REPORT ON GEOTECHNICAL INVESTIGATION CARRIED OUT FOR THE ETP-I PROJECT AT HALDIA REFINERY, IOCL, HALDIA, MEDINIPUR (E), WB

::CLIENT::
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District: Purba Medinipur,
West Bengal-721606

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PREFACE

In connection with the ETP-I Project at Haldia Refinery at IOCL, Haldia in East Medinipur W.B, it was felt necessary to carry out a detailed study about the soil before finalizing the choice and depth of foundations.

The assignment was carried out under the authority of **INDIAN OIL CORPORATION LIMITED, Haldia, West Bengal-721605** by **EFFWA INFRA & RESEARCH PRIVATE LIMITED,** Unit No. 07, Vardhman Complex, LBS Marg, Gokul Nagar, Thane - 400601**.** The fieldwork commenced on **28.11.2023** after receipt of WORK ORDER NO.- **29082860** dated **01.08.2023** and was completed on **01.12.2023**.

The report presented in the following pages is the outcome of thorough visual examination of the site, the samples and careful study of the data collected during the course of fieldwork and laboratory testing by a team of qualified Geotechnical engineers. The laboratory tests were carried out strictly in compliance with the relevant Indian Standard specifications under the vigilance of competent laboratory personnel. Checking and cross checking of test data were carried out to finally arrive at the reliable results. The fieldwork has been elaborated in Section - I whilst Section - II covers the field test and the ground condition. Section – III presents method of calculation, SBC and recommendation.

TABLE OF CONTENTS

TABLE OF APPENDIX

SECTION-I

1.0 INTRODUCTION & INVESTIGATION SCHEME

The soil investigation work in connection with the ETP-I Project **at Haldia Refinery, IOCL, Haldia** was awarded to **EFFWA INFRA & RESEARCH PRIVATE LIMITED,** Unit No. 07, Vardhman Complex, LBS Marg, Gokul Nagar, Thane – 400601 by **INDIAN OIL CORPORATION LIMITED,** Haldia Refinery, P.O.: Haldia Oil Refinery, District: Purba Medinipur, West Bengal-721606.

The assignment includes the following:

a) Construction of **2** boreholes through soil.
b) Collection of disturbed representative soil samples.
c) Collection of undisturbed soil samples.
d) Conducting SPT in the boreholes.
e) Laboratory testing of soil samples.
f) Submission of report in soft copy.

2.0 LOCATION & DESCRIPTION

The site is located at the proposed site of the **Haldia Refinery, IOCL Haldia.**

3.0 LOCATION OF TESTS

A total number of **2** boreholes were constructed at this site.

4.0 SOIL BORING

The boreholes were constructed (IS-1892/1979) by employing a mechanically operated soil boring equipment for advancement of the bores. The nominal diameter of the boreholes were 150 mm. Flush jointed mild steel temporary threaded casings were introduced as the boreholes advanced in order to prevent caving of the soil inside the bores. The sub-soil deposits encountered in the process are noted and reported stratumwise in the **field borelogs** depthwise. These records are available in **Appendix B** of this report.

5.0 SAMPLING

With the progress of the soil boring work, disturbed representative soil samples were collected in polythene bags. The disturbed soil samples were labeled depthwise and boreholewise after the respective field bore logs were prepared. The total number of standard penetration test and type of samples collected from the boreholes are given in the following table.

TABLE – I

Bore hole No	Boring Depth (m)	Standing Water level (m)	Samples collected		
			UDS	SPT	DS
1	30.45	2.30	3	20	5
2	30.45	1.80	2	20	3

SECTION-II

6.0 FIELD TEST

Only Standard Penetration Test and visual identification tests were conducted in the field.

6.1 STANDARD PENETRATION TEST

In order to determine the strength characteristics of the soil encountered at various depths in the boreholes, a Standard Penetration test (SPT) was carried out as per Indian Standard Specification No. 2131/1981.

A 63.50 Kg mass "Monkey hammer" was dropped freely from a height of 750mm on a jarring block connected to the drill strings and the Terzaghi Spilt - Spoon assembly. The summation of the number of blows to penetrate the second and third 150mm stretch of the penetrometer was recorded as the "N" value. The value and the depth were mentioned in the respective bore logs. Disturbed representative samples were also collected from the Split barrel sampler.

The relationship between N value and relevant consistency of soil suggested by Terzaghi and Peck are mentioned as under:

TABLE – II

TYPE OF SOIL	N – VALUE	CONSISTENCY
Plastic	< 2	Very soft
	2 – 4	Soft
	4 to 8	Firm
	8 to 15	Stiff
	15 to 30	Very stiff
	Over 30	Hard
Non plastic	< 4	Very loose
	5 – 10	Loose
	10 to 30	Medium
	30 to 50	Dense
	Over 50	Very dense

7.0 LABORATORY TESTS

Following tests are generally performed in the laboratory adopting standard practices depending on the nature of samples recovered.

1. Grain size analysis.
2. Natural Moisture Content.
3. Specific Gravity.
4. Bulk & Dry unit weight.
5. Consolidation tests.
6. Unconsolidated Undrained (UU) Tri-axial
7. Direct Shear Test and
8. Chemical Test (pH).

Laboratory test results are presented in a tabular form in the Appendix. All the tests were conducted as per relevant Indian Standard Specifications.

1. Grain size analysis [IS: 2720(PART-4)-1985]

By this test, the percentage of sand, silt and clay are determined by sieve analysis or wet mechanical analysis. Sieve analysis is carried out by sieving a known dry weight of sample through a set of standard sieves. The wet mechanical analysis is based on STOKE'S law, by virtue of velocity of falling particles. Certain weight of soil is dispersed in certain volume of water and the purpose is served by out the mixture after required intervals and oven drying.

2. Natural Moisture Content [IS: 2720(PART-2)-1973]

It is the ratio of the weight of water to the dry weight of soil determined by oven drying.

$w = (W_w / W_s) \times 100$ (%)

Where, w = natural moisture content

W_w = weight of water

W_s = weight of soil

3. Specific Gravity [IS: 2720(PART-3/SEC-2)-1980]

The specific gravity of a substance is the ratio of its weight in air to the weight of an equal volume of water at reference temperature 4°c. It is expressed by the formula-

$G = W / (V \times \gamma)$

Where, W = Weight of soil

V = Volume of soil
γ = Unit Weight of Water

It is a dimensionless ratio and therefore has no unit.

4. Bulk & Dry unit weight

Bulk unit weight is the weight of the undisturbed samples per unit volume determined by taking the weight and volume of the specimen. It is expressed as-

$$\gamma_t = W / V$$

Where, W = Weight of soil
V = Volume of soil

The dry unit weight of a soil mass is expressed as the ratio of the weight of solids W_s to the total volume V. It is expressed as

$$\gamma_d = W_s / V$$

5. Consolidation tests [IS: 2720(PART-15)-1986]

This test is necessary to estimate the settlement characteristics of cohesive soils. In the consolidation ring (6.2 cm dia Odometer) a 2 cm high sample is taken with porous stones on top and bottom. After saturation, a compressive load is applied and maintained for 24 hours. The compression of the sample is measured at regular intervals by a dial gauge. Thus, load increment is made and the procedure is repeated. From the results obtained e-log P curve is drawn. The volume compressibility $\mathbf{m_v}$ is measured by the following formula:

$$m_v = (\Delta H/H) X (1 / \Delta P)$$

6. Triaxial Shear Test [IS: 2720(PART-10)-1973]

Shear strength parameters C & f are usually determined from triaxial shear test. These parameters depend upon the drainage condition, stress history etc. Triaxial shear test is conducted on cohesive soils also depending on silt content. The samples in this test are subjected to different lateral stress as well as vertical stress. The lateral stress on the sample is kept constant when the test continues.

7. Direct Shear Test [IS: 2720(PART-39/SEC 1)-1977]

Shear strength parameters C &f are usually determined from direct shear test. These parameters depend upon the drainage condition, stress history etc. Direct shear test is conducted on cohessionless soils. The samples in this test are subjected to different vertical stress as well as lateral stress. The vertical stress on the sample is kept constant when the test continues.

8. Chemical Test of soil samples [IS: 2720(PART-27)-1987]

The following chemical test was performed in the laboratory-

pH Value : The pH value of the specimen was found out with the help of a DIGITAL pH-meter (Model: 111E, Make: Environmental & Scientific Instrument Co.) from filtered solutions.

8.0 GROUND CONDITION

Engineering classification of the deposits encountered at the boreholes has been done based on visual identification and laboratory tests. The sub-soil can broadly be classified under five main strata.

Stratum I: Stratum I consists of Top soil comprising **FILLED UP** soil (yellowish brown Silty Sand to blackish grey Clayey Silt with bricks, stone chips, kankar etc.). The average thickness of the stratum is 1.30 m.

Stratum II: Stratum II consists of Very soft to soft brownish grey Clayey **SILT** with fine sand. The thickness of the stratum is 7.90 m and the average N value is 2.

Stratum III: Stratum III consists of Soft to firm brownish grey Clayey **SILT** with fine sand. The thickness of the stratum is 9.00 m and the average N value is 5.

Stratum IV: Stratum IV consists of Soft to Firm to Stiff yellowish brown Clayey Sandy **SILT** with fine mica and kankar. The thickness of the stratum is 3.25 m and the average N value is 11.

Stratum V: Stratum V consists of Medium dense to dense brownish yellow fine **SAND** with mica. The stratum extended upto the termination depth and the average N value is 35.

9.0 GROUND WATER

Respective bore logs are provided with the actual depth where water was encountered after completion of the boring work. For design purpose it may be assumed at ground level. The observed ground water levels are as given below:

TABLE – III

Bore Hole No	Boring Depth (m)	Standing Water level (m)
1	30.45	2.30
2	30.45	1.80

10.0 GENERALISED SOIL PROFILE WITH DESIGN SOIL PARAMETERS

Stratum & Thickness* (m)	Depth (m) B.E.G.L	Description of Soil	N value	N M C (%)	L.L (%)	P.L (%)	B.D (KN/m^3)	Shear Parameter		Consolidation
								C (Kpa)	ϕ (Deg)	Cc/(1+e_0)
I 1.30	0 1.30	Top soil comprising **FILLED UP** soil (yellowish brown Silty Sand to blackish grey Clayey Silt with bricks, stone chips, kankar etc.).	-	-	-	-	16.00	-	-	-
II 7.90	1.30 9.20	Very soft to soft brownish grey Clayey **SILT** with fine sand.	2	32.00	36.00	17.00	18.11	23.00	5	0.623
III 9.00	9.20 18.20	Soft to firm brownish grey Clayey **SILT** with fine sand.	5	39.00	28.00	12.00	19.67	37.00	3	0.686
IV 3.25	18.20 21.45	Soft to Firm to Stiff yellowish brown Clayey Sandy **SILT** with fine mica and kankar.	11	17.00	-	-	21.57	76.00	10	-
V	21.45 Explored depth	Medium dense to dense brownish yellow fine **SAND** with mica.	35	-	NP	NP	21.50*	-	9	-

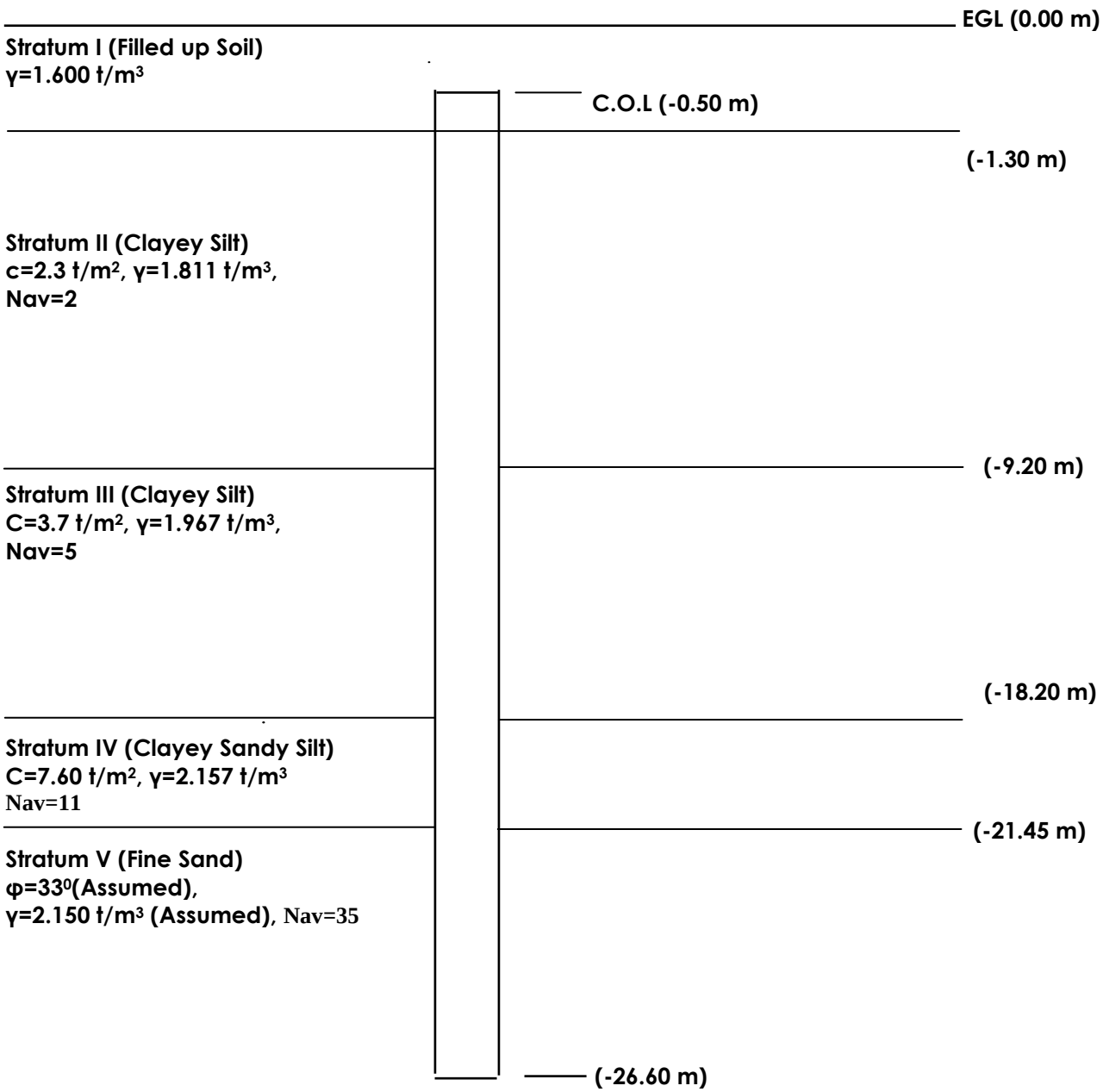
Note: (*) denotes assumed values

SECTION-III

11.0 TYPICAL CALCULATION FOR PILE LOAD CAPACITY

(As per I.S. 2911 (Part1/Sec2) – 2010)

WITH 0.50 M CUT-OFF LEVEL:



NOTE:

- **Dia of pile = 500 mm**
- **Bored depth below E.G.L=26.60 m**
- **C.O.L. = 0.50 m**
- **Shaft length = 26.10 m**
- **Concrete Grade M-30**
- **For Stratum V φ value obtained from Direct Shear test in the laboratory is 9^0 in an average. Whereas the same obtained from Fig. 1- IS 6403-1981 is nearly 37^0.**

We have opted for the conservative value of the two and taken 33^0 for the calculation.

