amount of core loss occurred.

**BH No. 03**

(00.00– 28.50)m : Overburden.

(28.50– 40.00)m : **Rock Description:** Highly (up to 37.00m) to moderately weathered, brownish grey, medium to coarse grains are interlocked and indistinctly foliated, densely compacted **Gneiss**.**Rock Properties:** Hard and strong rock.**Structural Condition:** Very closely spaced (>15 nos./m) fractures. Dominantly 3 sets of fractures. Open fracture surfaces are non-planar, slightly rough and altered.**Description of Core:** Recovered core occurs as continuous framework. Cores are mostly in lengths of 30-100mm and <30mm.**Rock Mass Structure:** The rock mass is very poor quality.

Partial drill water loss has been noticed for the entire depth.  
The formation rock is highly to moderately weathered and huge amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge amount of core loss occurred.

**BH No. 04**

(00.00– 28.50)m : Overburden.

(28.50– 40.00)m : **Rock Description:** Completely weathered, decomposed and disintegrated, brownish grey, fine to medium grained rock fragments, with remnants of highly weathered, dark grey and brownish alteration, medium grained **Gneiss** at 28.50-32.00m depth.

**Structural Condition:** Very closely spaced (>15 nos./m) fractures. Dominantly randomly oriented fractures. Open fracture surfaces are non-planar, slightly smooth and very altered.

**Description of Core:** Recovered core occurs as discontinuous framework. Cores are mostly in lengths of 30-100mm and <30mm.

**Rock Mass Structure:** The rock mass is very poor.

Partial drill water loss has been noticed for the entire depth.  
The formation rock is completely weathered and huge of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result complete to huge amount of core loss occurred.

**BH No. 05**

(00.00– 29.10)m : Overburden.

(29.10– 40.00)m : **Rock Description:** Highly (up to 35.00m) to moderately weathered, brownish grey, medium to coarse grains are interlocked and indistinctly foliated, densely compacted **Gneiss**.

**Rock Properties:** Hard and strong rock.

**Structural Condition:** Very closely spaced (>15 nos./m) fractures. Dominantly 3 sets of fractures. Open fracture surfaces are non-planar, slightly rough and altered.

**Description of Core:** Recovered core occurs as discontinuous framework. Cores are mostly in lengths of 30-100mm and <30mm.

**Rock Mass Structure:** The rock mass is very poor quality.

Partial drill water loss has been noticed for the entire depth.  
The formation rock is highly to moderately weathered and huge amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge amount of core loss occurred.

**ABH No. 06**

(00.00– 28.00)m : Overburden.

(28.00– 40.00)m : **Rock Description:** Highly weathered, light grey with brownish alteration, medium to coarse grains are interlocked and indistinctly foliated, densely compacted **Gneiss**.

**Rock Properties:** Hard and strong rock.

**Structural Condition:** Very closely spaced (>15 nos./m) fractures. Dominantly 3 sets of fractures. Open fracture surfaces are non-planar, slightly rough and altered.

**Description of Core:** Recovered core occurs as discontinuous framework. Cores are mostly in lengths of 30-100mm and <30mm.

**Rock Mass Structure:** The rock mass is very poor quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly to moderately weathered and huge amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge amount of core loss occurred.

**ABH No. 07**

(00.00– 28.10)m : Overburden.

(28.10– 40.00)m : **Rock Description:** Highly (up to 39.00m) to moderately weathered, light grey to dark grey with brownish alteration, medium to coarse grains are interlocked and indistinctly foliated, densely compacted **Gneiss**.

**Rock Properties:** Hard and strong rock.

**Structural Condition:** Very closely spaced (>15 nos./m) fractures. Dominantly 3 sets of fractures. Open fracture surfaces are non-planar, slightly rough and altered.

**Description of Core:** Recovered core occurs as discontinuous (up to 39.00m) to continuous framework. Cores are mostly in lengths of 30-100mm and <30mm.

**Rock Mass Structure:** The rock mass is very poor quality.

Partial drill water loss has been noticed for the entire depth.

The formation rock is highly to moderately weathered and huge amount of the rock mass is disintegrated. During drilling the disintegrated rock particles between fracture planes have been removed by drill water. As a result huge amount of core loss occurred.

For C. E. Testing Company private Limited,

*Deybanku Acharyya*

(Mr. D. Acharyya, Geologist)

*Sukha Paramanik*

(Mr. S. Paramanik, Geologist)

## 8. ELECTRICAL RESISTIVITY TEST

## REPORT ON ELECTRICAL RESISTIVITY TEST (ERT) FOR 5<sup>th</sup> ALUMINA REFINERY AT DAMANJODI, ODISHA AND PORT FACILITIES AT VISAKHAPATNAM

### INTRODUCTION:

Electrical Resistivity Test was carried out for Stream 5 project & Port facilities at Vizag Port on 14.04.2018 using resistivity meter (model DDR3) and following Indian standard Code: IS-3043 at two (2) locations around **Vizag Port Area**.

### METHODOLOGY:

The Soil Resistivity Survey is a method to find out the Electrical Resistivity (Specific Resistance) of a medium. It is the resistance offered by a unit cube of a particular medium (so called strata below the ground level) when a unit current passes perpendicular to the surface of a cross-sectional area A. The relation is given by Ohm's Law is –

$$\rho = R \times \frac{A}{L} \quad \text{ohm} \times \frac{\text{m}^2}{\text{m}} = \text{ohm} - \text{m} \text{ where}$$

$\rho$  = Resistivity, R = resistance offered by the medium of length L and Cross-sectional area A.

In electrical resistivity survey a known current I (direct current or low frequency alternating current) is sent into the ground through a pair of current electrodes A & B and the potential difference ( $\Delta V$ ) created in the medium is measured between another pair of electrodes M & N. The resistivity of the formation is then given

$$\rho = K \frac{\Delta V}{I} \quad \text{where } \rho \text{ is the apparent resistivity, } K \text{ is the geometric factor.}$$

In the Earth Resistivity Test, the Wenner configuration was followed. In this configuration two potential electrodes M & N are placed in a line with the current electrodes A & B, all four

being situated equidistance from one to another and disposed symmetrically with respect to a central point such that  $AM=MN=NB=a$ . The outer two electrodes A & B were used for sending current (I) and inner two M & N were used for measuring the potential differences ( $\Delta V$ ). The distance between each consecutive electrode (a) was kept constant and was progressively increased to reach the depth at which resistivity information are wanted. Suitable electrode spacing determines the conductivity of the top soil as well as the various subsurface layers occurring in the area under study. At each location, 4 sets of observations were taken for each of the electrode spacing (a) in eight directions (N-S, E-W, NE-SW and NW-SE) and in eight different electrode spacing viz.:  $a = 1.0\text{m}, 2.0\text{m}, 3.0\text{m}, 5.0\text{m}, 8.0\text{m}, 10.0\text{m}, 15.0\text{m}$  and  $25.0\text{m}$  were used to know the nature of change of resistivity.

The apparent resistivity was determined by the formula –

$$\rho = 6.28 a \frac{\Delta V}{I} \text{ where 'a' is the distance between the two consecutive}$$

Electrodes and  $\frac{\Delta V}{I}$  is R which is the observed resistance for measuring resistivity.

The mean value of the resistivity estimated was taken as the representative one.

The depth of investigation in an isotropic and homogeneous formation can be approximated to the distance between the consecutive two electrodes (a).

**INTERPRETATION:**

ERT observations were taken on 02 (Two) locations distributed over the different sites as given in the work schedule of the Client and for direction of observations also followed the same work schedule.

The summarized result of the resistivity measurements along with the co-ordinates and the RL at different locations are given in the table annexed hereto.

All the ERT curves are plotted as "a" (m) vs.  $\rho$  (ohm-m) and are exhibited in the form plates annexed hereto.

It may also please be noted that in the present investigation we have measured only the apparent resistivity which may be taken as a first approximation to the weighted average of the true resistivity of the subsurface stratum in which the current lines flow.

**CONCLUSION:-**

It can be concluded that the average apparent resistivity of the soil for different ERT locations are as hereunder:-

Sl. No.	ERT Location	Overall Mean Resistivity (Ohm -m)
1.	ERT - 01	2.10
2.	ERT - 02	18.06



**APPARENT RESISTIVITY VALUES****ERT No. 01**

SI No.	S ( M )	Apparent Electrical Resistivity (Ohm-m)				Mean
		( N - S )	( E - W )	( NE - SW )	( NW - SE )	
1	1.0	3.65	4.34	3.33	4.09	3.85
2	2.0	1.86	2.51	2.01	2.77	2.29
3	3.0	0.94	1.51	0.75	1.32	1.26
4	5.0	0.94	1.26	0.63	1.26	1.02
5	8.0	1.01	1.51	1.01	1.51	1.26
6	10.0	1.26	1.26	1.26	1.26	1.26
7	15.0	0.94	1.86	1.86	1.86	1.63
8	25.0	3.14	4.71	4.71	4.71	4.32

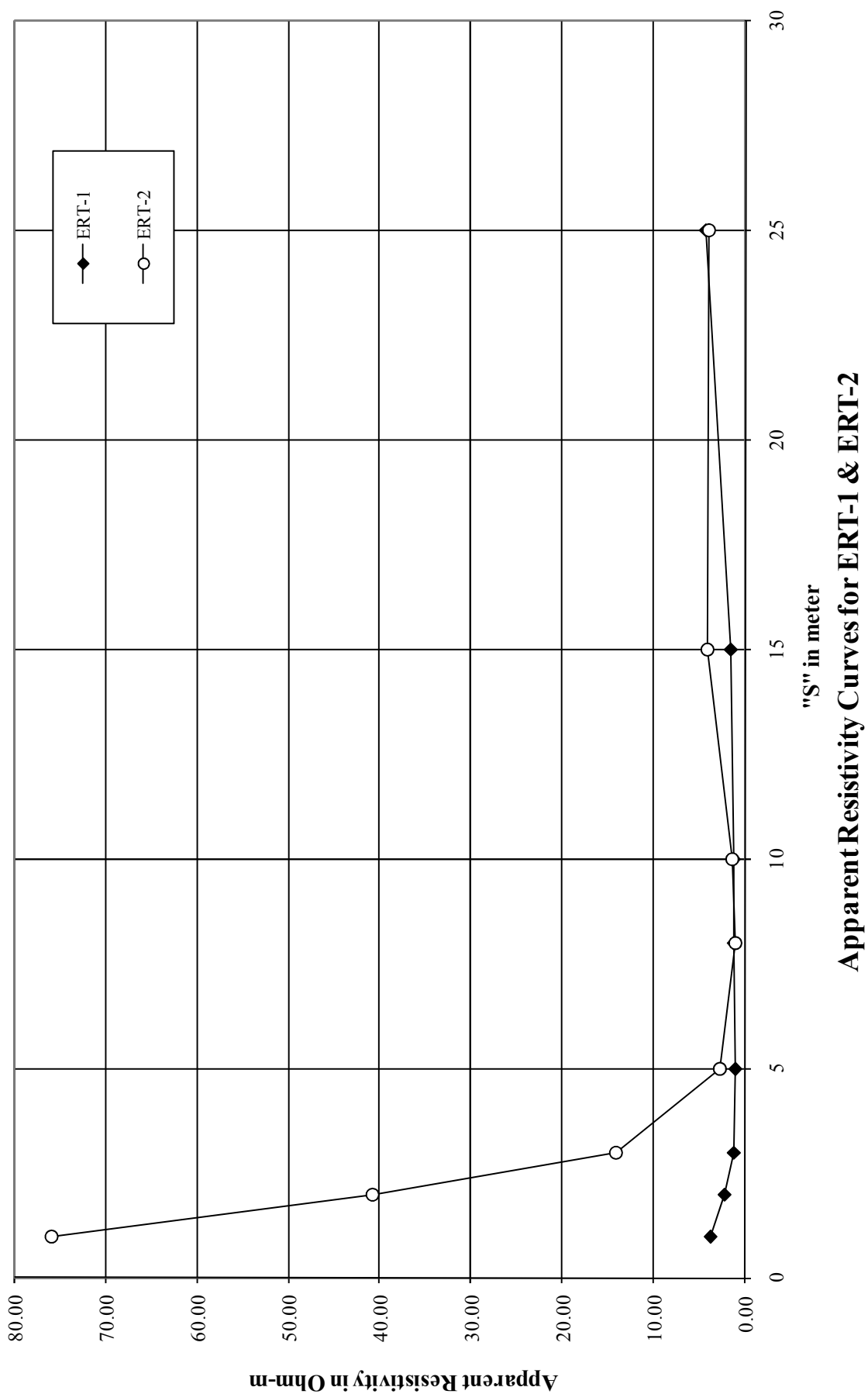
Mean Resistivity at ERT-01 is 2.10 Ohm - m.

**ERT No. 02**

SI No.	S ( M )	Apparent Electrical Resistivity (Ohm-m)				Mean
		( N - S )	( E - W )	( NE - SW )	( NW - SE )	
1	1.0	86.05	78.25	75.23	64.28	75.95
2	2.0	50.66	40.48	38.09	34.19	40.86
3	3.0	16.060	14.15	13.39	13.01	14.15
4	5.0	2.83	5.03	1.86	1.57	2.82
5	8.0	1.01	1.51	1.01	1.01	1.14
6	10.0	0.63	1.89	1.86	1.26	1.41
7	15.0	5.66	4.71	3.77	2.83	4.24
8	25.0	4.71	3.14	4.71	3.14	3.93

Mean Resistivity at ERT-02 is 18.06 Ohm - m.

## APPARENT RESISTIVITY CURVES



## APPENDICES

### SUBJECT

### SHEET NUMBER

#### **PART I: ALL FIELD TESTS RESULTS**

Bore Log Data Sheet  
Pit Log of TP & CBR  
Correction for Standard Penetration Test Values  
Corrected "n" vs. Depth plot  
Field Density Test Results

**A1**  
A2 – A15  
A16 – A17  
A18 – A20  
A21 – A22  
A23

#### **PART II: LABORATORY TEST RESULTS**

Laboratory Soil Test Results  
Laboratory Rock Test Results  
Swelling Test Results  
Summerised Compaction & CBR Test Results

**A24**  
A25 – A30  
A31 – A32  
A33  
A34

#### **PART III: CHARTS & GRAPHS**

Strength Curves  
Laboratory Compaction & CBR Curves  
e – Logp Curves  
Grain Size Distribution Curves

**A35**  
A36 – A37  
A38  
A39 – A45  
A46 – A60

#### **PART IV: SAMPLE CALCULATION**

Pile Capacity Calculation

**A61**  
A62

#### **PART V: PHOTOGRAPHS**

**A63**

**PART I: ALL FIELD TESTS RESULTS**

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.1

Co-ordinates E=3726.412  
N=5288.204

Field Test	Nos	Samples	Nos	Commencement Date : 26/04/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	6	Completion Date : 29/04/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	19	Level Of Ground : 98.406 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 0.50 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m Filled up soil consists of reddish brown, moorum with kankar & sand mixture. Observed plain cement concrete upto 0.10m.		8	6	2				DS-1/WS-1	0.50
2.30m Grey, silty clay.								DS-2	1.00
3.50m Very soft to soft, steel grey, clayey silt. Observed conch pcs. & sand mixture.		0	1	1				SPT-1	1.50-1.95
5.00m Very soft to soft, grey, silty clay.		0	1	1				DS-3	2.50
7.50m Very soft to soft, steel grey to grey, silty clay. Observed conch pcs.		0	1	1				UDS-1	3.00-3.45
		1	1	1				SPT-2	3.45-3.90
		0	1	1				DS-4	4.50
		0	1	1				SPT-3	5.00-5.45
		1	1	1				UDS-2	6.00-6.45
		0	1	1				SPT-4	6.45-6.90
		0	1	1				DS-5	7.50
		0	1	1				SPT-5	8.00-8.45
		0	1	1				*UDS-3	9.00-9.45
		1	1	2				SPT-6	9.55-10.00
		1	1	2				DS-6	10.50
		1	1	2				SPT-7	11.00-11.45
		1	1	2				*UDS-4	12.00-12.45
		1	1	2				SPT-8	12.55-13.00
		1	1	2				DS-7	13.50
		1	2	2				SPT-9	14.00-14.45
		1	2	2				UDS-5	15.00-15.45
		1	2	2				SPT-10	15.45-15.90
		1	2	2				DS-8	16.50
		1	2	2				SPT-11	17.00-17.45
		1	2	2				UDS-6	18.00-18.45
		1	2	2				SPT-12	18.45-18.90
20.00m 20.10m								DS-9	19.50

Job No : 4095

Created by : SKD

Created on : 16/05/2018








Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.1

Co-ordinates E=3726.412  
N=5288.204

Field Test	Nos	Samples	Nos	Commencement Date : 26/04/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	6	Completion Date : 29/04/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	19	Level Of Ground : 98.406 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 0.50 m.

DESCRIPTION	SYMBOL	N-VALUE				SAMPLES	
		EACH DIVN. = 15cm				Ref. No	Depth (m)
Very dense, whitish grey, sandy silt with kankar & stone pcs. 20.10m		11	26	48	74	SPT-13	20.00-20.45
		100	4.0	cm	Pentn. Refusal	*SPT-14	20.90-20.94
					Refusal	*SPT-15	21.00-21.03 21.00
		100	3.0	cm	Pentn.	R1	CR=23% RQD=Nil
Completely/highly weathered, light brownish grey, fine grained, completely fractured rock. 21.00m						R2	CR=18% RQD=Nil
						R3	CR=16% RQD=Nil
						R4	CR=16% RQD=Nil
						*SPT-16	25.00-25.03 25.00
		100	3.0	cm	Pentn.	R5	CR=Nil RQD=Nil
						DS-10	
						R6	CR=Nil RQD=Nil
Completely weathered, light brownish grey, fine grained, decomposed rock. 25.00m						DS-11	
						R7	CR=Nil RQD=Nil
						DS-12	
		100	4.0	cm	Pentn.	*SPT-17	28.00-28.04 28.00
						R8	CR=Nil RQD=Nil
						DS-13	
						R9	CR=12% RQD=Nil
						R10	CR=11% RQD=Nil
Completely weathered, whitish grey, fine grained, completely fractured rock. 29.00m						*SPT-18	31.00-31.03 31.00
		100	3.0	cm	Pentn.	R11	CR=Nil RQD=Nil
						DS-14	
						R12	CR=Nil RQD=Nil
						DS-15	
						R13	CR=Nil RQD=Nil
						DS-16	
		100	4.0	cm	Pentn.	*SPT-19	34.00-34.04 34.00
Completely weathered, light brownish grey, fine grained, decomposed rock. 32.00m						R14	CR=Nil RQD=Nil
						DS-17	
						R15	CR=Nil RQD=Nil
						DS-18	
						R16	CR=Nil RQD=Nil
						DS-19	
		100	3.0	cm	Pentn.	*SPT-20	37.00-37.03 37.00
						R17	CR=11% RQD=Nil
						R18	CR=15% RQD=Nil
						R19	CR=14% RQD=Nil
Completely weathered, light brownish grey to whitish grey, fine grained, completely fractured rock. 37.00m						*SPT-21	40.00-40.03 40.00
N.B. - '*' means sample could not be recovered. 40.00m							
		1064 of 1127	3.0	cm	Pentn.		

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.2

Co-ordinates E=3711.408  
N=5298.197

Field Test	Nos	Samples	Nos	Commencement Date : 20/04/2018
Penetrometer (SPT)	19	Undisturbed (UDS)	6	Completion Date : 25/04/2018
Cone (Pc)		Penetrometer (SPT)	19	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	23	Level Of Ground : 98.747 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 0.53 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
0.00m Filled up soil consists of reddish brown, moorum with kankar & sand mixture. Observed plain cement concrete upto 0.10m.		15	8	6				DS-1 DS-2 SPT-1	0.50 1.00 1.50-1.95
2.50m Grey, silty clay.								DS-3	2.50
3.45m		0	1	2				UDS-1 SPT-2	3.00-3.45 3.45-3.90
Soft, steel grey, silty clay. Observed conch pcs. & sand mixture. Also obs. traces of organic matter.		0	1	2				DS-4 SPT-3	4.50 5.00-5.45
8.00m		1	2	2				UDS-2 SPT-4	6.00-6.45 6.45-6.90
Medium, grey, silty clay. Observed micaschist.		2	3	3				DS-5	7.50
11.00m		2	3	4				SPT-5	8.00-8.45
Very soft to soft, steel grey, silty clay. Observed conch pcs.		2	3	4				UDS-3 SPT-6	9.00-9.45 9.45-9.90
14.00m		0	1	1				DS-6	10.50
Soft, grey, silty clay. Obs. traces of organic matter.		0	1	1				SPT-7	11.00-11.45
18.45m		1	2	2				*UDS-4 SPT-8	12.00-12.45 12.55-13.00
19.80m		1	2	2				DS-7	13.50
20.10m		2	2	3				SPT-9	14.00-14.45
		2	2	2				UDS-5 SPT-10	15.00-15.45 15.45-15.90
		2	2	2				DS-8	16.50
		2	2	3				SPT-11	17.00-17.45
		2	2	3				UDS-6	18.00-18.45
		2	2	3				SPT-12	18.45-18.90
		2	2	3				DS-9	19.50
		2	2	3				SPT-13	19.80-20.04



Job No : 4095

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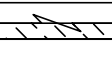
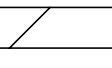
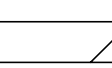
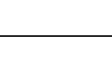
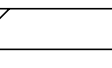
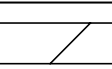
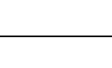
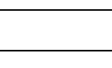
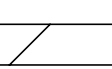
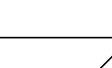
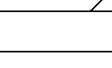
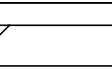
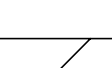
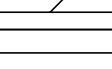
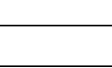

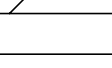

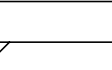
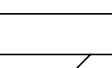
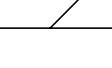
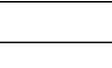
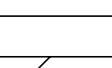
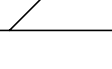
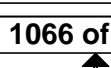
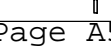
Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.2

Co-ordinates E=3711.408  
N=5298.197

Field Test	Nos	Samples	Nos	Commencement Date : 20/04/2018
Penetrometer (SPT)	19	Undisturbed (UDS)	6	Completion Date : 25/04/2018
Cone (Pc)		Penetrometer (SPT)	19	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	23	Level Of Ground : 98.747 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 0.53 m.