12.0 ENGINEERING APPRAISAL

ENGINEERING APPRAISAL

DISCUSSION

From the study of the borelogs and results of both field as well as laboratory tests the followings are observed:

Stratum I: Stratum I consists of Top soil comprising **FILLED UP** soil (yellowish brown Silty Sand to blackish grey Clayey Silt with bricks, stone chips, kankar etc.). The average thickness of the stratum is 1.30 m.

Stratum II: Stratum II consists of Very soft to soft brownish grey Clayey **SILT** with fine sand. The thickness of the stratum is 7.90 m and the average N value is 2.

Stratum III: Stratum III consists of Soft to firm brownish grey Clayey **SILT** with fine sand. The thickness of the stratum is 9.00 m and the average N value is 5.

Stratum IV: Stratum IV consists of Soft to Firm to Stiff yellowish brown Clayey Sandy **SILT** with fine mica and kankar. The thickness of the stratum is 3.25 m and the average N value is 11.

Stratum V: Stratum V consists of Medium dense to dense brownish yellow fine **SAND** with mica. The stratum extended upto the termination depth and the average N value is 35.

CHOICE OF FOUNDATION

Any foundation system for a proposed structure should satisfy certain stability conditions. These are

a) There should be adequate factor of safety against the possible shear failure of the soil underneath the foundation

and

b) The settlement of the foundation should be within permissible limit.

PILE FOUNDATION

Pile foundation in the form of 450 mm dia bored cast-in-situ RCC piles may be considered for the main structure. The safe vertical pile load capacity has been presented in Table-V along with the horizontal and uplift capacity.

TABLE – IV

Dia of pile	C.O.L. (m)	F.O.S	Shaft length (m)	Total Boring depth from E.G.L (m)	Vertical load bearing capacity (kN)				Uplift capacity (KN)	Horizontal capacity (KN)
					Skin Friction (kN)	End Bearing (kN)	Ultimate Vertical Load Bearing Capacity (kN)	Safe Vertical Load Bearing Capacity (kN)		
500	0.50	3.0	26.10	2 x 30.45 m	1435.327	371.44	1806.767	600	555	30

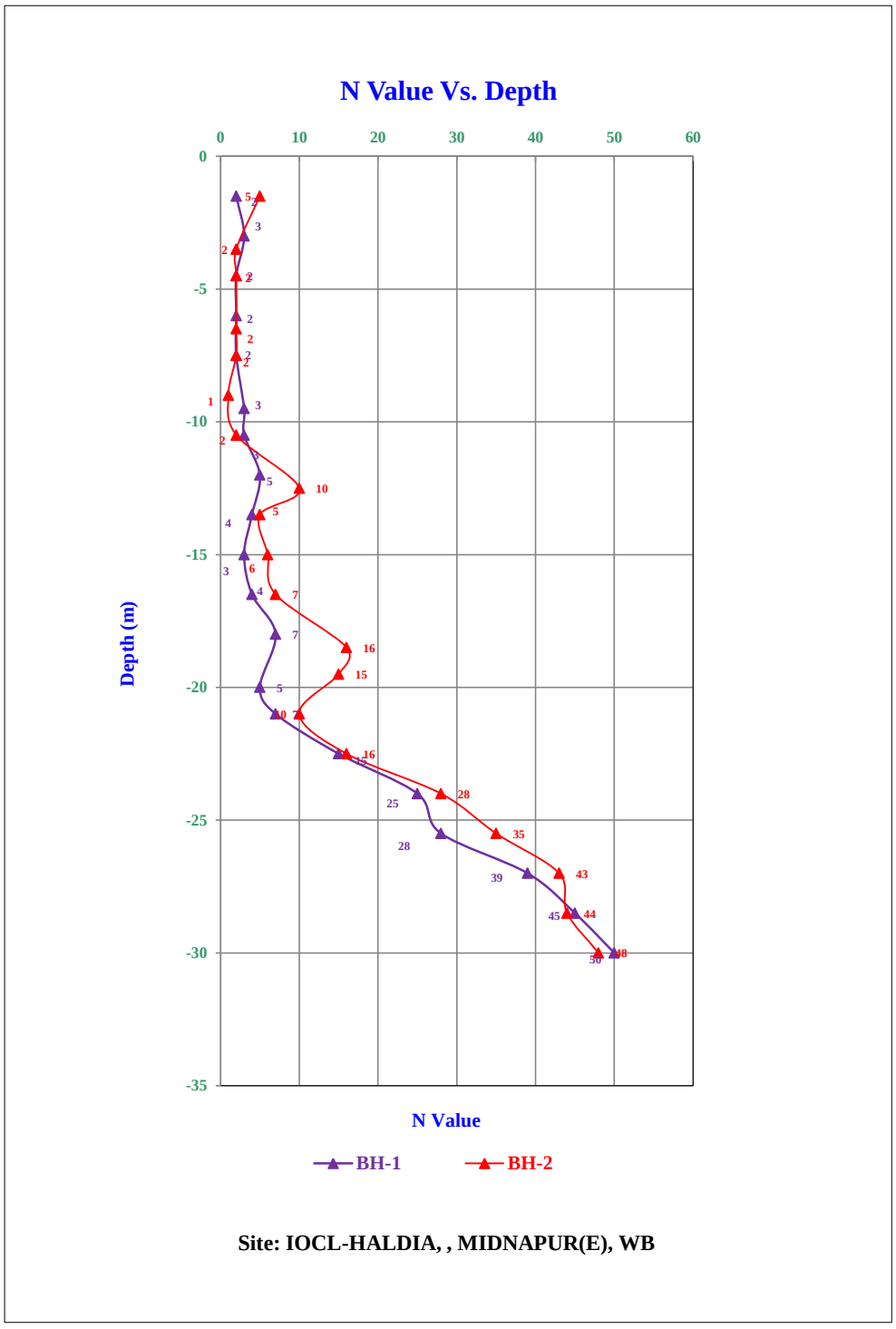
Note: The vertical load bearing capacity has been calculated considering I. Skin Friction Component and the II. End Bearing Component. The structural designer is free to consider or discard the end bearing component in the bored cast-in-situ pile in soft alluvium formation.

13.0 RECOMMENDATION

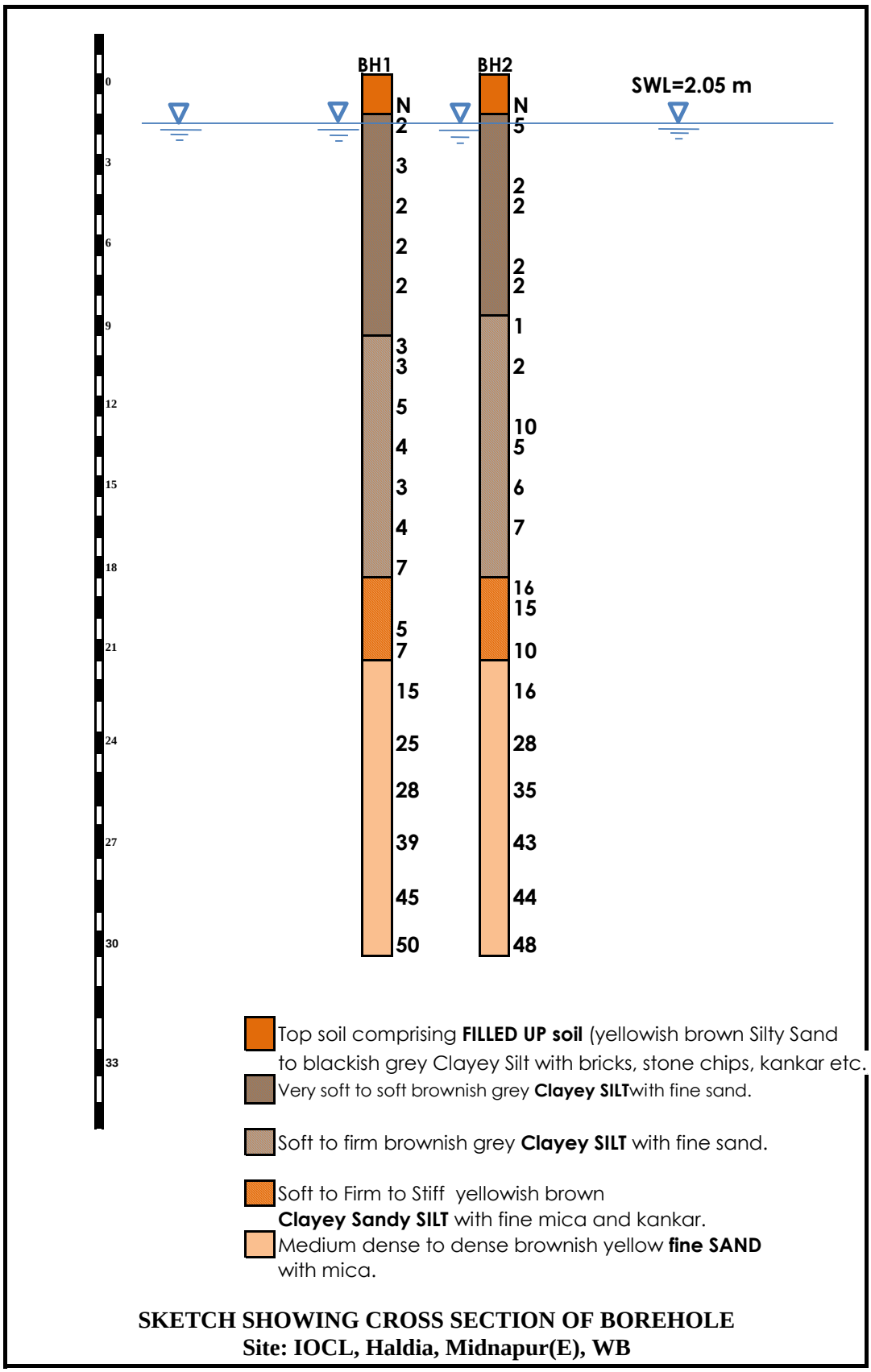
PILE FOUNDATION

- In case of heavily loaded structures Pile foundation is recommended at this site for the proposed main structure. The safe axial load bearing capacity of 500 mm diameter bored cast-in-situ R.C.C piles has been calculated and presented in Table-IV. However, the actual load bearing capacity may be determined by conducting Initial Pile Load Test.
- The execution of piles shall be done with utmost care and with quality supervision. **IS: 2911(Part I/Sec2)-2010** read with latest revision shall generally be followed for the design and execution of the piling work.
- Concrete of proper grade and slump shall be used in construction of the pile shafts. Cover from main reinforcement to the surface of the pile-shaft shall be maintained properly in order to save the re-bars from rusting.
- Load test (Routine) may be conducted as per I.S. 2911 (Part 4)-1985 (Reaffirmed 2006) read with latest revision on piles in the project after their installation and maturity.

APPENDIX-A



Site: IOCL-HALDIA, , MIDNAPUR(E), WB



SKETCH SHOWING CROSS SECTION OF BOREHOLE
Site: IOCL, Haldia, Midnapur(E), WB

APPENDIX-B

BORELOG DATA SHEET									**Borehole No.:BH1**
Site: IOCL, Haldia									**Job No. 23-24/15**
Boring equipment: **Mechanical Cable Tools**						Boring method: **Wash**			
Stuck at:	Sealed at :		**Water Level: 2.30m**			**Co ordinate: N=468.716, E=212.160**			
Boring diameter: **150 mm**		Casing diameter:**160 mm**				**R.L.= 100.500 m**			
Termination depth(m): **30.45 m**		Orientation: Vertical		Commenced on: **28.11.2023**		Completed on: **29.11.2023**		Sheet No.: **1/1**	
No. of disturbed samples (D): **5**		**No. of undisturbed samples (UDS): 3**				**No. of SPT (Dp): 20**			
Detail of samples									
Depth (m) From To	Type	Ref. No.	Casing Depth (m)	Thickness of stratum (m)	N Value	Explored - -	Description	R.L. (m)	L O G
0.00-0.50	Ds	1	-		-		**Stratum I** Top soil comprising **Filled up Soil** (yellowish brown Silty Sand to blackish grey Clayey Silt with bricks, stone chips, kankar etc.) **(0.50-1.40 m)**		
0.50-1.00	Ds	2							
1.50-1.95	Dp	3	1.50		1+1+1=2				
2.50-2.95	UDS	4			-		**Stratum II**		
2.95-3.00	Dc	5			-				
3.00-3.45	Dp	6	3.00		1+1+2=3		Very soft to soft brownish grey **Clayey Silt** with fine sand**.**		
4.50-4.95	Dp	7		-	0+1+1=2				
6.00-6.45	Dp	8			0+1+1=2		**(1.40-9.40 m)**		
7.50-7.95	Dp	9			1+1+1=2				
9.00-9.45	UDS	10			-				
9.45-9.50	Dc	11			-		**Stratum III**		
9.50-9.95	Dp	12			1+1+2=3				
10.50-10.95	Dp	13			1+1+2=3				
12.00-12.45	Dp	14			1+2+3=5		Soft to firm brownish grey **Clayey Silt** with fine sand.		
13.50-13.95	Dp	15			1+2+2=4				
15.00-15.45	Dp	16			1+1+2=3				
16.50-16.95	Dp	17			1+2+2=4				
18.00-18.45	Dp	18			2+3+4=7	28.11.2023	**(9.40-18.20 m)**		
19.50-19.95	UDS	19			-		**Stratum IV**		
19.95-20.00	Dc	20			-				
20.00-20.45	Dp	21			2+2+3=5		Soft to firm yellowish brown **Clayey Sandy Silt** with fine mica.		
21.00-21.45	Dp	22			3+3+4=7		**(18.20-21.50 m)**		
22.50-22.95	Dp	23			4+7+8=15		**Stratum V**		
24.00-24.45	Dp	24			5+12+13=25		Medium dense to dense brownish yellow **fine Sand** with mica.		
25.50-25.95	Dp	25			5+13+15=28				
27.00-27.45	Dp	26			7+14+25=39				
28.50-28.95	Dp	27			15+20+25=45				
30.00-30.45	Dp	28			17+22+28=50	29.11.2023	**(End of borehole)**		

D = Disturbed samples Dc = Disturbed samples from cutting shoe Dp = Disturbed sample from Penetrometer Ws = Water sample
DWS = Disturbed wash sample UDS = Undisturbed soil sample SWL = Standing water level

BORELOG DATA SHEET									**Borehole No.:BH2**
Site: IOCL, Haldia									**Job No. 23-24/15**
Boring equipment: **Mechanical Cable Tools**						Boring method: **Wash**			
Stuck at:	Sealed at :		**Water Level: 1.80m**			**Co ordinate: N=477.820, E=196.890**			
Boring diameter: **150 mm**		Casing diameter:**160 mm**				**R.L.= 100.050 m**			
Termination depth(m): **30.45 m**		Orientation: Vertical		Commenced on: **30.11.2023**		Completed on: **01.12.2023**		Sheet No.: **1/1**	
No. of disturbed samples (D): **3**		**No. of undisturbed samples (UDS): 2**				**No. of SPT (Dp): 20**			
Detail of samples									
Depth (m) From To	Type	Ref. No.	Casing Depth (m)	Thickness of stratum (m)	N Value	Explored - -	Description	R.L. (m)	L O G
0.00-0.50	Ds	30	-		-		**Stratum I** Top soil comprising filled up soil (blackish grey Clayey **Silt** with bricks etc.) **(0.00-1.20 m)**		
1.50-1.95	Dp	31	1.50		1+2+3=5				
3.00-3.50	UDS (Slipped)	32	3.00		-		**Stratum II**		
3.50-3.95	Dp	34			0+1+1=2		Very soft to soft brownish grey **Clayey Silt.**		
4.50-4.95	Dp	35			0+1+1=2				
6.00-6.45	UDS	36		-	-		**(1.20-9.00 m)**		
6.45-6.50	Dc	37			-				
6.50-6.95	Dp	38			0+1+1=2				
7.50-7.95	Dp	39			0+1+1=2				
9.00-9.45	Dp	40			0+0+1=1		**Stratum III**		
10.50-10.95	Dp	41			0+1+1=2				
12.00-12.50	UDS (Slipped)	42			-				
12.50-12.95	Dp	43			3+4+6=10		Soft to firm brownish grey **Clayey Silt** with fine sand.		
13.50-13.95	Dp	44			2+2+3=5				
15.00-15.45	Dp	45			2+3+3=6				
16.50-16.95	Dp	46			2+3+4=7		**(9.00-18.20 m)**		
18.00-18.45	UDS	47			-				
18.45-18.50	Dc	48			-		**Stratum IV**		
18.50-18.95	Dp	49			3+6+10=16	30.11.2023	**Stiff** yellowish brown **Clayey Sandy Silt** with fine mica and kankar. **(18.20-21.40 m)**		
19.50-19.95	Dp	50			2+6+9=15				
21.00-21.45	Dp	51			3+4+6=10				
22.50-22.95	Dp	52			3+6+10=16		**Stratum V**		
24.00-24.45	Dp	53			4+14+14=28		Medium dense to dense brownish yellow **fine Sand** with mica.		
25.50-25.95	Dp	54			6+15+20=35				
27.00-27.45	Dp	55			10+21+22=43				
28.50-28.95	Dp	56			12+18+26=44				
30.00-30.45	Dp	57			14+20+28=48	01.12.2023	**(End of borehole)**		

D = Disturbed samples Dc = Disturbed samples from cutting shoe Dp = Disturbed sample from Penetrometer Ws = Water sample
DWS = Disturbed wash sample UDS = Undisturbed soil sample SWL = Standing water level

Borehole No.	Sampling Depth (m)	Type	Sample No.	Natural Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	GRAIN SIZE ANALYSIS (%)				SHEAR TEST (kPa)						Free Swell Index (%)	Specific Gravity	DENSITY (KN/m^3)	
							Gravel	Sand	Silt	Clay	Unconfined Compression Test		Unconsolidated Undrained		Direct Shear				Bulk	Dry
											Undisturbed	Disturbed	C	Φ	C	Φ				
1	1.50-1.95	SPT	3				0	67	14	19										
	2.50-2.95	UDS	4	30									65	3				2.64	17.70	13.6
	3.00-3.45	SPT	6		58	22														
	4.50-4.95	SPT	7															2.85		
	6.00-6.45	SPT	8				0	66	16	18										
	9.00-9.45	UDS	10	47			0	51	34	15			22	1				2.74	18.61	12.66
	12.00-12.45	SPT	14		42	NP														
	16.50-16.95	SPT	17				0	54	25	21										
	19.50-19.95	UDS	19	19									52	5					20.73	17.41
	20.00-20.45	SPT	21															2.59		
	22.50-22.95	SPT	23													7			15.66	
	24.00-24.45	SPT	24				0	86	14	0										
	27.00-27.45	SPT	26	,												7		2.71	16.40	
	1.50-1.95	SPT	31															2.73		
2	4.50-4.95	SPT	35		14	12														
	6.00-6.45	UDS	36	34									23	5				2.7	18.51	13.80
	7.50-7.95	SPT	39				0	55	38	7										
	9.00-9.45	SPT	40	47														2.7		
	10.50-10.95	SPT	41															2.63		
	15.00-15.45	SPT	45	42														2.69		
	16.50-16.95	SPT	46		13	12														
	18.00-18.45	UDS	47	17									76	10					21.57	13.80
	18.50-18.95	SPT	49				0	57	21	21										
	24.00-24.45	SPT	53				0	85	15	0										
	25.50-25.95	SPT	54													12			19.20	
	28.50-28.95	SPT	56															2.65		
	30.00-30.45	SPT	57													8			18.23	

CONSOLIDATION TEST RESULT

m_v (m^2/KN x 10^{-4})

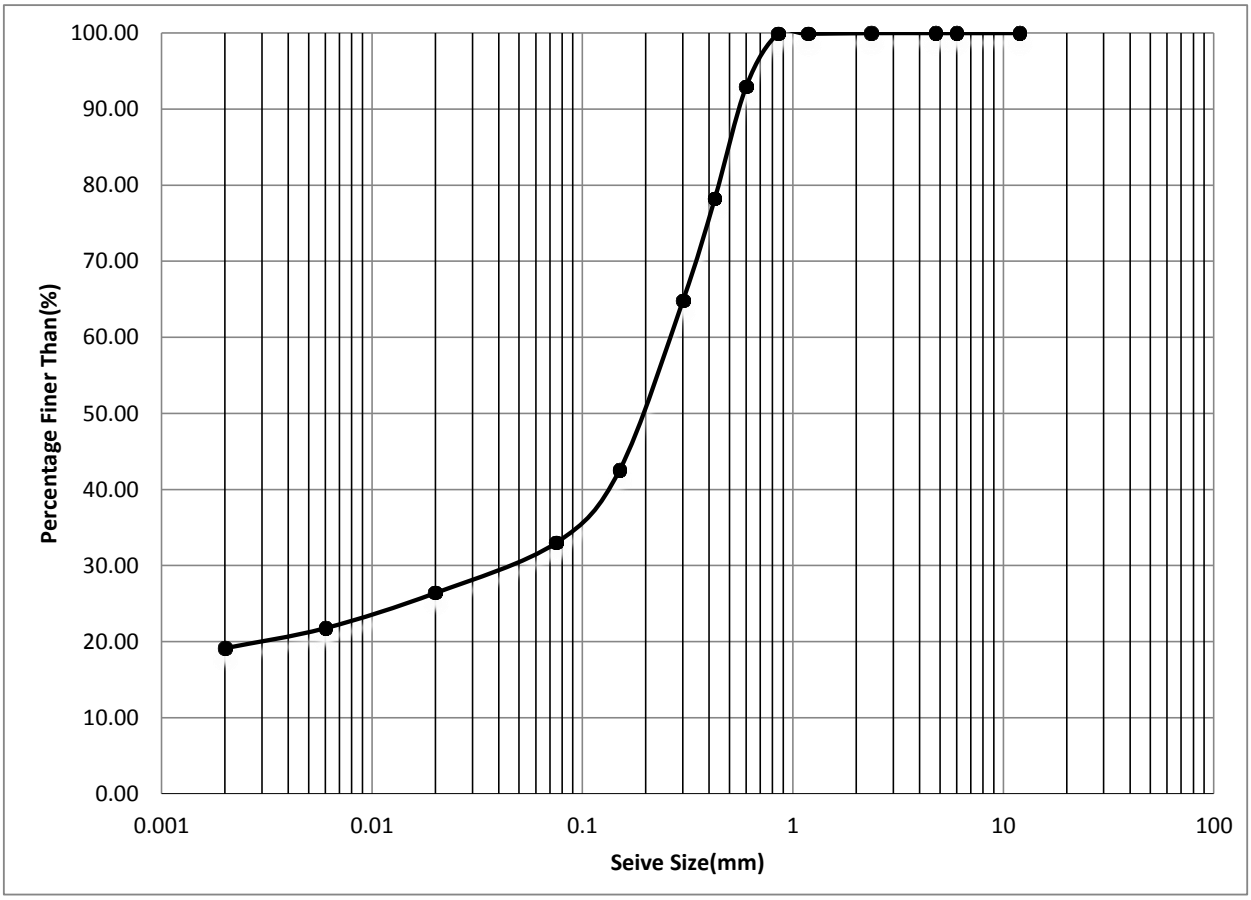
BH No.	Depth (m)	Sample No.	Pressure range in Kg/cm^2									
			0 – 0.10	0.10 – 0.25	0.25 – 0.50	0.50 – 1.00	1.00 – 2.00	2.00 – 4.00	4.00 – 8.00		eo	Sp. Gravity
1	2.50-2.95	4	7.50	5.40	5.40	5.40	4.27	3.51	2.39		0.936	2.64
1	9.00 - 9.45	10	27.00	29.60	20.70	14.75	8.88	5.78	3.45		1.153	2.73
2	6.00-6.45	36	18.50	22.80	15.20	11.40	8.03	5.03	3.13		0.956	2.70

RESULT OF CHEMICAL TESTS ON SOIL AND WATER SAMPLE:

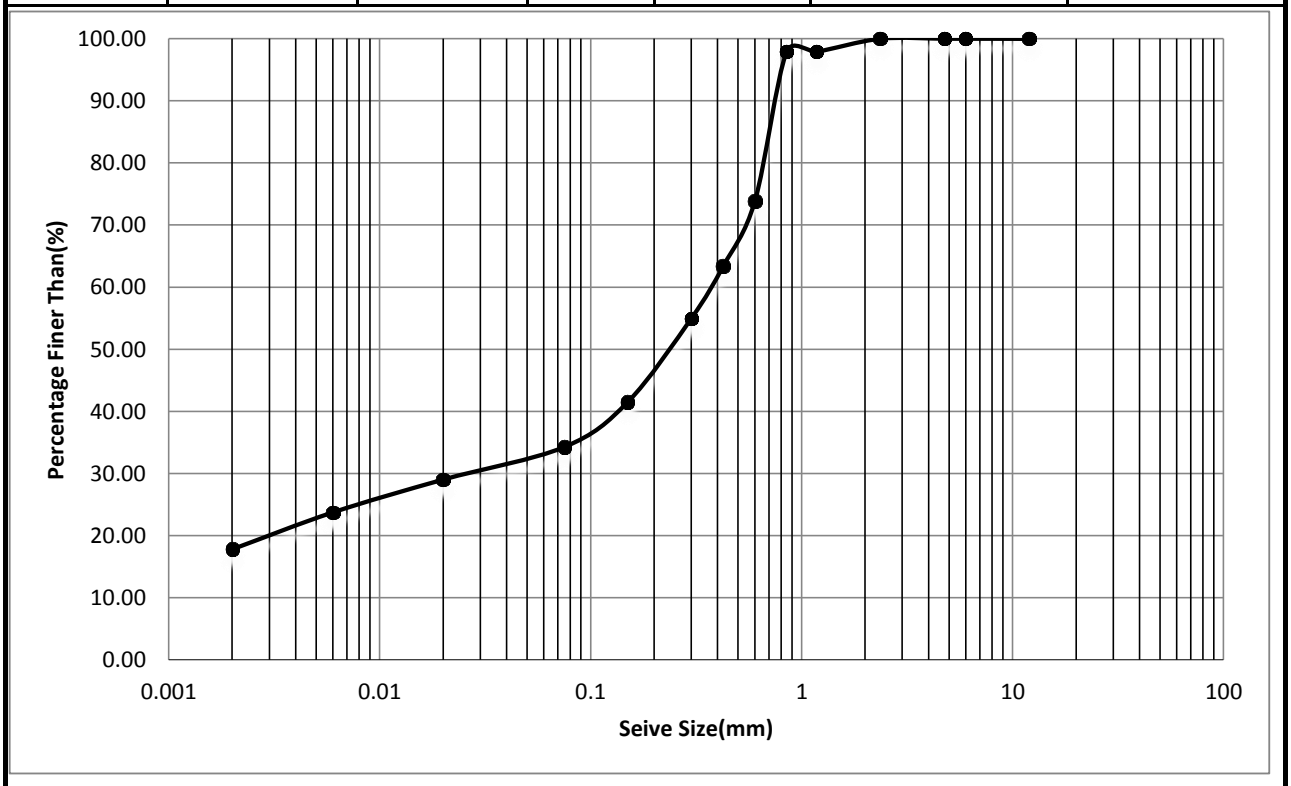
BH No.	Type of Sample	Depth (m)	pH (13°C)	Cl^- (ppm)	SO_3 (ppm)
BH-1	Water	2.30	7.7	968.00	204.60
BH-2	Soil	3.50-3.95	7.11	296.87	168.27