DESCRIPTION	SYMBOL	N-VALUE		SAMPLES	
		EACH DIVN. = 15cm		Ref. No	Depth (m)
Hard, light brownish grey, clayey silt with sand mixture & stone pcs.		100	3.0 cm Pentn. Refusal	*SPT-14	20.20-20.23
		100	Refusal	*SPT-15	20.30-20.32
		2.0 cm Pentn.		R1	CR=23%/RQD=0
		NX rotary drilling from 20.30m to 40.00m		R2	CR=14% RQD=Nil
Completely to highly weathered, light brownish grey, fine grained, highly fractured rock.				R3	CR=22% RQD=Nil
				R4	CR=21% RQD=Nil
				R5	CR=Nil RQD=Nil
				DS-10	CR=Nil RQD=Nil
				R6	CR=Nil RQD=Nil
				DS-11	CR=Nil RQD=Nil
Completely weathered, light brownish grey to deep grey, fine grained, decomposed rock.		100	Refusal	R7	CR=Nil RQD=Nil
		3.0 cm Pentn.		*SPT-16	27.00-27.03
				R8	CR=Nil RQD=Nil
				DS-13	CR=Nil RQD=Nil
				R9	CR=Nil RQD=Nil
				DS-14	CR=Nil RQD=Nil
				R10	CR=16% RQD=Nil
				R11	CR=14% RQD=Nil
				R12	CR=Nil RQD=Nil
				DS-15	CR=Nil RQD=Nil
				R13	CR=Nil RQD=Nil
				DS-16	CR=Nil RQD=Nil
				R14	CR=Nil RQD=Nil
		100	Refusal	DS-17	CR=Nil RQD=Nil
		4.0 cm Pentn.		*SPT-17	34.00-34.04
Completely weathered, deep grey, fine grained, decomposed rock.				R15/DS-18	CR=Nil
				R16	CR=Nil RQD=Nil
				DS-19	CR=Nil RQD=Nil
				R17	CR=Nil RQD=Nil
				DS-20	CR=Nil RQD=Nil
		100	Refusal	*SPT-18	37.00-37.03
		3.0 cm Pentn.		R18/DS-21	CR=Nil RQD=Nil
				R19	CR=Nil RQD=Nil
				DS-22	CR=Nil RQD=Nil
				R20	CR=Nil RQD=Nil
				DS-23	CR=Nil RQD=Nil
N.B. - '*' means sample could not be recovered.		100	Refusal	*SPT-19	40.00-40.03
		3.0 cm Pentn.			40.00

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.3

Co-ordinates E=3728.127  
N=4871.401

Field Test	Nos	Samples	Nos	Commencement Date : 13/04/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	8	Completion Date : 18/04/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 98.555 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 1.28 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m Filled up soil consists of blackish grey, silty clay with coal dust & stone.		5	2	2					4	
2.50m Loose, light grey, silty sand. Observed mica.		2	2	4					6	
		2	3	4					7	
6.00m		1	1	2					3	
		1	1	2					3	
		1	2	2					4	
		1	1	2					3	
		1	1	2					3	
		1	1	2					3	
		1	2	2					4	
		1	1	2					3	
		1	2	2					4	
		1	2	2					4	
		1	2	2					4	
20.00m 20.10m		1	2	2					4	

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.3

Co-ordinates E=3728.127  
N=4871.401

Field Test	Nos	Samples	Nos	Commencement Date : 13/04/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	8	Completion Date : 18/04/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 98.555 m.
		Water Sample (WS)	1	Water Struck At :
				Standing Water Level : 1.28 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
20.10m		2	2	3	5			SPT-13	20.00-20.45
Medium, deep grey, silty clay with low % of sand mixture. Observed calcareous nodules.					6			*UDS-7	21.00-21.45
		2	3	3				SPT-14	21.55-22.00
					6			DS-10	22.50
		3	3	3				SPT-15	23.00-23.45
					7			*UDS-8	24.00-24.45
26.00m		3	3	4				SPT-16	24.55-25.00
					51			DS-11	25.50
		7	20	31				SPT-17	26.00-26.45
Very dense, light brownish grey, silty sand with clay binder. Observed calcareous nodules.					56			DS-12	27.00
		9	22	34				SPT-18	27.50-27.95
28.20m		100	120	dm Pentn. >100				SPT-19	28.20-28.32
28.50m		100	4.0	cm Pentn. Refusal				*SPT-20	28.40-28.44
Very dense, light grey, compacted sandy silt with calcareous nodules & stone pcs.					Refusal			*SPT-21	28.50-28.53
28.50m		100							28.50
Highly weathered, reddish brown to grey, fine grained, fractured rock.					3.0	cm Pentn.		R1	CR=22% RQD=Nil
					NX rotary drilling from 28.50m to 40.00m				
								R2	CR=24% RQD=Nil
								R3	CR=27% RQD=Nil
								R4	CR=34% RQD=Nil
								R5	CR=35% RQD=Nil
								R6	CR=38% RQD=10%
								R7	CR=37% RQD=Nil
								R8	CR=40% RQD=12%
								R9	CR=50% RQD=38%
								R10	CR=51% RQD=13%
38.00m								R11	CR=65% RQD=23%
Moderately to slightly weathered, reddish brown to grey, fine grained, fractured rock.									
N.B. - '*' means sample could not be recovered.									
40.00m									

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.4

Co-ordinates E=3685.208  
N=4874.159

Field Test	Nos	Samples	Nos	Commencement Date : 28/03/2018
Penetrometer (SPT)	23	Undisturbed (UDS)	8	Completion Date : 06/04/2018
Cone (Pc)		Penetrometer (SPT)	23	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	20	Level Of Ground : 98.628 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.20 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
Filled up soil with brownish grey, silty sand with rock dust & rock pieces.									DS-1	0.50
									DS-2	1.00
		8	10	12					SPT-1	1.50-1.95
Medium dense, light grey, silty sand. Observed clayey silt with sand mixture from 4.00m.									*UDS-1	2.50-2.95
		6	12	14					SPT-2	3.00-3.45
									DS-3	4.00
		5	7	12					SPT-3	4.50-4.95
									*UDS-2	5.50-5.95
		4	5	10					SPT-4	6.00-6.45
									DS-4	7.00
Medium dense, light grey, clayey silty sand / clayey sandy silt.		6	8	13					SPT-5	7.50-7.95
									*UDS-3	8.50-8.95
		6	10	14					SPT-6	9.00-9.45
									DS-5	10.00
		4	9	16					SPT-7	10.50-10.95
									*UDS-4	11.50-11.95
		8	14	14					SPT-8	12.00-12.45
									DS-6	13.00
		3	6	6					SPT-9	13.50-13.95
									*UDS-5	14.50-14.95
		2	7	8					SPT-10	15.00-15.45
									DS-7	16.00
		2	4	6					SPT-11	16.50-16.95
									*UDS-6	17.50-17.95
		3	5	7					SPT-12	18.00-18.45
									DS-8	19.00
									SPT-13	19.50-19.95
		6	6	10						

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.4

Co-ordinates E=3685.208  
N=4874.159

Field Test	Nos	Samples	Nos	Commencement Date : 28/03/2018
Penetrometer (SPT)	23	Undisturbed (UDS)	8	Completion Date : 06/04/2018
Cone (Pc)		Penetrometer (SPT)	23	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	20	Level Of Ground : 98.628 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.20 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
20.10m								
Stiff to very stiff, light grey, silty clay / clayey silt. Observed sand mixture.		8	10	14			*UDS-7	20.50-20.95
					24		SPT-14	21.00-21.45
		7	10	12			DS-9	22.00
					22		SPT-15	22.50-22.95
25.00m		8	12	14			*UDS-8	23.50-23.95
					26		SPT-16	24.00-24.45
		7	10	22			DS-10	25.00
					32		SPT-17	25.50-25.95
Dense to very dense, whitish grey, compacted sandy silt.		14	48	50			DS-11	26.50
					>100		SPT-18	27.00-27.37
		100	4.0	cm	Pentn. Refusal		DS-12	28.00
					Refusal		*SPT-19	28.40-28.44
28.50m							*SPT-20	28.50-28.53
Completely to highly weathered, whitish grey, fine grained, fractured rock.		100	3.0	cm	Pentn.		R1	CR=11% RQD=Nil
		NX rotary drilling from 28.50m to 40.00m					R2	CR=15% RQD=Nil
							R3	CR=28% RQD=Nil
							R4	CR=Nil RQD=Nil
32.00m							DS-13	
Completely weathered, whitish grey, fine grained, decomposed rock.							R5	CR=Nil RQD=Nil
							DS-14	
		100			Refusal		*SPT-21	34.00-34.03
			3.0	cm	Pentn.		R6/DS-15	CR=Nil RQD=Nil
							R7	CR=Nil RQD=Nil
							DS-16	
							R8	CR=Nil RQD=Nil
							DS-17	
		100			Refusal		*SPT-22	37.00-37.04
			4.0	cm	Pentn.		R9/DS-18	CR=Nil, RQD=Nil
							R10	CR=Nil RQD=Nil
							DS-19	
							R11	CR=Nil RQD=Nil
							DS-20	
N.B. - '*' means sample could not be recovered.							*SPT-23	40.00-40.02
40.00m		100	2.0	cm	Pentn.			

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.5

Co-ordinates E=3667.113  
N=4864.169

Field Test	Nos	Samples	Nos	Commencement Date : 07/04/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	9	Completion Date : 13/04/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 98.973 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.39 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m Filled up with light grey, silty clay.									DS-1 DS-2	0.50 1.00
1.50m Loose, light grey, silty sand.		1	2	4					SPT-1	1.50-1.95
3.45m Very soft, light brownish grey, clayey silt.		0	1	0					DS-3 UDS-1 SPT-2	2.50 3.00-3.45 3.45-3.90
6.00m Very loose, grey, silty sand.		0	1	1					DS-4 SPT-3	4.50 5.00-5.45
7.30m		5	2	2					UDS-2 SPT-4	6.00-6.45 6.45-6.90
		0	1	2					DS-5 SPT-5	7.50 8.00-8.45
		0	2	2					*UDS-3 SPT-6	9.00-9.45 9.55-10.00
		1	1	2					DS-6 SPT-7	10.50 11.00-11.45
		1	1	2					*UDS-4 SPT-8	12.00-12.45 12.55-13.00
		1	2	2					DS-7 SPT-9	13.50 14.00-14.45
		1	1	2					*UDS-5 SPT-10	15.00-15.45 15.55-16.00
		1	2	2					DS-8 SPT-11	16.50 17.00-17.45
		1	2	2					*UDS-6 SPT-12	18.00-18.45 18.55-19.00
									DS-9	19.50
20.10m										

Job No : 4095

Created by : SKD

Created on : 16/05/2018

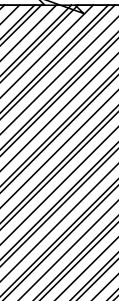
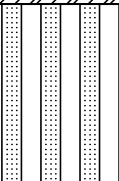
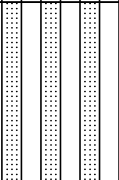
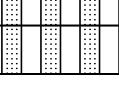


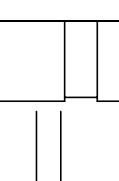
Sheet No:

## BORE LOG DATA SHEET

## BORE HOLE NO.5

Co-ordinates E=3667.113  
N=4864.169

Field Test	Nos	Samples	Nos	Commencement Date : 07/04/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	9	Completion Date : 13/04/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 98.973 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.39 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
20.10m Soft, deep grey, silty clay. Observed conch pcs.		2	2	2	4		SPT-13	20.00-20.45
					4		*UDS-7	21.00-21.45
		2	2	2			SPT-14	21.55-22.00
					4		DS-10	22.50
		2	2	2			SPT-15	23.00-23.45
23.80m Medium dense, reddish brown, clayey silty sand with high % of kankar mixture.					26		*UDS-8	24.00-24.45
		19	13	13			SPT-16	24.55-25.00
					31		DS-11	25.50
26.00m Dense, light brownish grey, silty sand. Observed laminated clay.		8	13	18			SPT-17	26.00-26.45
					34		*UDS-9	27.00-27.45
		7	14	20			SPT-18	27.55-28.00
28.50m Very dense, whitish grey, silty sand. Observed decomposed rock particles.		100	130	cm Pentn. >100			DS-12	28.50
29.10m					Refusal		SPT-19	28.80-28.93
							*SPT-20	29.10-29.14
		100					R1	CR=13%/RQD=0
		4.0	cm Pentn.					30.00
							R2	CR=16% RQD=Nil
33.00m Completely weathered, whitish grey, fine grained, fractured rock.								31.00
							R3	CR=18% RQD=Nil
		100					*SPT-21	32.00-32.04
		4.0	cm Pentn.				R4	CR=17%/RQD=0
								33.00
34.00m Highly weathered, grey, fine grained, highly fractured rock.							R5	CR=21% RQD=Nil
								34.00
							R6	CR=29% RQD=Nil
								35.00
							R7	CR=35% RQD=Nil
								36.00
							R8	CR=40% RQD=Nil
								37.00
							R9	CR=35% RQD=10%
								38.00
							R10	CR=45% RQD=Nil
								39.00
39.00m Moderately weathered, grey, fine grained, highly fractured rock.							R11	CR=52% RQD=Nil
40.00m								40.00
N.B. - '*' means sample could not be recovered.								

1072 of 1127

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO.ABH6

Co-ordinates E=3677.334  
N=4868.150

Field Test	Nos	Samples	Nos	Commencement Date : 30/04/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	8	Completion Date : 04/05/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 98.828 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.28 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m Filled up soil consists of light brownish grey, silty sand with rubbish & stone pcs.		1	3	4					DS-1 DS-2 SPT-1	0.50 1.00 1.50-1.95
2.40m Vey loose, light grey, silty sand. Observed kankar & conch pcs.		2	2	1					DS-3 *UDS-1 SPT-2	2.50 3.00-3.45 3.55-4.00
5.00m Very loose to loose, grey, silty sand.		2	2	2					DS-4 SPT-3	4.50 5.00-5.45
8.00m Soft, deep grey, silty clay. Observed conch pcs. & micaschist.		1	2	2					*UDS-2 SPT-4 DS-5 SPT-5	6.00-6.45 6.55-7.00 7.50 8.00-8.45
13.50m Soft, grey, silty clay. Observed conch pcs.		1	2	2					UDS-3 SPT-6 DS-6 SPT-7	9.00-9.45 9.45-9.90 10.50 11.00-11.45
20.10m		2	2	2					UDS-4 SPT-8 DS-7 SPT-9	12.00-12.45 12.45-12.90 13.50 14.00-14.45
		1	1	2					UDS-5 SPT-10 DS-8 SPT-11	15.00-15.45 15.45-15.90 16.50 17.00-17.45
		2	2	2					UDS-6 SPT-12 DS-9	18.00-18.45 18.45-18.90 19.50



Job No : 4095

Created by : SKD

Created on : 16/05/2018

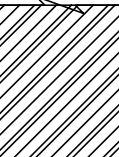
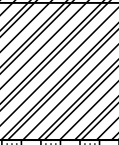
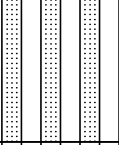
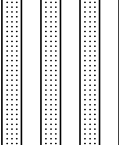
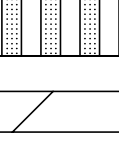
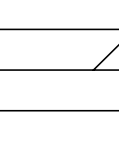

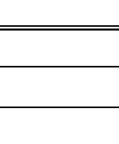
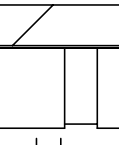
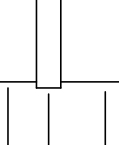
Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO.ABH6

Co-ordinates E=3677.334  
N=4868.150

Field Test	Nos	Samples	Nos	Commencement Date : 30/04/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	8	Completion Date : 04/05/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 98.828 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.28 m.

DESCRIPTION	SYMBOL	N-VALUE						SAMPLES	
		EACH DIVN. = 15cm						Ref. No	Depth (m)
20.10m Soft, grey, silty clay. Observed conch pcs.		1	2	2				SPT-13	20.00-20.45
								*UDS-7	21.00-21.45
22.00m		1	2	2				SPT-14	21.55-22.00
Medium, grey, silty clay. Observed conch pcs.								DS-10	22.50
23.70m		2	2	3				SPT-15	23.00-23.45
Dense, light brownish grey, silty sand with kankar & stone pcs. Observed laminated clay.								*UDS-8	24.00-24.45
25.50m		20	18	22				SPT-16	24.55-25.00
Very dense, light brownish grey, silty sand with stone pcs.								DS-11	25.50
28.00m		22	28	36				SPT-17	26.00-26.45
Completely weathered, whitish grey, fine grained, completely fractured rock.								DS-12	27.00
		30	100	6.0	cm	Pentn.	>100	SPT-18	27.50-27.71
28.00m		100	4.0	cm	Pentn.	Refusal		*SPT-19	27.90-27.94
								*SPT-20	28.00-28.03
								R1	CR=15%/RQD=0
								R2	CR=18% RQD=Nil
								R3	CR=17% RQD=Nil
31.00m		100						*SPT-21	31.00-31.04
Highly weathered, grey, fine grained, highly fractured rock.								R4	CR=26%/RQD=0
								R5	CR=28% RQD=Nil
33.00m								R6	CR=25% RQD=Nil
Highly weathered, grey, fine grained, highly fractured rock.								R7	CR=25% RQD=Nil
								R8	CR=26% RQD=Nil
35.00m								R9	CR=30% RQD=Nil
								R10	CR=32% RQD=Nil
Highly to moderately weathered, grey, fine grained, highly fractured rock.								R11	CR=34% RQD=Nil
								R12	CR=44% RQD=Nil
N.B. - '*' means sample could not be recovered.									
40.00m									

1074 of 1127

Job No : 4095

Created by : SKD

Created on : 16/05/2018

Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO. ABH7

Co-ordinates E=3658.208  
N=4881.319

Field Test	Nos	Samples	Nos	Commencement Date : 05/05/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	8	Completion Date : 08/05/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 98.681 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.30 m.

DESCRIPTION	SYMBOL	N-VALUE							SAMPLES	
		EACH DIVN. = 15cm							Ref. No	Depth (m)
0.00m Filled up soil consists of brownish grey, silty sand with rubbish & kankar.									DS-1	0.50
									DS-2	1.00
		4	4	5					SPT-1	1.50-1.95
2.00m Loose, grey, silty sand.									DS-3	2.50
		1	2	3					*UDS-1	3.00-3.45
									SPT-2	3.55-4.00
4.50m Very soft, grey, silty clay. Observed conch pcs.		2	1	1					DS-4	4.50
									SPT-3	5.00-5.45
		0	1	1					*UDS-2	6.00-6.45
									SPT-4	6.55-7.00
7.50m Very soft to soft, deep grey, silty clay. Observed conch pcs. & micaschist.		0	1	1					DS-5	7.50
									SPT-5	8.00-8.45
		1	1	2					UDS-3	9.00-9.45
									SPT-6	9.45-9.90
		1	2	2					DS-6	10.50
									SPT-7	11.00-11.45
12.45m		2	2	2					UDS-4	12.00-12.45
									SPT-8	12.45-12.90
		1	1	2					DS-7	13.50
									SPT-9	14.00-14.45
		1	1	2					UDS-5	15.00-15.45
									SPT-10	15.45-15.90
		1	2	2					DS-8	16.50
									SPT-11	17.00-17.45
		1	2	2					UDS-6	18.00-18.45
									SPT-12	18.45-18.90
20.00m 20.10m									DS-9	19.50

Job No : 4095

Created by : SKD

Created on : 16/05/2018

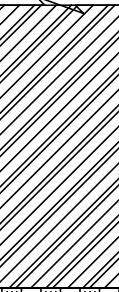
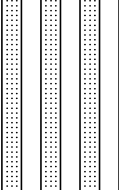
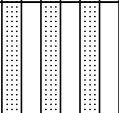
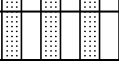
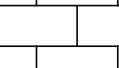
Sheet No:

## BORE LOG DATA SHEET

BORE HOLE NO. ABH7

Co-ordinates E=3658.208  
N=4881.319

Field Test	Nos	Samples	Nos	Commencement Date : 05/05/2018
Penetrometer (SPT)	21	Undisturbed (UDS)	8	Completion Date : 08/05/2018
Cone (Pc)		Penetrometer (SPT)	21	Bore Hole Diameter : 150mm / NX.
Vane (V)		Disturbed (DS)	12	Level Of Ground : 98.681 m.
		Water Sample (WS)	0	Water Struck At :
				Standing Water Level : 1.30 m.

DESCRIPTION	SYMBOL	N-VALUE					SAMPLES	
		EACH DIVN. = 15cm					Ref. No	Depth (m)
20.10m Medium, dark grey, silty clay. Observed decomposed wood, conch pcs. & siltstone pcs.		2	3	2	5		SPT-13	20.00-20.45
					6		*UDS-7	21.00-21.45
		3	3	3			SPT-14	21.55-22.00
					5		DS-10	22.50
		3	2	3			SPT-15	23.00-23.45
23.60m Dense, whitish grey, sandy silt with stone pcs. Observed laminated clay.					42		*UDS-8	24.00-24.45
		14	19	23			SPT-16	24.55-25.00
					52		DS-11	25.50
26.00m Very dense, light grey, silty sand.		15	20	32			SPT-17	26.00-26.45
							DS-12	27.00
27.50m Very dense, brownish grey, silty sand with kankar & stone pcs.		36	100	130	cm Pentr. >100		SPT-18	27.50-27.78
28.10m		100	4.0	cm Pentr. Refusal			*SPT-19	28.00-28.03
					Refusal		*SPT-20	28.10-28.14
		100					R1	CR=19%/RQD=0
					4.0 cm Pentr.			29.00
					NX rotary drilling from 28.10m to 40.00m		R2	CR=17% RQD=Nil
					Refusal		R3	CR=12% RQD=Nil
		100					*SPT-21	31.00-31.03
					3.0 cm Pentr.		R4	CR=13%/RQD=0
32.00m							R5	CR=25% RQD=Nil
							R6	CR=22% RQD=Nil
							R7	CR=24% RQD=Nil
35.00m							R8	CR=28% RQD=Nil
							R9	CR=35% RQD=Nil
							R10	CR=39% RQD=Nil
							R11	CR=42% RQD=12%
39.00m Moderately weathered, deep grey, fine grained, highly fractured rock.							R12	CR=51% RQD=Nil
40.00m								40.00

1076 of 1127



Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4 0 9 5

Created by : Chandrani

Created on : 02 / 07 / 2018

Sheet No:

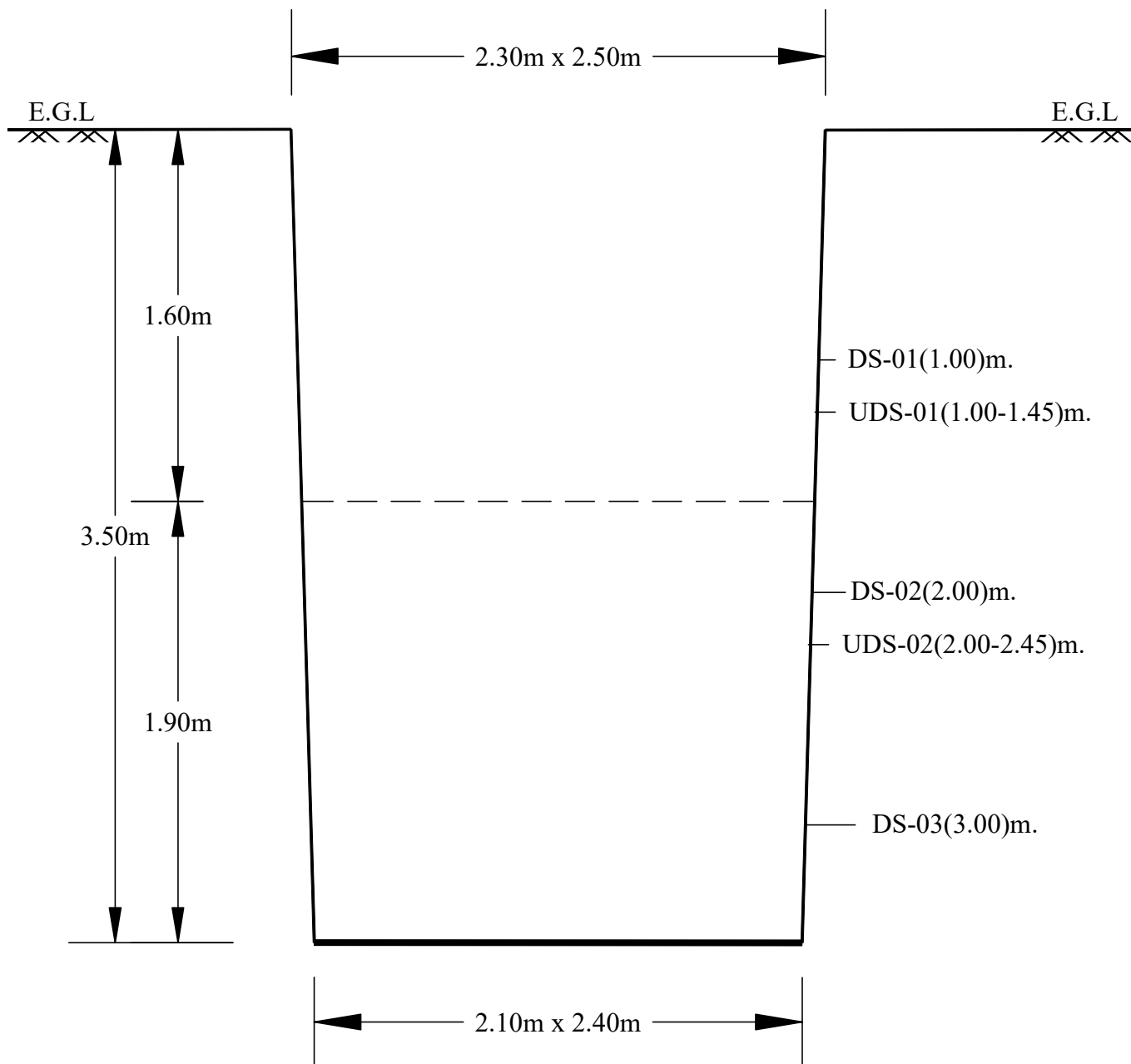
Co-ordinates:

E = 3684.023M.

N = 5268.553M.

RL = 98.626M.

SWL = 1.50m



Description of Soil:-

(EGL-1.60)m:- Filled up with brownish grey to blackish grey silty clay with concrete, boulders.

(1.60-3.50)m:- Blackish grey silty clay.