APPENDIX-C

GRAIN SIZE CURVE

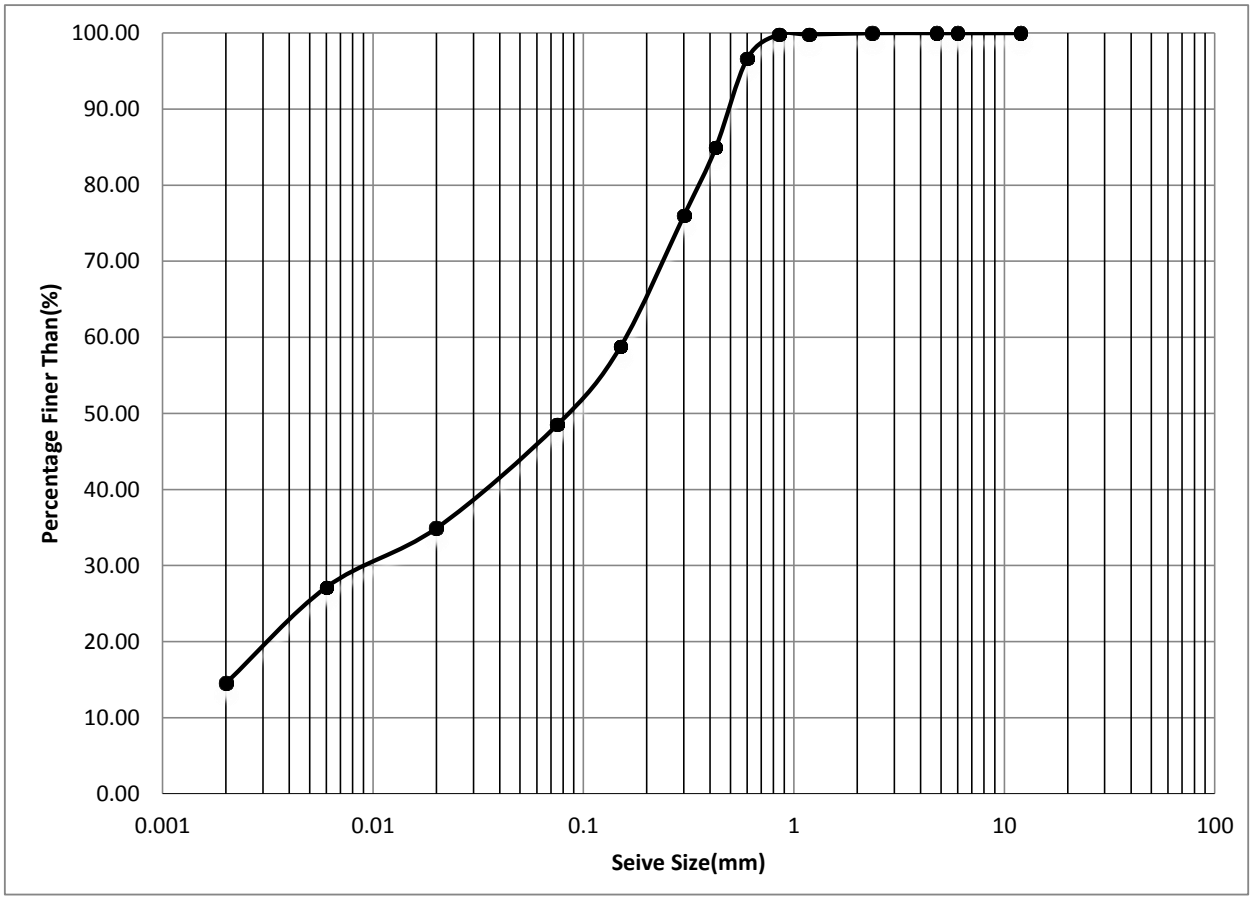


Borehole No.	Area	Depth(m)	Grain Size Analysis(%)			
			Gravel	Sand	Silt	Clay
1	IOCL, Haldia	1.50 - 1.95	0	67	13.86	19.14

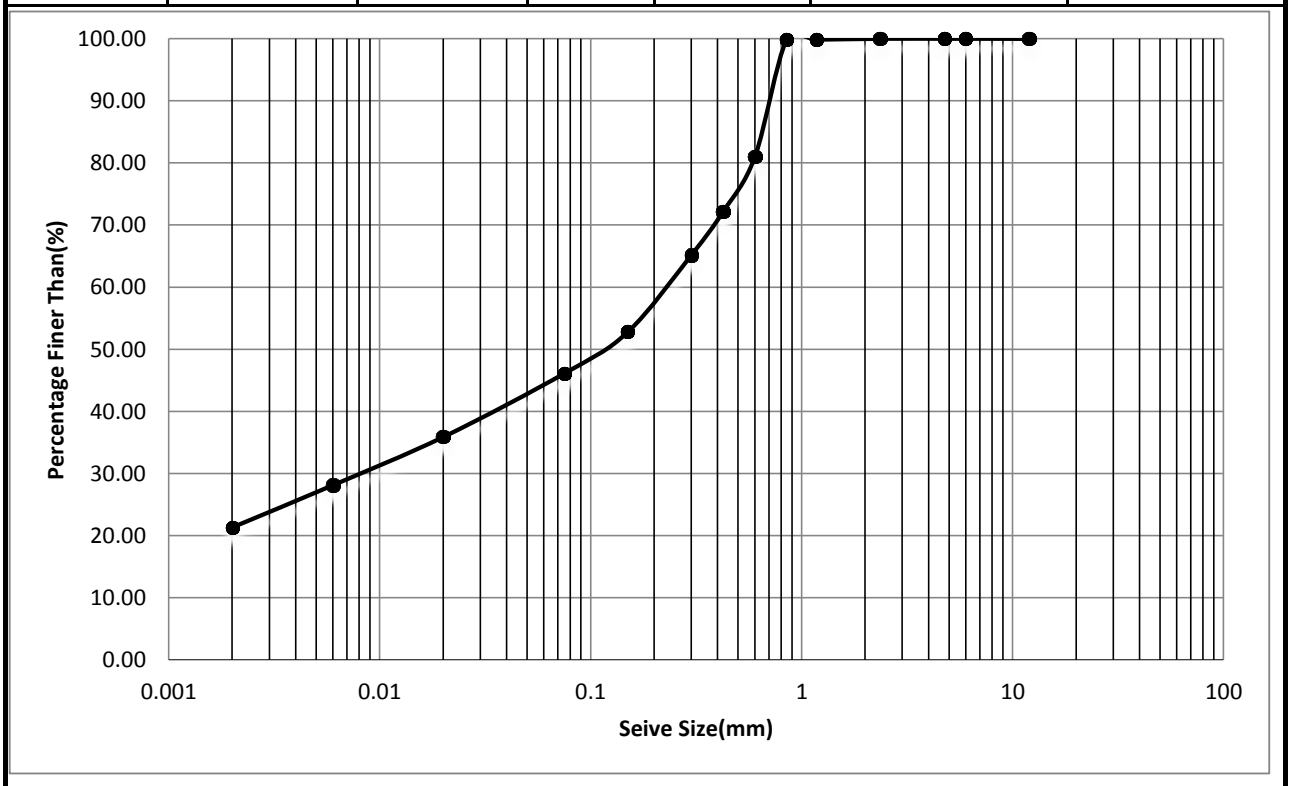


Borehole No.	Area	Depth(m)	Grain Size Analysis(%)			
			Gravel	Sand	Silt	Clay
1	IOCL, Haldia	6.00 - 6.45	0	65.71578947	16.46421053	17.82

GRAIN SIZE CURVE

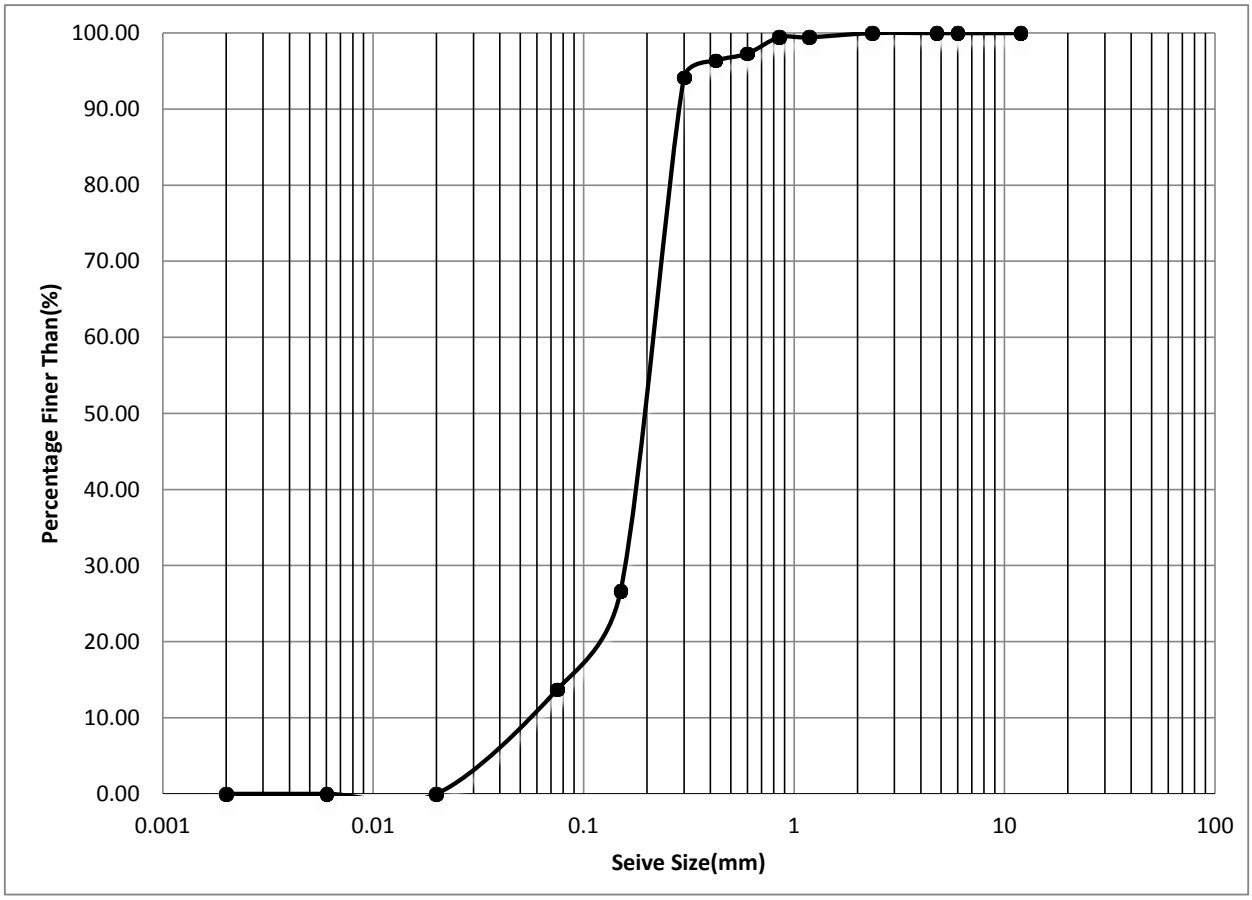


Borehole No.	Area	Depth(m)	Grain Size Analysis(%)			
			Gravel	Sand	Silt	Clay
1	IOCL, Haldia	9.00 - 9.45	0	51.5	33.95	14.55

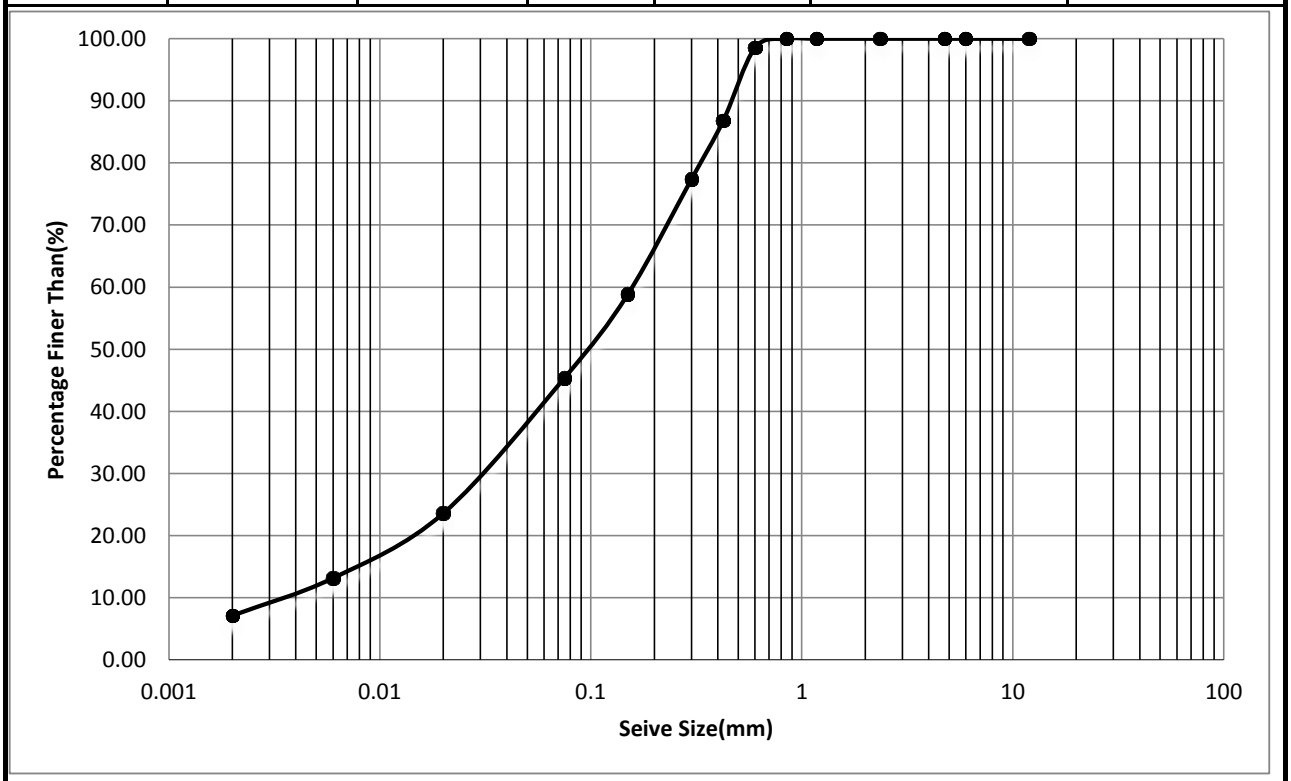


Borehole No.	Area	Depth(m)	Grain Size Analysis(%)			
			Gravel	Sand	Silt	Clay
1	IOCL, Haldia	16.50 - 16.95	0	53.87058824	24.78941176	21.34

GRAIN SIZE CURVE

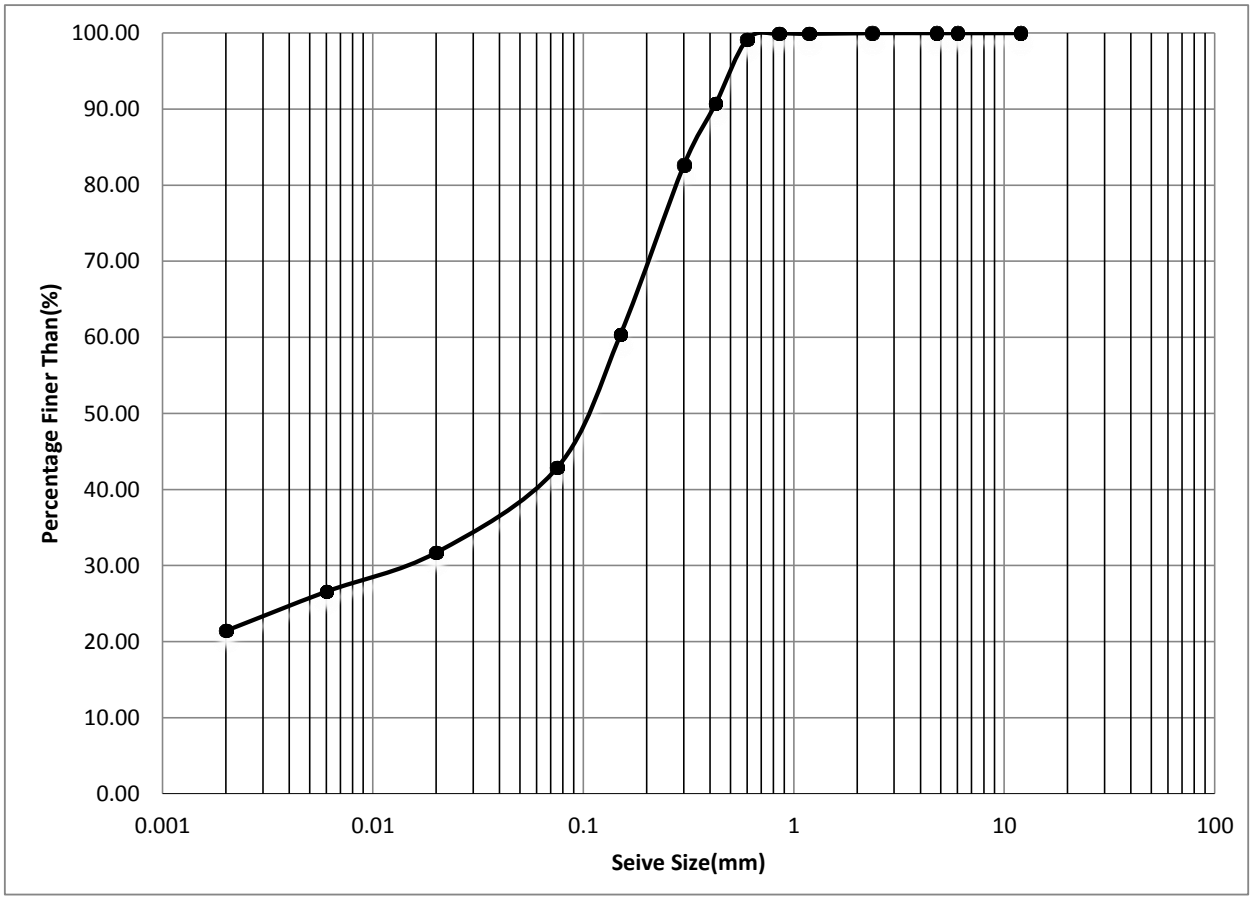


Borehole No.	Area	Depth(m)	Grain Size Analysis(%)			
			Gravel	Sand	Silt	Clay
1	IOCL, Haldia	24.00 - 24.45	0	86.27777778	13.72222222	0

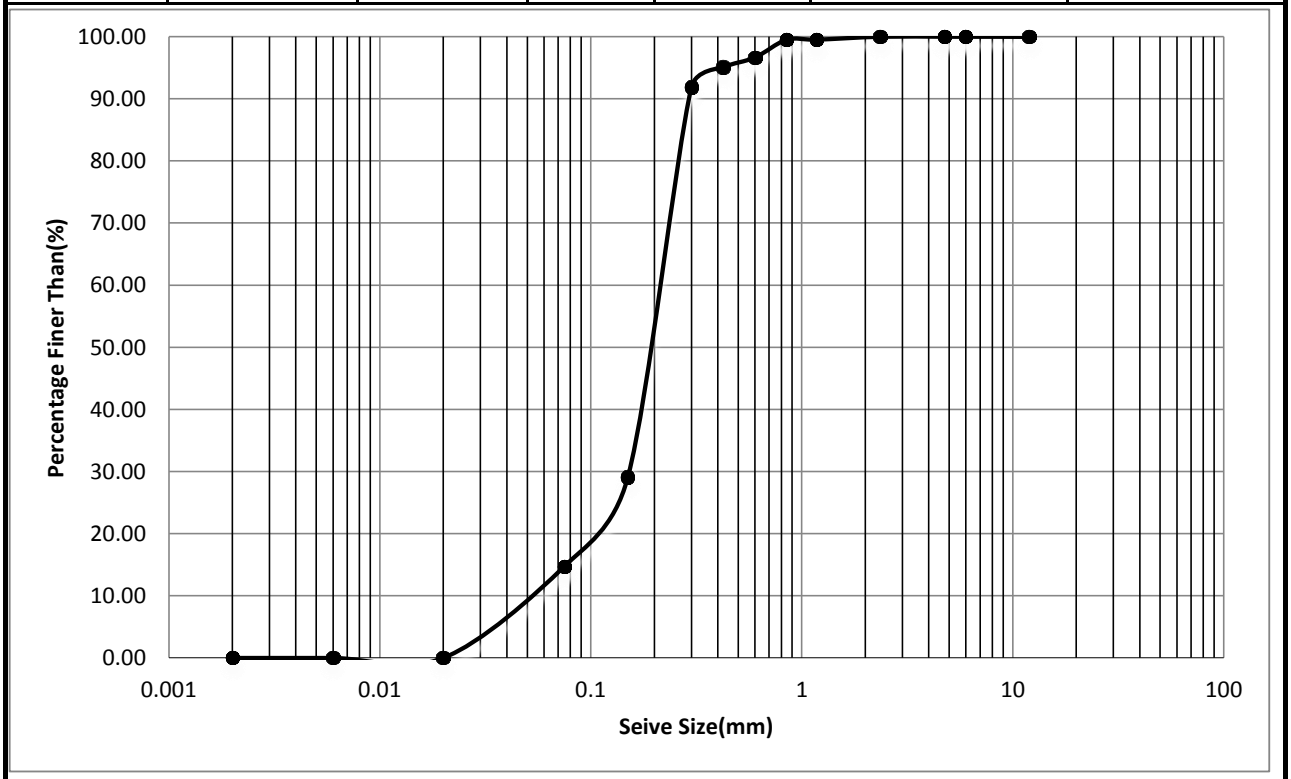


Borehole No.	Area	Depth(m)	Grain Size Analysis(%)			
			Gravel	Sand	Silt	Clay
2	IOCL, Haldia	7.50 - 7.95	0	54.62222222	38.24222222	7.135555556

GRAIN SIZE CURVE

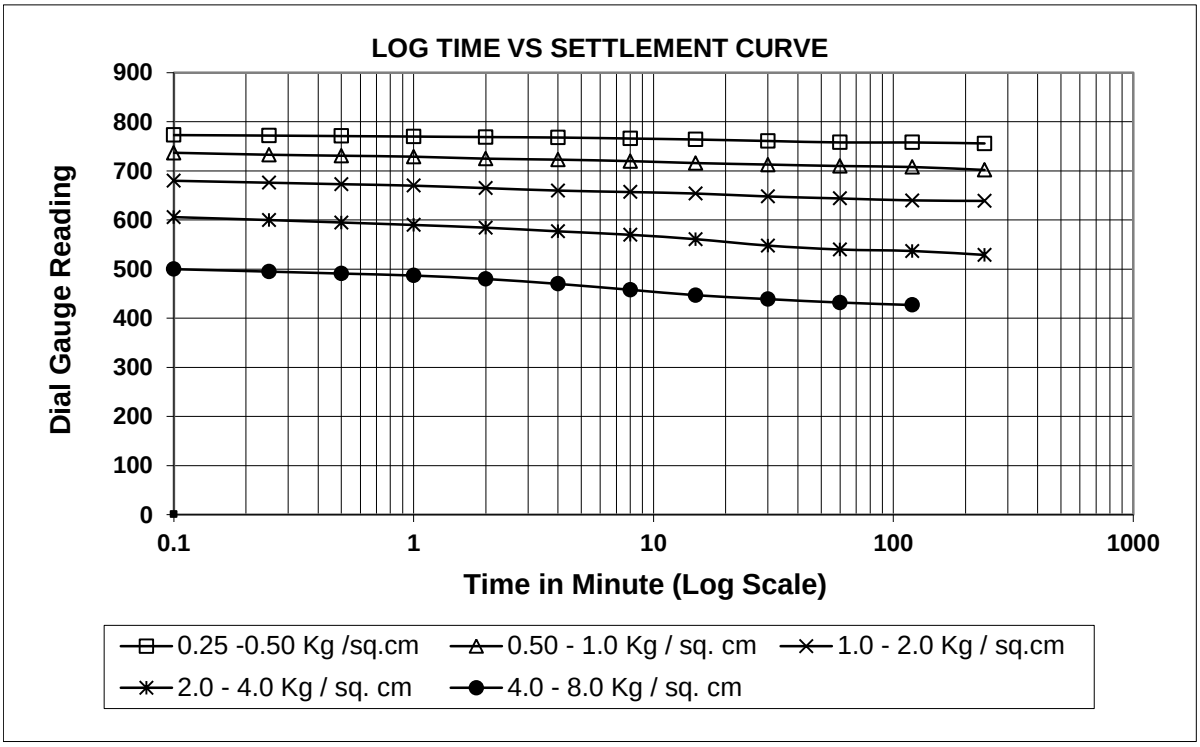


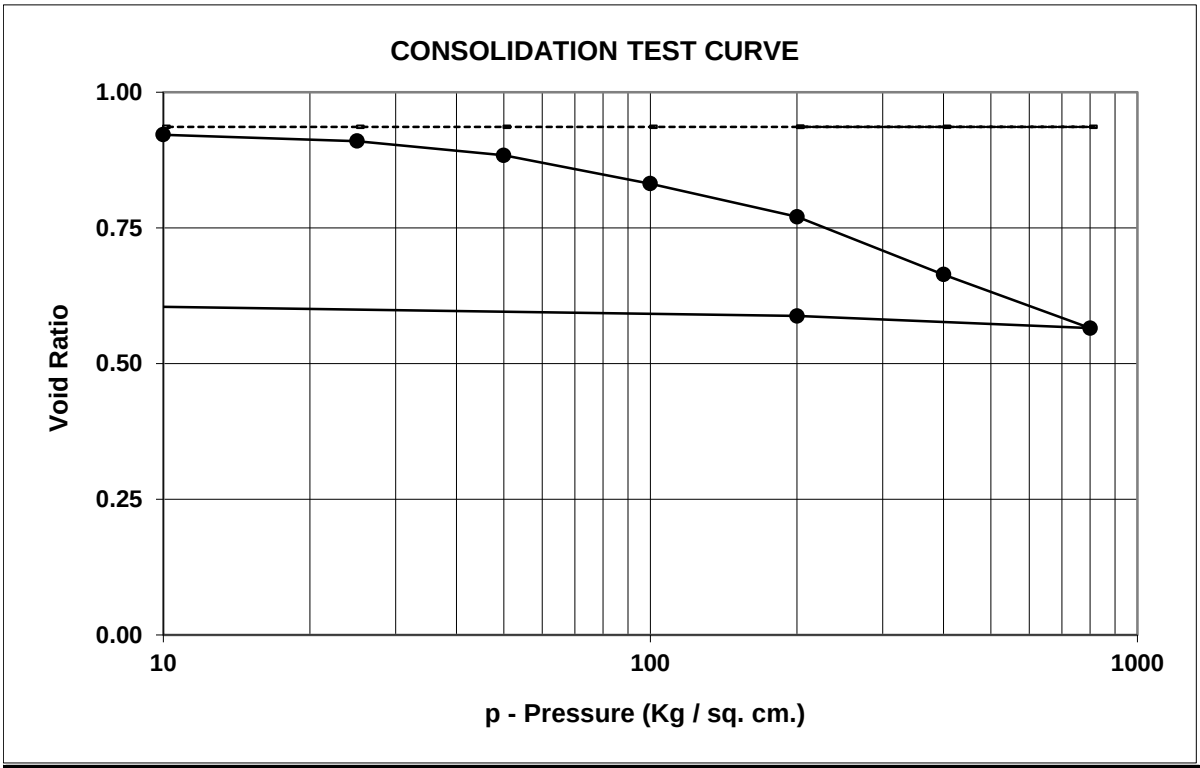
Borehole No.	Area	Depth(m)	Grain Size Analysis(%)			
			Gravel	Sand	Silt	Clay
2	IOCL, Haldia	18.50 - 18.95	0	57.12	21.44	21.44



Borehole No.	Area	Depth(m)	Grain Size Analysis(%)			
			Gravel	Sand	Silt	Clay
2	IOCL, Haldia	24.00 - 24.45	0	85.24705882	14.75294118	0