PIT LOG OF TP - 01

1077 of 1127





Project : Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

**CETEST**

Job No : 4 0 9 5

Created by : Chandrani

Created on : 02 / 07 / 2018

Sheet No:

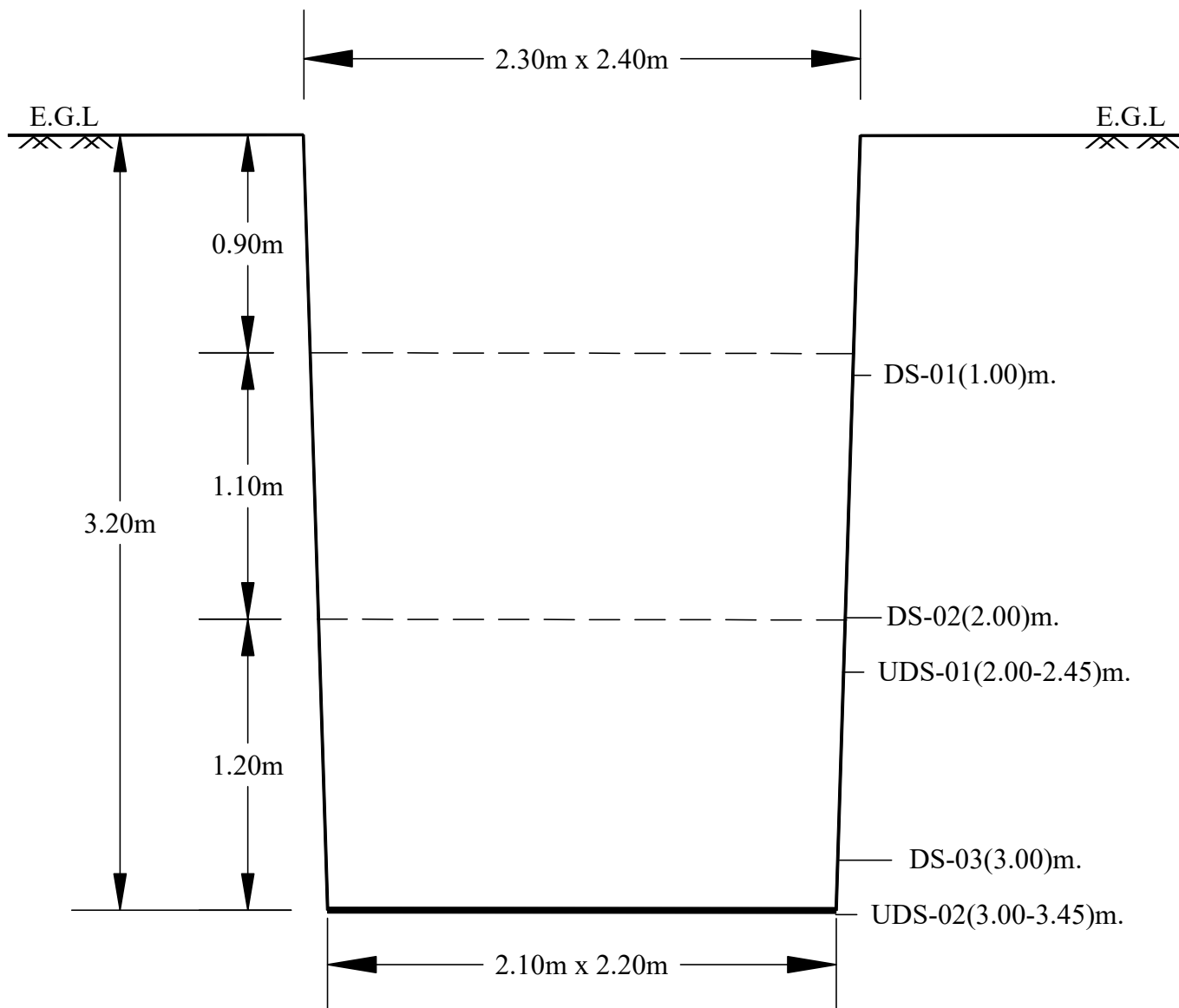
Co-ordinates:

E = 3680.428M.

N = 4885.612M.

RL = 98.845M.

SWL = 1.80m



Description of Soil:-

(EGL-1.60)m:- Filled up with boulders, kankar, garbages.

(1.60-3.50)m:- Reddish brown silty clay with moorum.

(1.60-3.50)m:- Whitish grey silty fine sand.

PIT LOG OF TP - 02

1078 of 1127



**CORRECTION FOR STANDARD PENETRATION TEST VALUES**

Bore Hole No:	Starting Depth (M)	Ending Depth (M)	Average Depth (M)	Field 'N' Values	Cor. 'N' for Ovp. & Dilatancy (if reqd)	Reduced Level (M)	Stratum
BH01	1.50	1.95	1.73	8	08	96.68	Fill
BH01	3.45	3.90	3.68	2	02	94.73	I
BH01	5.00	5.45	5.23	2	02	93.18	I
BH01	6.45	6.90	6.68	2	02	91.73	I
BH01	8.00	8.45	8.23	2	02	90.18	I
BH01	9.55	10.00	9.78	2	02	88.63	I
BH01	11.00	11.45	11.23	2	02	87.18	I
BH01	12.55	13.00	12.78	3	03	85.63	I
BH01	14.00	14.45	14.23	3	03	84.18	I
BH01	15.45	15.90	15.68	4	04	82.73	I
BH01	17.00	17.45	17.23	4	04	81.18	I
BH01	18.45	18.90	18.68	4	04	79.73	I
BH01	20.00	20.45	20.23	74	37	78.18	VI
BH02	1.50	1.95	1.73	14	14	97.02	Fill
BH02	3.45	3.90	3.68	3	03	95.07	I
BH02	5.00	5.45	5.23	3	03	93.52	I
BH02	6.45	6.90	6.68	4	04	92.07	I
BH02	8.00	8.45	8.23	6	06	90.52	I
BH02	9.45	9.90	9.68	7	07	89.07	I
BH02	11.00	11.45	11.23	2	02	87.52	I
BH02	12.55	13.00	12.78	2	02	85.97	I
BH02	14.00	14.45	14.23	4	04	84.52	I
BH02	15.45	15.90	15.68	4	04	83.07	I
BH02	17.00	17.45	17.23	4	04	81.52	I
BH02	18.45	18.90	18.68	5	05	80.07	I
BH02	19.80	20.04	19.92	>100	100	78.83	III
BH03	1.50	1.95	1.73	4	04	96.83	Fill
BH03	3.45	3.90	3.68	6	07	94.88	IV
BH03	5.00	5.45	5.23	7	08	93.33	IV
BH03	6.45	6.90	6.68	3	03	91.88	I
BH03	8.00	8.45	8.23	3	03	90.33	I
BH03	9.55	10.00	9.78	4	04	88.78	I
BH03	11.00	11.45	11.23	3	03	87.33	I
BH03	12.55	13.00	12.78	3	03	85.78	I
BH03	14.00	14.45	14.23	3	03	84.33	I
BH03	15.55	16.00	15.78	4	04	82.78	I
BH03	17.00	17.45	17.23	4	04	81.33	I
BH03	18.55	19.00	18.78	4	04	79.78	I

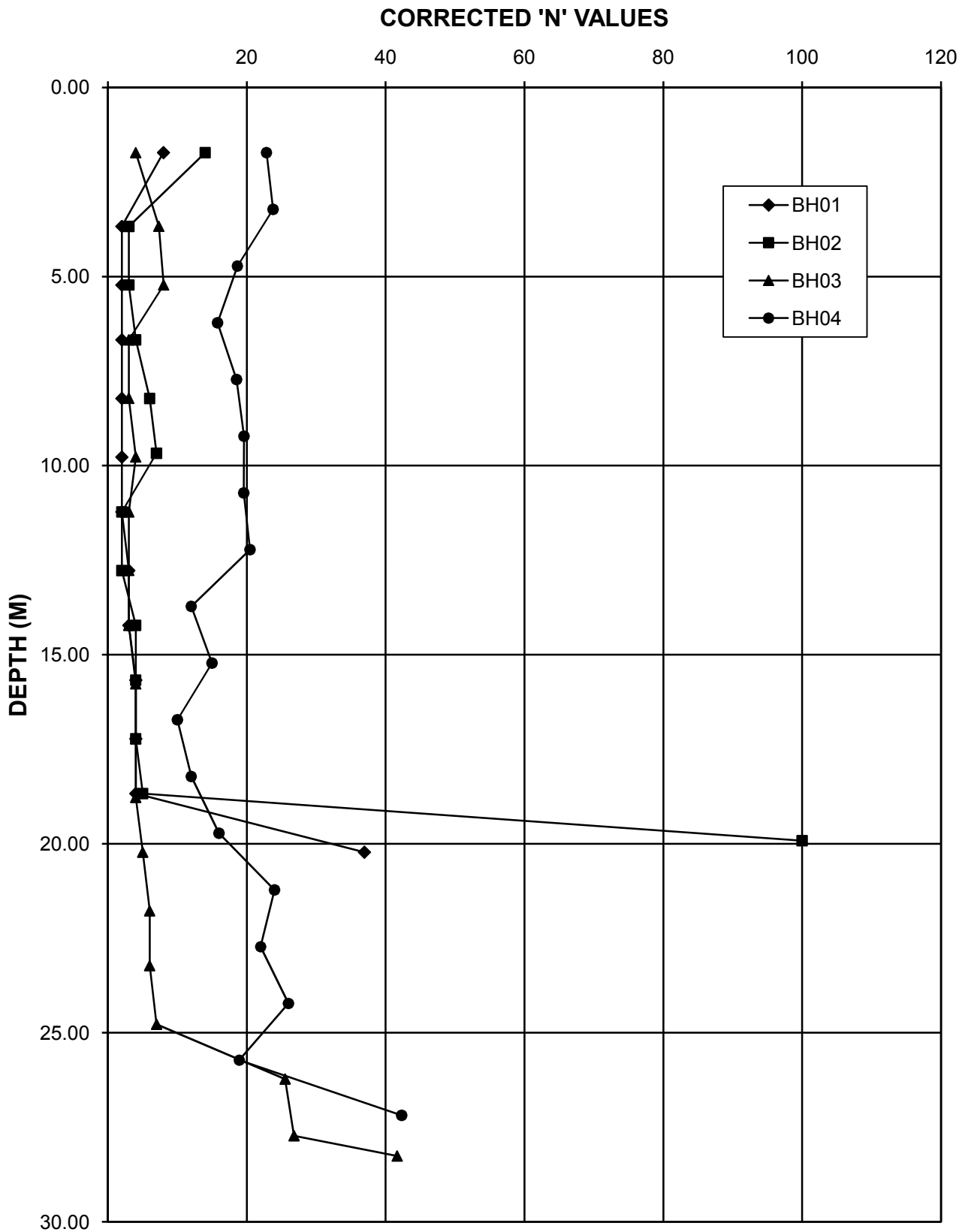
Bore Hole No:	Starting Depth (M)	Ending Depth (M)	Average Depth (M)	Field 'N' Values	Cor. 'N' for Ovp. & Dilatancy (if reqd)	Reduced Level (M)	Stratum
BH03	20.00	20.45	20.23	5	05	78.33	I
BH03	21.55	22.00	21.78	6	06	76.78	I
BH03	23.00	23.45	23.23	6	06	75.33	I
BH03	24.55	25.00	24.78	7	07	73.78	I
BH03	26.00	26.45	26.23	51	26	72.33	VI
BH03	27.50	27.95	27.73	56	27	70.83	VI
BH03	28.20	28.32	28.26	>100	42	70.30	VI
BH04	1.50	1.95	1.73	22	23	96.90	V
BH04	3.00	3.45	3.23	26	24	95.40	V
BH04	4.50	4.95	4.73	19	19	93.90	V
BH04	6.00	6.45	6.23	15	16	92.40	V
BH04	7.50	7.95	7.73	21	19	90.90	V
BH04	9.00	9.45	9.23	24	20	89.40	V
BH04	10.50	10.95	10.73	25	20	87.90	V
BH04	12.00	12.45	12.23	28	20	86.40	V
BH04	13.50	13.95	13.73	12	12	84.90	II
BH04	15.00	15.45	15.23	15	15	83.40	II
BH04	16.50	16.95	16.73	10	10	81.90	II
BH04	18.00	18.45	18.23	12	12	80.40	II
BH04	19.50	19.95	19.73	16	16	78.90	II
BH04	21.00	21.45	21.23	24	24	77.40	II
BH04	22.50	22.95	22.73	22	22	75.90	II
BH04	24.00	24.45	24.23	26	26	74.40	II
BH04	25.50	25.95	25.73	32	19	72.90	VI
BH04	27.00	27.37	27.19	>100	42	71.44	VI
BH05	1.50	1.95	1.73	6	08	97.25	IV
BH05	3.45	3.90	3.68	1	01	95.30	I
BH05	5.00	5.45	5.23	2	02	93.75	I
BH05	6.45	6.90	6.68	4	04	92.30	IV
BH05	8.00	8.45	8.23	3	03	90.75	I
BH05	9.55	10.00	9.78	4	04	89.20	I
BH05	11.00	11.45	11.23	3	03	87.75	I
BH05	12.55	13.00	12.78	3	03	86.20	I
BH05	14.00	14.45	14.23	4	04	84.75	I
BH05	15.55	16.00	15.78	3	03	83.20	I
BH05	17.00	17.45	17.23	4	04	81.75	I
BH05	18.55	19.00	18.78	4	04	80.20	I
BH05	20.00	20.45	20.23	4	04	78.75	I
BH05	21.55	22.00	21.78	4	04	77.20	I
BH05	23.00	23.45	23.23	4	04	75.75	I
BH05	24.55	25.00	24.78	26	17	74.20	V

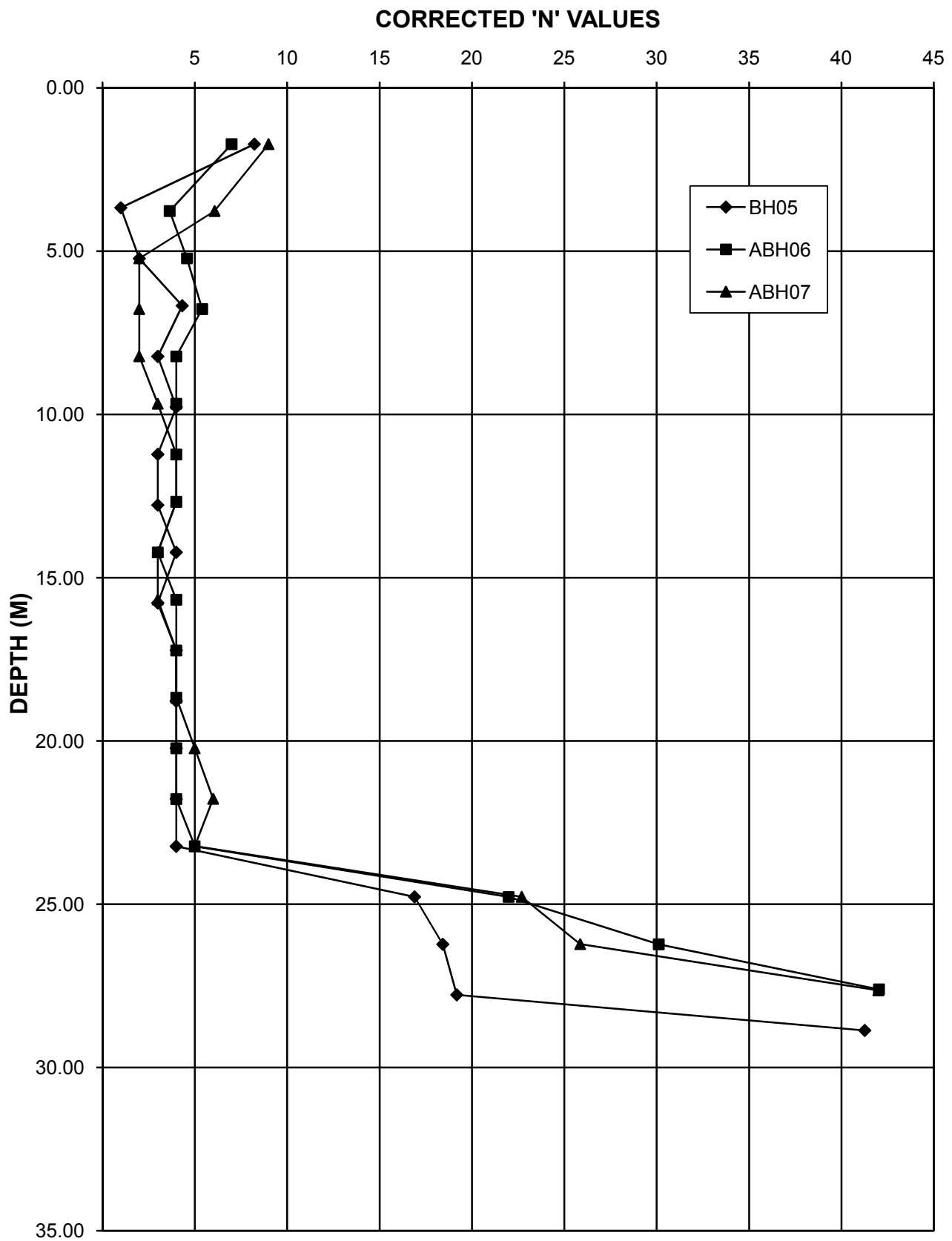
Job No. : 4095

Sheet No.

Bore Hole No:	Starting Depth (M)	Ending Depth (M)	Average Depth (M)	Field 'N' Values	Cor. 'N' for Ovp. & Dilatancy (if reqd)	Reduced Level (M)	Stratum
BH05	26.00	26.45	26.23	31	18	72.75	VI
BH05	27.55	28.00	27.78	34	19	71.20	VI
BH05	28.80	28.93	28.87	>100	41	70.11	VI
ABH06	1.50	1.95	1.73	7	07	97.10	Fill
ABH06	3.55	4.00	3.78	3	04	95.05	IV
ABH06	5.00	5.45	5.23	4	05	93.60	IV
ABH06	6.55	7.00	6.78	5	05	92.05	IV
ABH06	8.00	8.45	8.23	4	04	90.60	I
ABH06	9.45	9.90	9.68	4	04	89.15	I
ABH06	11.00	11.45	11.23	4	04	87.60	I
ABH06	12.45	12.90	12.68	4	04	86.15	I
ABH06	14.00	14.45	14.23	3	03	84.60	I
ABH06	15.45	15.90	15.68	4	04	83.15	I
ABH06	17.00	17.45	17.23	4	04	81.60	I
ABH06	18.45	18.90	18.68	4	04	80.15	I
ABH06	20.00	20.45	20.23	4	04	78.60	I
ABH06	21.55	22.00	21.78	4	04	77.05	I
ABH06	23.00	23.45	23.23	5	05	75.60	I
ABH06	24.55	25.00	24.78	40	22	74.05	VI
ABH06	26.00	26.45	26.23	64	30	72.60	VI
ABH06	27.50	27.71	27.61	>100	42	71.22	VI
ABH07	1.50	1.95	1.73	9	09	96.96	Fill
ABH07	3.55	4.00	3.78	5	06	94.91	IV
ABH07	5.00	5.45	5.23	2	02	93.46	I
ABH07	6.55	7.00	6.78	2	02	91.91	I
ABH07	8.00	8.45	8.23	2	02	90.46	I
ABH07	9.45	9.90	9.68	3	03	89.01	I
ABH07	11.00	11.45	11.23	4	04	87.46	I
ABH07	12.45	12.90	12.68	4	04	86.01	I
ABH07	14.00	14.45	14.23	3	03	84.46	I
ABH07	15.45	15.90	15.68	3	03	83.01	I
ABH07	17.00	17.45	17.23	4	04	81.46	I
ABH07	18.45	18.90	18.68	4	04	80.01	I
ABH07	20.00	20.45	20.23	5	05	78.46	I
ABH07	21.55	22.00	21.78	6	06	76.91	I
ABH07	23.00	23.45	23.23	5	05	75.46	I
ABH07	24.55	25.00	24.78	42	23	73.91	VI
ABH07	26.00	26.45	26.23	52	26	72.46	VI
ABH07	27.50	27.78	27.64	>100	42	71.04	VI





**CORRECTED 'N' Vs DEPTH PLOT**

**Summarised Field Density Test Results**

Test Location	Depth of Test (M)	Avg. Field Bulk Density (gm/cc)	Avg. Field Dry Density (gm/cc)	Moisture Content (%)
TP-01	1.00	1.570	1.490	6
	2.00	1.630	1.510	8
TP-02	2.00	1.590	1.500	6

## **PART II: LABORATORY TEST RESULTS**

Job No. : 4095

Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk Dens./cc	Dry Dens./cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits				IS Classifi cation	Grain Size			Test Method
									Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	CH %		Sand %	Silt %	Clay %	
BH01	UDS01	3.00	Brownish grey clayey silt with sand mixture.	2.69	2.69	2.69	47 S						58	24	22	CH		36	36	28 *	See the Note
BH01	UDS02	6.00	Deep grey silty clay with traces of organic matter.	1.56	1.02	2.49	64 S 52 T 77 C	1.818	UNCONFD	0.11	0					CH-OH*	8	51	41		Do
									0.0 0.096												
									0.0 0.107												
									0.0 0.118												
									REMOULD	0.07	0										
									0.0 0.061												
									0.0 0.075												
									0.0 0.085												
BH01	SPT06	9.55	Dark grey silty clay with traces of organic matter.										77	23	11	CH-OH					Do
BH01	UDS05	15.00	Deep grey silty clay with traces of silt stone & organic matter.	1.55	0.96	2.50	69 S 62 T		UNCONFD	0.14	0		66	32	7	CH-OH	13	42	45		Do
									0.0 0.161												
									0.0 0.142												
									0.0 0.123												
									REMOULD	0.10	0										
									0.0 0.119												
									0.0 0.098												
									0.0 0.085												
BH01	UDS06	18.00	Deep grey silty clay with organic matter.	1.55	0.96	2.51	72 S 62 T		UNCONFD	0.14	0					CH-OH*	5	48	47		Do
									0.0 0.161												
									0.0 0.142												
									0.0 0.123												
									REMOULD	0.10	0										
									0.0 0.119												
									0.0 0.098												
									0.0 0.085												
BH01	SPT13	20.00	Brownish grey rock dust & rock pieces.													SM	21	56	23(Silt+Clay)		Do
BH02	UDS01	3.00	Brownish grey clayey silt with traces of sand mixture.	1.68	1.19	2.54	41 S 42 T		UNCONFD	0.19	0		53	28	22	CH	22	60	18		Do
									0.0 0.212												
									0.0 0.186												
									0.0 0.159												
									REMOULD	0.11	0										
									0.0 0.136												
									0.0 0.108												
									0.0 0.081												

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results					Atter. Limits			IS		Grain Size			Test Method
				Dens. gms/cc	Dens. gms/cc					Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Classifi cation	Gravl %	Sand %	Silt %	Clay %		
BH02	UDS02	6.00	Deep grey silty clay with organic matter.	1.47	0.89	2.27	89 S	65 T		UNCONF	0.07	0	72	31	10	CH-OH			3	52	45	Do	
										0.0 0.052													
										0.0 0.065													
										0.0 0.079													
										REMOULD	0.04	0											
										0.0 0.026													
										0.0 0.040													
										0.0 0.053													
BH02	UDS03	9.00	Deep grey clayey silt with sand mixture.	1.92	1.49	2.67	31 S	29 T		TRSH-UU	0.35	0				CH-OH*			5	60	35	Do	
										3.0 0.362													
										2.0 0.345													
										1.0 0.343													
BH02	UDS05	15.00	Deep grey silty clay.										61	33	7	MH						Do	
BH02	UDS06	18.00	Deep grey silty clay with organic matter.	1.49	0.92	2.41	71 S	63 T		UNCONF	0.08	0				CH-OH*			3	66	31	Do	
										0.0 0.065													
										0.0 0.091													
										0.0 0.077													
										REMOULD	0.05	0											
										0.0 0.040													
										0.0 0.053													
										0.0 0.053													
BH02	SPT13	19.80	Reddish brown clayey silt with sand mixture, traces of rock dust & rock pieces.										40	22		Cl			11	32	57(Silt+Clay)	Do	
BH03	UDS01	3.00	Brownish grey silty sand.	1.62	1.35		19 S	20DR		DRSH-CU	0.05	29				SM-SP			90	10(Silt+Clay)		Do	
										0.5 0.317													
										1.0 0.614													
										2.0 1.160													
BH03	UDS02	6.00	Deep grey silty clay with organic matter.	1.53	0.97	2.45	67 S	58 T		TRSH-UU	0.08	0	66	20		CH-OH			4	43	53	Do	
										3.0 0.145													
										2.0 0.077													
										1.0 0.029													
										UNCONF	0.08	0											
										0.0 0.119													
										0.0 0.059													
										0.0 0.048													

Job No. : 4095

Sheet No.