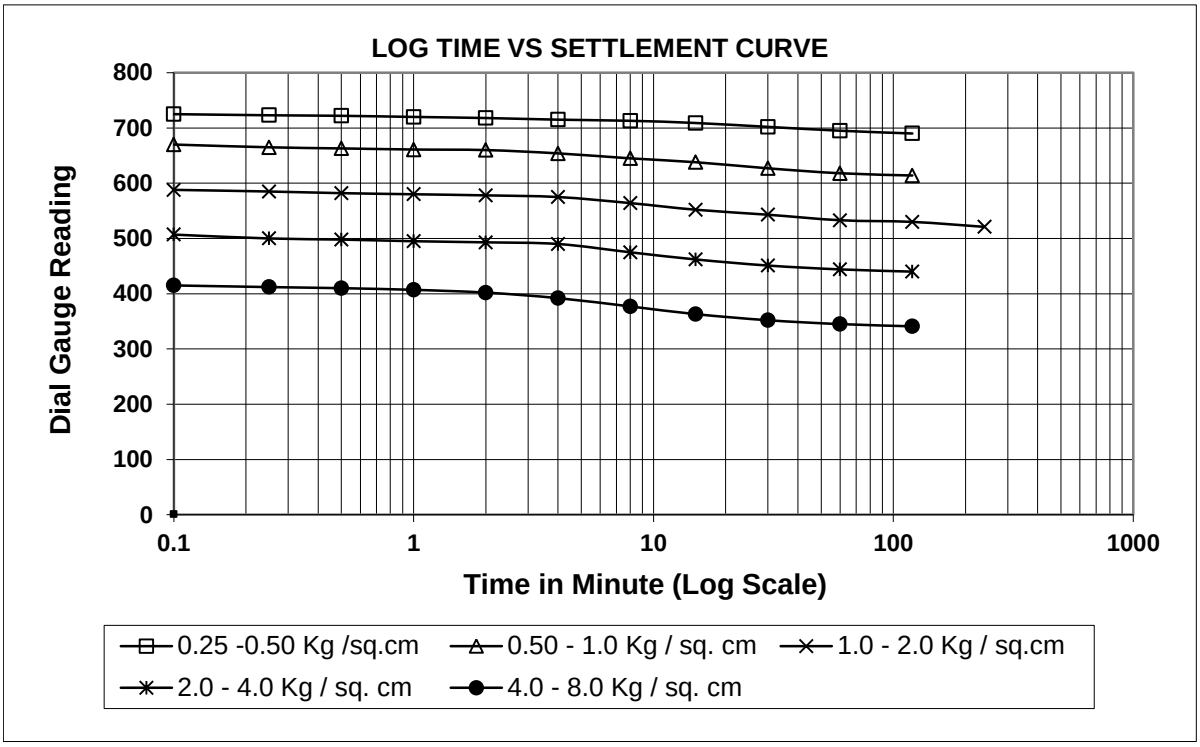
Borehole No : 1 Depth (m) : 2.50 - 2.95

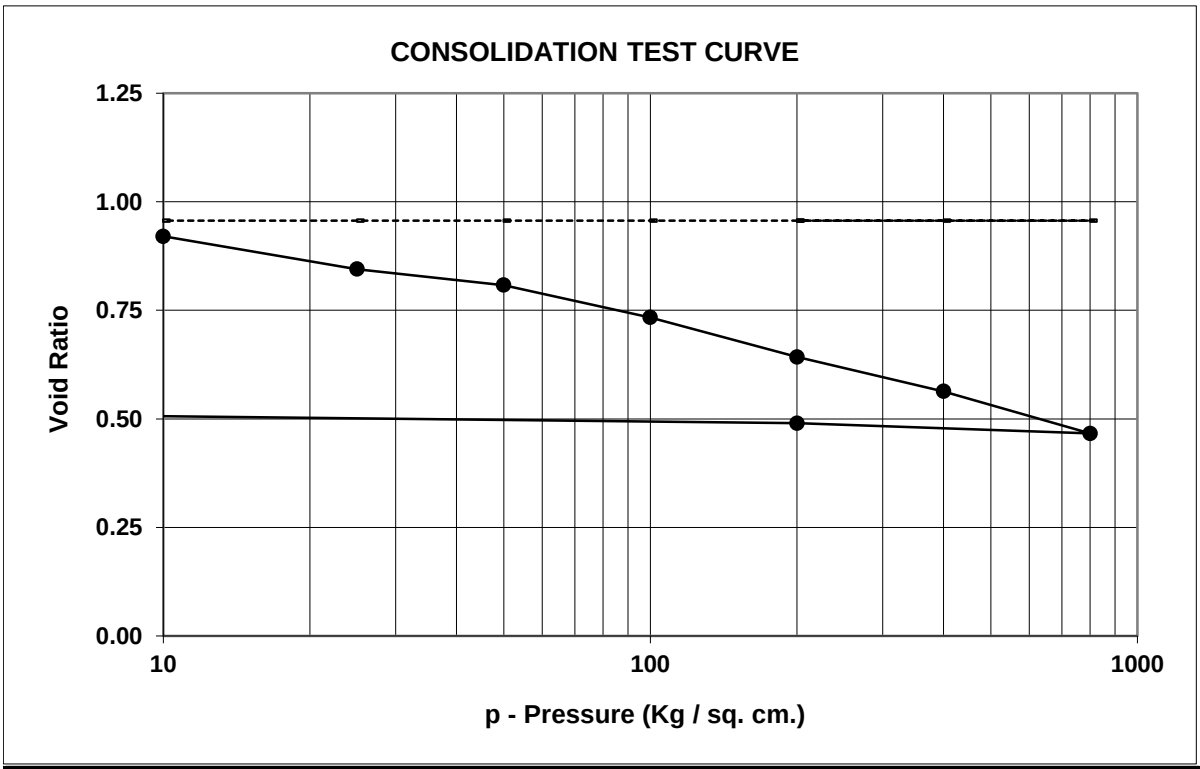




Initial Void Ratio(e0) : **0.9359**

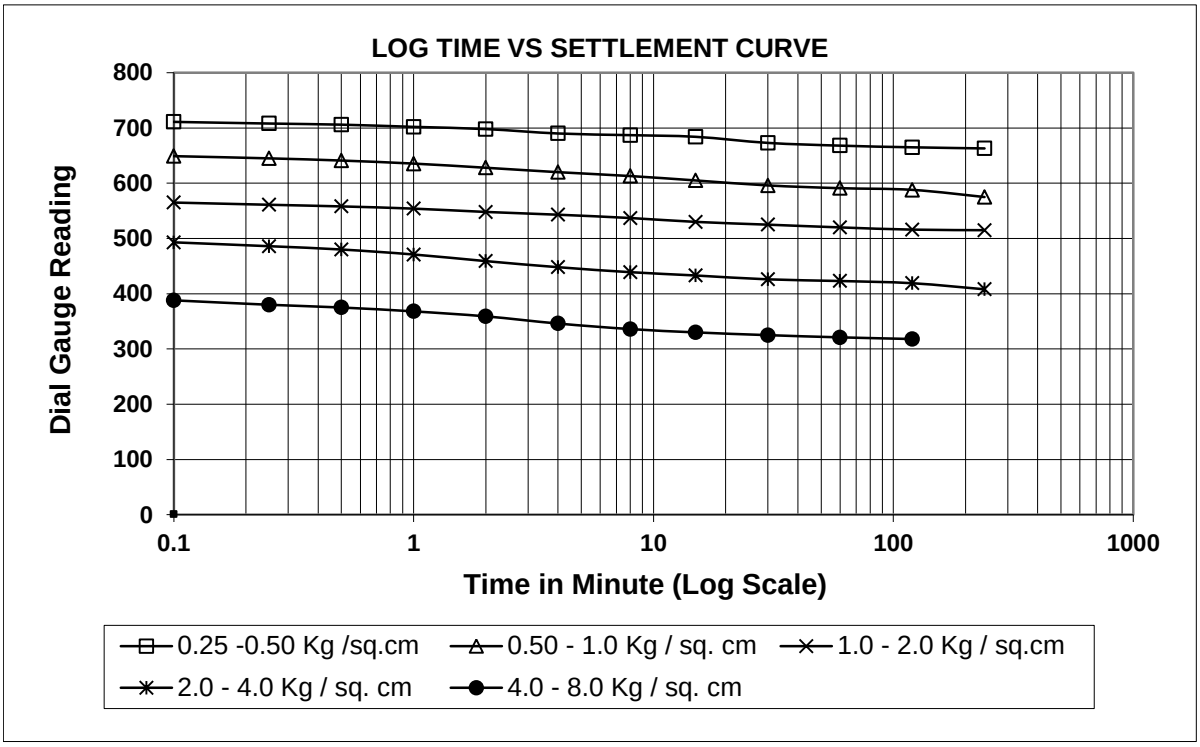
Borehole No : 2 Depth (m) : 6.00 - 6.45

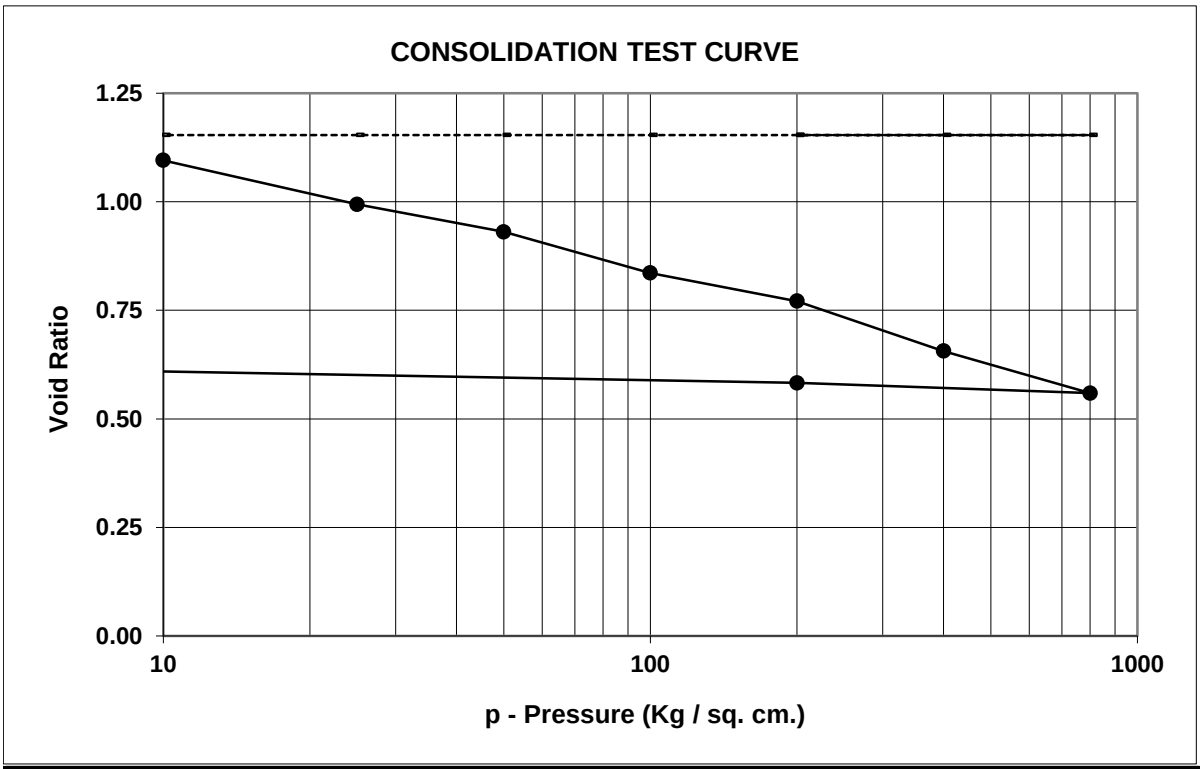




Initial Void Ratio(e0) : **0.9563**

Borehole No : 1 Depth (m) : 9.00 - 9.45





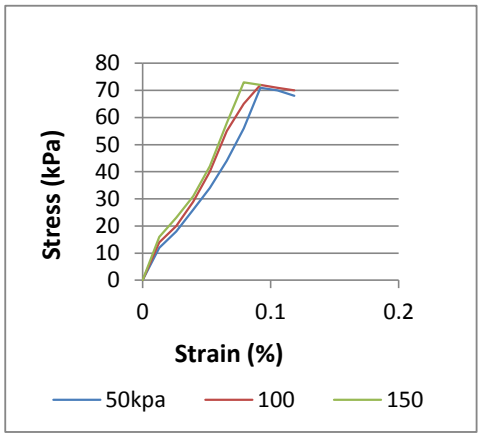
Initial Void Ratio(e0) : **1.1534**

SAMPLE NO._____ **JOB NO. 23-24/15**

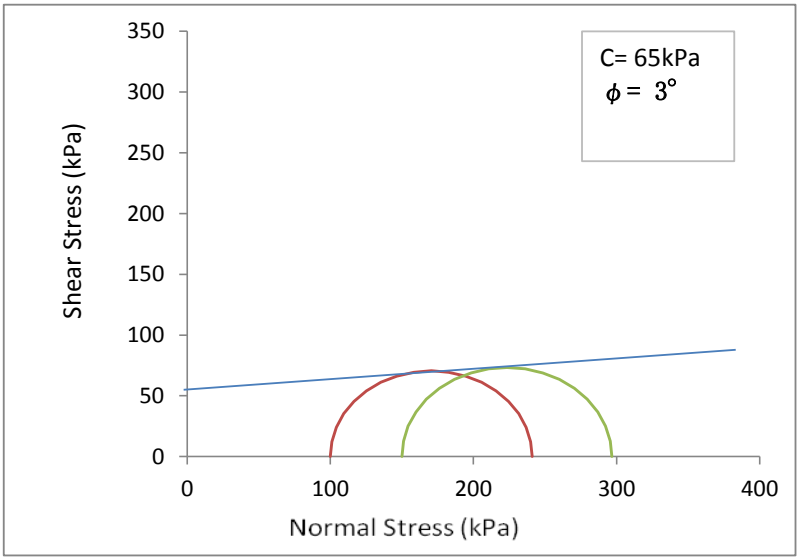
SAMPLE DEPTH - 2.50 - 2.95M. **TYPE OF TEST-UU**

BOREHOLE NO. 1

Stress Vs Strain Curve



Mode of failure Specimen-1 Cell Pressure (σ_3)	Δ
Mode of failure Specimen-1 Cell Pressure (σ_3)	□
Mode of failure Specimen-1 Cell Pressure (σ_3)	○



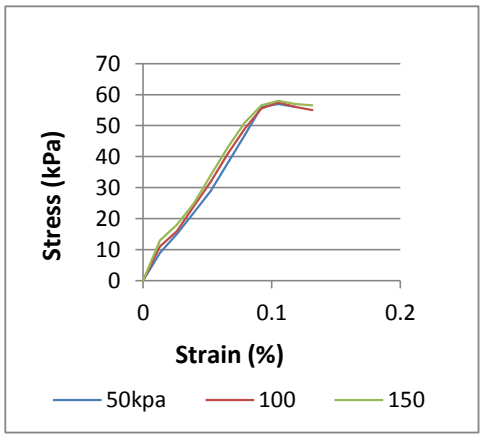
JOB NO.23-24/15

SAMPLE NO._____ **JOB. NO. 23-24/15**

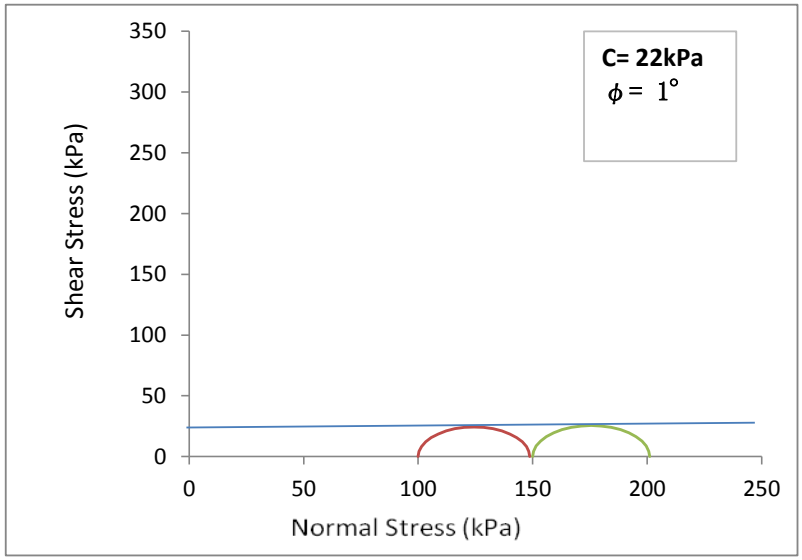
DEPTH:-9.00 - 9.45 M. **TYPE OF TEST-UU**

BOREHOLE NO.-1

Stress Vs Strain Curve



Mode of failure Specimen-1 Cell Pressure (σ_3)	Δ
Mode of failure Specimen-1 Cell Pressure (σ_3)	□
Mode of failure Specimen-1 Cell Pressure (σ_3)	○



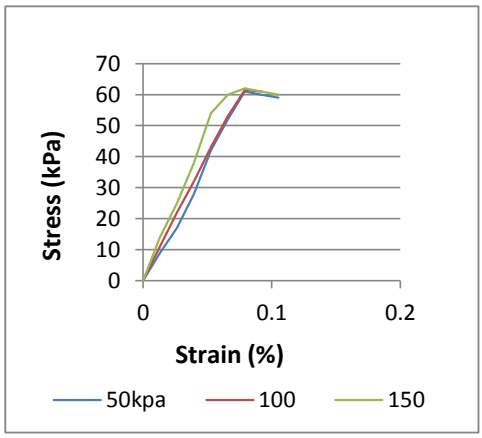
JOB NO. 23-24/15

SAMPLE NO._____ **JOB. NO. 23-24/15**

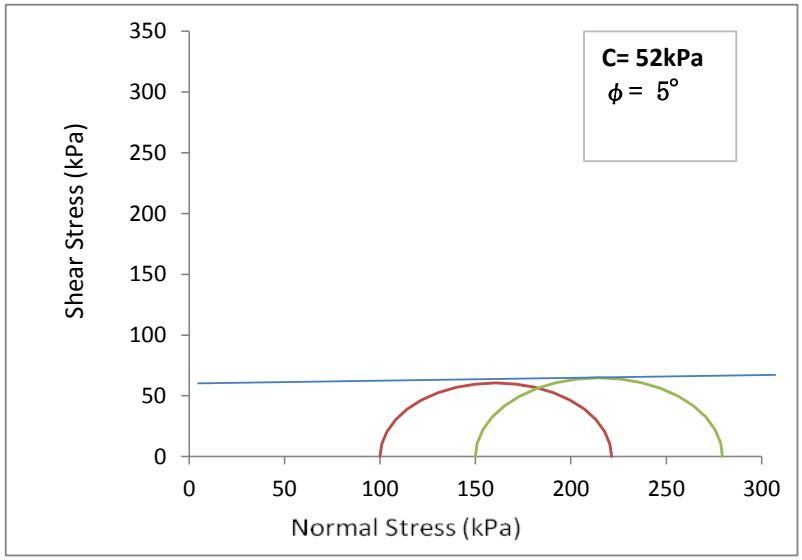
DEPTH:- 19.50 - 19.95 M. **TYPE OF TEST-UU**

BOREHOLE NO.-1

Stress Vs Strain Curve



Mode of failure Specimen-1 Cell Pressure (σ_3)	Δ
Mode of failure Specimen-1 Cell Pressure (σ_3)	□
Mode of failure Specimen-1 Cell Pressure (σ_3)	○



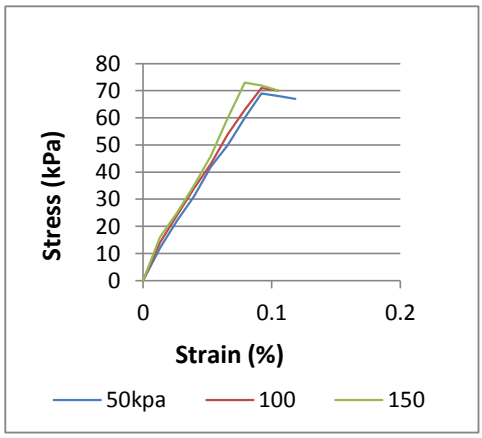
JOB NO. 23-24/15

SAMPLE NO._____ **JOB. NO. 23-24/15**

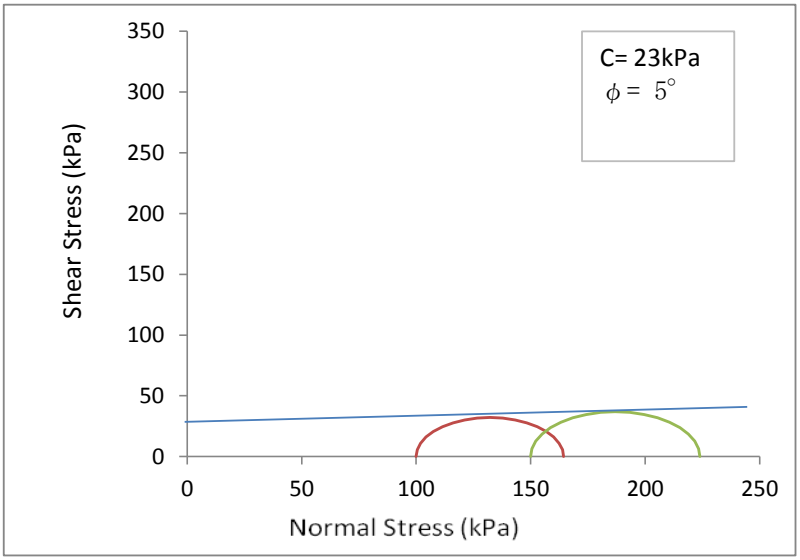
DEPTH:- 6.00 - 6.45 M. **TYPE OF TEST-UU**

BOREHOLE NO.-2

Stress Vs Strain Curve



Mode of failure Specimen-1 Cell Pressure (σ_3)	Δ
Mode of failure Specimen-1 Cell Pressure (σ_3)	□
Mode of failure Specimen-1 Cell Pressure (σ_3)	○

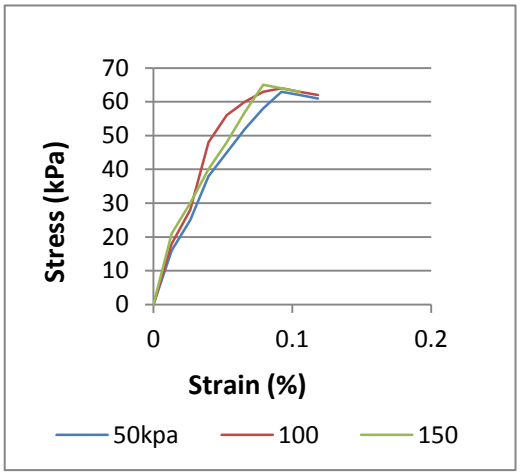


JOB NO. 23-24/15

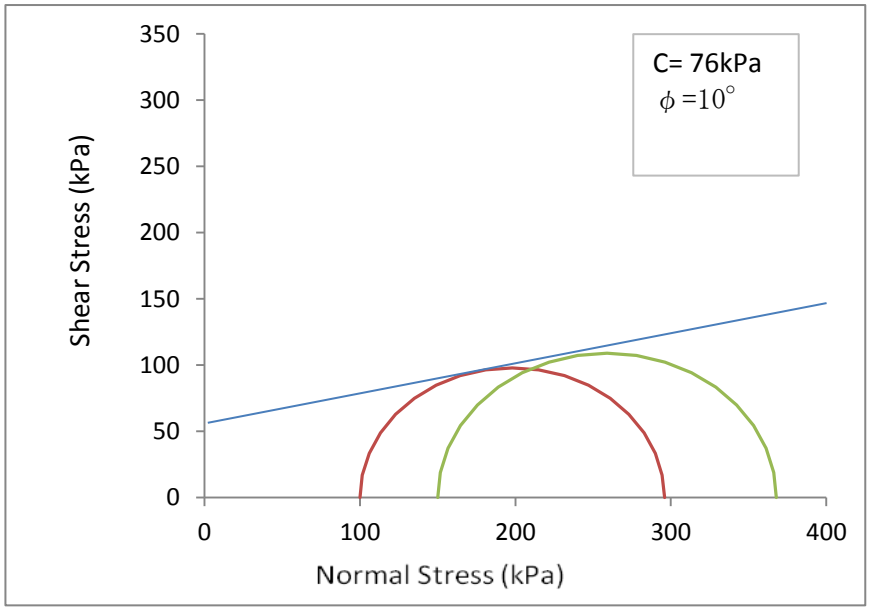
SAMPLE NO._____ **JOB NO. 23-24/15**

DEPTH:- 18.00 - 18.45 M. **TYPE OF TEST-UU**

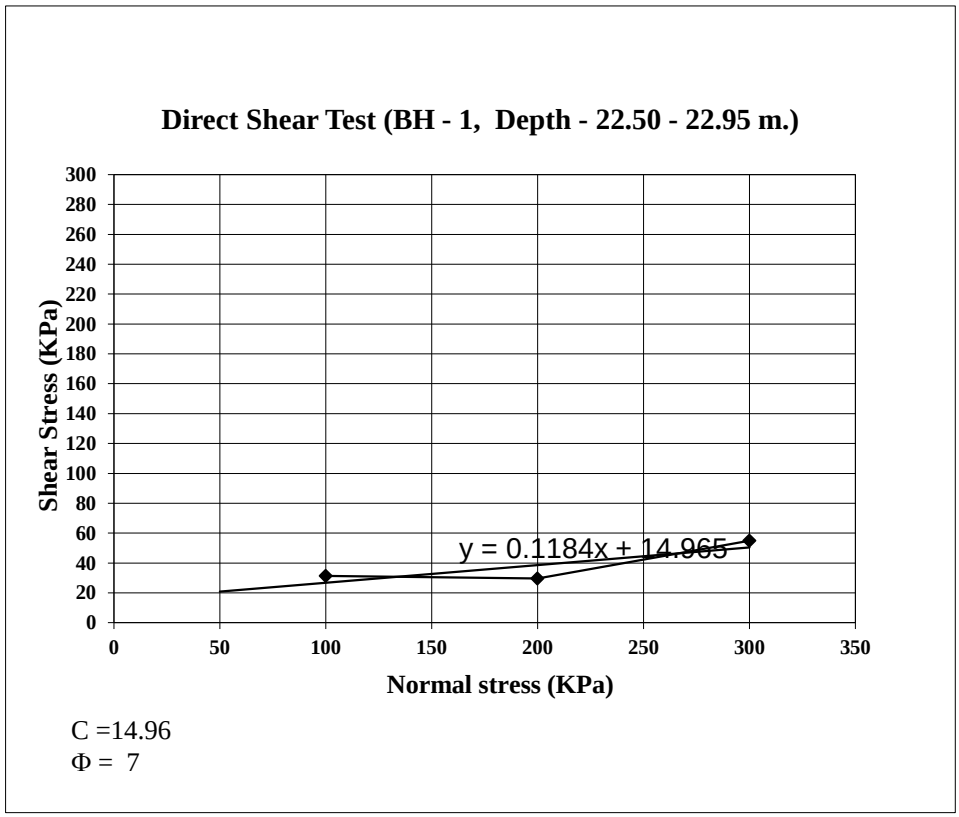
BOREHOLE NO. 2



Mode of failure Specimen-1 Cell Pressure (σ_3)	Δ
Mode of failure Specimen-1 Cell Pressure (σ_3)	□
Mode of failure Specimen-1 Cell Pressure (σ_3)	○