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results					Atter. Limits			IS Classification	Grain Size			Test Method
				Dens. gms/cc	Pc/Pn kg/sqcm					Shear kg/sqcm	Cohesn kg/sqcm	Fricdn Deg.	LL %	PL %	SL %	Sand %	Silt %		Clay %			
										REMOULD	0.05											
										0.0	0.074											
										0.0	0.049											
										0.0	0.037											
BH03	SPT06	9.55	Blackish grey silty clay with traces of conch.														CH-OH*	3	97(Silt+Clay)		Do	
BH03	SPT10	15.55	Deep grey silty clay.				2.40										CH-OH*	4	57	39	Do	
BH03	SPT13	20.00	Dark grey silty clay with traces of conch.											36	13	9	Cl				Do	
BH03	SPT16	24.55	Dark grey silty clay with traces of conch.											48	15		Cl				Do	
BH03	SPT17	26.00	Reddish brown silty sand with traces of clay binder & kankar.														SM	65	35(Silt+Clay)		Do	
BH04	DS01	0.50	Reddish brown silty sand with traces of rock dust, rock pieces & clay binder.														SM	14	58	28(Silt+Clay)	Do	
BH04	SPT02	3.00	Light grey silty sand with traces of clay binder.			1.75	1.50		17DR			DRSH-CU	0.03	32			SM-SP	89	11(Silt+Clay)		Do	
												0.5	0.352									
												1.0	0.644									
												2.0	1.280									
BH04	SPT04	6.00	Light grey silty sand with traces of clay binders.														SM	77	23(Silt+Clay)		Do	
BH04	SPT07	11.50	Light grey silty sand with traces of mica & clay binder.														SM	80	20(Silt+Clay)		Do	
BH04	SPT08	12.00	Light grey silty sand with traces of mica.														SM	83	17(Silt+Clay)		Do	

1088 of 1127

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results					Atter. Limits			IS Classification	Grain Size			Test Method
				Dens. gms/cc	Dens. gms/cc					Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Gravl %		Sand %	Silt %	Clay %	
BH04	SPT11	16.50	Deep grey silty clay.				2.59										Cl*		4	67	29	Do
BH04	SPT14	21.00	Blackish grey silty clay with traces of conch.											42	21	12	Cl		4	96(Silt+Clay)		Do
BH04	SPT16	24.00	Dark grey silty clay.				2.64										Cl*		4	57	39	Do
BH04	SPT17	25.50	Brownish grey silty sand with traces of kankar & moorum.														SM	9	61	30(Silt+Clay)		Do
BH05	UDS01	3.00	Brownish grey silty sand with traces of clay binder.	1.65	1.42			16 S 16DR		DRSH-CU 0.5 1.0 2.0	0.01	0.265 0.551 1.075	28				SM		85	15(Silt+Clay)		Do
BH05	SPT02	3.45	Brownish grey sily clay / clayey silt.											41	15	14	Cl					Do
BH05	UDS02	6.00	Brownish grey silty sand with traces of clay binder.	1.66	1.38			19 S 20DR		DRSH-CU 0.5 1.0 2.0	0.03	0.308 0.617 1.184	30				SM		87	13(Silt+Clay)		Do
BH05	SPT05	8.00	Deep grey silty clay.				2.37										CH-OH*		3	51	46	Do
BH05	SPT08	12.55	Dark grey silty clay.											79	30		CH					Do
BH05	SPT12	18.55	Dark grey silty clay.											68	21		CH					Do
BH05	SPT16	24.55	Brownish grey clayey silty sand / clayey sandy silt.				2.67										SM		74	20	6	Do



Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS			Grain Size				Test Method
				Dens. gms/cc						Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Classification	Gravl %	Sand %	Silt %	Clay %			
BH05	SPT17	26.00	Brownish grey silty sand with traces of kankar.															SM-SP		90	10	(Silt+Clay)	Do	
ABH06	SPT03	5.00	Brownish grey silty sand with traces of conch mixture.															SM		69	31	(Silt+Clay)	Do	
ABH06	UDS03	9.00	Deep grey silty clay with traces of conch shell and organic matter.	1.54	0.91	2.49	64 S 68 T 89 C		2.052	TRSH-UU 3.0 0.150 2.0 0.144 1.0 0.131 UNCONFD 0.0 0.110 0.0 0.085 0.0 0.118 REMOULD 0.0 0.063 0.0 0.050 0.0 0.074	0.14	0	87	36	15	CH-OH		5	51	44		Do		
ABH06	UDS04	12.00	Deep grey silty clay with organic matter.			2.48	71 S											CH-OH*		8	38	54	Do	
ABH06	UDS05	15.00	Deep grey silty clay with organic matter.	1.54	0.91	2.44	67 S 70 T 83 C		1.894	UNCONFD 0.0 0.163 0.0 0.142 0.0 0.117 REMOULD 0.0 0.109 0.0 0.098 0.0 0.074	0.14	0	76	35	28	CH-OH		5	53	42		Do		
ABH06	UDS06	18.00	Deep grey silty clay with organic matter.	1.45	0.82	2.40	90 S 76 T			UNCONFD 0.0 0.076 0.0 0.086 0.0 0.062 REMOULD 0.0 0.051 0.0 0.063 0.0 0.038	0.07	0	65	31	7	CH-OH		12	42	46		Do		
ABH06	SPT16	24.55	Brownish grey silty sand with rock dust & rock pieces.															SM		31	48	21	(Silt+Clay)	Do

Bore Hole	Sample Number	Depth M	Sample Description	Bulk		Dry Dens. gms/cc	Spec. Grav.	Nat. Mois. %	Void Ratio	Strength Test Results				Atter. Limits			IS		Grain Size				Test Method
				Dens. gms/cc						Pc/Pn kg/sqcm	Shear kg/sqcm	Cohesn kg/sqcm	Frictn Deg.	LL %	PL %	SL %	Classifi cation	Gravl %	Sand %	Silt %	Clay %		
ABH07	SPT03	5.00	Greyish brown clayey silt with traces of sand mixture & conch.			2.61											CH-OH*	16	50	34	Do		
ABH07	UDS03	9.00	Deep grey silty clay with organic matter.	1.53	0.92	2.59	70 S 73 T 82 C	2.080		UNCONFD	0.10	0	65	27	7	CH-OH	7	46	47	Do			
										0.0 0.097													
										0.0 0.111													
										0.0 0.098													
										REMOULD	0.08	0											
										0.0 0.062													
										0.0 0.076													
										0.0 0.088													
ABH07	UDS04	12.00	Deep grey silty clay with traces of organic matter.	1.56	0.94	2.55	58 S 66 T			TRSH-JU	0.06	0	86	37		CH-OH	8	46	46	Do			
										3.0 0.072													
										2.0 0.062													
										1.0 0.059													
ABH07	UDS05	15.00	Deep grey silty clay with organic matter.	1.52	0.93	2.45	77 S 63 T 84 C	2.005		UNCONFD	0.18	0	66	25		CH-OH	14	53	33	Do			
										0.0 0.195													
										0.0 0.155													
										0.0 0.177													
										REMOULD	0.12	0											
										0.0 0.133													
										0.0 0.097													
										0.0 0.116													
ABH07	UDS06	18.00	Deep grey silty clay with organic matter.	1.53	0.93	2.45	75 S 65 T			UNCONFD	0.15	0				CH-OH*	9	45	46	Do			
										0.0 0.134													
										0.0 0.161													
										0.0 0.149													
										REMOULD	0.10	0											
										0.0 0.087													
										0.0 0.101													
										0.0 0.123													
ABH07	SPT14	21.55	Dark grey silty clay with traces of organic matter.										64	20	10	CH-OH				Do			
ABH07	SPT16	24.55	Brownish grey rock dust & rock pieces.													SM	54	30	16(Silt+Clay)	Do			

\* - Classification in this case is based on average layer properties.

Job No. : 4095

Sheet No.

## LABORATORY ROCK TEST RESULTS

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive Strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Young's Modulus, kg/sqcm	Test Method
				Bulk	Dry				Dry	Saturated				
BH-01	1	21.00-22.00	Highly weathered, light brownish grey, fine grained, completely fractured rock.	2.259	2.221	1.730	4.0069	2.3136	--	--	--	--	--	* See the Note
BH-01	4	24.00-25.00	Completely weathered, light brownish grey, fine grained, completely fractured rock.	2.732	2.716	0.600	1.9231	2.7691	--	--	--	12.25	--	Do
BH-01	9	29.00-30.00	Completely weathered, whitish grey, fine grained, completely fractured rock.	2.611	2.542	2.704	13.4250	2.9365	--	--	--	--	--	Do
BH-02	1	20.30-21.00	Highly weathered, light brownish grey, fine grained, highly fractured rock.	2.581	2.575	0.219	0.6963	2.5932	--	--	--	--	--	Do
BH-02	4	23.00-24.00	Highly weathered, light brownish grey, fine grained, highly fractured rock.	2.477	2.435	1.737	4.3139	2.5445	--	--	--	26.29	--	Do
BH-02	10	29.00-30.00	Completely weathered, whitish grey, fine grained, completely fractured rock.	2.511	2.434	3.134	10.3571	2.7157	--	--	--	--	--	Do
BH-03	3	31.00-32.00	Highly weathered, reddish brown, fine grained, fractured rock.	2.760	2.755	0.182	0.5928	2.7710	--	--	--	60.82	--	Do
BH-03	11	39.00-40.00	Slightly weathered, reddish brown, fine grained, fractured rock.	2.874	2.837	1.335	4.7128	2.9769	--	108	--	--	11244	Do
BH-04	1	28.50-30.00	Completely weathered, whitish grey, fine grained, fractured rock.	2.543	2.513	1.188	7.9385	2.7299	--	--	--	26.62	--	Do
BH-04	2	30.00-31.00	Completely weathered, whitish grey, fine grained, fractured rock.	2.450	2.397	2.183	9.0000	2.6342	--	--	--	--	--	Do
BH-04	3	31.00-32.00	Highly weathered, whitish grey, fine grained, fractured rock.	3.118	3.113	0.137	0.5645	3.1310	--	--	--	37.30	--	Do
BH-05	3	31.00-32.00	Completely weathered, whitish grey, fine grained, fractured rock.	2.492	2.448	1.809	8.4364	2.6732	--	--	--	13.39	--	Do
BH-05	9	37.00-38.00	Highly weathered, grey, fine grained, highly fractured rock.	2.842	2.839	0.073	0.2361	2.8462	--	593	--	--	27221	Do

BH No.	Run No.	Depth (M)	Description	Density (gm/cc)		Water Content (%)	Porosity %	Specific Gravity	Unconfined Compressive Strength (kg/sqcm)		Coefficient of softening	Point Load Strength Index (kg/sqcm)	Young's Modulus, kg/sqcm	Test Method
				Bulk	Dry				Dry	Saturated				
BH-05	11	39.00-40.00	Moderately weathered, grey, fine grained, highly fractured rock.	2.831	2.828	0.140	0.4251	2.8396	--	--	--	75.30	--	Do
ABH-06	1	28.00-29.00	Completely weathered, whitish grey, fine grained, fractured rock.	2.446	2.392	2.249	7.5600	2.5876	--	--	--	--	--	Do
ABH-06	4	31.00-32.00	Highly weathered, whitish grey, fine grained, fractured rock.	2.352	2.318	1.452	3.5667	2.4039	--	--	--	--	--	Do
ABH-06	9	36.00-37.00	Highly weathered, grey, fine grained, highly fractured rock.	2.565	2.561	0.144	0.4400	2.5727	--	--	--	--	--	Do
ABH-07	2	29.00-30.00	Completely weathered, whitish grey, fine grained, fractured rock.	2.709	2.703	0.197	0.7333	2.7233	--	--	--	37.34	--	Do
ABH-07	5	32.00-33.00	Highly weathered, deep grey, fine grained, highly fractured rock.	2.809	2.800	0.306	0.9429	2.8271	--	--	--	--	--	Do
ABH-07	11	38.00-39.00	Moderately weathered, deep grey, fine grained, highly fractured rock.	2.642	2.543	3.884	19.1774	3.1466	--	--	--	--	--	Do

**SWELLING TEST RESULTS**

Bore Hole No.	Sample No.	Depth (M)	Description	Free Swell Index, (%)	Swelling Pressure, (kg/sqcm)	PI (%)	Test Methods
BH-01	UDS-01	3.00	Brownish grey clayey silt with sand mixture.	28.57	--	34	*See the note
BH-02	UDS-02	6.00	Deep grey silty clay with traces of organic matter.	90.00	0.92	41	Do
BH-03	UDS-02	6.00	Deep grey silty clay with traces of organic matter.	68.18	0.012	46	Do
BH-04	SPT-02	3.00	Light grey silty sand with traces of clay binder.	2.38	--	--	Do
BH-05	UDS-01	3.00	Brownish grey silty sand.	0.00	0.00	--	Do
ABH-06	UDS-03	9.00	Deep grey silty clay with traces of organic matter.	81.82	0.00	51	Do
ABH-07	UDS-05	15.00	Deep grey silty clay with traces of organic matter.	80.95	0.00	41	Do

**SUMMERISED LABORATORY COMPACTION AND CBR TEST RESULTS**

SL No	Sample No	Depth (M)	Description	Standard Proctor Compaction Test		Soaked CBR Value at 95% of MDD (%)			Recommended Soaked CBR (%)	Permeability on samples compacted at MDD/OMC (cm/sec)	Test Method
				OMC (%)	MDD (gm/cc)	2.50mm Penetration	5.00mm Penetration				
1	TP01/DS01	1.00	Dark grey silty clay with decomposed rock, traces of sand mixture & conch.	16.70	1.766	10.38	8.78		10	$4.44 \times 10^{-06}$	*See the note

**\*Note: Test Methods**

Bulk Density & Dry Density: Ref. CET/SOP/01, Issue No. 01-(Page 27 & 39 of 40)  
 Natural Moisture Content: IS 2720 (Part 2)  
 Specific Gravity: IS 2720 (Part 3),  
 Grain size analysis: IS 2720 (Part 4)  
 Liquid Limit & Plastic Limit: IS 2720 (Part 5)  
 Shrinkage Limit: IS 2720 (Part 6)  
 Standard Proctor Compaction Test (Light Compaction): IS 2720 (Part 7)  
 Laboratory Determination of CBR: IS 2720 (Part 16)  
 Laboratory Permeability Test: IS 2720 (Part 17)

Unconfined Compressive Strength Test: IS 2720 (Part 10)  
 Triaxial Test (TRSH-UU): IS 2720 (Part 11)  
 Direct Shear Test (DRSH-CU): IS 2720 (Part 13)  
 Consolidation Properties (Void Ratio): IS 2720 (Part 15)  
 Free Swell Index: IS 2720 (Part 40)  
 Swelling Pressure: IS 2720 (Part 41)  
 Water Content, Bulk & Dry Density and Porosity: IS 13030  
 Unconfined Compressive Strength: IS 9143.  
 Point Load Index: IS 8764.

**C.E. Testing Company Pvt. Ltd.**

Prepared By

*Sudip Nath*

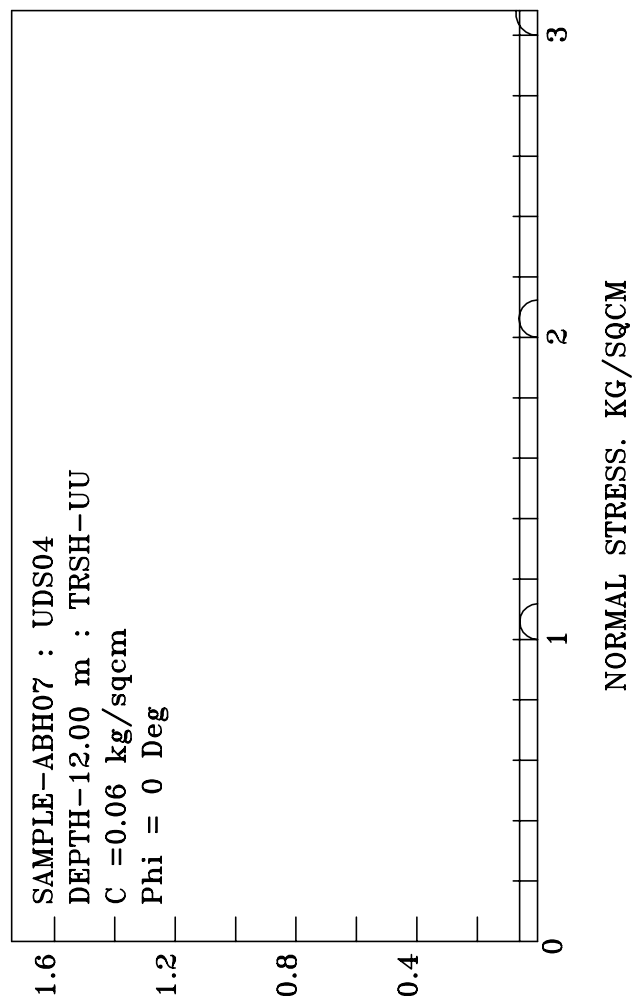
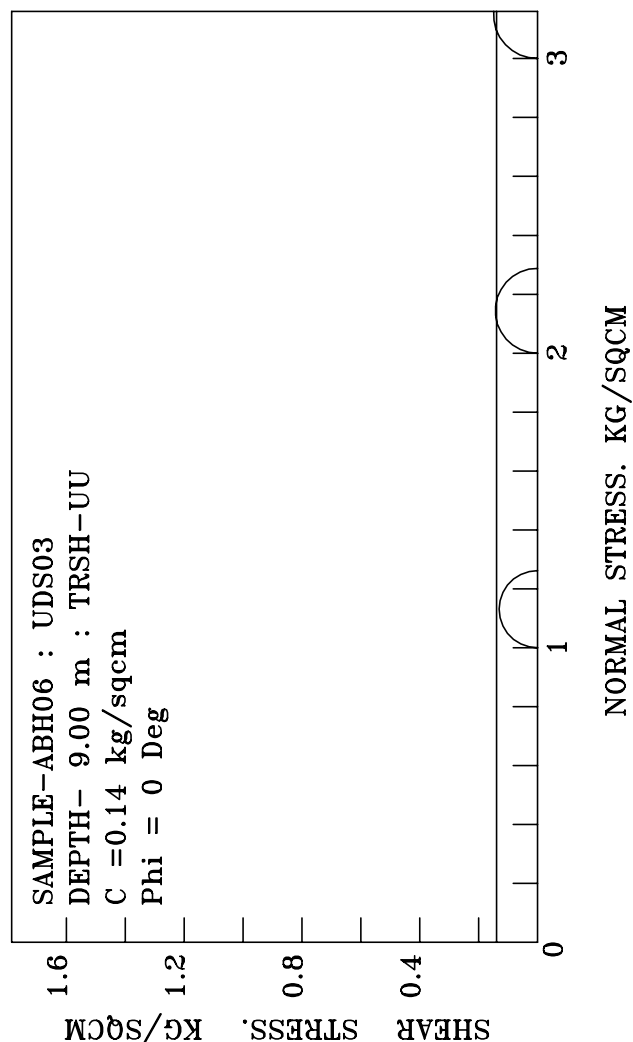
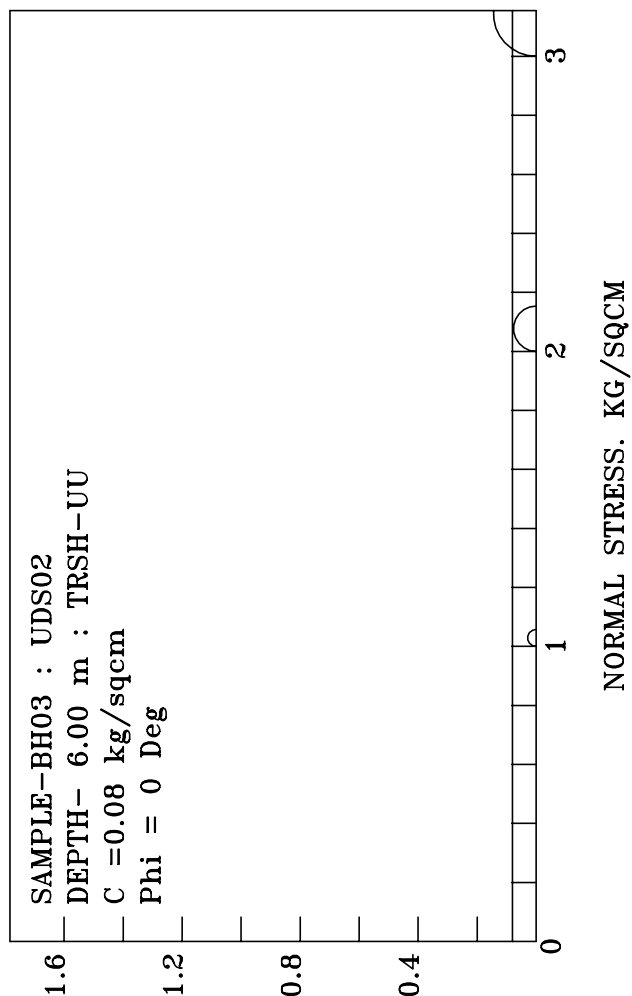
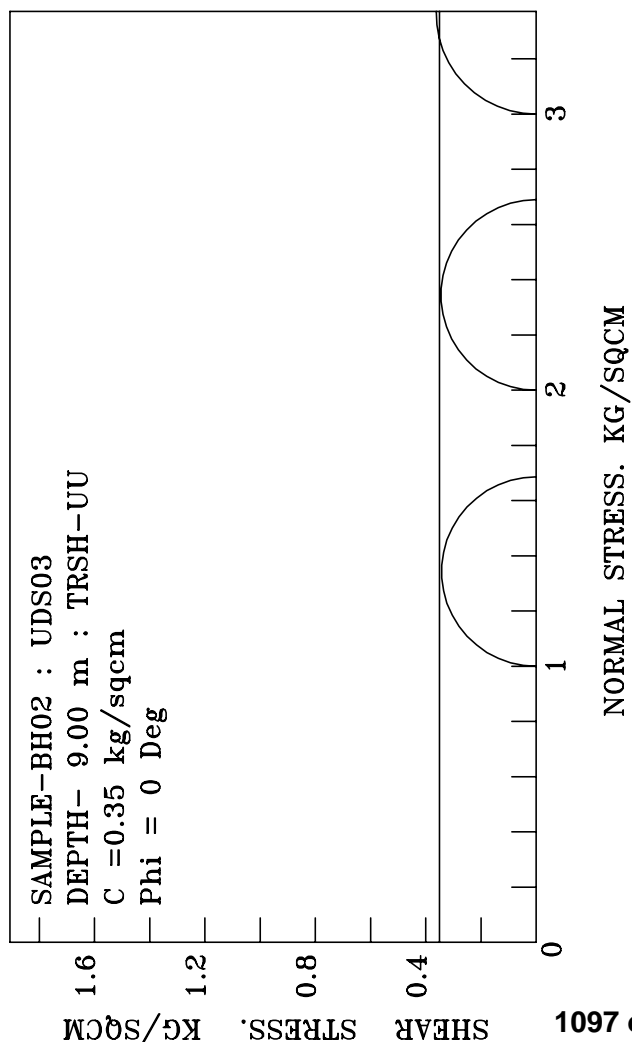
(I. Chowdhury)  
Deputy Technical Manager

Checked & Approved By

*Sudip Nath*

(Sudip Nath)  
Technical Manager

### **PART III: CHARTS & GRAPHS**



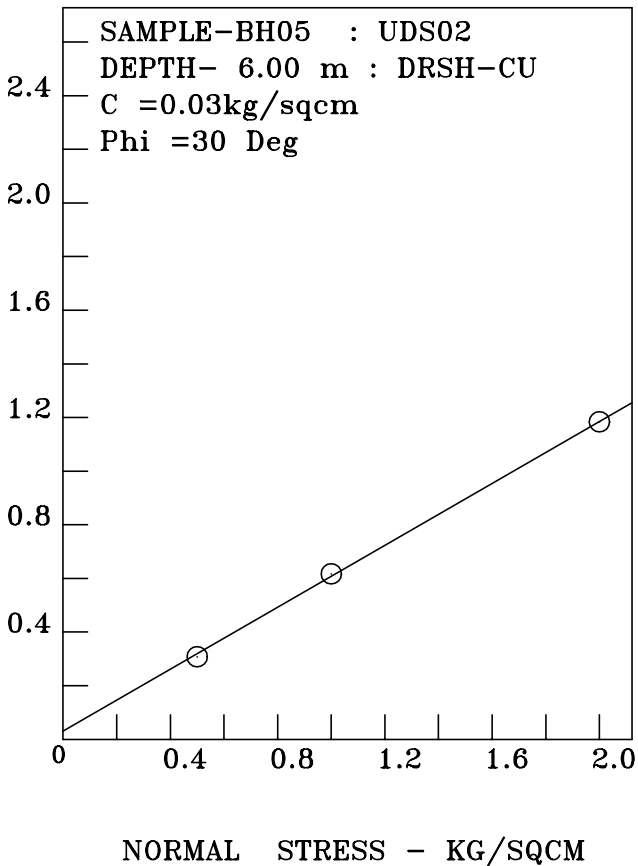
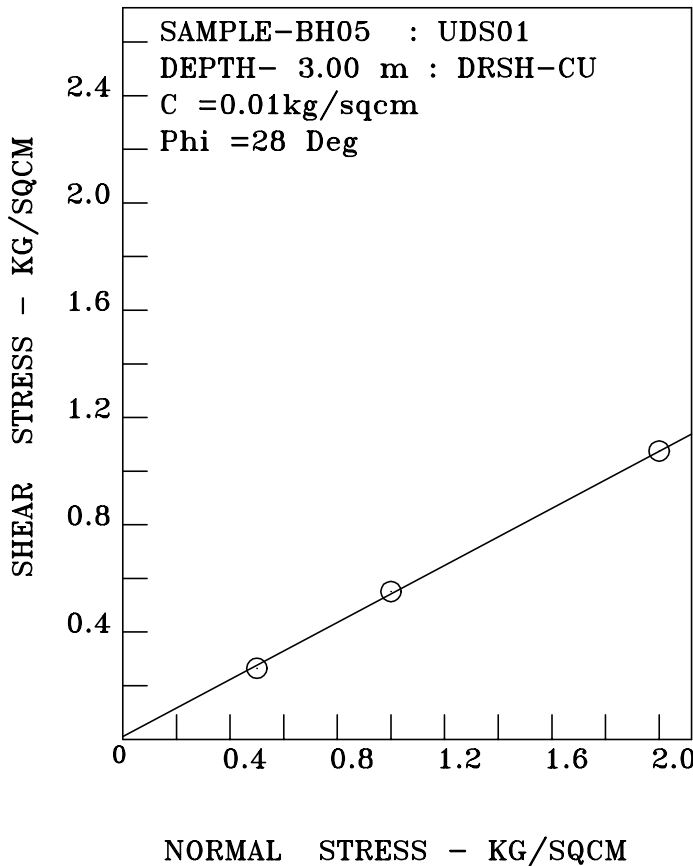
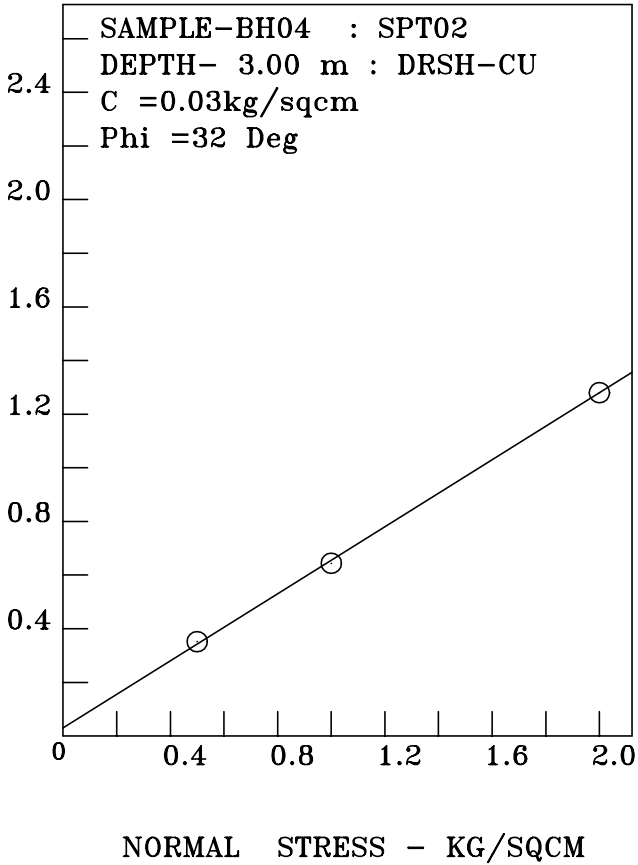
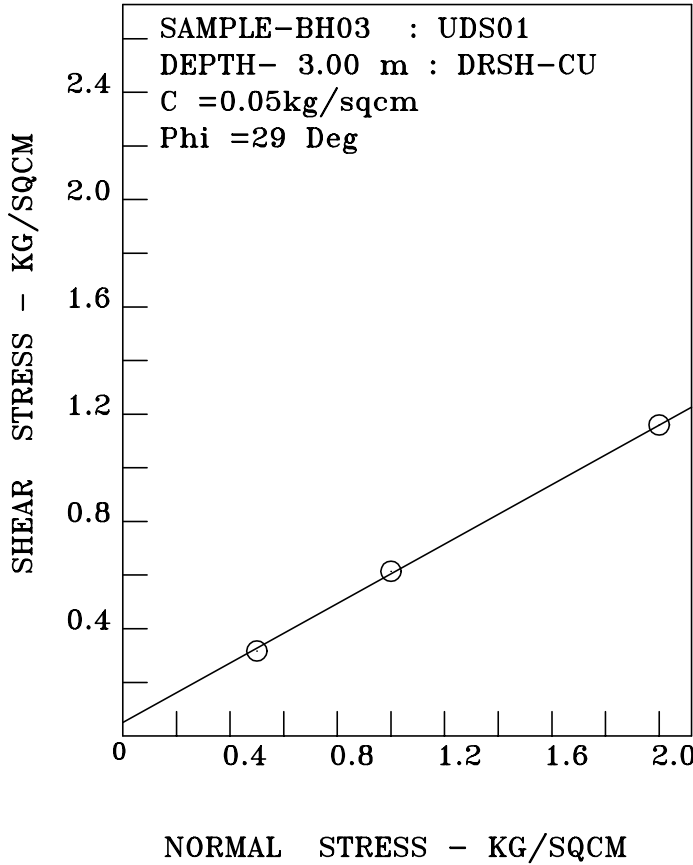


Job No :4095

Created by :S.Mal

Created on :

Sheet No:

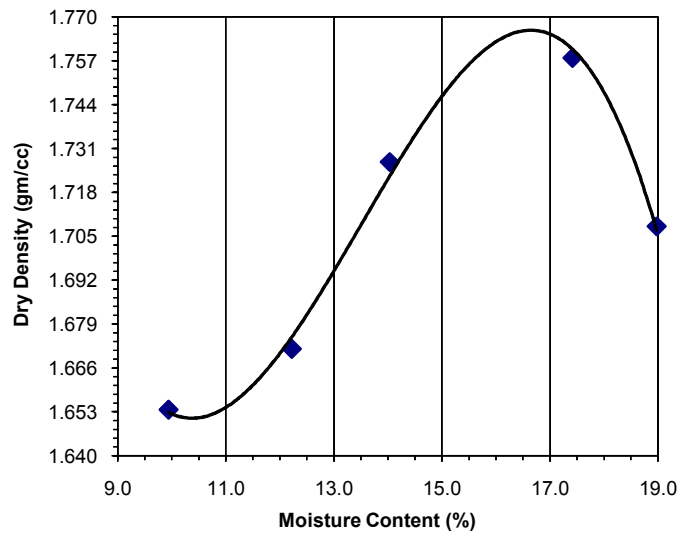


**C.B.R. & PROCTOR TEST RESULTS.**

TP01 / DS01

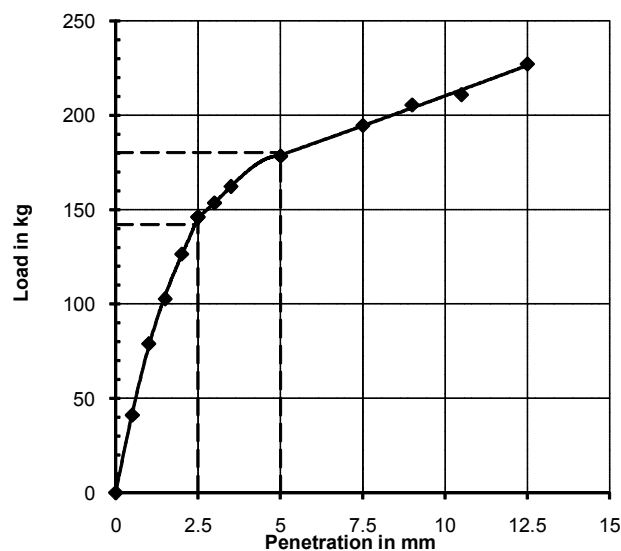
Depth = 1.00m

Maximum Dry Density : 1.766 gm/cc  
Optimum Moisture Content: 16.70 %

**O.M.C. GRAPH**

TYPE :- SOAKED

Penetration (mm)	CBR (%)
2.5	10.38
5.0	8.78

**CBR GRAPH**

**CONSOLIDATION TEST RESULTS**

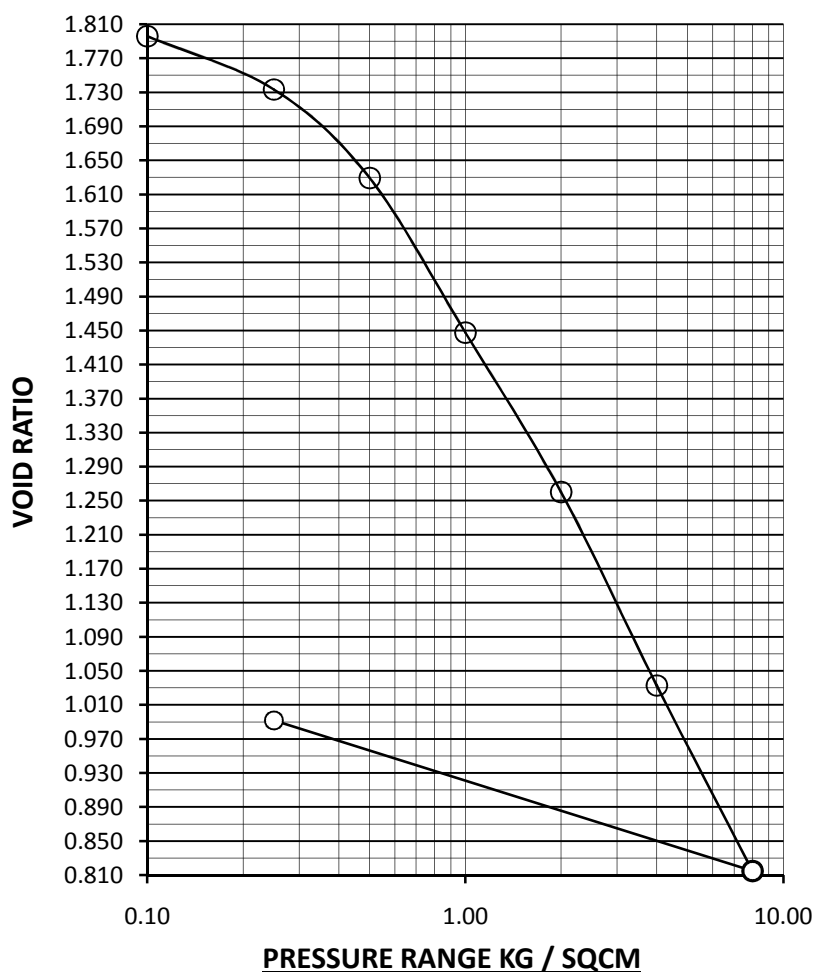
Sample Number: BH-01/UDS-02

Depth : 6-6.45 meters

Description : Deep grey silty clay with traces of organic matters.

Water content: Initial=76.9% Final =42.4% Initial Void Ratio =1.818

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	78	1.796	0.0781				
0.10 - 0.25	222	1.733	0.1494	5.41	0.1413	760.0	1.029
0.25 - 0.50	369	1.629	0.1524	4.34	0.1458	640.0	1.077
0.50 - 1.00	643	1.448	0.1381	5.29	0.1308	541.0	1.004
1.00 - 2.00	664	1.260	0.0766	3.61	0.0738	662.0	0.574
2.00 - 4.00	806	1.033	0.0503	3.72	0.0485	881.0	0.263
4.00 - 8.00	772	0.815	0.0268	4.79	0.0255	755.0	0.149
8.00 - 0.25	627	0.992	0.0126				

**e-logp Curve**

**CONSOLIDATION TEST RESULTS**

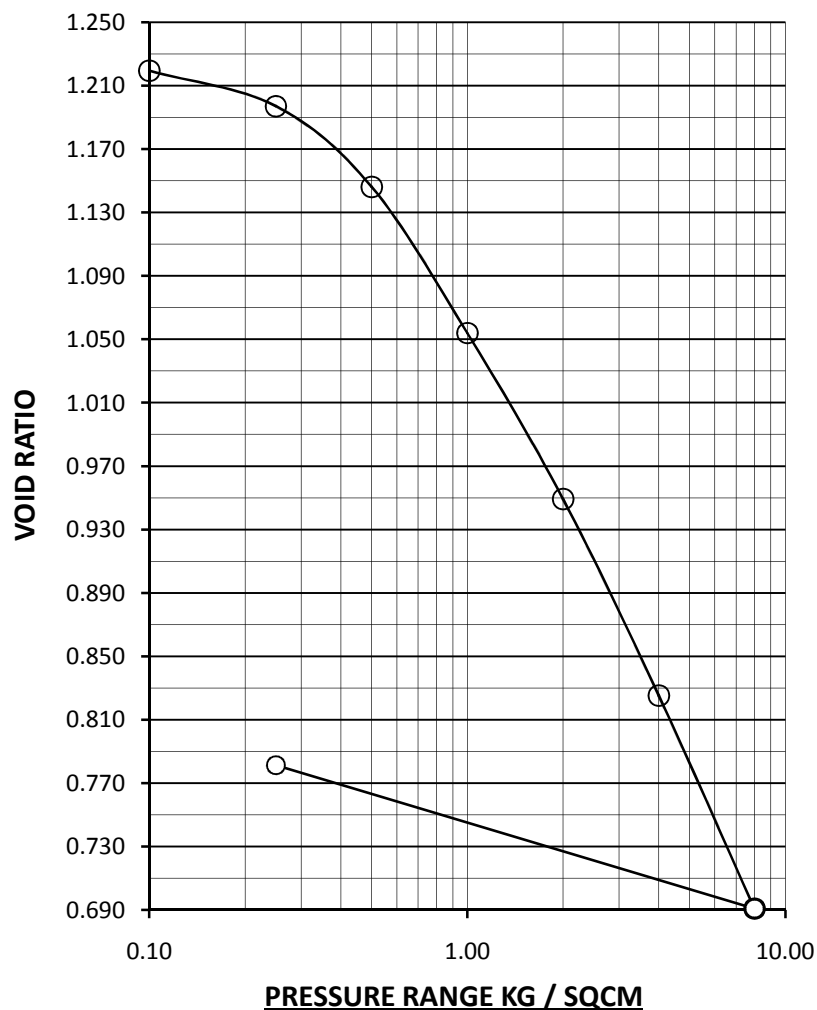
Sample Number: BH-02/UDS-01

Depth : 3-3.45 meters

Description : Deep grey silty clay with traces of organic matter.

Water content: Initial=53.2% Final =34.6% Initial Void Ratio =1.231

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	50	1.219	0.0500				
0.10 - 0.25	100	1.197	0.0671	14.00	0.0577	378.0	2.151
0.25 - 0.50	228	1.146	0.0927	6.58	0.0866	481.1	1.578
0.50 - 1.00	413	1.054	0.0859	9.44	0.0778	288.4	2.288
1.00 - 2.00	469	0.949	0.0510	4.26	0.0488	388.2	1.377
2.00 - 4.00	555	0.825	0.0318	7.31	0.0295	252.8	1.604
4.00 - 8.00	602	0.691	0.0184	7.21	0.0171	166.4	1.690
8.00 - 0.25	405	0.781	0.0069				

**e-logp Curve**

**CONSOLIDATION TEST RESULTS**

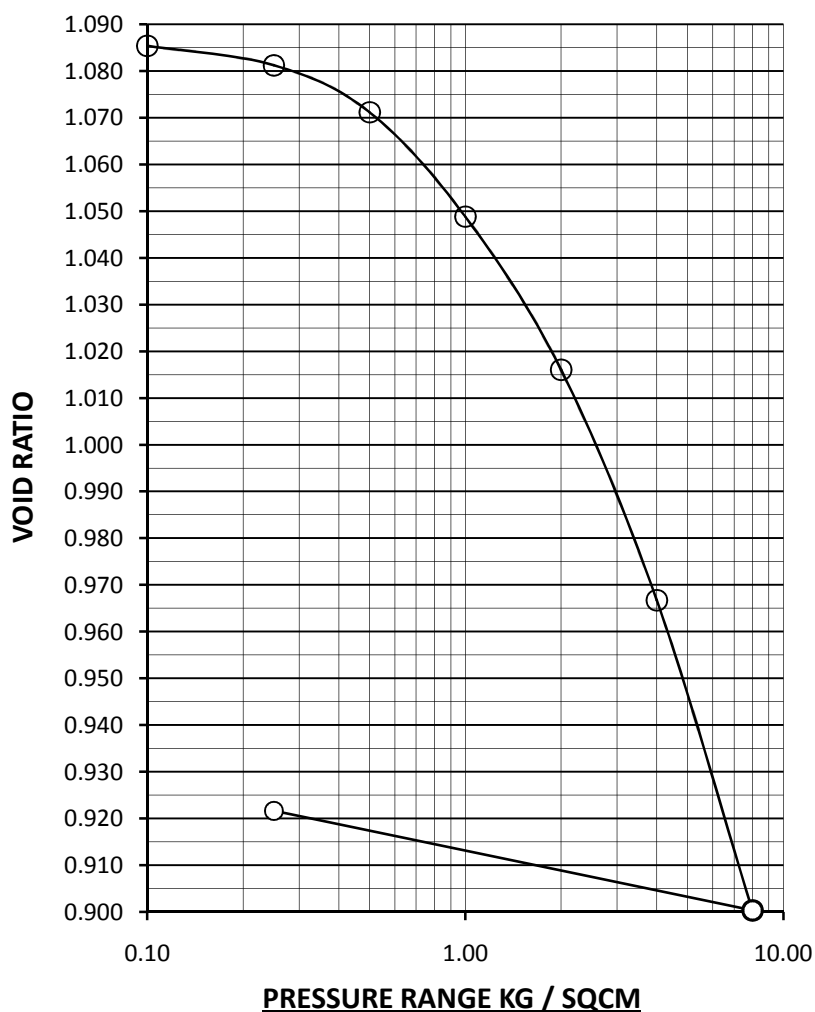
Sample Number: BH-02/UDS-03

Depth : 9-9.45 meters

Description : Deep grey silty clay with sand mixture &amp; traces of organic matter.

Water content: Initial=46.4% Final =31.9% Initial Void Ratio =1.087

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	6	1.085	0.0060				
0.10 - 0.25	20	1.081	0.0134	30.00	0.0093	185.9	4.525
0.25 - 0.50	48	1.071	0.0193	8.33	0.0177	691.8	1.199
0.50 - 1.00	107	1.049	0.0216	12.15	0.0190	786.3	1.022
1.00 - 2.00	157	1.016	0.0160	10.19	0.0144	163.4	4.658
2.00 - 4.00	236	0.967	0.0122	20.76	0.0097	393.2	1.778
4.00 - 8.00	318	0.900	0.0084	30.50	0.0059	848.3	0.727
8.00 - 0.25	102	0.922	0.0014				

**e-logp Curve**

**CONSOLIDATION TEST RESULTS**

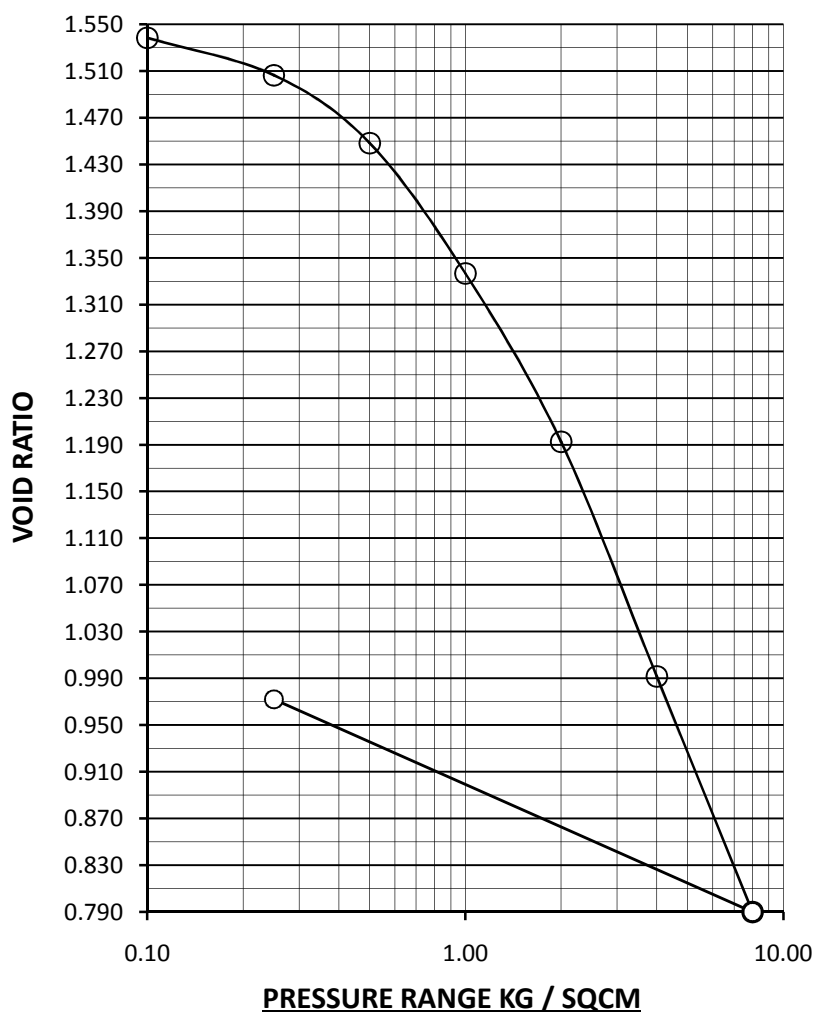
Sample Number: BH-03/UDS-02

Depth : 6-6.45 meters

Description : Deep grey silty clay with traces of organic matter.

Water content: Initial=69.1% Final =46.1% Initial Void Ratio =1.55

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	46	1.538	0.0459				
0.10 - 0.25	126	1.506	0.0843	11.11	0.0749	467.0	1.741
0.25 - 0.50	228	1.448	0.0927	12.28	0.0813	171.4	4.409
0.50 - 1.00	438	1.337	0.0911	2.51	0.0889	261.2	2.499
1.00 - 2.00	566	1.193	0.0617	7.95	0.0568	366.2	1.398
2.00 - 4.00	788	0.992	0.0458	4.06	0.0439	380.1	0.918
4.00 - 8.00	792	0.790	0.0253	5.05	0.0240	404.5	0.490
8.00 - 0.25	715	0.972	0.0131				

**e-logp Curve**

**CONSOLIDATION TEST RESULTS**

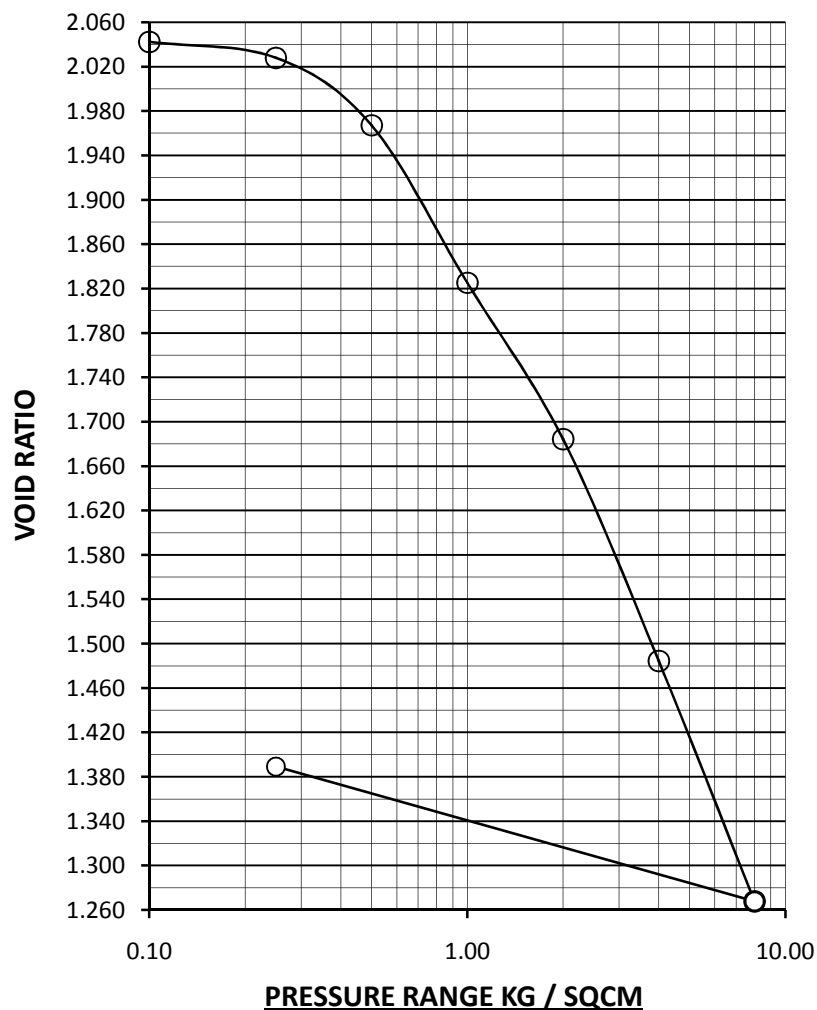
Sample Number: ABH-06/UDS-03

Depth : 9-9.45 meters

Description : Deep grey silty clay with traces of organic matter.

Water content: Initial=88.9% Final =46.4% Initial Void Ratio =2.052

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	31	2.042	0.0310				
0.10 - 0.25	47	2.028	0.0314	4.26	0.0301	194.4	4.269
0.25 - 0.50	199	1.967	0.0802	1.51	0.0790	266.5	2.961
0.50 - 1.00	465	1.825	0.0956	1.29	0.0944	364.4	1.878
1.00 - 2.00	462	1.684	0.0499	2.10	0.0488	561.2	0.981
2.00 - 4.00	655	1.485	0.0372	3.82	0.0358	398.8	1.024
4.00 - 8.00	710	1.268	0.0218	5.77	0.0205	266.4	0.989
8.00 - 0.25	398	1.389	0.0069				

**e-logp Curve**

Job No. 4095

Sheet No.

**CONSOLIDATION TEST RESULTS**

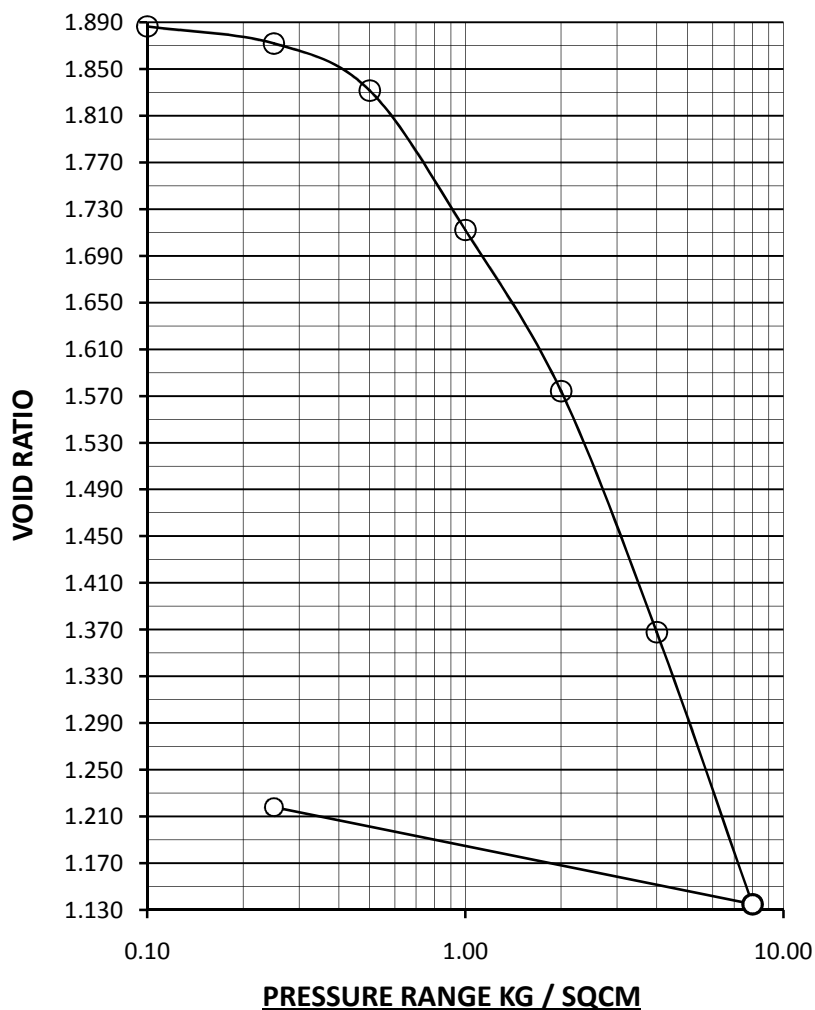
Sample Number: ABH-06/UDS-05

Depth : 15-15.45 meters

Description : Deep grey silty clay with traces of organic matter.

Water content: Initial=83.2% Final =46.9% Initial Void Ratio =1.894

$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000. $C_v$ sqcm/sec
0.00 - 0.10	27	1.887	0.0270				
0.10 - 0.25	51	1.872	0.0341	9.80	0.0308	261.6	3.170
0.25 - 0.50	139	1.832	0.0561	5.76	0.0528	112.6	7.084
0.50 - 1.00	412	1.712	0.0843	3.64	0.0812	366.2	1.938
1.00 - 2.00	476	1.574	0.0508	9.03	0.0462	488.1	1.185
2.00 - 4.00	713	1.368	0.0401	4.91	0.0381	520.0	0.815
4.00 - 8.00	804	1.135	0.0246	6.47	0.0230	475.2	0.550
8.00 - 0.25	287	1.218	0.0050				

**e-logp Curve**



**CONSOLIDATION TEST RESULTS**

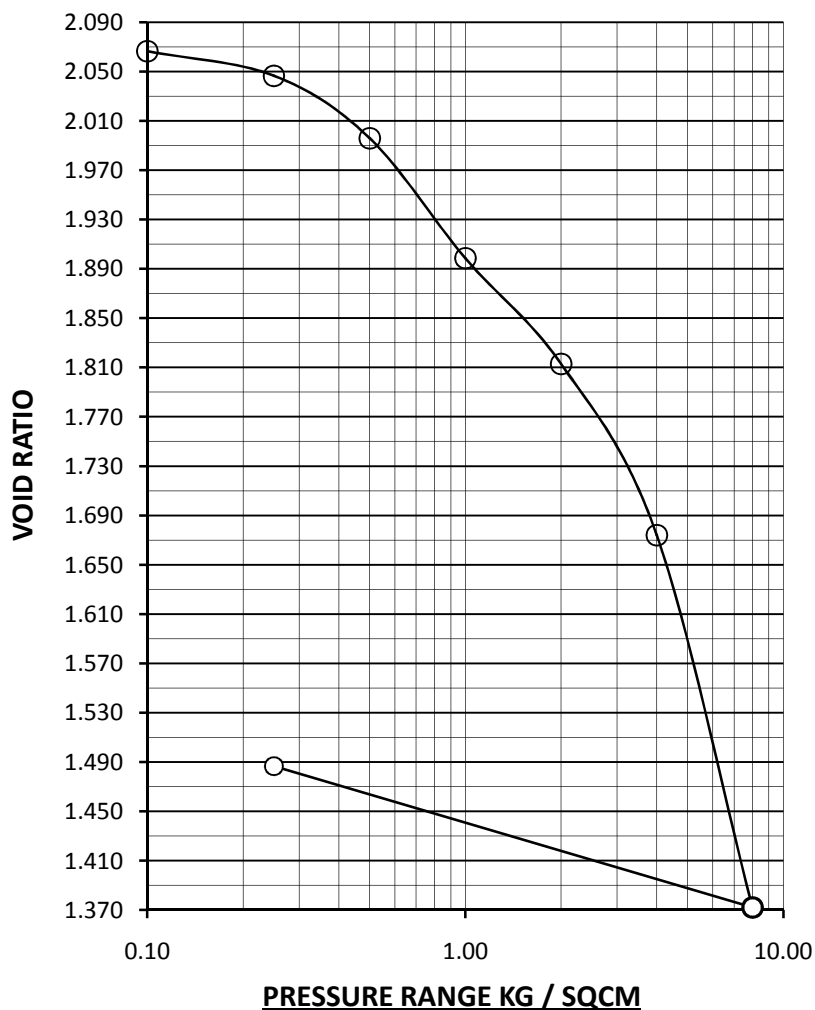
Sample Number: ABH-07/UDS-03

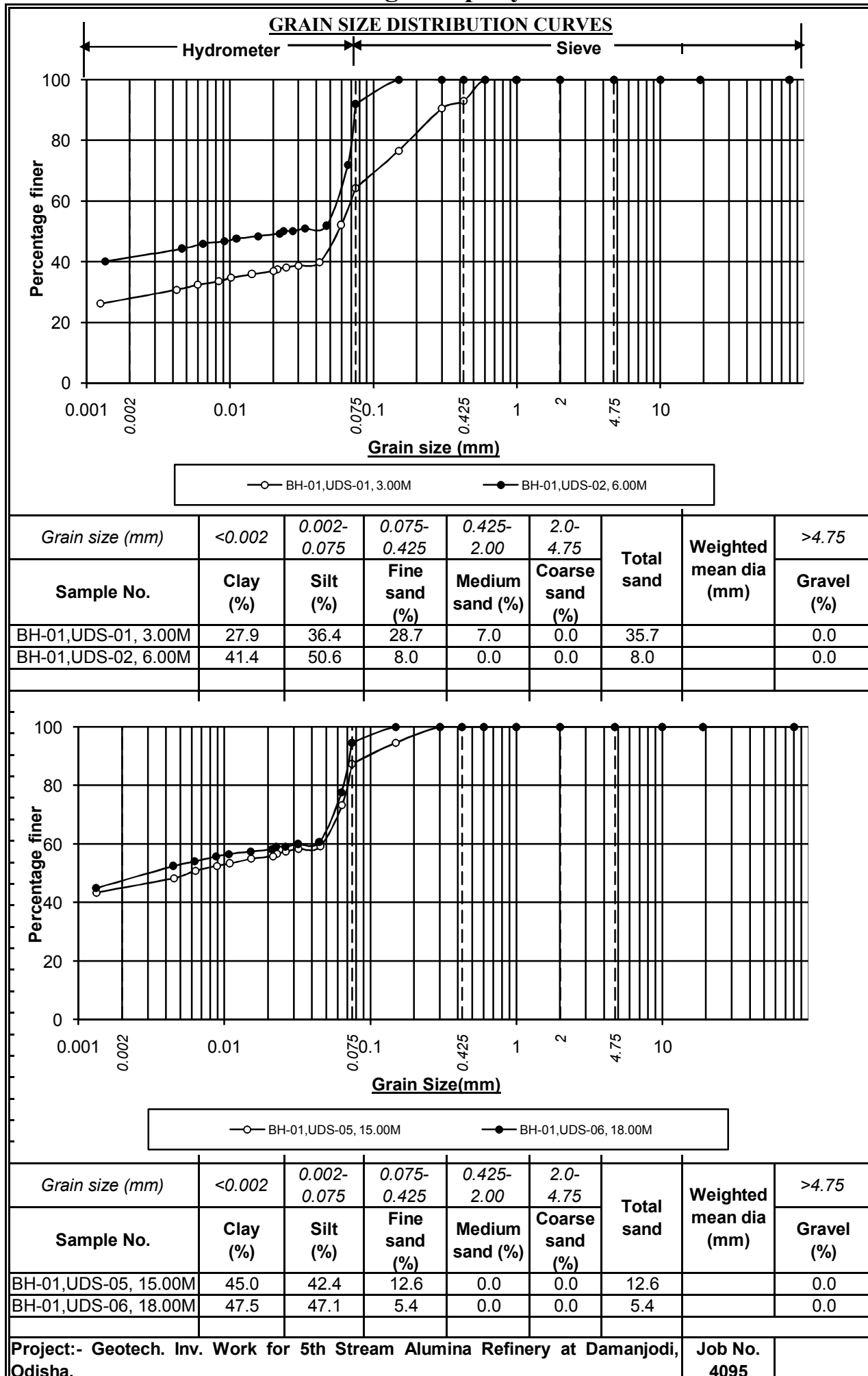
Depth : 9-9.45 meters

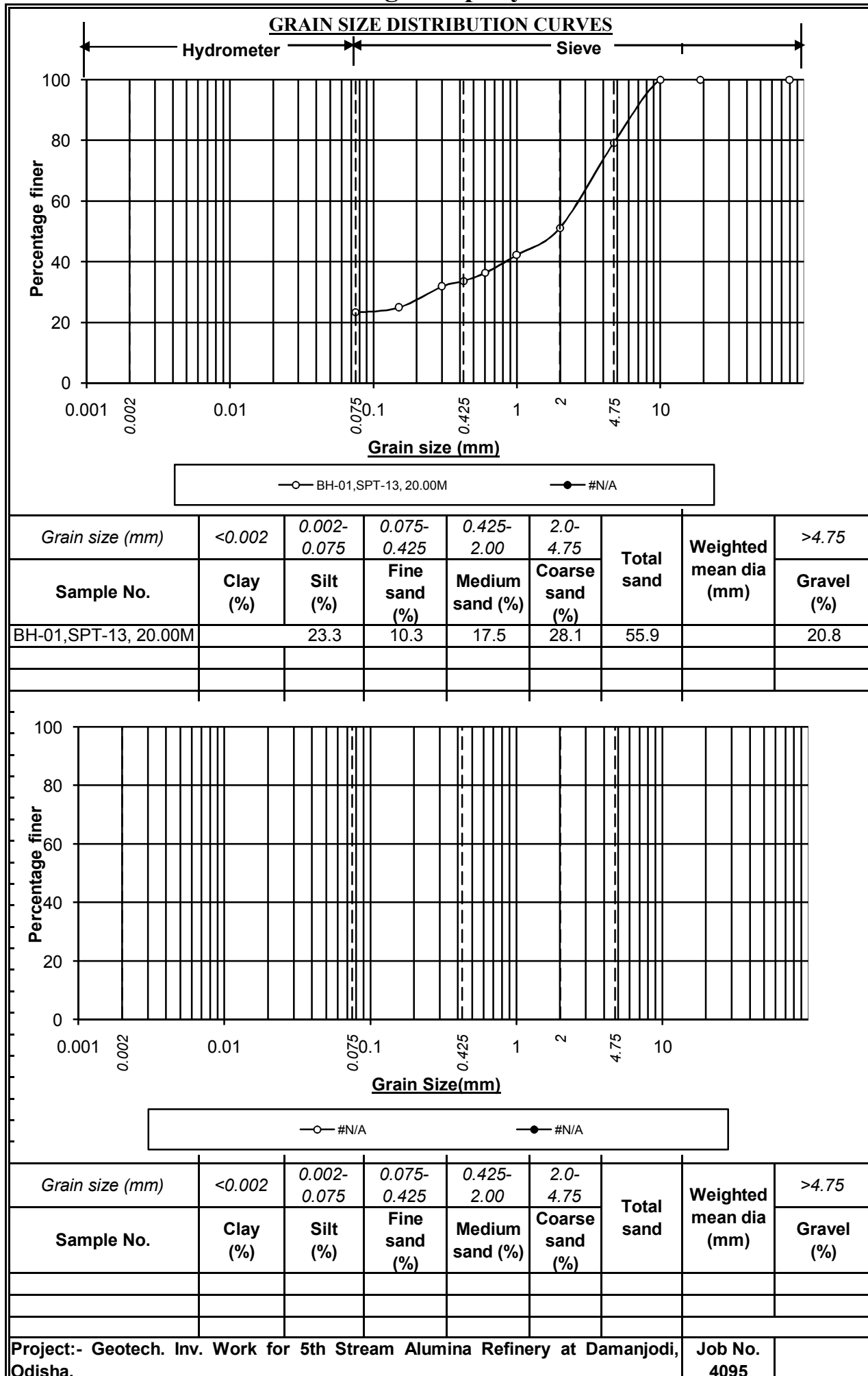
Description : Deep grey silty clay with organic matters.

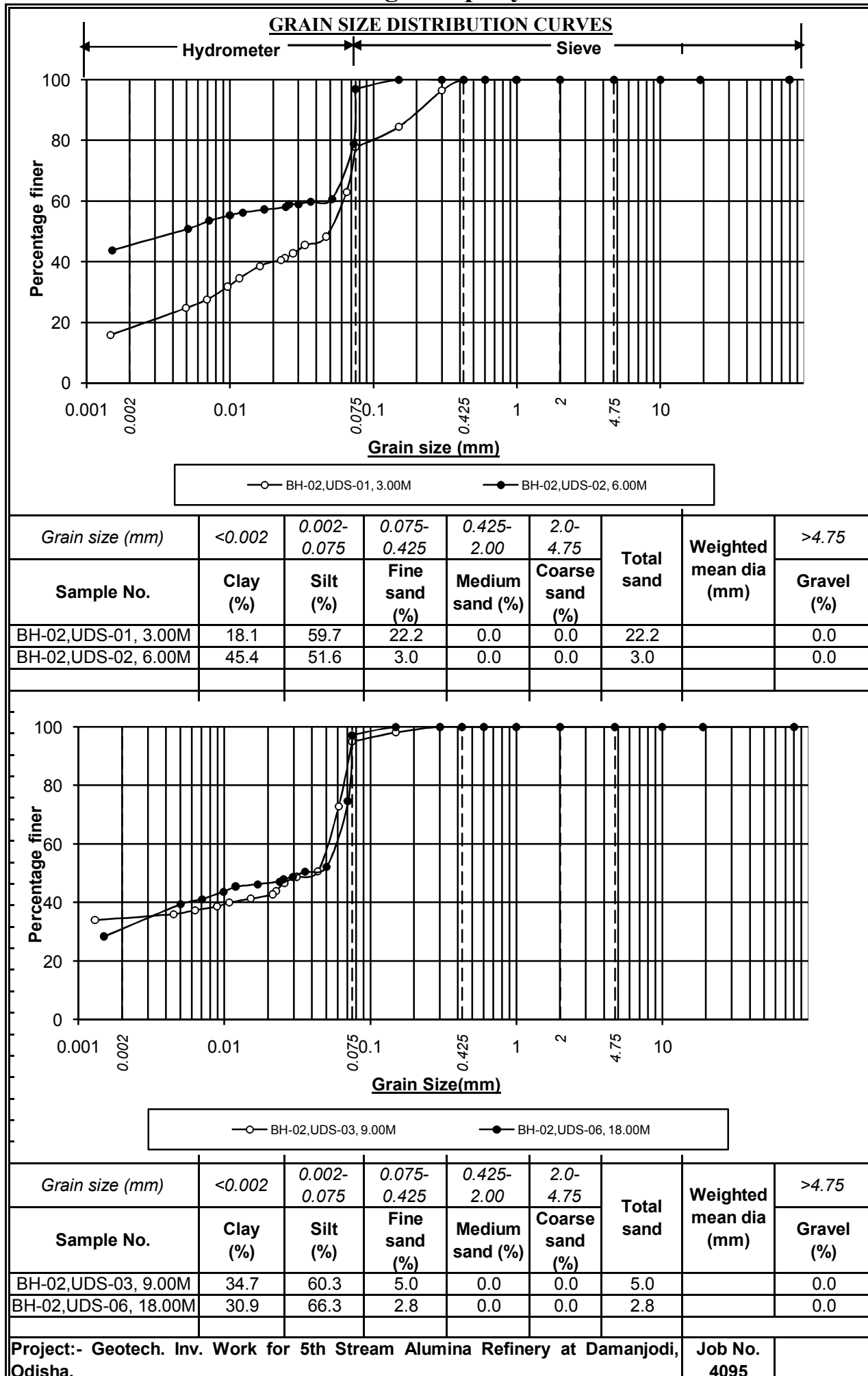
Water content: Initial=82.4% Final =45% Initial Void Ratio =2.08

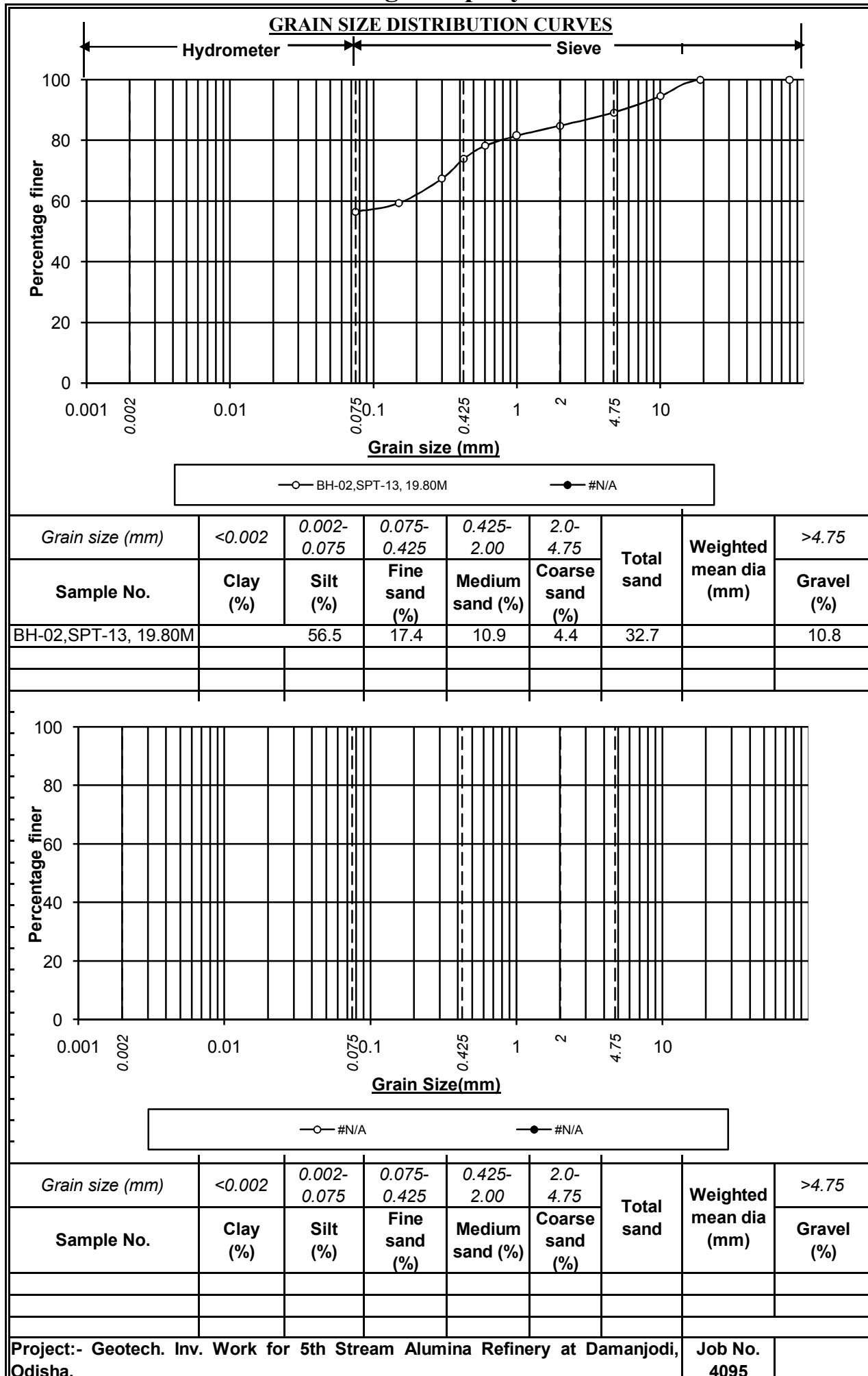
$P_1 - P_2$ Kg/Sqcm	Dial Change	Void Ratio	$M_v$ Sqcm/kg	Comprn %	$M_{vc}$ sqcm/kg	T90 Sec	1000.C <sub>v</sub> sqcm/sec
0.00 - 0.10	43	2.067	0.0431				
0.10 - 0.25	65	2.047	0.0436	3.08	0.0423	237.6	3.447
0.25 - 0.50	164	1.996	0.0665	2.60	0.0647	275.3	2.838
0.50 - 1.00	315	1.899	0.0649	3.49	0.0626	366.2	1.926
1.00 - 2.00	278	1.813	0.0296	7.91	0.0273	282.2	2.185
2.00 - 4.00	450	1.674	0.0247	4.89	0.0235	388.1	1.329
4.00 - 8.00	978	1.372	0.0282	4.81	0.0269	265.4	1.297
8.00 - 0.25	371	1.487	0.0062				

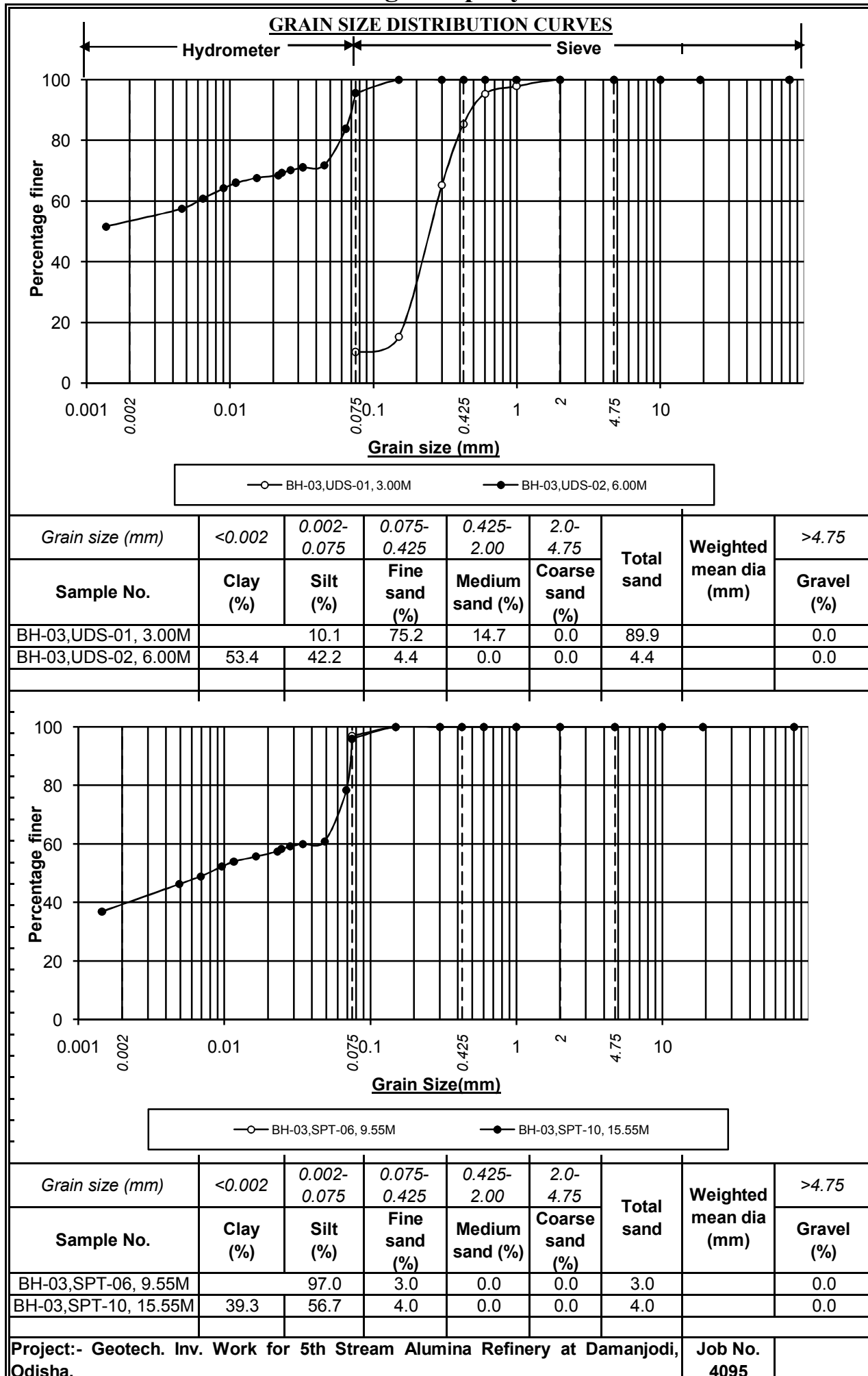
**e-logp Curve**

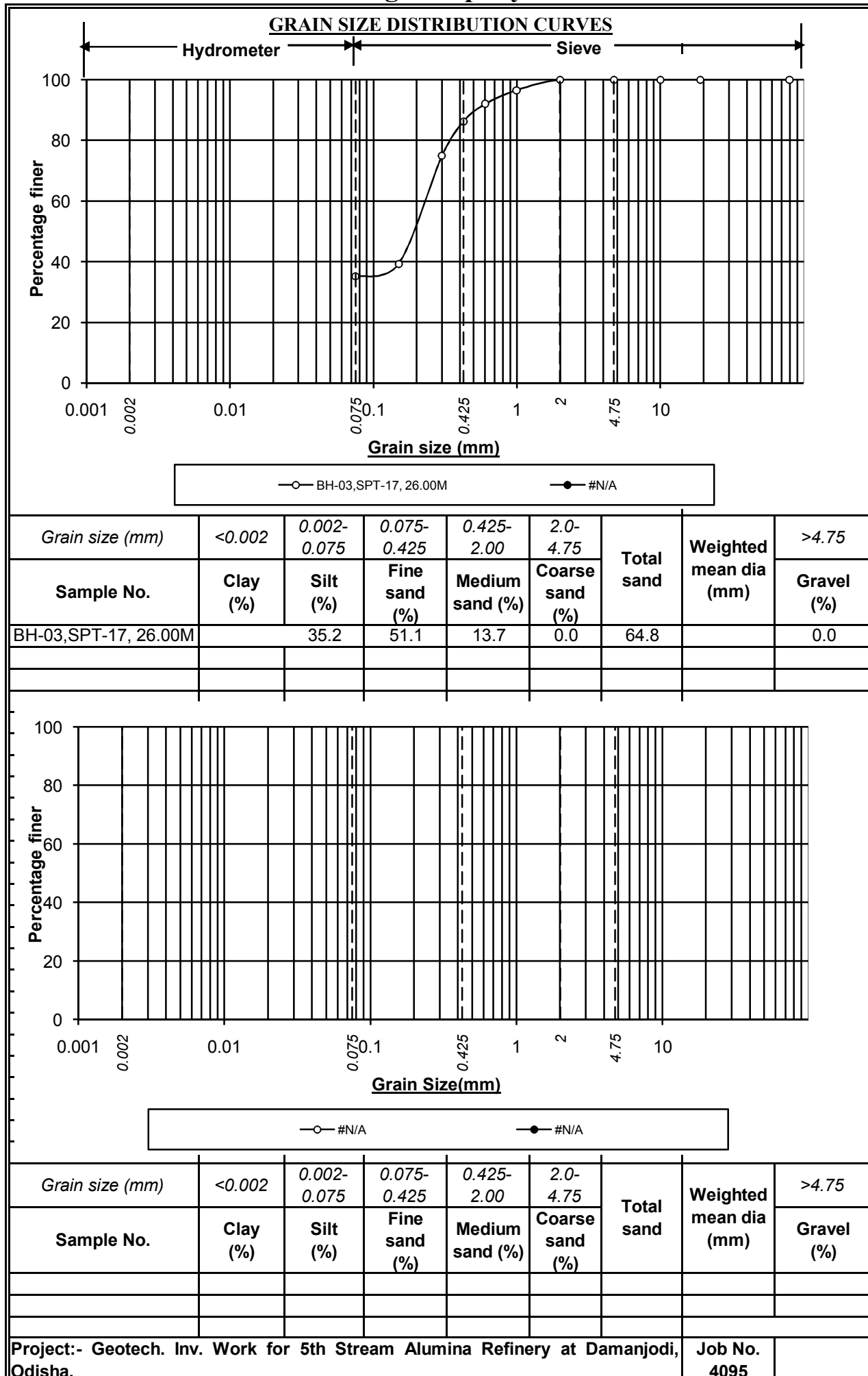


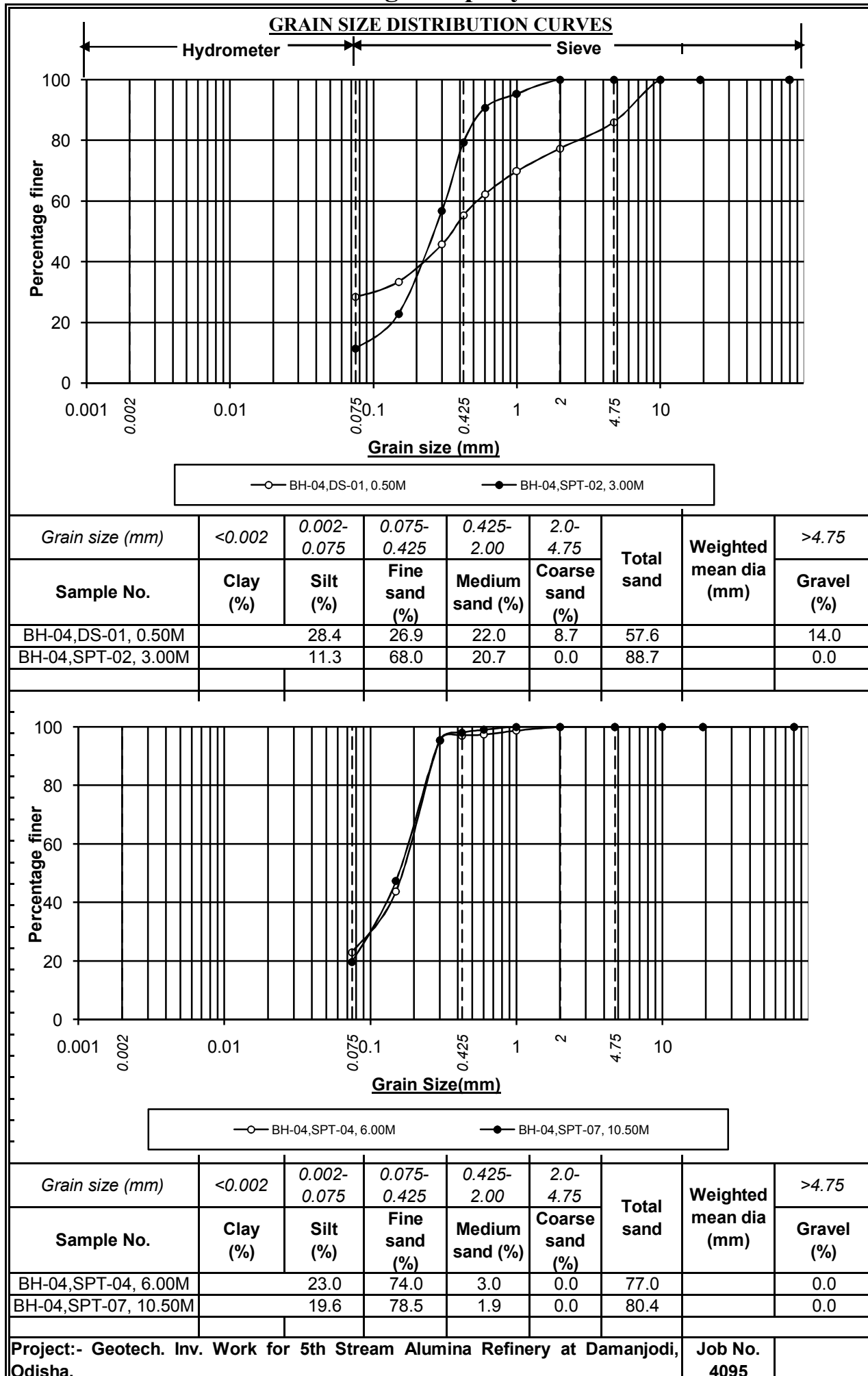




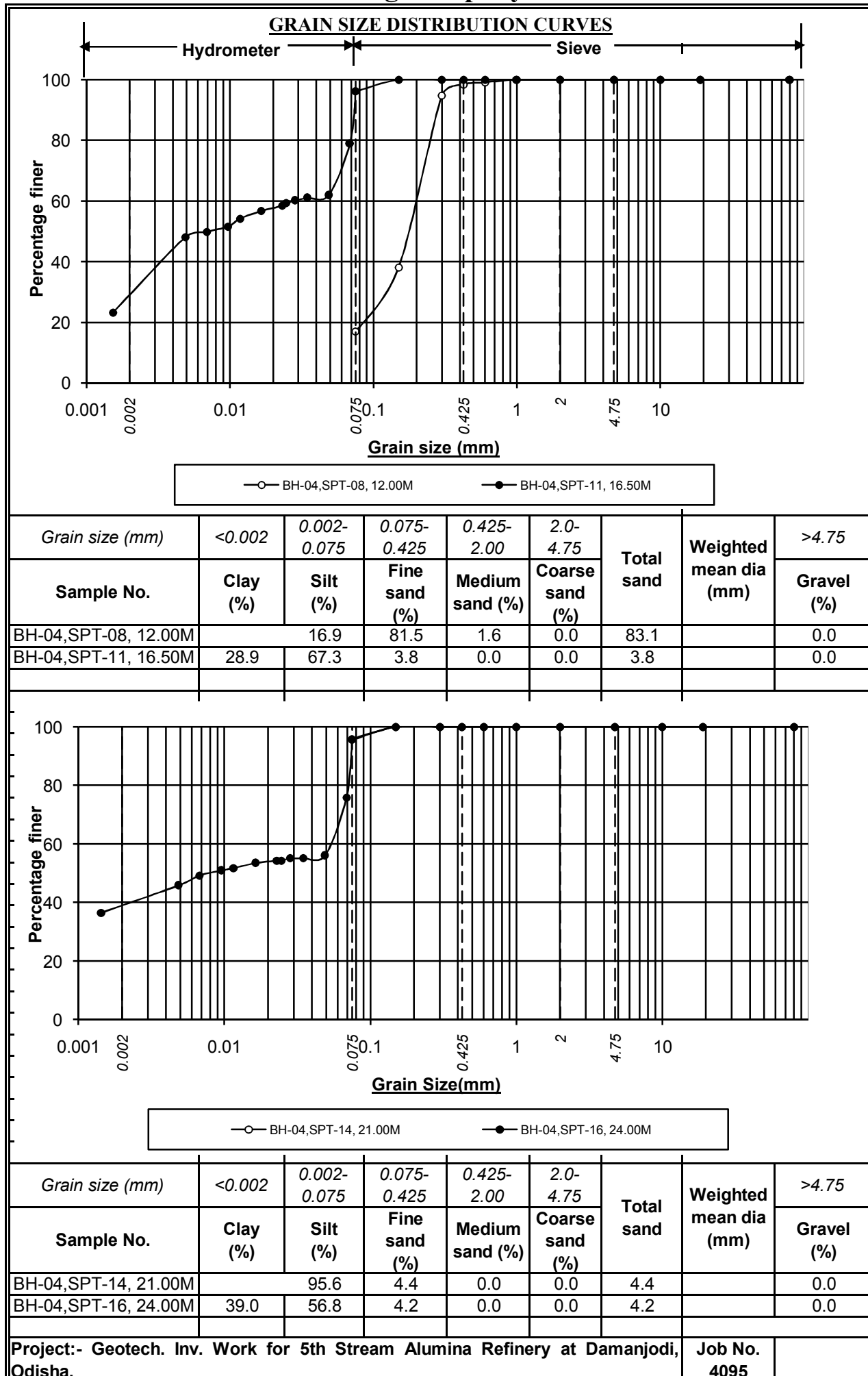


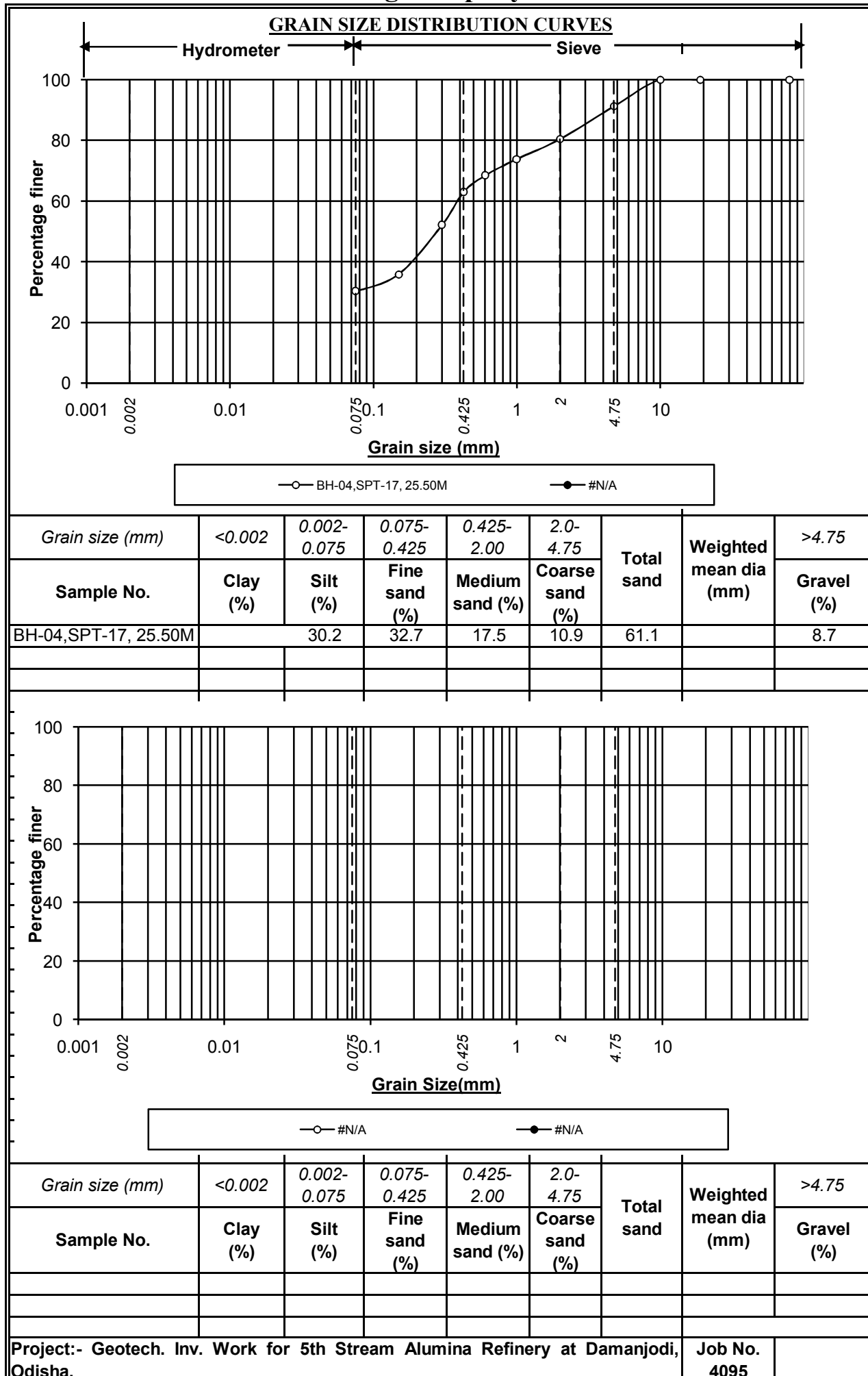


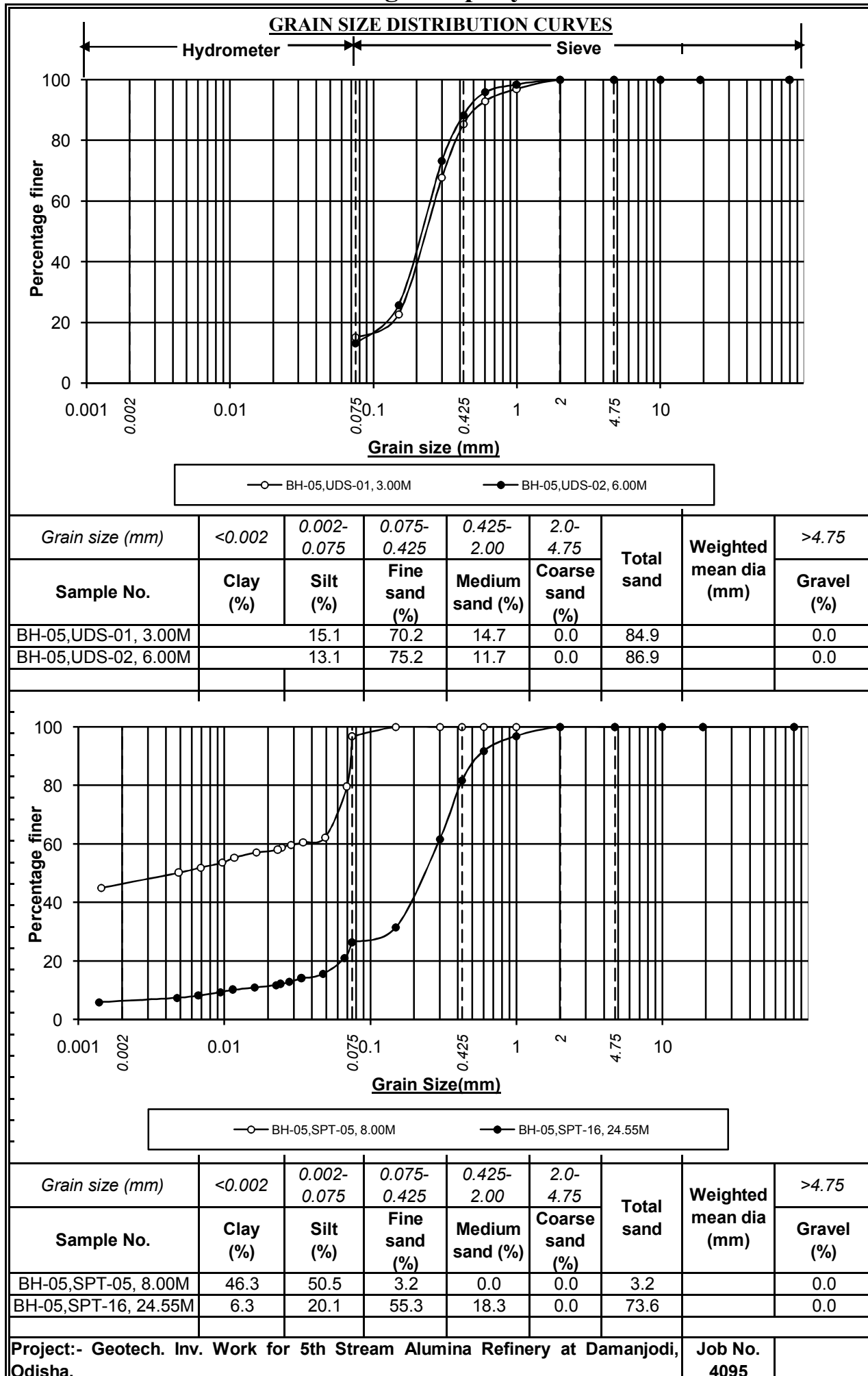


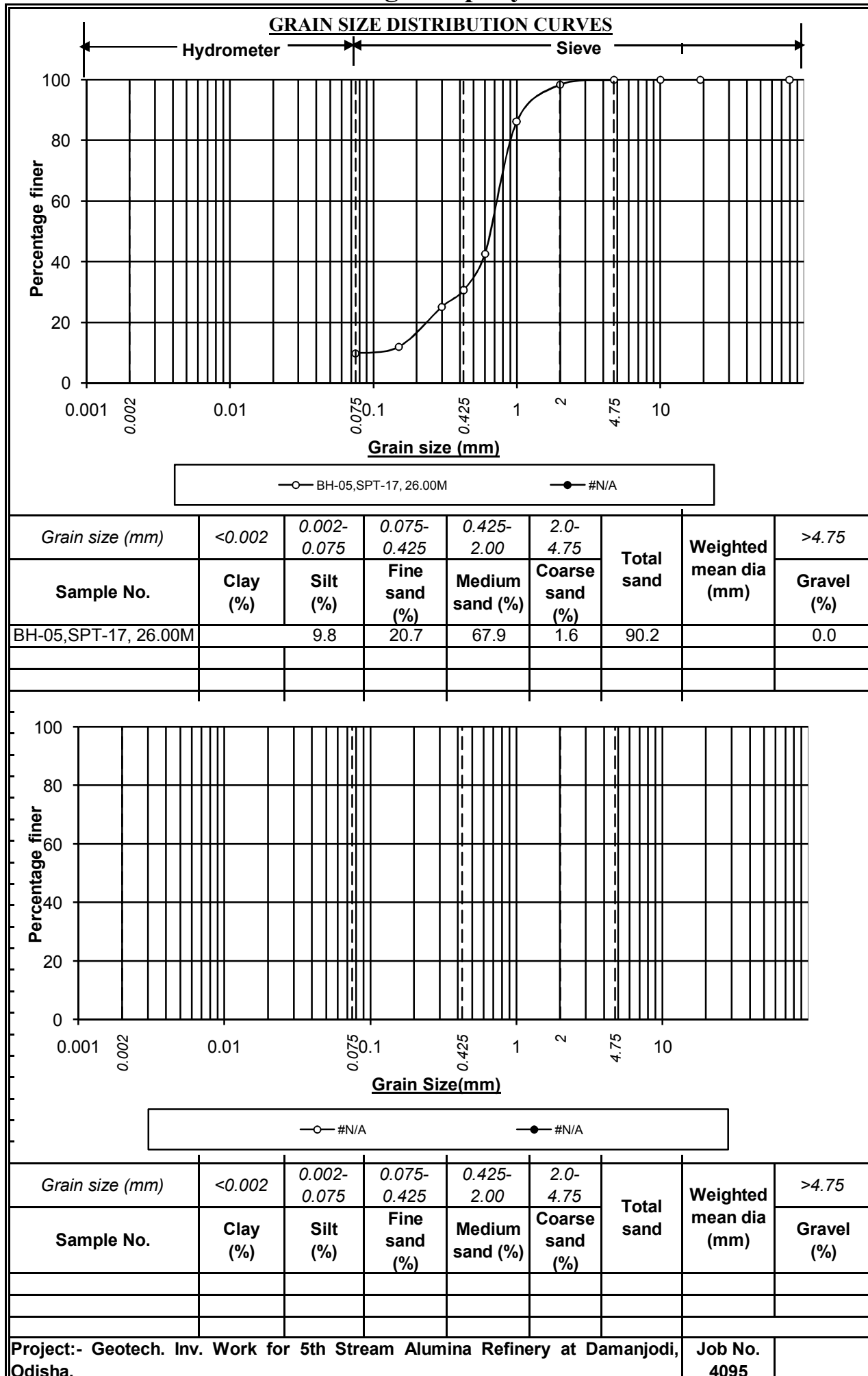


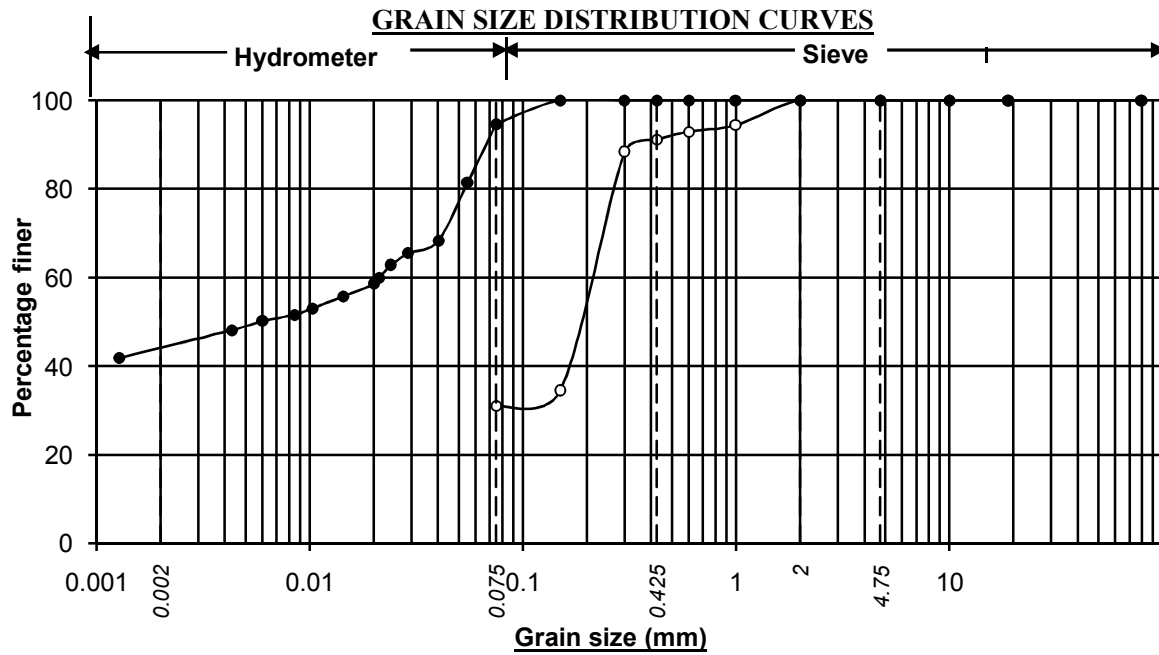




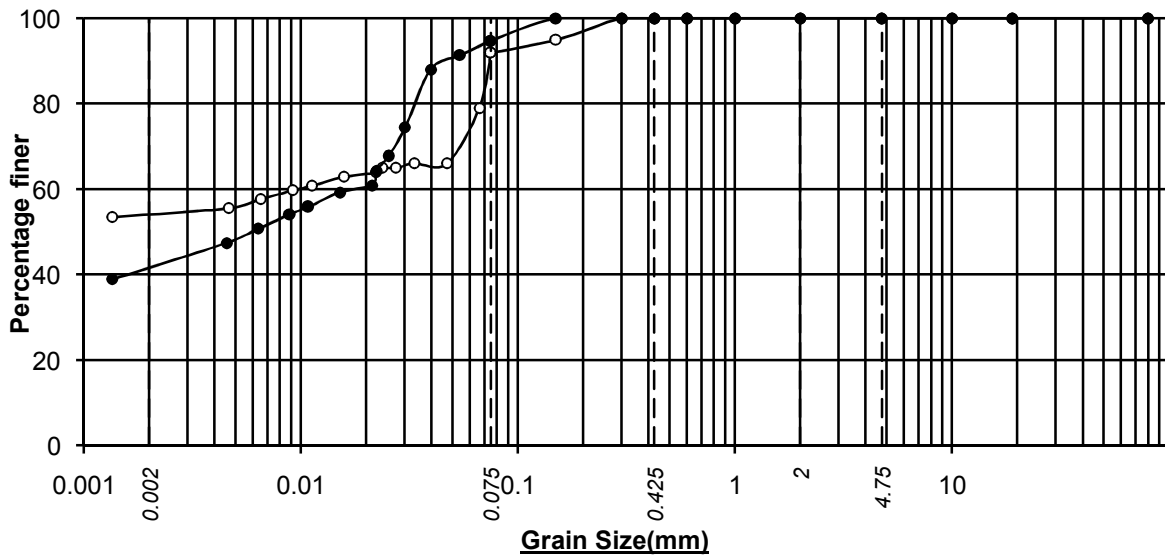








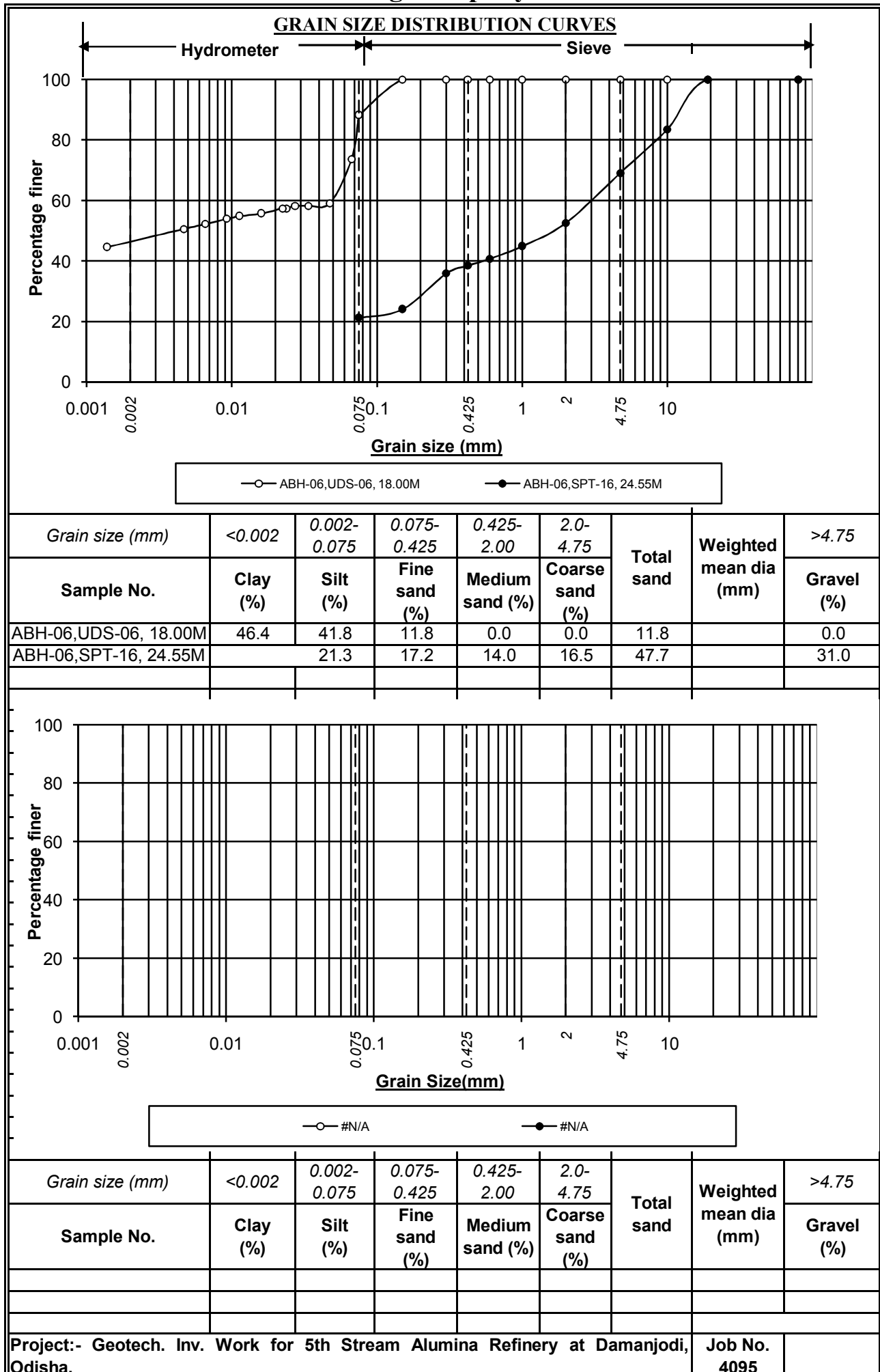
Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
ABH-06,SPT-03, 5.00M		31.0	60.1	8.9	0.0	69.0		0.0
ABH-06,UDS-03, 9.00M	44.1	50.5	5.4	0.0	0.0	5.4		0.0

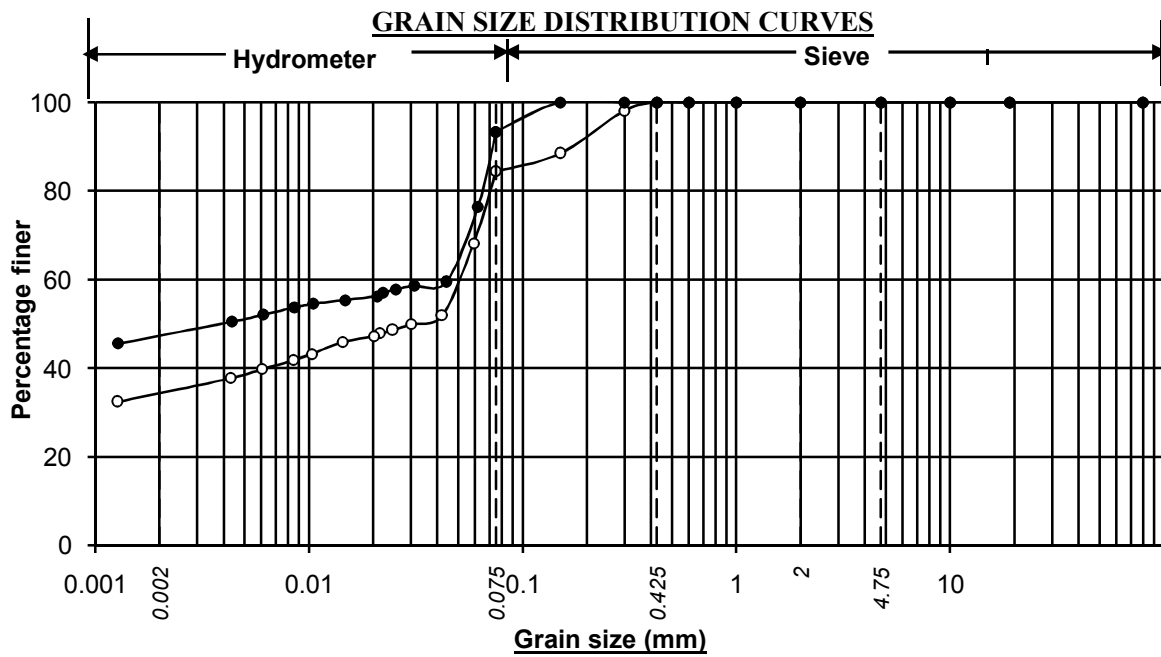


Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
ABH-06,UDS-04, 12.00M	54.1	37.9	8.0	0.0	0.0	8.0		0.0
ABH-06,UDS-05, 15.00M	41.6	53.2	5.2	0.0	0.0	5.2		0.0

**Project:- Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.**

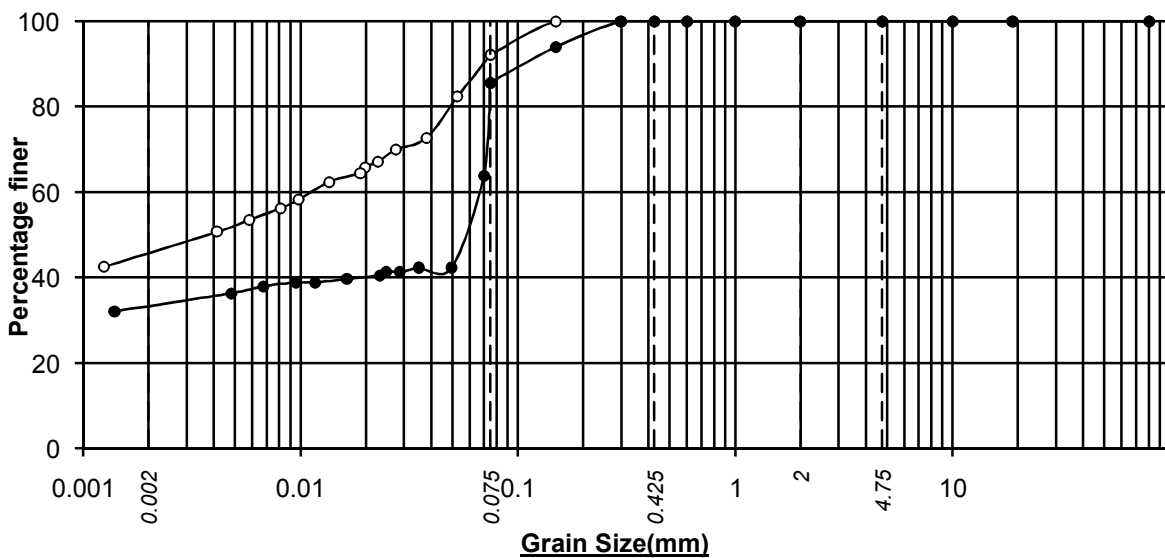
**Job No.  
4095**





—○— ABH-07,SPT-03, 5.00M      —●— ABH-07,UDS-03, 9.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
ABH-07,SPT-03, 5.00M	34.4	50.1	15.5	0.0	0.0	15.5		0.0
ABH-07,UDS-03, 9.00M	47.4	46.0	6.6	0.0	0.0	6.6		0.0

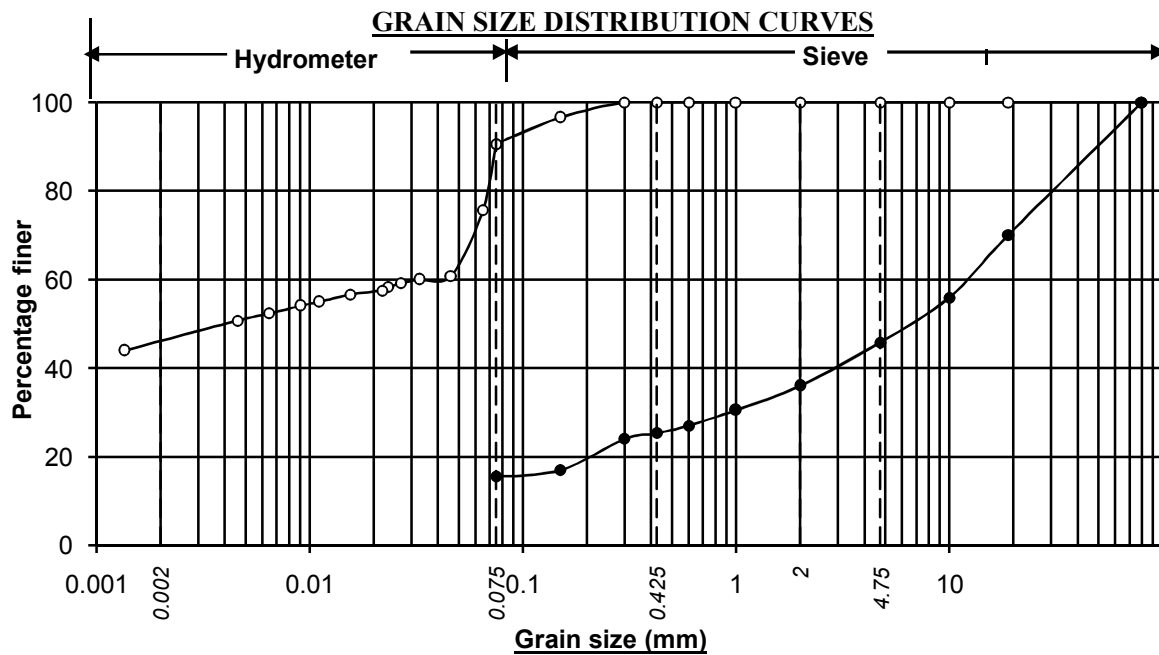


—○— ABH-07,UDS-04, 12.00M      —●— ABH-07,UDS-05, 15.00M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
ABH-07,UDS-04, 12.00M	45.7	46.4	7.9	0.0	0.0	7.9		0.0
ABH-07,UDS-05, 15.00M	33.3	52.3	14.4	0.0	0.0	14.4		0.0

**Project:- Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.**

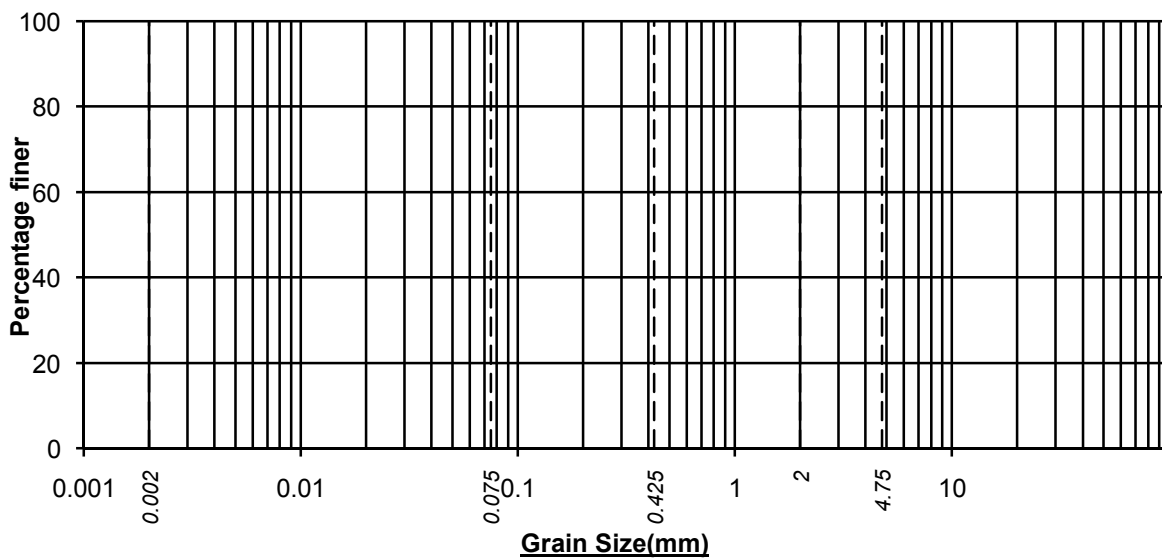
**Job No.  
4095**



—○— ABH-07,UDS-06, 18.00M

—●— ABH-07,SPT-16, 24.55M

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)
ABH-07,UDS-06, 18.00M	46.1	44.5	9.4	0.0	0.0	9.4		0.0
ABH-07,SPT-16, 24.55M		15.5	9.8	10.7	9.8	30.3		54.2



—○— #N/A

—●— #N/A

Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.00	2.0-4.75	Total sand	Weighted mean dia (mm)	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)			Gravel (%)

Project:- Geotech. Inv. Work for 5th Stream Alumina Refinery at Damanjodi, Odisha.

Job No.  
4095



## **PART IV: SAMPLE CALCULATION**

### SAMPLE PILE CAPACITY CALCULATION (Around BH-03)

Bottom depth of Pile = 28.00 m below EGL  
 Cut-off Length = 2.50 m  
 Diameter of Pile = 750 mm  
 FOS of Shaft Resistance = 2.50  
 FOS for End Bearing = 2.50  
 So, maximum Depth upto which pressure will increase = 11.25 m

Critical depth  
 Maximum OVP = 15.00 D  
 6.6525 t/sqm

Layer No.	Top Depth (M)	Bottom Depth (M)	Eff. Depth (M)	Cohesion (kg/sqcm)	$\Phi$ (Degree)	Adhesion Factor ( $\alpha$ )	$K_0$	Eff. Density (gm/cc)	Mean Pressure (t/sqm)
IV	2.50	8.00	5.50	0.00	28	1.000	1.00	0.60	3.15
I	8.00	26.00	18.00	0.25	0	1.000	1.00	0.57	6.49
VI	26.00	28.00	2.00	0.00	32	1.000	1.10	0.90	6.65

Layer No.	Eff. Depth (M)	Effective $\sigma_z$ (t/sqm)	$f_{s1} = \alpha C$	$f_{s2} = K_0 \sigma_z \tan \Phi$	$f_s = f_{s1} + f_{s2}$ (t/sqm)	Ultimate Shaft Resistance (T)	Safe Shaft Resistance (T)
IV	5.50	3.15	0.00	1.67	1.67	21.70	8.68
I	18.00	6.49	2.50	0.00	2.50	106.03	42.41
VI	2.00	6.65	0.00	4.57	4.57	21.55	8.62
	25.50					149.28	59.71

#### For End Bearing

Cohesion C = 0 kg/sqcm  
 Friction Angle = 32 °  
 So,  $N_c$  = 62  
 $N_q$  = 29.44  
 Eff. Ovp. Pressure =  $p(\text{tip})$   
 $q(\text{tip}) = C.N_c + p(\text{tip}).N_q = 195.83$  t/sqm  
 Ultimate End Bearing = 86.51 T  
 Safe End Bearing = 34.61 T  
 Safe Shaft Resistance = 59.71 T  
 So, Total Pile Capacity = 94.32 T

#### Uplift Pile Capacity:

Uplift capacity =  $\frac{1}{3} \times [(\text{Shaft Resistance in Vertical Capacity}) + \text{self weight of pile (Buoyant)}]$   
 $= \frac{1}{3} \times [149.28 + (3.1415/4) \times (750/1000)^2 \times (28 - 2.5) \times (2.5 - 1)]$   
 $= 55.39$

**So, Recommended Uplift Capacity = 55 ton**

**So, Recommended Vertical Pile Capacity = 90 T**

## **PART V: PHOTOGRAPHS**