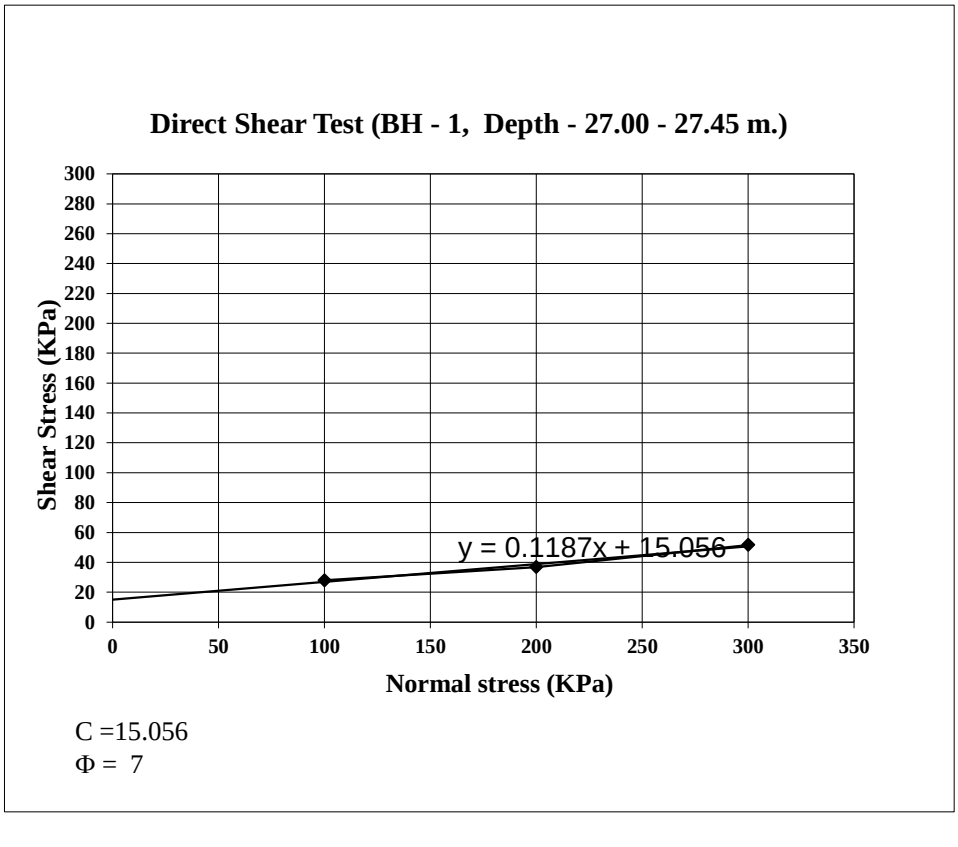


JOB NO. 23-24/15



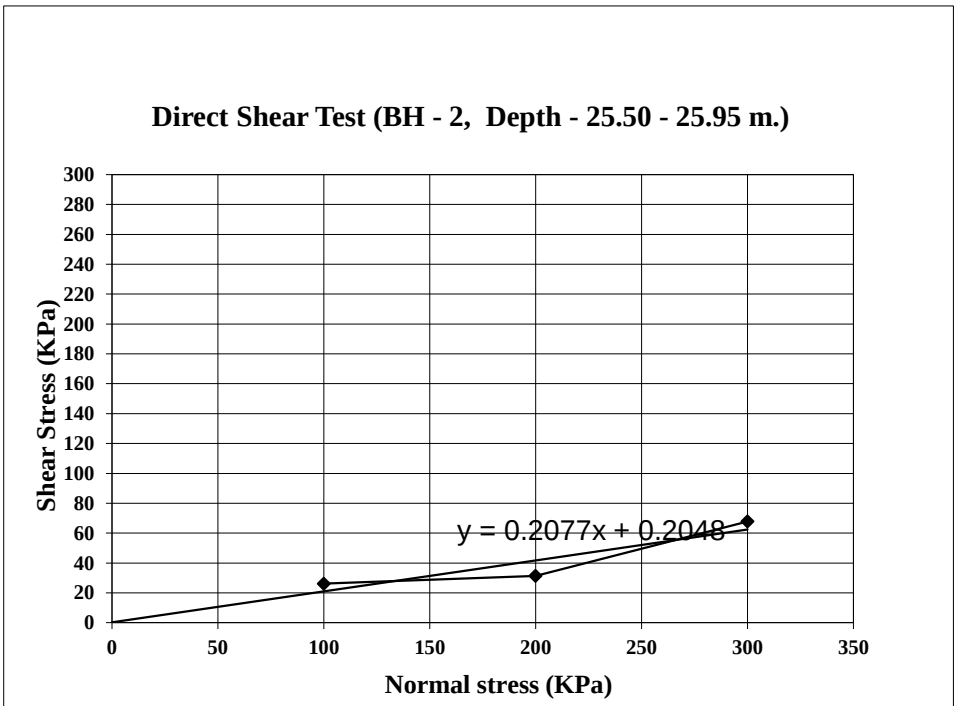
C =14.96
Φ = 7

N.M.C= 25.07%
B.D= 15.66
D.D= 12.52



C =15.056
Φ = 7

N.M.C = 26.65%
B.D = 16.40
D.D = 12.95



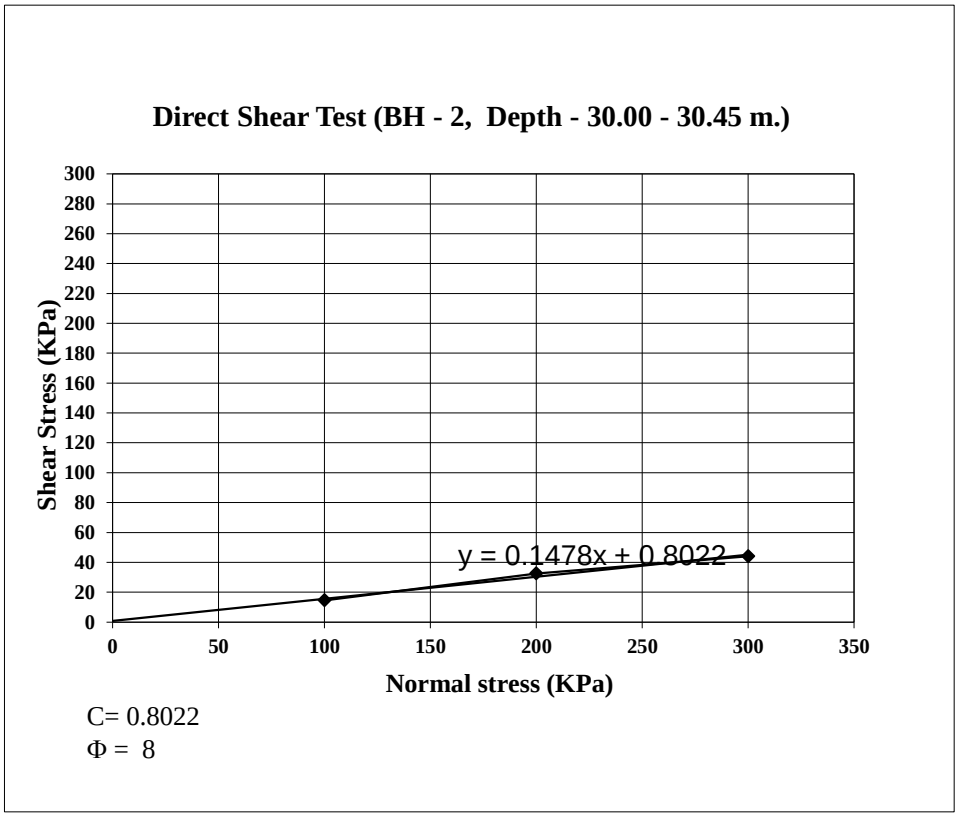
C= 0.2048

Φ = 12

N.M.C= 26.10%

B.D = 19.20

D.D = 15.225



C= 0.8022

Φ = 8

N.M.C= 24.03%

B.D = 18.23

D.D = 14.695

CONVERSION TABLE

Multiply	To convert	To
1000	T	Kg
10	Kg	N
0.10	KN	T
1	Pa	N/m^2
0.01	KPa	Kg/cm^2
10	Kg/m^2	N/m^2
1	T/m^3	g/cc
10	T/m^2	KPa
10	MPa (N/mm^2)	Kg/cm^2
0.10	T/m^2	Kg/cm^2
10	MN/m^2	Kg/cm^2

R. V. BRIGGS & CO. PRIVATE LTD.

ANALYTICAL CONSULTING & TECHNICAL CHEMISTS

(AN ISO 9001:2015 & ISO 45001: 2018 CERTIFIED COMPANY)

TAHER MANSION, 1ST FLOOR

9, BENTINCK STREET, KOLKATA - 700 001

Phone : (033) 4044-3380/3381/3382 / 3383, Fax : 33 2248-0447

E-mail : rvbriggs.kolkata@gmail.com, Website : www.rvbriggs.com

CIN : U51109WB1931PTC007007

TC-12347

TEST REPORT

No. SOIL(S)/23-24/54 - 59 (06 nos.) **Date: 15 December 2023** **Page 1 of 1**

Issued to : **M/s. GEOTREAT**
Chatterjee Lodge, 83/46 Dum Dum Road,
Kolkata-700074

Your Ref. No. : Letter No. 1296 dtd. 05.12.2023

Description of Sample : Soil

Sample Submitted by the Party on : 05.12.2023

Analysis completed on : 14.12.2023

Parameter Tested:
SG, Cl, SO_3 and pH

Test Method: Specific Gravity: IS: 2720 (Part-3,Sec.1)-1980
Chloride: SOP No.: RVB/SOP/05/35,
Ref.:Titrimetric (Argentometric)
Sulphate: IS: 2720 (Part-27)-1977
pH: IS: 2720 (Part-26) 1987

TEST FINDINGS:

Site : IOCL, Haldia, East Midnapore

Sl. No.	Our Ref. No.	Mark On Sample	Test Parameter / Results			
			Specific Gravity (SG)	Chloride as Cl (mg/kg)	Sulphate as SO_3 (mg/kg)	pH Value
1.	SOIL(S)/23-24/54	BH No. 01, Depth (m): 20.00-20.45, No.21, Dt.29.11.2023, Remarks: 2+2+3, N=5	2.59	--	--	--
2.	SOIL(S)/23-24/55	BH No. 01, Depth (m): 4.50-4.95, No.7, Dt.28.11.2023, Remarks: 0+1+1, N=2	2.85	--	--	--
3.	SOIL(S)/23-24/56	BH No. 02, Depth (m): 28.50-28.95, No.56, Dt.01.12.2023, Remarks: 12+18+26, N=44	2.65	--	--	--
4.	SOIL(S)/23-24/57	BH No. 02, Depth (m): 1.50-1.95, No.31, Dt.30.11.2023, Remarks: 1+2+3, N=5	2.73	--	--	--
5.	SOIL(S)/23-24/58	BH No. 02, Depth (m): 3.50-3.95, No.34, Dt.30.11.2023, Remarks: 0+1+1, N=2	--	296.87	168.27	7.11
6.	SOIL(S)/23-24/59	BH No. 02, Depth (m): 10.50-10.95, No.41, Dt.30.11.2023, Remarks: 0+1+1, N=2	2.63	--	--	--

-: END OF TEST REPORT :-

Report Verified by
(J. Das)

(Dr. R. KARIM)
Technical Manager
Authorised Signatory

R. V. BRIGGS & CO. PRIVATE LTD.

ANALYTICAL CONSULTING & TECHNICAL CHEMISTS

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TAHER MANSION, 1ST FLOOR

9, BENTINCK STREET, KOLKATA - 700 001

Phone : (033) 4044-3380/3381/3382 / 3383, Fax : 33 2248-0447

E-mail : rvbriggs.kolkata@gmail.com, Website : www.rvbriggs.com

CIN : U51109WB1931PTC007007

TEST REPORT

No. W(S)/23-24/1675 **Date : December 13, 2023**

Issued to : **M/S. GEOTREAT**
"Chatterjee Lodge" 83/46 Dum Dum Road, Kolkata-700074

Your Ref. : Letter dtd. 05.12.2023
Sample Description : Water
Mark on Sample : BH No.: 1, Depth (m) 2.30
Site : IOCL, Haldia, East Midnapore
Sample Submitted On : 05.12.2023
Test Completed on : 09.12.2023

Parameters Tested:
Chemical Parameters
pH,Sulphate & Chloride,

Chemical Test Findings :

Sl No.	Test parameters	Test Method	Unit	Result	Norms as per IS : 10500, 2012 (2nd Rev.), Amend., June 2015	
					Acceptable Limit	Permissible Limit
1	pH value	IS: 3025 (Part-11): 1983	---	7.7	6.5 - 8.5	No Relaxation
2	Chloride as Cl	IS: 3025 (Part-32): 1988	mg/l	968	250 Max.	1000 Max.
3	Sulphate as SO_3	IS: 3025 (Part-24): 1986	mg/l	204.6	---	---

Remarks on Chemical Test Report :
The above mentioned sample of drinking water complies with IS: 10500, 2012 (2nd Rev.) & Satisfactory for drinking purpose, in respect of the above mentioned parameters.

Turbidity is beyond the acceptable limit but within the permissible limit.

: END OF TEST REPORT :

Report Verified by
(J. Das)

J. Mukherjee
Quality Manager
Authorized Signatory
For R.V.BRIGGS & CO. PRIVATE LTD.

ss

R. V. BRIGGS & CO. PRIVATE LTD.

ANALYTICAL CONSULTING & TECHNICAL CHEMISTS

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Phone : (033) 4044-3380/3381/3382 / 3383, Fax : 33 2248-0447

E-mail : rvbriggs.kolkata@gmail.com, Website : www.rvbriggs.com

CIN : U51109WB1931PTC007007

TC-12347

TEST REPORT

No. SOIL(S)/23-24/60 & 61 (02 nos.) **Date: 12 December 2023**

Issued to : **M/s. GEOTREAT**
Chatterjee Lodge, 83/46 Dum Dum Road,
Kolkata-700074

Your Ref. No. : Letter No. 1297 dtd. 17.12.2023

Description of Sample : Soil

Sample Submitted by the Party on : 07.12.2023

Analysis completed on : 12.12.2023

Parameter Tested:
Bulk Density

Test Method: IS: 2720 (Part-28)-1974

TEST FINDINGS:

Site : IOCL, Haldia, East Midnapore

Sl. No.	Our Ref. No.	Mark On Sample	Test Parameter / Results
			Bulk Density (Dry) (gm/cc)
1.	SOIL(S)/23-24/60	BH No. 01, Depth (m): 9.00 – 9.45	1.22
2.	SOIL(S)/23-24/61	BH No. 02, Depth (m): 18.00 – 18.45	1.48

-: END OF TEST REPORT :-

Report Verified by
(J. Das)

(Dr. R. KARIM)
Technical Manager
Authorised Signatory

National Accreditation Board for Testing and Calibration Laboratories

CERTIFICATE OF ACCREDITATION

R.V.BRIGGS & CO. PVT. LTD.

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

9 BENTINCK STREET,THAIR MANSION, KOLKATA, WEST BENGAL, INDIA

in the field of

TESTING

Certificate Number: TC-12347

Issue Date: 30/09/2023 **Valid Until:** 29/09/2025

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Name of Legal Entity: R.V. Briggs & Company Pvt. Ltd.

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer