



**OIL INDIA LIMITED**

DULIAJAN, ASSAM  
3X10MW GAS ENGINE  
GENERATOR PLANT

*REPORT  
ON*

GEOTECHNICAL INVESTIGATION WORK AT DULIAJAN POWER  
STATION OF OIL INDIA LIMITED (OIL) IN DIBRUGARH , ASSAM

Owner's Consultant



**Development Consultants Pvt. Ltd.**  
BLOCK DG-4 , SECTOR – II , SALT LAKE  
CITY , KOLKATA – 700 091

Geotechnical and Survey Agency



**CONSTELL CONSULTANTS PVT. LTD.**  
CF-38, Sector-I, Salt Lake City  
Kolkata-700064

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## **C H A P T E R   -   I**

### **1.0 INTRODUCTION**

1.1 Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam has been carried out by Constell Consultants Pvt. Ltd., CF-38, Sector-I, Salt Lake City, Kolkata-700 064.

1.2 This soil investigation report has been prepared based on the following operation :

- i) Sinking three (3) bore holes upto a depth of 30.0m below the existing ground level in all kinds of soil formation including collection of undisturbed / disturbed soil samples and conducting Standard Penetration Tests.
- ii) Conducting one (1) In-situ permeability test in a bore hole by Falling Head method.
- iii) Conducting two (2) Static Cone Penetration Tests at specified locations.
- iv) Conducting one (1) Plate Load Test at specified location by using 45cm x 45cm size of square plate at a depth of 3.5m below natural ground level
- v) Conducting one (1) Block Vibration test at a depth of 3.5m below natural ground level at specified location.
- vi) Conducting one (1) Soil Resistivity Test at specified location.
- vii) Conducting two (2) field CBR Tests as specified.

1.3 The formation at the site is reported for various layers present at their respective depths along with their thickness. As ground water table location influences the method of construction of foundation at a site, its depth also needed to be found out. However, it should be noted that the depth of groundwater table observed during the investigation could differ from those encountered during construction and operational life of the constructed facility depending on prevailing meteorological conditions.

1.4 During sinking of bore holes and conducting test pits soil samples both in disturbed and undisturbed conditions are to be collected for laboratory tests. The disturbed samples

would be subjected to tests to obtain soil index properties. The undisturbed soil samples, however, would be used mainly for conducting tests to obtain shear strength parameters as well as consolidation characteristics of the soil representing the strata.

- 1.5 Since the investigation could not cover the regional sub-soil features, due weightage for the variations of sub-surface layers in its horizontal and vertical extent is to be given in selecting design basis.

## CHAPTER - II

### 2.0 PROJECT DETAILS

- 2.1 The site for the investigation work is situated inside the existing power plant of Duliajan Power Station of Oil India Limited at Duliajan in Assam.
- 2.2 The field work consisted of sinking three (3) bore holes upto a maximum depth of 30.86m below the existing ground level, conducting one (1) In-situ-permeability test in a bore hole, two (2) Static Cone Penetration tests, one (1) Plate Load Test, one (1) Block Vibration Test, one (1) Soil Resistivity Test and two (2) field CBR Test at specified locations. The details of field work like, location (Co-ordinate), bore hole / test no., ground elevation, depth of bore hole / test, water level and the dates of commencement and completion are furnished below.

Bore Hole / Test No.	Location (Co-ordinate)		Ground Elevation	Depth of bore hole / Test	Water Level b.g.l	Start Date	End Date
	North	East	(m)	(m)	(m)		
BH-1	3027853.9	728406.6	+118.5	30.63	3.93	03.04.19	05.04.19
BH-2	3027840.2	728357.7	+118.2	30.39	3.52	30.03.19	03.04.19
*BH-3	3027787.1	728362.5	+118.4	30.86	3.77	27.03.19	30.03.19
SCPT-1	3027730.8	728350.0	+118.2	22.60	-	23.04.19	23.04.19
SCPT-2	3027815.2	728357.2	+118.2	20.60	-	21.04.19	21.04.19
PLT-1	3027895.5	728304.9	+118.1	3.50	-	18.04.19	19.04.19
BVT-1	3027794.4	728348.2	+118.2	3.50	-	29.04.19	29.04.19
ERT-1	3027822.9	728358.4	+118.3	-	-	14.04.19	14.04.19
CBR-1	3027819.9	728327.1	+118.1	0.80	-	25.04.19	25.04.19
CBR-2	3027743.0	728332.0	+118.1	0.50	-	24.04.19	24.04.19
<p style="text-align: center;"><b>Note:</b> b.g.l.= below ground level *In-situ-permeability test was carried out from 4.80m to 5.00m depth in BH-3</p>							

2.3 The bore holes of 150 mm diameter were explored with the help of auger and cable operated shell using engine driven mechanical winch as per IS 1892-1979. Here the auger is turned in the bottom of the hole through auger pipes. Due to this the soil cuttings are held in the auger and are drawn to the surface by pulling the auger out of the hole each time the auger is filled. In continuation to auger boring shell is used which is a 127mm diameter steel cylinder with a cutting edge at the bottom and is fitted with a hinged one-way flap valve at the bottom. The bore hole is advanced by raising the shell upto a height and allowing it to fall and this is repeated several times till sufficient amount of soil enters the shell. When the shell gets nearly filled with soil, it is lifted out of the bore hole and emptied. This method of boring is followed upto a suitable depth below the existing ground level.

For further advancement of bore hole mud rotary boring method was adopted. In this method the boring is advanced by a cutter fixed to drill pipes, which are rotated by means of pipe wrenches. Bentonite solution is pushed simultaneously by a mechanical pump. The slurry flowing out of cutter bottom mixes up with the cut soil and flows up to the ground surface, and slurry tank after passing through settling pits and back to the slurry tank. The process is continuous and the same slurry can be used several times. The cutting tool is lowered slowly with the help of a double pulley system fixed on a tripod. This method of boring was followed upto the explored depth of the bore hole.

2.4 Seamless flush jointed steel casings of Sx (150mm) size was used to prevent any caving of bore hole and was inserted simultaneously with the advancement of boring operation.

2.5 The undisturbed samples were collected from the bore holes wherever possible, with the help of a thin walled sampler, as per the IS: 2132-1986 "Code of practice for thin walled tube sampling of soils". The area ratio of the sampler is of the order of twelve percent and the inside clearance is around two percent. The sample tube about 500mm long and 100mm inner diameter, is coupled with the sampler with a drive head, vent holes and ball

check valve to complete the sampling assembly. While sampling below the water table inside the bore hole, the entrapped water has the opportunity to escape through this valve at the top. The sampling assembly is then lowered inside the bore holes by connecting a string of 'A' / 'AW' size drill rods to it. The assembly is driven to a predetermined depth with the help of jarring link. On completion of sampling operation, the sampler is first rotated (so that the soil would shear off on a horizontal plane at the cutting shoe edge) and then raised to the surface. The undisturbed sample is waxed at both ends with proper identification mark on the tube sampler.

- 2.6 Standard Penetration Tests were conducted inside the bore holes at 1.5m intervals as per IS 2131-1981 "Method of standard penetration tests for soils". The split spoon sampler used is of standard design and dimension. The spoon is advanced by driving with a drop hammer weighing 63.5 kg falling freely through a height of 75 cm. A record of the number of blows required to penetrate every 15 cm. to a depth of 45cm is kept. The number of blows required for the last 30 cm penetration of the split spoon sampler is recorded as 'N'-value. On completion of the test, the sampler is lifted to the ground, opened and the specimen of the soil sample is stored in double polythene bags with the proper identification mark. The penetration number, 'N' has been shown against the corresponding depths in the bore logs.
- 2.7 Representative disturbed samples were collected regularly and wherever the stratum changed. These samples are taken from the cutting edge of undisturbed samples and the split spoon samplers after standard penetration tests. These samples are labelled depth wise and used in the preparation of bore hole log and for general identification and classification purposes.
- 2.8 One (1) In-situ permeability test was carried out by Falling Head method as per IS: 5529 (Part-I) 1985. The test result is furnished in the enclosed permeability test data sheet in page no.B-9 of this report.

2.9 Static Cone Penetration Tests were conducted at two (2) specified location as per IS:4968 (Part-III)-1976 with the help of a hydraulically operated equipment of 20 Tonne capacity. In this method first the cone is pushed into the ground and then the cone and friction jacket assembly is pushed in the ground. The resistance in both the cases has been recorded from the pressure gauge. This procedure is repeated after pushing the combined cone, friction jacket and mantle tube assembly to the next depth at which the cone and friction resistance values are required. The field test data and graphical representations of cone resistances, frictional resistances and friction ratio with depth are plotted and are shown in page nos. C-1 to C-6 of this report.

2.10 Plate load test was carried out at one (1) specified location at 3.50m depth below the natural ground level using 45.0cm x 45.0cm Plate. Test pit of 3.0m x 3.0m at the bottom is dug at the test location. The bottom level of pit is then dressed properly and a thin layer of sand is spread underneath the test plate. The test plate is placed in such a way that the centre of the plate coincides with the centre of reaction girder with the help of a plumb bob and horizontally leveled by a spirit level to avoid eccentric loading. The hydraulic jack is centrally placed over the plate so as to transfer load to the plate. A ball and socket arrangement has been inserted to keep the direction of the load vertical throughout the test.

Thus the load on the plate is applied by reaction type loading arrangement through hydraulic jack and the settlement of the plate is noted from dial gauges fixed on the plate at prescribed intervals as mentioned in IS: 1888-1982. In this process when the desired minimum rate of settlement (0.02mm / min) is attained or when the two successive readings of dial gauges are nearly constant, the next increment of load is applied on the plate through hydraulic jack with pressure gauge attachment. This procedure is followed till the total settlement of the plate reaches 25mm or the maximum load is applied. Thus the settlement corresponding to an applied load is noted and load settlement curves are



plotted. The plate load test data sheets and results are submitted in page nos.D-1 to D-7 of this report.

- 2.11 In order to get different dynamic properties one (1) Block vibration test was carried out at a depth of 3.5m below natural ground level on concrete block of size 0.75m x 0.75m x 1.50m at the centre of the pit with M15 concrete. The equipment used to carryout the test consisted of 3 H.P. single-phase D.C. motor, Oscillator, Speed Control Unit and Vibration Sensor & Indicator. The oscillator is mounted on the block so that it generates purely vertical sinusoidal vibrations and the line of the vibrating forces passes through the centre of gravity of the block. The acceleration pick-up is fixed on the top of the concrete block in such a way so that the sensing axis of pick-up is parallel to the direction of vibration. 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 unto the resonant frequency and a few 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. Four sets of reading were taken for different eccentric angles. The datasheets are provided with the report. The data thus obtained from vertical vibration test are tabulated in the sheets enclosed and graphs are plotted to find out the resonant frequency and corresponding amplitude.  $C_u$ ,  $E$ ,  $G$  and damping factor ( $\xi$ ) are evaluated based on the resonant frequency and maximum amplitude. The field test data and figures are provided in page nos E-1 to E-2 of this report.
- 2.12 Soil resistivity test at one location (ERT-1) was carried out by Wenner's Four Electrode Method in N-S and E-W directions with electrode separation ( $S$ ) = 1.0, 3.0, 5.0, 10.0, 15.0 and 20.0 m using Digital AC Resistivity Meter which could produce current in a constant Current Mode in the form of square wave at a frequency of 2.5 Hz. Voltage measurement is carried out by a measuring unit after eliminating cultural noise as well as cable induction

effect through an inbuilt notch filter. The data thus obtained are used to calculate Apparent Resistivity and the values along with graphical representation are shown in page no.F-1 of this report.

- 2.13 Field CBR Tests were carried out at two (2) specified location at varying depth below the existing ground level. The test surfaces are dressed, then saturated by ponding water to get the field CBR value in soaked condition and loaded with adequate surcharge weight to get the actual condition. On completion of all these necessary arrangement for testing, load is applied on the penetration piston at the rate of 1.25mm/min and corresponding readings at specified penetration intervals are noted in adherence to the principles in IS:2720 (Part XXXI)-1969. Finally the load penetration curves are plotted and are shown in page no.G-1 to G-4 of this report.
- 2.14 The field work commenced on 27.03.2019 and was completed on 29.04.2019. The depth of water level in the bore holes was measured 24 hours after the completion of bore hole. No artesian condition was encountered in any of the bore holes.

## C H A P T E R - I I I

### **3.0 LABORATORY TESTING**

3.1 The following laboratory tests are carried out on undisturbed and disturbed soil samples for identification and classification purposes and to obtain other relevant properties of the sub-surface formation.

- (a) Natural Moisture Content
- (b) Sieve analysis
- (c) Hydrometer analysis
- (d) Liquid Limit and Plastic Limit
- (e) Bulk and Dry Density
- (f) Triaxial Shear Test (Unconsolidated Un-drained)
- (g) Direct Shear Test
  - i) On undisturbed sample
  - ii) On remoulded sample
- (h) Specific Gravity
- (i) Consolidation Test

3.2 Chemical analysis of soil and water samples were also carried out for the determination of different parameters as specified.

3.3 All these tests are conducted as per relevant IS Code where such exists and the test results are tabulated in Tables attached herewith.

## C H A P T E R - I V

### 4.0 DISCUSSION AND RECOMMENDATION

4.1 The sub-soil investigation work has been investigated by sinking three (3) bore holes explored upto a maximum depth of 30.86m below the existing ground level, conducting one (1) in-situ permeability test, two (2) Static Cone Penetration tests, one (1) Plate Load Test, one (1) Block Vibration Test, one (1) Soil Resistivity Test and two (2) field CBR Test at specified locations. The field investigation data and the results of laboratory test conducted on samples collected from the bore holes indicate the presence of two layers beside a filled up layer at the surface. The details of layers like layer no., description of layer and the thickness of each layer as encountered in the bore holes are furnished below.

Layer No.	Description	Layer Thickness (m)		
		BH-1	BH-2	BH-3
—	Fill consisting of sandy silty clay with gravels / brick pieces / brick soling etc.	0.60	0.30	0.70
I	Firm / stiff silty clay / clayey silt with traces of sand	2.40	2.70	2.30
II	Medium dense / dense silty sand / sand	27.63	*27.39	27.86
*2.0m thick band of very stiff / hard silty clay (high silt content) is found to be present within this layer from 23.0m to 25.0m depth in BH-2 as shown in sub-soil profile.				

**Note:** The description of layers is very much generalized. For detail description refer respective bore hole logs.

4.2 The water level in the bore holes during the period of field work are shown in the respective bore logs. The laboratory test results are tabulated in table nos. H/1-1 to H/5. The bore hole location plan is shown in fig. no. A/1. The graphical representation of field and corrected 'N' values with RL are shown in fig. nos. B/1 & B/2 respectively. The sub-soil formation as revealed by the bore holes are shown in fig. nos. I/1. The grain size distribution curves are shown in fig. nos. J/1 to J/12. The Mohr's diagrams from Tri-axial shear test and normal stress vs shear stress plot from Direct Shear Test are shown in fig. nos. J/13 to J/18. The e-log p curves from consolidation test are shown in fig. nos. J/19 to J/21.

4.3 On close scrutiny of field and laboratory test results and based on experience and judgement, necessary soil parameters (bore hole wise) for the purpose of design of foundation are tabulated in the following table.

**BH-1**

LAYER DETAILS					Corrected N Value	Bulk Density ( $t/m^3$ )	Shear Strength parameter	Shear Modulus ( $kg/cm^2$ )
No.	Description	R.L (m)		Thick -ness				
		From	To	( $m$ )				
—	Brick soling followed by sandy silty clay with brick pieces	+118.5 (G.L.)	+117.9	0.6	—	§1.800	—	—
I	Firm silty clay / clayey silt with traces of sand	+117.9	+115.5	2.4	7	1.855	c=3.3t/m <sup>2</sup>	15.60
II	Medium dense / dense silty sand	+115.5	+112.0	3.5	11 & 16	1.830	φ=31°	52.78
		+112.0	+109.0	3.0	26 & 28	§2.000	§φ=34.5°	§77.78
		+109.0	+94.0	15.0	32 to 49	§2.070	§φ=36°	§87.04
		+94.0	+91.0	3.0	28 & 29	§2.010	§φ=35°	§80.56
		+91.0	+87.9 (T.L.)	3.1	30 to 38	§2.030	§φ=35.5°	§90.74
G.L= Ground Level, T.L.= Termination Level, § = Recommended Value								

**BH-2**

LAYER DETAILS					Corrected N Value	Bulk Density ( <i>t/m<sup>3</sup></i> )	Shear Strength parameter	Shear Modulus ( <i>kg/cm<sup>2</sup></i> )
No.	Description	R.L (m)		Thick -ness				
		From	To	( <i>m</i> )				
—	Fill consisting of sandy silty clay with gravels	+118.2 (G.L.)	+117.9	0.3	—	§1.800	—	—
I	Firm / stiff silty clay with traces of sand	+117.9	+115.2	2.7	9	1.879	c=3.9t/m <sup>2</sup>	18.00
II	Medium dense / dense silty sand / sand ; very stiff / hard silty clay (high silt content) observed from 23.00m to 25.00m depth	+115.2	+110.2	5.0	19 to 23	1.895	φ=32.5°	66.67
		+110.2	+105.7	4.5	25 to 29	§2.000	§φ=34.5°	§77.78
		+105.7	+95.2	10.5	32 to 45	§2.050	§φ=36°	§87.04
		+95.2	+93.2	2.0	31 & 40	§2.040	§c=15.0t/m <sup>2</sup>	§49.80
		+93.2	+87.8 (T.L.)	5.4	31 to 36	§2.040	§φ=35.5°	§89.81
G.L= Ground Level, T.L.= Termination Level, § = Recommended Value								

**BH-3**

LAYER DETAILS					Corrected N Value	Bulk Density ( <i>t/m<sup>3</sup></i> )	Shear Strength parameter	Shear Modulus ( <i>kg/cm<sup>2</sup></i> )
No.	Description	R.L (m)		Thick -ness				
		From	To	( <i>m</i> )				
—	Fill consisting of sandy silty clay with gravels , brick pieces etc.	+118.4 (G.L.)	+117.7	0.7	—	§1.800	—	—
I	Firm / stiff silty clay / clayey silt with traces of sand	+117.7	+115.4	2.3	11	1.906	c=4.6t/m <sup>2</sup>	20.40
II	Medium dense / dense silty sand / sand	+115.4	+113.4	2.0	16	1.845	φ=31.5°	57.41
		+113.4	+108.9	4.5	20 to 23	§1.935	§φ=33°	§67.59
		+108.9	+105.9	3.0	27 & 29	§2.010	§φ=35°	§79.63
		+105.9	+92.4	13.5	31 to 38	§2.050	§φ=36°	§91.67
		+92.4	+89.4	3.0	28 & 29	§2.010	§φ=35°	§80.56
		+89.4	+87.5 (T.L.)	1.9	31 & 34	§2.030	§φ=35.5°	§87.96
G.L= Ground Level, T.L.= Termination Level, § = Recommended Value								

The sample calculations for level wise variation of shear modulus obtained from dynamic test (SPT) results are presented in page no. K-10.

- 4.4 In view of the sub-soil formation encountered in this area shallow open foundation may be provided to carry the load from superstructure. The estimated net allowable bearing capacities of different size of footing when placed at different depths below existing ground level are presented in the following table. The settlement in all the cases will remain within the permissible limit as per IS Code of practice.

Bore Hole No.	Size of foundation	Depth of Foundation b.g.l	Estimated Net Allowable Bearing Capacity
		(m)	(t/m <sup>2</sup> )
BH-1, BH-2 & BH-3	1.5m x 1.5m	1.0	10.0
	3.0m x 3.0m		9.4
	4.0m x 4.0m		9.3
	1.0m wide		8.1
	2.0m wide		7.5
	4.0m wide		7.1
	6.0m wide		7.0
	8.0m wide		7.0
	10.0m wide		6.9
	1.5m x 1.5m	2.0	11.2
	3.0m x 3.0m		10.0
	4.0m x 4.0m		9.7
	1.0m wide		9.5
	2.0m wide		8.1
	4.0m wide		7.5
	6.0m wide		7.3
	8.0m wide		7.1
	10.0m wide		7.1
	1.5m x 1.5m	3.0	13.7
	3.0m x 3.0m		11.5
	4.0m x 4.0m		11.0
	1.0m wide		16.1
	2.0m wide		12.6
	4.0m wide		11.0
	6.0m wide		15.7
	8.0m wide		15.4
	10.0m wide		15.2

- 4.5 In case of higher load deep foundation in the form of bored cast-in-situ concrete pile may be provided to carry the load from superstructure. The suggested load carrying capacities of different dia. of piles when placed at different founding levels with cut-off level at R.L.+117.0m are furnished in the following table.

Location  (m)	Pile Dia  (m)	Cut off Level  (m)	Founding level  (m)	Suggested Pile Capacity (t)			
				Vertical	Uplift	Lateral	
						Fixed head pile	Free head pile
BH-1,2 & 3	0.45	+117.0	+103.0	55.0	25.0	3.0	1.2
			+98.0	70.0	35.0	3.0	1.2
			+93.0	85.0	45.0	3.0	1.2
	0.60		+103.0	110.0	40.0	5.5	2.1
			+98.0	125.0	65.0	5.5	2.1
			+93.0	140.0	85.0	5.5	2.1

- 4.6 The above mentioned pile capacities have been calculated on the basis of available and conventional static formula using a factor of safety of 2.5. However it is essential to install the piles with good engineering practice. In reality the actual pile load capacity is dependant on proper installation of pile. The piles may be installed at a centre to centre spacing of  $3.0 \times d$ , where 'd' is the diameter of a pile. Initial load test on piles should be carried out as per BIS 2911 (Part-4) and based on pile load test data final safe design load on a pile should be adopted.



4.7 The results of Static Cone Penetration Tests along with the graphical representation of Cone Resistance, Frictional Resistance and Friction Ratio are shown in Annexure-C of this report. The interpretation of layer type along with average representative cone resistance ( $q_c$ ) and frictional resistance ( $f_s$ ) of various layers / sub-layers are furnished in the following tables.

SCPT No.	R.L.		Description	Average $q_c$ (Kg/cm <sup>2</sup> )	Average $f_s$ (Kg/cm <sup>2</sup> )
	From (m)	To (m)			
SCPT-1	0.0	0.2	–	0.30	0.008
	0.2	4.2	Firm / stiff silty clay / clayey silt	22.34	1.118
	4.2	22.6	Medium dense / dense to very dense silty sand / sand	213.19	4.040

SCPT No.	R.L.		Description	Average $q_c$ (Kg/cm <sup>2</sup> )	Average $f_s$ (Kg/cm <sup>2</sup> )
	From (m)	To (m)			
SCPT-2	0.0	0.6	–	0.30	0.008
	0.6	3.2	Stiff silty clay / clayey silt	16.69	0.892
	3.2	20.6	Medium dense / dense to very dense silty sand / sand	268.22	3.721

4.8 One (1) plate load test was carried out at specified location using 45cm x 45cm plate at 3.50m depth below the existing ground level. The plate load test results and load settlement curves (both in arithmetic and logarithmic plots) are presented in page nos. D-1 to D-7 of this report.

The bearing capacities from Plate Load Test are calculated as follows.

### PLT-1

From load-settlement curve (logarithmic plot fig no. 1/2) yield point = 2.88 kg/cm<sup>2</sup>,

Therefore, Safe Bearing capacity of the plate =  $\frac{2.88}{2.5}$  kg/cm<sup>2</sup> = 1.15 kg/cm<sup>2</sup> say **11.5 t/m<sup>2</sup>**

where factor of safety = 2.5

The Modulus of sub-grade reaction (k) as estimated from plate load test are furnished below.

Test No.	Modulus of Sub-grade Reaction				
	Uncorrected Value	Corrected for load deflection	* <sup>1</sup> Corrected for bending	* <sup>2</sup> Corrected for size of plate	Corrected value
	(Ku) (kg/cm <sup>3</sup> )	(Kd) (kg/cm <sup>3</sup> )	(Kb) (kg/cm <sup>3</sup> )	(Kp) (kg/cm <sup>3</sup> )	(K) (kg/cm <sup>3</sup> )
PLT-1	8.5	8.5	7.6	4.9	4.9
* <sup>1</sup> As per fig.-5 of IS 9214-1979, * <sup>2</sup> As per fig.-3 of IS 9214-1979					

### Calculation for Modulus of sub-grade reaction (k):

Location: PLT-1

Uncorrected Value, Ku = (0.7 / deflection) kg/cm<sup>3</sup>

$$= (0.7/0.082) = 8.5 \text{ kg/cm}^3$$

[deflection 0.082cm corresponding to 0.7kg/cm<sup>2</sup> load - from **fig. no.1/1**]

Corrected for load deflection, Kd = Ku = 8.5 kg/cm<sup>3</sup>

Corrected for bending of Plate, Kb = 7.9 kg/cm<sup>3</sup>, for Ku = 8.5 kg/cm<sup>3</sup>

[from fig.-5 of clause no. 5.1.3 of IS 9214:1979]

Corrected for size of plate, Kp = Kb/1.54 = 4.9 kg/cm<sup>3</sup>

[As per fig.-3 of clause no. 5.1.1 of IS 9214:1979, for (45cmx45cm) Square Plate  
i.e, ≈ 50.8cm dia. Circular Plate corresponding factor = 1.54]

Therefore, Corrected value, K = 4.9 kg/cm<sup>3</sup>

4.9 The test results obtained from vertical vibration test are used to find out the values of  $C_u$ ,  $C_\tau$ ,  $C_\phi$ ,  $C_\psi$ ,  $\xi$ ,  $G$  following the methodology laid down in IS: 5249-1992. In order to use the dynamic parameters from the test results for the design of actual foundation it is suggested to make necessary correction of the test results in respect of

- Actual foundation area
- Actual confining pressure
- Actual strain level

The corrected values of dynamic parameters with all the above considerations excepting the strain level have been incorporated for contact area  $10\text{m}^2$  and confining pressure of  $10\text{ t/m}^2$ . The values thus calculated are shown in table below. For any other contact area and confining pressure the dynamic properties may be found out from sample calculation. In case of strain level, the value of these parameters may be evaluated for the actual strain level by linear interpolation.

Test No.	R.L. of Test Points (m)	Properties from Test				Properties for contact area $10\text{m}^2$ or more and confining pressure of $1.0\text{ kg/cm}^2$						Damping co-efficient ( $\xi$ )
		$C_u\text{ kg/cm}^3$	$E\text{ kg/cm}^2$	$G\text{ kg/cm}^2$	Strain $\times 10^{-4}$	$C_u\text{ kg/cm}^3$	$C_\tau\text{ kg/cm}^3$	$C_\phi\text{ kg/cm}^3$	$C_\psi\text{ kg/cm}^3$	$E\text{ kg/cm}^2$	$G\text{ kg/cm}^2$	
BVT-1	+118.2	3.60	209.66	77.65	4.00 to 14.67	1.01	0.58	2.01	0.87	58.82	21.76	0.22

The sample calculation for different parameters from Block Vibration test is presented in page nos.K-6 to K-9.

- 4.10 Soil Resistivity tests have been conducted at one (1) location viz. ERT-1 as shown in the location plan. The maximum and minimum values of apparent resistivity corresponding to ERT-1 observed along NW-SE and NE-SW direction along with appropriate electrode separation are given in following table.

Test No.	NW-SE				NE-SW			
	Max. Apparent Resistivity	Electrode Separation [s]	Min. Apparent Resistivity	Electrode Separation [s]	Max. Apparent Resistivity	Electrode Separation [s]	Min. Apparent Resistivity	Electrode Separation [s]
	Ω-m	m	Ω-m	m	Ω-m	m	Ω-m	m
ERT-1	172.57	10.00	55.82	20.00	176.17	10.00	53.31	20.00

On the basis of the value tabulated, it is found that the maximum value of apparent resistivity of 176.17 Ohm-m has been recorded in NE-SW direction for electrode separation of 10.0 m. Likewise, the minimum value of apparent resistivity of 53.31 Ohm-m has been recorded in NE-SW direction for electrode separation of 20.00 m.

- 4.11 In-situ Permeability test by Falling head method was carried out at 4.80m depth below the existing ground level in BH-3 and the test result is shown in page no.B-9 of this report. The permeability value is found to be  $4.2 \times 10^{-6}$  cm/sec.
- 4.12 Field CBR test were carried out at two (2) specified locations and the test results are shown in page nos.G-1 to G-4 of this report. The CBR values thus obtained varies from 2.9% and 3.6%.
- 4.13 The results of chemical analysis of soil and water samples are tabulated in Table nos. H/4 and H/5 respectively. Based on the results concrete to be used in foundation construction should be in line with recommendations of IS:456 – 2000.

- 4.14 Considering the presence of firm / stiff silty clay / clayey silt with traces of sand upto 3.0m below the existing ground level followed by medium dense silty sand / sand in this area, the excavation may be carried out at a slope of 1V:1.75H up to a depth of 3.0m below the existing ground level. For excavations which may be kept for long durations and for deeper excavations retaining structures are to be adopted.
- 4.15 The lateral earth pressure co-efficient at rest condition for cohesive soil  $K_0$  is calculated from the two equations to get an approximate prediction, and the average values are suggested in the following tables. [Refer equation (2-21) and (2-21a) of Foundation Analysis and Design, Fifth edition by J. E. Bowles]

$$K_0 = 0.19 + 0.233 \log_{10} I_p \quad [\text{Suggested by Alpan (1967)}]$$

$$K_0 = 0.44 + 0.0042 I_p \quad [\text{Suggested by Holtz and Kovacs (1981)}]$$

$K_0$  for cohesionless soil is estimated based on the following equation as suggested by

Jaky (1948) :

$$K_0 = 1 - \sin \phi \quad [\text{Refer equation (2-18a) of Foundation Analysis and Design, Fifth edition by J. E. Bowles}]$$

The earth pressure equations proposed by Rankine, can be used to estimate the active and passive earth pressure co-efficients:

[Refer Fig 4-2 of Foundation Analysis and Design, Fifth edition by J. E. Bowles]

$$\text{Active earth pressure co-efficient, } K_a = \tan^2(45^\circ - \phi / 2)$$

$$\text{Passive earth pressure co-efficient, } K_p = \tan^2(45^\circ + \phi / 2)$$

Bore-hole wise lateral earth pressure co-efficient for different layers in the project area are furnished below:

**BH-1**

LAYER DETAILS					At Rest K <sub>0</sub>	Active, K <sub>a</sub>	Passive, K <sub>p</sub>
No.	Description	R.L (m)		Thick- ness			
		From	To	(m)			
—	Brick soling followed by sandy silty clay with brick pieces	+118.5 (G.L.)	+117.9	0.6	-	-	-
I	Firm silty clay / clayey silt with traces of sand	+117.9	+115.5	2.4	0.45	1.00	1.00
II	Medium dense / dense silty sand	+115.5	+112.0	3.5	0.49	0.32	3.13
		+112.0	+109.0	3.0	0.43	0.28	3.61
		+109.0	+94.0	15.0	0.41	0.26	3.85
		+94.0	+91.0	3.0	0.43	0.27	3.70
		+91.0	+87.9 (T.L.)	3.1	0.42	0.27	3.77
G.L= Ground Level, T.L.= Termination Level							

**BH-2**

LAYER DETAILS					At Rest K <sub>0</sub>	Active K <sub>a</sub>	Passive, K <sub>p</sub>
No.	Description	R.L (m)		Thick- ness			
		From	To	(m)			
—	Fill consisting of sandy silty clay with gravels	+118.2 (G.L.)	+117.9	0.3	-	-	-
I	Firm / stiff silty clay with traces of sand	+117.9	+115.2	2.7	0.49	1.00	1.00
II	Medium dense / dense silty sand / sand ; very stiff / hard silty clay (high silt content) observed from 23.00m to 25.00m depth	+115.2	+110.2	5.0	0.46	0.30	3.32
		+110.2	+105.7	4.5	0.43	0.28	3.61
		+105.7	+95.2	10.5	0.41	0.26	3.85
		+95.2	+93.2	2.0	0.46	1.00	1.00
		+93.2	+87.8 (T.L.)	5.4	0.42	0.27	3.77
G.L= Ground Level, T.L.= Termination Level							

**BH-3**

LAYER DETAILS					At Rest K <sub>0</sub>	Active K <sub>a</sub>	Passive, K <sub>p</sub>
No.	Description	R.L (m)		Thick- ness			
		From	To	(m)			
—	Fill consisting of sandy silty clay with gravels , brick pieces etc.	+118.4 (G.L.)	+117.7	0.7	-	-	-
I	Firm / stiff silty clay / clayey silt with traces of sand	+117.7	+115.4	2.3	0.45	1.00	1.00
II	Medium dense / dense silty sand / sand	+115.4	+113.4	2.0	0.48	0.31	3.19
		+113.4	+108.9	4.5	0.46	0.30	3.39
		+108.9	+105.9	3.0	0.43	0.26	3.85
		+105.9	+92.4	13.5	0.41	0.26	3.85
		+92.4	+89.4	3.0	0.43	0.27	3.77
		+89.4	+87.5 (T.L.)	1.9	0.42	0.27	3.77
G.L= Ground Level, T.L.= Termination Level							

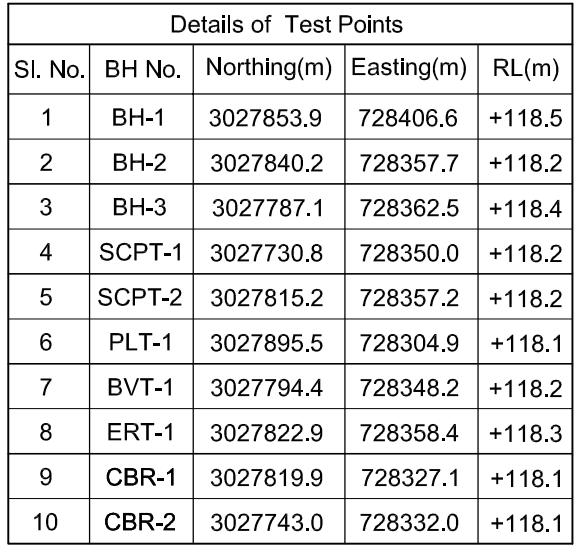
for **CONSTELL CONSULTANTS PRIVATE LIMITED**

Dated September 17, 2019

**B. N. BASAK**  
M.E., MIE, MIGS, MIRC, MISEG  
DIRECTOR

## **CHAPTER-V**





**Notes :-**

1. All dimensions are in metre, unless otherwise mentioned.
2. Location (Co-ordinate) of Bore Holes are based on Reference Points J-1 and J-2 whose co-ordinates are N=3027635.740, E=728409.524 and N=3027701.900, E=728402.717 respectively.
3. Reduced Level of Bore Holes are carried from the corner of Power House ( as shown by the client ) whose value is 120.049m.

## Field Test Location Plan for Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam



### BORE / DRILL LOG

Project: Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam	Bore Hole No. : BH-1
Location : N 3027853.9 , E 728406.6	Ground Elevation : +118.5m
Method of Boring / Drilling : Auger & Shell / Rotary	Water Level (Static) : 3.93m b.g.l
Boring / Drilling Equipment : Mechanical Winch (GO-18)	Dia.of Boring / Drilling: Sx (150mm)
Casing Lowered : Sx-12.68m	Date : From 03.04.19 To 05.04.19

Date (dd / mm)	Elevation (m)	Depth / RUN (m)		Length (m)	Nature of Sampling	SPT : No. of blows					Time Taken (min)	Total length of Core Pieces (m)	Core Recovery (%)	R.Q.D. (%)	Description
		From	To			0-15 cm	15-30 cm	30-45 cm	45-60 cm	N' Value					
03/04	+118.5	0.00													Brick soling followed by brownish grey sandy silty clay with brick pieces
	+117.9	0.60	-	-	D	-	-	-	-	-	-	-	-	-	0.60m
		1.50	2.00	0.50	U	-	-	-	-	-	-	-	-	-	Firm brownish yellow silty clay / clayey silt with traces of sand
		2.00	2.45	0.45	P	2	3	4	-	7	-	-	-	-	
	+115.5	3.00	3.50	0.50	U	-	-	-	-	-	-	-	-	-	3.00m
		3.50	3.95	0.45	P	3	5	5	-	10	-	-	-	-	Medium dense / dense yellowish brown / grey silty sand
	04/04	5.00	5.45	0.45	P	5	7	9	-	16	-	-	-	-	
		6.50	6.95	0.45	P	16	17	19	-	36	-	-	-	-	
		8.00	8.45	0.45	P	14	19	23	-	42	-	-	-	-	
		9.50	9.95	0.45	P	14	22	30	-	52	-	-	-	-	
		11.00	11.45	0.45	P	16	28	38	-	66	-	-	-	-	
		12.50	12.95	0.45	P	26	44	50	-	94	-	-	-	-	
		14.00	14.45	0.45	P	28	45	55	-	100	-	-	-	-	
		15.50	15.95	0.45	P	21	37	49	-	86	-	-	-	-	

**NOTES**

1. Abbreviation Used : U-Undisturbed Sample C-Core Sample D-Disturbed Sample P-Standard Penetration Test V-Vane Shear Test
2. Level at which Artesian Condition experienced and its pressure, if any :
3. Water Loss with depth, if any :
4. Colour of water during drilling :

Site Engineer : G.C.Bag	Driller: H.Sinha	Job No.: CCPL/19021175
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### BORE / DRILL LOG

<b>Project:</b> Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam  <b>Location :</b> N 3027853.9 , E 728406.6  <b>Method of Boring / Drilling :</b> Auger & Shell / Rotary  <b>Boring / Drilling Equipment :</b> Mechanical Winch (GO-18)  <b>Casing Lowered :</b> Sx-12.68m	<b>Bore Hole No. :</b> BH-1  <b>Ground Elevation :</b> +118.5m  <b>Water Level (Static) :</b> 3.93m b.g.l  <b>Dia.of Boring / Drilling:</b> Sx (150mm)  <b>Date :</b> From 03.04.19 To 05.04.19
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Date (dd / mm)	Elevation (m)	Depth / RUN (m)		Length (m)	Nature of Sampling	SPT : No. of blows					Time Taken (min)	Total length of Core Pieces (m)	Core Recovery (%)	R.Q.D. (%)	Description
		From	To			0-15 cm	15-30 cm	30-45 cm	45-60 cm	N' Value					
05/04		17.00	17.45	0.45	P	19	30	47	-	77	-	-	-	-	Medium dense / dense yellowish brown / grey silty sand
		18.50	18.95	0.45	P	20	31	49	-	80	-	-	-	-	
		20.00	20.45	0.45	P	27	42	51	-	93	-	-	-	-	
		21.50	21.95	0.45	P	28	46	56	-	102	-	-	-	-	
		23.00	23.45	0.45	P	25	44	50	-	94	-	-	-	-	
		24.50	24.95	0.45	P	20	30	33	-	63	-	-	-	-	
		26.00	26.45	0.45	P	19	32	36	-	68	-	-	-	-	
		27.50	27.95	0.45	P	20	33	37	-	70	-	-	-	-	
		29.00	29.45	0.45	P	21	36	42	-	78	-	-	-	-	
		30.63	31.08	0.45	P	28	43	59	-	102	-	-	-	-	
	+87.9	30.63	(Termination Depth)												
NOTES	1. Abbreviation Used : <b>U</b> -Undisturbed Sample <b>C</b> -Core Sample <b>D</b> -Disturbed Sample <b>P</b> -Standard Penetration Test <b>V</b> -Vane Shear Test														
	2. Level at which Artesian Condition experienced and its pressure, if any :														
	3. Water Loss with depth, if any :														
	4. Colour of water during drilling :														
Site Engineer : G.C.Bag						Driller: H.Sinha						Job No.: CCPL/19021175			



### BORE / DRILL LOG

Project: Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam	Bore Hole No. : BH-2
Location : N 3027840.2 , E 728357.7	Ground Elevation : +118.2m
Method of Boring / Drilling : Auger & Shell / Rotary	Water Level (Static) : 3.52m b.g.l
Boring / Drilling Equipment : Mechanical Winch (GO-18)	Dia.of Boring / Drilling: Sx (150mm)
Casing Lowered : Sx-14.26m	Date : From 30.03.19 To 03.04.19

Date (dd / mm)	Elevation (m)	Depth / RUN (m)		Length (m)	Nature of Sampling	SPT : No. of blows					Time Taken (min)	Total length of Core Pieces (m)	Core Recovery (%)	R.Q.D. (%)	Description
		From	To			0-15 cm	15-30 cm	30-45 cm	45-60 cm	N' Value					
30/03	+118.2	0.00													Fill consisting of dark grey sandy silty clay with gravels
	+117.9	0.30	-	-	D	-	-	-	-	-	-	-	-	-	0.30m
		1.50	2.00	0.50	U	-	-	-	-	-	-	-	-	-	Firm / stiff brownish yellow silty clay with traces of sand
		2.00	2.45	0.45	P	3	4	5	-	9	-	-	-	-	
01/04	+115.2	3.00	3.50	0.50	U	-	-	-	-	-	-	-	-	-	3.00m
		3.50	3.95	0.45	P	7	10	10	-	20	-	-	-	-	Medium dense / dense yellowish grey / grey silty sand / sand ; very stiff / hard grey silty clay (high silt content) observed from 23.00m to 25.00m depth
		4.50	5.00	0.50	U	Slipped				-	-	-	-	-	
		5.00	5.45	0.45	P	8	12	15	-	27	-	-	-	-	
		6.50	6.95	0.45	P	10	14	17	-	31	-	-	-	-	
		8.00	8.45	0.45	P	9	17	20	-	37	-	-	-	-	
		9.50	9.95	0.45	P	13	18	20	-	38	-	-	-	-	
		11.00	11.45	0.45	P	12	15	32	-	47	-	-	-	-	
		12.50	12.95	0.45	P	18	27	40	-	67	-	-	-	-	
		14.00	14.45	0.45	P	28	40	49	-	89	-	-	-	-	

**NOTES**

1. Abbreviation Used : U-Undisturbed Sample C-Core Sample D-Disturbed Sample P-Standard Penetration Test V-Vane Shear Test
2. Level at which Artesian Condition experienced and its pressure, if any :
3. Water Loss with depth, if any :
4. Colour of water during drilling :

Site Engineer : G.C.Bag	Driller: H.Sinha	Job No.: CCPL/19021175
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### BORE / DRILL LOG

Project: Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam

Bore Hole No. : BH-2

Location : N 3027840.2 , E 728357.7

Ground Elevation : +118.2m

Method of Boring / Drilling : Auger & Shell / Rotary

Water Level (Static) : 3.52m b.g.l

Boring / Drilling Equipment : Mechanical Winch (GO-18)

Dia.of Boring / Drilling: Sx (150mm)

Casing Lowered : Sx-14.26m

Date : From 30.03.19 To 03.04.19

Date (dd / mm)	Elevation (m)	Depth / RUN (m)		Length (m)	Nature of Sampling	SPT : No. of blows					Time Taken (min)	Total length of Core Pieces (m)	Core Recovery (%)	R.Q.D. (%)	Description
		From	To			0-15 cm	15-30 cm	30-45 cm	45-60 cm	N' Value					
02/04		15.50	15.95	0.45	P	24	35	43	-	78	-	-	-	-	Medium dense / dense yellowish grey / grey silty sand / sand ; very stiff / hard grey silty clay (high silt content) observed from 23.00m to 25.00m depth
		17.00	17.45	0.45	P	17	29	37	-	66	-	-	-	-	
		18.50	18.95	0.45	P	17	26	29	-	55	-	-	-	-	
		20.00	20.45	0.45	P	16	29	37	-	66	-	-	-	-	
		21.50	21.95	0.45	P	20	29	40	-	69	-	-	-	-	
		23.00	23.45	0.45	P	11	14	26	-	40	-	-	-	-	
		24.50	24.95	0.45	P	12	15	16	-	31	-	-	-	-	
03/04		25.00	25.50	0.50	U	-	-	-	-	-	-	-	-	-	
		27.50	27.95	0.45	P	23	32	43	-	75	-	-	-	-	
		29.00	29.45	0.45	P	28	40	45	-	85	-	-	-	-	
		30.39	30.84	0.45	P	29	39	56	-	95	-	-	-	-	
		+87.8	30.39	(Termination Depth)											
NOTES	1. Abbreviation Used : <b>U</b> -Undisturbed Sample <b>C</b> -Core Sample <b>D</b> -Disturbed Sample <b>P</b> -Standard Penetration Test <b>V</b> -Vane Shear Test														
	2. Level at which Artesian Condition experienced and its pressure, if any :														
	3. Water Loss with depth, if any :														
	4. Colour of water during drilling :														
Site Engineer : G.C.Bag						Driller: H.Sinha						Job No.: CCPL/19021175			

### BORE / DRILL LOG

<b>Project:</b> Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam  <b>Location :</b> N 3027787.1 , E 728362.5  <b>Method of Boring / Drilling :</b> Auger & Shell / Rotary  <b>Boring / Drilling Equipment :</b> Mechanical Winch (GO-18)  <b>Casing Lowered :</b> Sx-17.30m	<b>Bore Hole No. :</b> BH-3  <b>Ground Elevation :</b> +118.4m  <b>Water Level (Static) :</b> 3.77m b.g.l  <b>Dia.of Boring / Drilling:</b> Sx (150mm)  <b>Date :</b> From 27.03.19 To 30.03.19
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Date (dd / mm)	Elevation (m)	Depth / RUN (m)		Length (m)	Nature of Sampling	SPT : No. of blows					Time Taken (min)	Total length of Core Pieces (m)	Core Recovery (%)	R.Q.D. (%)	Description
		From	To			0-15 cm	15-30 cm	30-45 cm	45-60 cm	N' Value					
27/03	+118.4	0.00													Fill consisting of dark grey sandy silty clay with gravels , brick pieces etc.
		0.50	-	-	D	-	-	-	-	-	-	-	-	-	
	+117.7	0.70	-	-	D	-	-	-	-	-	-	-	-	-	0.70m
		1.50	2.00	0.50	U	-	-	-	-	-	-	-	-	-	Firm / stiff yellowish grey silty clay / clayey silt with traces of sand
	+115.4	2.00	2.45	0.45	P	4	5	6	-	11	-	-	-	-	
		3.00	3.50	0.50	U	-	-	-	-	-	-	-	-	-	3.00m
		3.50	3.95	0.45	P	5	7	7	-	14	-	-	-	-	Medium dense / dense grey / yellowish grey silty sand / sand
		4.30	4.80	0.50	U	Slipped					-	-	-	-	
		4.80	5.00	0.20	FP1	Falling Head					-	-	-	-	
		5.00	5.45	0.45	P	8	11	15	-	26	-	-	-	-	
28/03		6.50	6.95	0.45	P	8	11	14	-	25	-	-	-	-	
		8.00	8.45	0.45	P	9	14	17	-	31	-	-	-	-	
		9.50	9.95	0.45	P	16	19	23	-	42	-	-	-	-	
		11.00	11.45	0.45	P	16	20	27	-	47	-	-	-	-	
		11.50	-	-	D	-	-	-	-	-	-	-	-	-	

**NOTES**

1. Abbreviation Used : **U**-Undisturbed Sample **C**-Core Sample **D**-Disturbed Sample **P**-Standard Penetration Test **V**-Vane Shear Test
2. Level at which Artesian Condition experienced and its pressure, if any :
3. Water Loss with depth, if any :
4. Colour of water during drilling :

Site Engineer : G.C.Bag	Driller: H.Sinha	Job No.: CCPL/19021175
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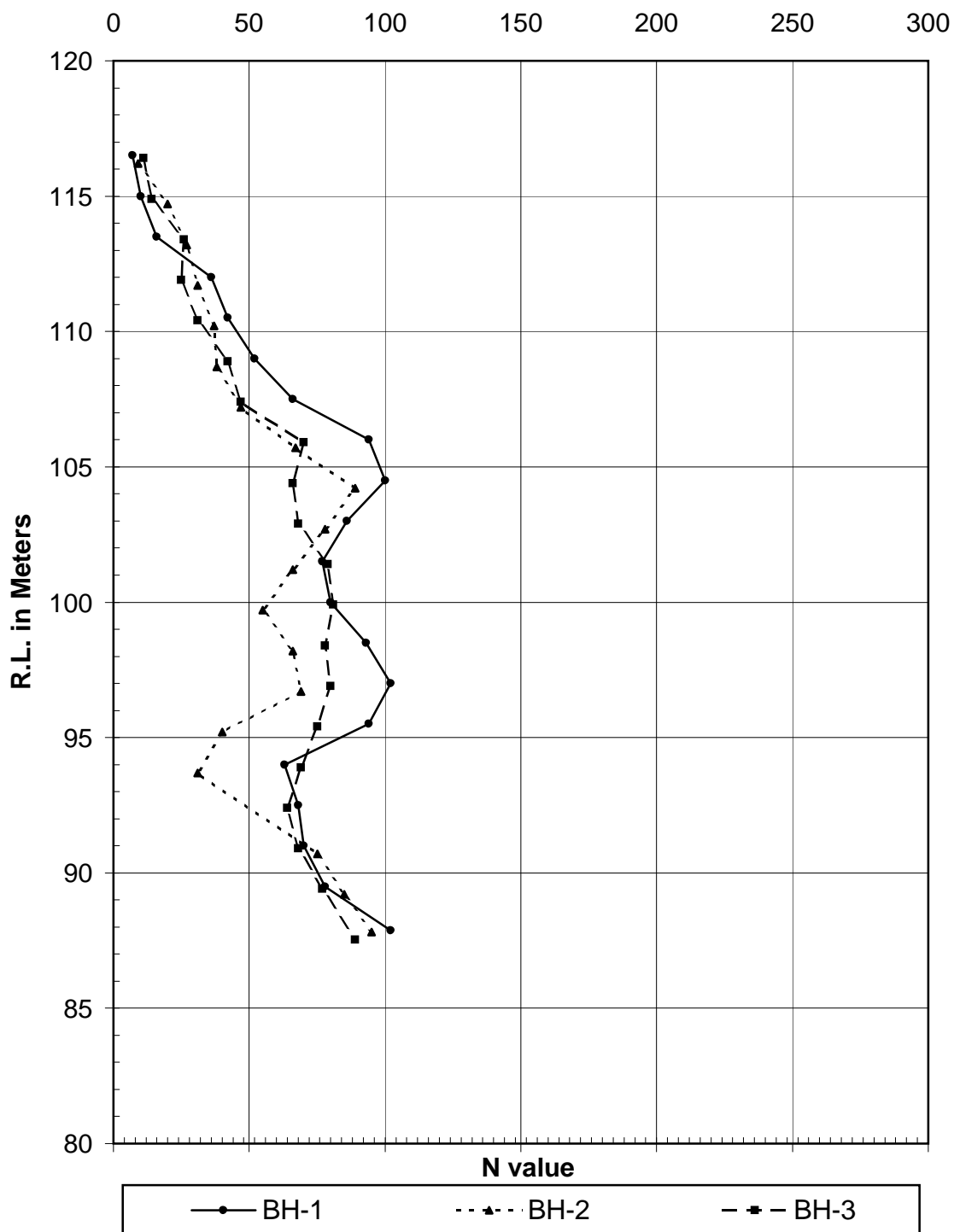


### BORE / DRILL LOG

Project: Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam	Bore Hole No. : BH-3
Location : N 3027787.1 , E 728362.5	Ground Elevation : +118.4m
Method of Boring / Drilling : Auger & Shell / Rotary	Water Level (Static) : 3.77m b.g.l
Boring / Drilling Equipment : Mechanical Winch (GO-18)	Dia.of Boring / Drilling: Sx (150mm)
Casing Lowered : Sx-17.30m	Date : From 27.03.19 To 30.03.19

Date (dd / mm)	Elevation (m)	Depth / RUN (m)		Length (m)	Nature of Sampling	SPT : No. of blows					Time Taken (min)	Total length of Core Pieces (m)	Core Recovery (%)	R.Q.D. (%)	Description
		From	To			0-15 cm	15-30 cm	30-45 cm	45-60 cm	N' Value					
29/03		12.50	12.95	0.45	P	20	29	41	-	70	-	-	-	-	Medium dense / dense grey / yellowish grey silty sand / sand
		14.00	14.45	0.45	P	19	27	39	-	66	-	-	-	-	
		15.50	15.95	0.45	P	18	28	40	-	68	-	-	-	-	
		17.00	17.45	0.45	P	20	37	42	-	79	-	-	-	-	
		18.50	18.95	0.45	P	20	39	42	-	81	-	-	-	-	
		20.00	20.45	0.45	P	19	36	42	-	78	-	-	-	-	
		21.50	21.95	0.45	P	20	35	45	-	80	-	-	-	-	
		23.00	23.45	0.45	P	20	35	40	-	75	-	-	-	-	
		24.50	24.95	0.45	P	18	30	39	-	69	-	-	-	-	
		26.00	26.45	0.45	P	18	29	35	-	64	-	-	-	-	
30/03		27.50	27.95	0.45	P	20	32	36	-	68	-	-	-	-	
		29.00	29.45	0.45	P	20	34	43	-	77	-	-	-	-	
		30.86	31.31	0.45	P	33	42	47	-	89	-	-	-	-	
	+87.5	30.86	(Termination Depth)												
NOTES	1. Abbreviation Used : <b>U</b> -Undisturbed Sample <b>C</b> -Core Sample <b>D</b> -Disturbed Sample <b>P</b> -Standard Penetration Test <b>V</b> -Vane Shear Test 2. Level at which Artesian Condition experienced and its pressure, if any : 3. Water Loss with depth, if any : 4. Colour of water during drilling :														
Site Engineer : G.C.Bag						Driller: H.Sinha						Job No.: CCPL/19021175			

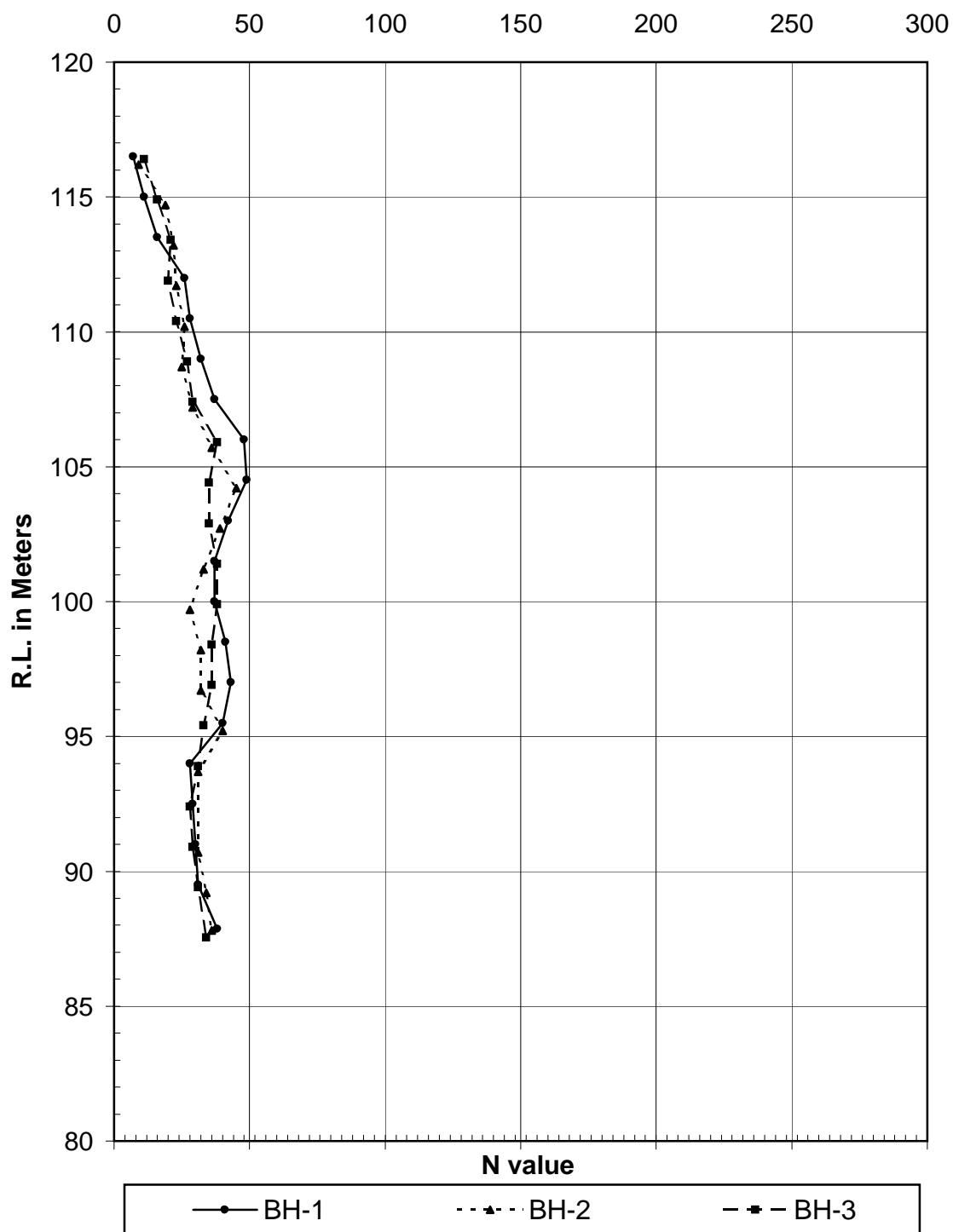
## GRAPHICAL REPRESENTATION OF FIELD N-VALUE WITH R.L.



<b>Project :</b> Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam	<b>Job No.:</b> CCPL/19021175
	<b>Fig No.:</b> B/1



### GRAPHICAL REPRESENTATION OF CORRECTED N-VALUE WITH R.L.



**Project :** Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam

**Job No.:** CCPL/19021175

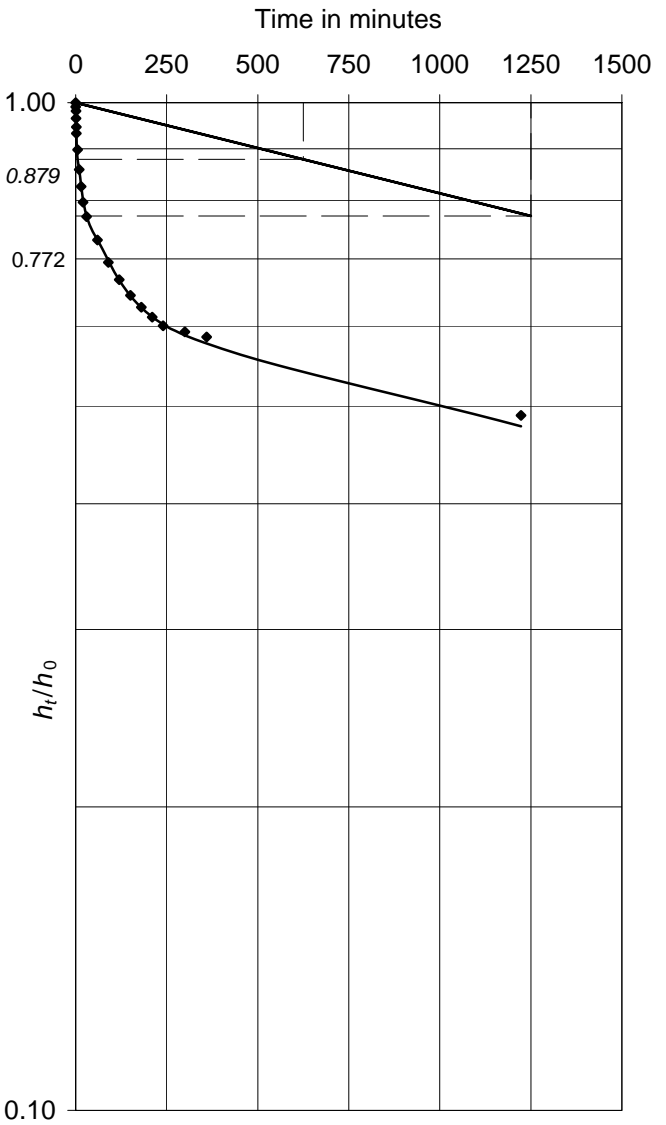
**Fig No.:** B/2

IN-SITU PERMEABILITY TEST (FALLING HEAD METHOD)

Test location	: N 3027787.1 , E 728362.5	Test Number	: BH-3/FP1
Ground elevation	: +118.4m	Static Water level	: 3.77m below G.L.
Diameter of hole (2R)	: 168.0mm	Height of Casing above ground level	: 0.50m
Inner diameter of casing / intake pipe (d)	: 150.0mm	Length of casing in the hole	: 4.80m
Depth tested	: 4.80m - 5.00m	Total depth of hole	: 5.00m
Length of test section (L)	: 0.20m	Date & time of start	: 27.03.19 11:47 hrs

Data sheet

Time vs.  $h_t/h_0$  plot

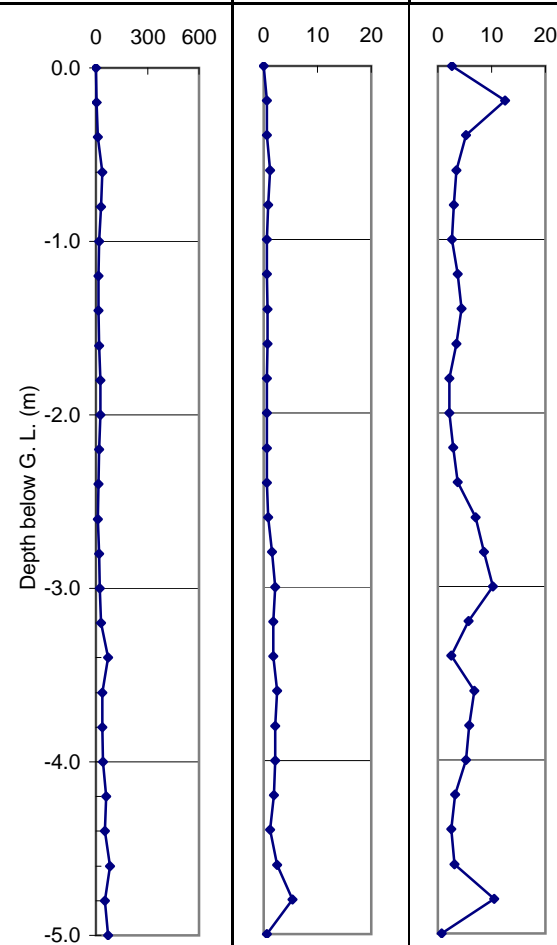
Time interval (minute)	Water level in intake pipe (cm)	$h_t$ (cm)	$h_t/h_0$	<p>Time in minutes</p> 
0.00	0.00	427.0	1.0000	
0.25	4.00	423.0	0.9906	
0.50	8.00	419.0	0.9813	
1.00	15.00	412.0	0.9649	
1.50	23.00	404.0	0.9461	
2.00	29.00	398.0	0.9321	
5.00	43.50	383.5	0.8981	
10.00	60.50	366.5	0.8583	
15.00	74.50	352.5	0.8255	
20.00	87.00	340.0	0.7963	
30.00	98.00	329.0	0.7705	
60.00	115.00	312.0	0.7307	
90.00	130.50	296.5	0.6944	
120.00	142.00	285.0	0.6674	
150.00	152.00	275.0	0.6440	
180.00	159.50	267.5	0.6265	
210.00	165.50	261.5	0.6124	
240.00	170.50	256.5	0.6007	
300.00	174.00	253.0	0.5925	
360.00	177.00	250.0	0.5855	
1223.00	218.00	209.0	0.4895	
$K = \frac{d^2}{8L} \log_e \frac{L}{R} \frac{\log_e h_1/h_2}{t_2 - t_1} = 4.21\text{E-}06\text{cm/sec}$				0.10

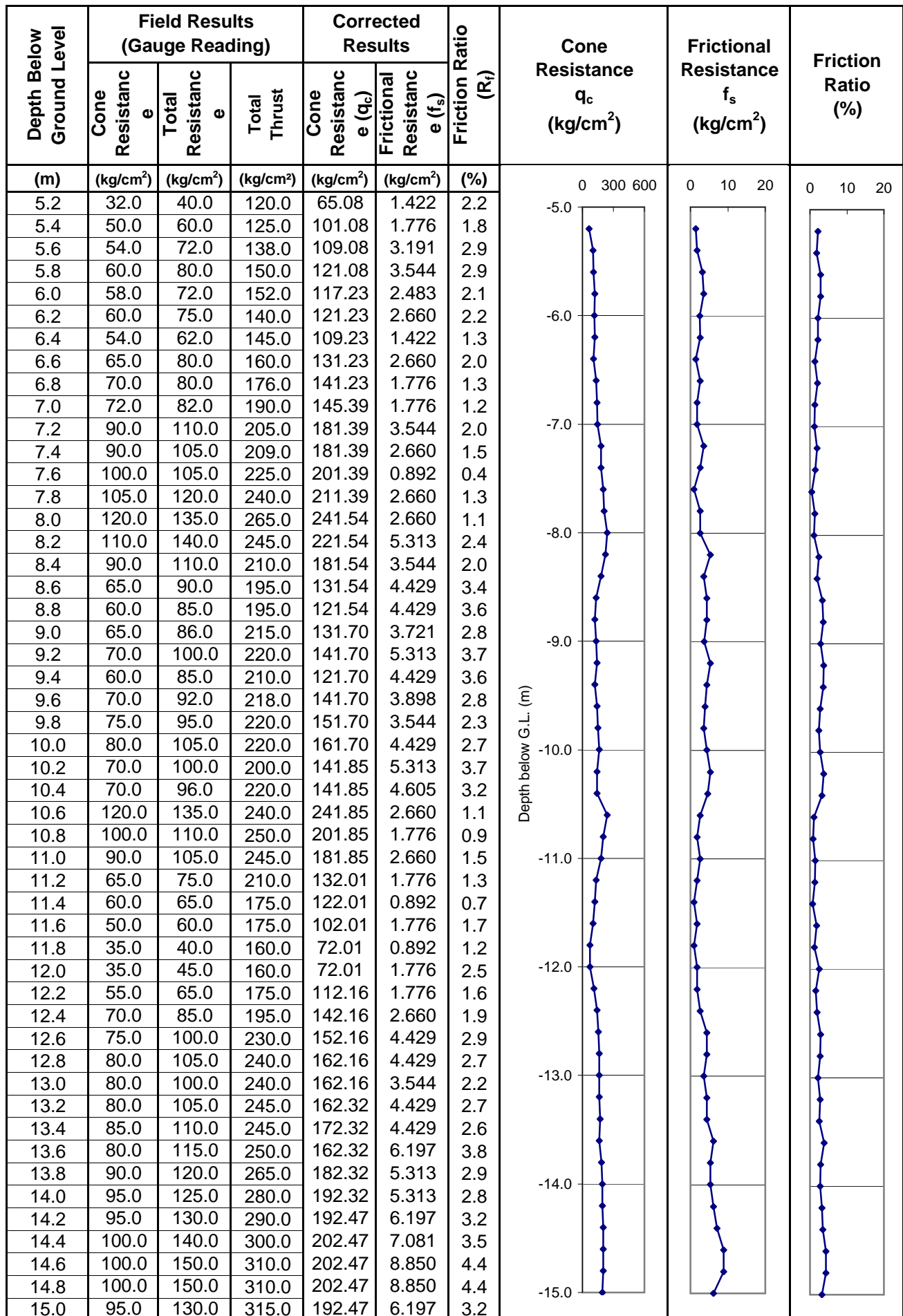
Legend:  $h_1$  = head of water in the intake pipe at time  $t_1$  above static water level,  
 $h_2$  = head of water in the intake pipe at time  $t_2$  above static water level;  
 $h_0$  = depth of static water level at time  $t_0$ ,  
 $h_t$  = head of water in the intake pipe at any time  $t$

**Project:** Geotechnical Investigation Work at Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam

**STATIC CONE PENETRATION TEST RESULTS (SCPT)**

Job No. : CCPL/19021175	Weight of cone, first rod and drive hammer : 3.00 kg
Project : Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam	Weight of each sounding rod : 1.55 kg
Location : N 3027730.8, E 728350.0	Cone Area at Base : 10.00 sq. cm.
Test No. : SCPT - 1	Plunger Area : 20.00 sq. cm.
Borehole reference : -	Weight of Friction Jacket : 0.88 kg
R.L. : +118.2m	Outer Diameter of Friction Jacket : 3.60 cm.
S.W.L. : -	Length of Friction Jacket : 10.00 cm.
Date : 23.04.2019	Surface Area of Friction Jacket : 113.10 sq. cm.

Depth Below Ground Level	Field Results (Gauge Reading)			Corrected Results		Friction Ratio ( $R_f$ )	Cone Resistance $q_c$ (kg/cm <sup>2</sup> )	Frictional Resistance $f_s$ (kg/cm <sup>2</sup> )	Friction Ratio (%)
	Cone Resistance	Total Resistance	Total Thrust	Cone Resistance ( $q_c$ )	Frictional Resistance ( $f_s$ )				
(m)	(kg/cm <sup>2</sup> )	(kg/cm <sup>2</sup> )	(kg/cm <sup>2</sup> )	(kg/cm <sup>2</sup> )	(kg/cm <sup>2</sup> )	(%)			
0.0	0.0	0.0	0.0	0.30	0.008	2.6			
0.2	2.0	5.0	10.0	4.30	0.538	12.5			
0.4	5.0	8.0	15.0	10.30	0.538	5.2			
0.6	18.0	25.0	32.0	36.30	1.246	3.4			
0.8	15.0	20.0	30.0	30.30	0.892	2.9			
1.0	10.0	13.0	25.0	20.46	0.538	2.6			
1.2	7.0	10.0	25.0	14.46	0.538	3.7			
1.4	8.0	12.0	28.0	16.46	0.715	4.3			
1.6	10.0	14.0	20.0	20.46	0.715	3.5			
1.8	12.0	15.0	25.0	24.46	0.538	2.2			
2.0	12.0	15.0	26.0	24.46	0.538	2.2			
2.2	9.0	12.0	26.0	18.61	0.538	2.9			
2.4	7.0	10.0	29.0	14.61	0.538	3.7			
2.6	6.0	11.0	40.0	12.61	0.892	7.1			
2.8	9.0	18.0	48.0	18.61	1.599	8.6			
3.0	10.0	22.0	62.0	20.77	2.130	10.3			
3.2	15.0	25.0	98.0	30.77	1.776	5.8			
3.4	35.0	45.0	94.0	70.77	1.776	2.5			
3.6	18.0	32.0	92.0	36.77	2.483	6.8			
3.8	18.0	30.0	94.0	36.77	2.130	5.8			
4.0	20.0	32.0	105.0	40.92	2.130	5.2			
4.2	30.0	41.0	109.0	60.92	1.953	3.2			
4.4	25.0	32.0	116.0	50.92	1.246	2.4			
4.6	40.0	54.0	118.0	80.92	2.483	3.1			
4.8	25.0	55.0	112.0	50.92	5.313	10.4			
5.0	35.0	38.0	112.0	71.08	0.538	0.8			



- C-3 -

**STATIC CONE PENETRATION TEST RESULTS (SCPT)**

Job No. : CCPL/19021175	Weight of cone, first rod and drive hammer : 3.00 kg
Project : Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam	Weight of each sounding rod : 1.55 kg
Location : N 3027815.2, E 728357.2	Cone Area at Base : 10.00 sq. cm.
Test No. : SCPT - 2	Plunger Area : 20.00 sq. cm.
Borehole reference : -	Weight of Friction Jacket : 0.88 kg
R.L. : +118.2m	Outer Diameter of Friction Jacket : 3.60 cm.
S.W.L. : -	Length of Friction Jacket : 10.00 cm.
Date : 21.04.2019	Surface Area of Friction Jacket : 113.10 sq. cm.

Depth Below Ground Level	Field Results (Gauge Reading)			Corrected Results		Friction Ratio (R <sub>f</sub> )	Cone Resistance q <sub>c</sub> (kg/cm <sup>2</sup> )	Frictional Resistance f <sub>s</sub> (kg/cm <sup>2</sup> )	Friction Ratio (%)
	Cone Resistance	Total Resistance	Total Thrust	Cone Resistance (q <sub>c</sub> )	Frictional Resistance (f <sub>s</sub> )				
(m)	(kg/cm <sup>2</sup> )	(kg/cm <sup>2</sup> )	(kg/cm <sup>2</sup> )	(kg/cm <sup>2</sup> )	(kg/cm <sup>2</sup> )	(%)	<div>0 300 600</div> <div>0.0</div> <div>-1.0</div> <div>-2.0</div> <div>-3.0</div> <div>-4.0</div> <div>-5.0</div> <div>Depth below G. L. (m)</div>	<div>0 10 20</div> <div>0</div> <div>10</div> <div>20</div>	<div>0 10 20</div> <div>0</div> <div>10</div> <div>20</div>
0.0	0.0	0.0	0.0	0.30	0.008	2.6			
0.2	0.0	0.0	0.0	0.30	0.008	2.6			
0.4	0.0	0.0	0.0	0.30	0.008	2.6			
0.6	1.0	1.0	5.0	2.30	0.008	0.3			
0.8	3.0	4.0	15.0	6.30	0.185	2.9			
1.0	2.0	3.0	15.0	4.46	0.185	4.1			
1.2	2.0	3.0	10.0	4.46	0.185	4.1			
1.4	5.0	6.0	14.0	10.46	0.185	1.8			
1.6	5.0	6.0	16.0	10.46	0.185	1.8			
1.8	6.0	7.0	17.0	12.46	0.185	1.5			
2.0	4.0	5.0	19.0	8.46	0.185	2.2			
2.2	7.0	8.0	27.0	14.61	0.185	1.3			
2.4	4.0	5.0	32.0	8.61	0.185	2.1			
2.6	5.0	6.0	45.0	10.61	0.185	1.7			
2.8	10.0	15.0	48.0	20.61	0.892	4.3			
3.0	6.0	11.0	50.0	12.77	0.892	7.0			
3.2	20.0	25.0	75.0	40.77	0.892	2.2			
3.4	40.0	46.0	85.0	80.77	1.069	1.3			
3.6	38.0	52.0	100.0	76.77	2.483	3.2			
3.8	50.0	75.0	130.0	100.77	4.429	4.4			
4.0	55.0	65.0	144.0	110.92	1.776	1.6			
4.2	62.0	70.0	130.0	124.92	1.422	1.1			
4.4	55.0	65.0	145.0	110.92	1.776	1.6			
4.6	56.0	60.0	140.0	112.92	0.715	0.6			
4.8	62.0	65.0	142.0	124.92	0.538	0.4			
5.0	60.0	65.0	150.0	121.08	0.892	0.7			

Depth Below Ground Level	Field Results (Gauge Reading)			Corrected Results		Friction Ratio ( $R_f$ )	Cone Resistance $q_c$ ( $\text{kg}/\text{cm}^2$ )	Frictional Resistance $f_s$ ( $\text{kg}/\text{cm}^2$ )	Friction Ratio (%)
	Cone Resistanc e	Total Resistanc e	Total Thrust	Cone Resistanc e ( $q_c$ )	Frictional Resistanc e ( $f_s$ )				
(m)	( $\text{kg}/\text{cm}^2$ )	( $\text{kg}/\text{cm}^2$ )	( $\text{kg}/\text{cm}^2$ )	( $\text{kg}/\text{cm}^2$ )	( $\text{kg}/\text{cm}^2$ )	(%)	<div><div>0300600</div><div>Depth below G.L. (m)</div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
5.2	65.0	68.0	152.0	131.08	0.538	0.4	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
5.4	70.0	73.0	154.0	141.08	0.538	0.4	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
5.6	72.0	75.0	156.0	145.08	0.538	0.4	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
5.8	70.0	76.0	155.0	141.08	1.069	0.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
6.0	65.0	70.0	162.0	131.23	0.892	0.7	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
6.2	70.0	75.0	170.0	141.23	0.892	0.6	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
6.4	70.0	73.0	165.0	141.23	0.538	0.4	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
6.6	64.0	74.0	165.0	129.23	1.776	1.4	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
6.8	62.0	75.0	164.0	125.23	2.307	1.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
7.0	58.0	62.0	170.0	117.39	0.715	0.6	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
7.2	65.0	70.0	180.0	131.39	0.892	0.7	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
7.4	62.0	72.0	184.0	125.39	1.776	1.4	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
7.6	70.0	75.0	190.0	141.39	0.892	0.6	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
7.8	70.0	75.0	188.0	141.39	0.892	0.6	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
8.0	75.0	90.0	190.0	151.54	2.660	1.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
8.2	68.0	75.0	195.0	137.54	1.246	0.9	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
8.4	80.0	85.0	215.0	161.54	0.892	0.6	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
8.6	92.0	96.0	230.0	185.54	0.715	0.4	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
8.8	90.0	98.0	236.0	181.54	1.422	0.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
9.0	95.0	110.0	240.0	191.70	2.660	1.4	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
9.2	100.0	120.0	252.0	201.70	3.544	1.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
9.4	98.0	100.0	275.0	197.70	0.361	0.2	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
9.6	95.0	98.0	278.0	191.70	0.538	0.3	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
9.8	90.0	110.0	290.0	181.70	3.544	2.0	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
10.0	100.0	115.0	295.0	201.70	2.660	1.3	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
10.2	85.0	110.0	290.0	171.85	4.429	2.6	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
10.4	100.0	120.0	305.0	201.85	3.544	1.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
10.6	105.0	125.0	300.0	211.85	3.544	1.7	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
10.8	98.0	120.0	295.0	197.85	3.898	2.0	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
11.0	80.0	90.0	240.0	161.85	1.776	1.1	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
11.2	60.0	70.0	250.0	122.01	1.776	1.5	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
11.4	100.0	115.0	310.0	202.01	2.660	1.3	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
11.6	130.0	148.0	360.0	262.01	3.191	1.2	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
11.8	148.0	162.0	385.0	298.01	2.483	0.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
12.0	150.0	180.0	400.0	302.01	5.313	1.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
12.2	160.0	190.0	425.0	322.16	5.313	1.6	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
12.4	200.0	225.0	440.0	402.16	4.429	1.1	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
12.6	180.0	200.0	470.0	362.16	3.544	1.0	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
12.8	160.0	200.0	488.0	322.16	7.081	2.2	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
13.0	170.0	195.0	480.0	342.16	4.429	1.3	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
13.2	175.0	200.0	486.0	352.32	4.429	1.3	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
13.4	190.0	192.0	500.0	382.32	0.361	0.1	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
13.6	190.0	230.0	505.0	382.32	7.081	1.9	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
13.8	200.0	240.0	505.0	402.32	7.081	1.8	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
14.0	195.0	210.0	555.0	392.32	2.660	0.7	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
14.2	190.0	205.0	510.0	382.47	2.660	0.7	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
14.4	192.0	215.0	510.0	386.47	4.075	1.1	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
14.6	180.0	210.0	510.0	362.47	5.313	1.5	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
14.8	182.0	205.0	510.0	366.47	4.075	1.1	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		
15.0	180.0	200.0	610.0	362.47	3.544	1.0	<div><div>01020</div><div></div><div>-5.0-6.0-7.0-8.0-9.0-10.0-11.0-12.0-13.0-14.0-15.0</div></div>		

- C-6 -



PLATE LOAD TEST RESULTS

**Project** : Geotechnical investigation work at Duliajail **Location** : N 3027895.5  
Power Station of Oil India Limited in E 728304.9  
Dibrugarh, Assam

**Test No.** : PLT-1 **Ground Elevation** : +118.1 m

**Method of Loading** : Reaction **Plate Size** : 45cm x 45cm

**Pit Size** : 3.0m x 3.0m **Depth** : 3.50m b.g.l.

**Dial Gauge Constant** : 0.01 mm **Static Water Level** : Not Encountered

**Load per Division of Pressure Gauge** : 200 Kg **Date of Test** : 18.04.19 to 19.04.19

Time	Time Intervals	Pressure gauge reading	Intensity of load w.r.t. plate size	SETTLEMENT				Average Dial reading	Settlement
				Dial Gauge Reading					
[d/m/y hh:mm]	[min]	[kg]	[kg/cm <sup>2</sup> ]	1	2	3	4		[mm]
18/4/2019 9:31	0.00	200.0	0.099	0.0	0.0	0.0	0.0	Seating Load	
	1.00			40.0	35.0	30.0	37.0		
	2.25			47.0	37.0	32.0	40.0		
	4.00			48.0	38.0	33.0	41.0		
	6.25			48.0	39.0	33.0	41.0		
	9.00			49.0	39.0	34.0	42.0		
	16.00			49.0	39.0	35.0	42.0		
	25.00			49.0	40.0	35.0	42.0		
	36.00			49.0	40.0	35.0	42.0		
	49.00			51.0	41.0	36.0	43.0		
18/4/2019 10:31	60.00	200.0	0.099	51.0	41.0	36.0	43.0	42.75	0.428
18/4/2019 10:35	0.00	700.0	0.346	0.0	0.0	0.0	0.0	(Re-set)	
	1.00			12.0	20.0	25.0	26.0		
	2.25			13.0	22.0	27.0	28.0		
	4.00			14.0	23.0	29.0	29.0		
	6.25			14.0	24.0	30.0	29.0		
	9.00			14.0	24.0	30.0	29.0		
	16.00			14.0	24.0	30.0	30.0		
	25.00			14.0	24.0	30.0	30.0		
	36.00			14.0	24.0	30.0	30.0		
	49.00			15.0	24.0	30.0	30.0		
18/4/2019 11:35	60.00	700.0	0.346	15.0	24.0	30.0	30.0	24.75	0.248
18/4/2019 11:36	0.00	1,400.0	0.691	-	-	-	-		
	1.00			55.0	69.0	85.0	78.0		
	2.25			59.0	75.0	91.0	84.0		
	4.00			62.0	78.0	94.0	88.0		
	6.25			62.0	78.0	95.0	89.0		
	9.00			62.0	78.0	95.0	89.0		
	16.00			63.0	80.0	97.0	91.0		
	25.00			65.0	81.0	98.0	92.0		
	36.00			65.0	81.0	99.0	92.0		
	49.00			66.0	81.0	99.0	92.0		
18/4/2019 12:36	60.00	1,400.0	0.691	66.0	81.0	99.0	92.0	84.50	0.845

Time	Time Intervals	Pressure gauge reading	Intensity of load w.r.t. plate size	SETTLEMENT					Settlement
				Dial Gauge Reading				Average Dial reading	
<i>[d/m/y hh:mm]</i>	<i>[min]</i>	<i>[kg]</i>	<i>[kg/cm<sup>2</sup>]</i>	1	2	3	4		<i>[mm]</i>
18/4/2019 12:37	0.00	2,100.0	1.037	-	-	-	-	148.50	1.485
	1.00			90.0	114.0	137.0	130.0		
	2.25			98.0	119.0	141.0	132.0		
	4.00			105.0	124.0	147.0	137.0		
	6.25			108.0	128.0	150.0	140.0		
	9.00			109.0	130.0	151.0	141.0		
	16.00			112.0	132.0	155.0	144.0		
	25.00			113.0	135.0	170.0	150.0		
	36.00			119.0	139.0	172.0	152.0		
	49.00			120.0	143.0	173.0	153.0		
	60.00			122.0	144.0	174.0	154.0		
18/4/2019 13:37	0.00	2,800.0	1.383	-	-	-	-	181.00	1.810
	1.00			139.0	160.0	194.0	173.0		
	2.25			141.0	163.0	197.0	177.0		
	4.00			143.0	164.0	198.0	179.0		
	6.25			145.0	165.0	198.0	179.0		
	9.00			146.0	167.0	200.0	180.0		
	16.00			150.0	173.0	205.0	185.0		
	25.00			152.0	174.0	205.0	187.0		
	36.00			152.0	175.0	206.0	188.0		
	49.00			152.0	176.0	207.0	188.0		
	60.00			152.0	176.0	208.0	188.0		
18/4/2019 14:39	0.00	3,500.0	1.728	-	-	-	-	247.25	2.473
	1.00			200.0	225.0	260.0	239.0		
	2.25			208.0	230.0	270.0	243.0		
	4.00			210.0	232.0	271.0	248.0		
	6.25			210.0	233.0	271.0	250.0		
	9.00			211.0	235.0	271.0	251.0		
	16.00			212.0	237.0	273.0	253.0		
	25.00			213.0	238.0	274.0	254.0		
	36.00			214.0	240.0	276.0	255.0		
	49.00			215.0	241.0	276.0	255.0		
	60.00			216.0	241.0	276.0	256.0		
18/4/2019 15:40	0.00	4,200.0	2.074	-	-	-	-	302.50	3.025
	1.00			242.0	271.0	307.0	285.0		
	2.25			252.0	279.0	313.0	293.0		
	4.00			255.0	282.0	315.0	294.0		
	6.25			257.0	282.0	317.0	297.0		
	9.00			263.0	289.0	323.0	302.0		
	16.00			266.0	291.0	325.0	309.0		
	25.00			269.0	294.0	329.0	312.0		
	36.00			271.0	295.0	330.0	312.0		
	49.00			271.0	296.0	330.0	313.0		
	60.00			271.0	296.0	330.0	313.0		

Time	Time Intervals	Pressure gauge reading	Intensity of load w.r.t. plate size	SETTLEMENT				Average Dial reading	Settlement
				Dial Gauge Reading					
[d/m/y hh:mm]	[min]	[kg]	[kg/cm <sup>2</sup> ]	1	2	3	4		[mm]
18/4/2019 16:42	0.00	5,000.0	2.469	-	-	-	-	377.25	3.773
	1.00			300.0	325.0	362.0	340.0		
	2.25			305.0	331.0	370.0	348.0		
	4.00			309.0	334.0	373.0	351.0		
	6.25			311.0	335.0	375.0	353.0		
	9.00			314.0	339.0	377.0	355.0		
	16.00			325.0	348.0	389.0	365.0		
	25.00			329.0	355.0	394.0	370.0		
	36.00			339.0	364.0	406.0	381.0		
	49.00			342.0	368.0	409.0	386.0		
	60.00			343.0	369.0	409.0	387.0		
18/4/2019 17:57	75.00	5,000.0	2.469	343.0	369.0	410.0	387.0	377.25	3.773
18/4/2019 17:59	0.00	6,500.0	3.210	-	-	-	-	563.75	5.638
	1.00			470.0	490.0	550.0	410.0		
	2.25			480.0	505.0	560.0	419.0		
	4.00			490.0	516.0	565.0	430.0		
	6.25			498.0	525.0	574.0	436.0		
	9.00			502.0	528.0	579.0	441.0		
	16.00			511.0	537.0	587.0	449.0		
	25.00			519.0	544.0	593.0	555.0		
	36.00			522.0	547.0	596.0	560.0		
	49.00			526.0	550.0	599.0	565.0		
	60.00			528.0	555.0	603.0	566.0		
75.00	529.0	556.0	603.0	566.0					
18/4/2019 19:29	90.00	6,500.0	3.210	529.0	556.0	604.0	566.0	563.75	5.638
18/4/2019 19:30	0.00	8,000.0	3.951	-	-	-	-	822.25	8.223
	1.00			650.0	660.0	690.0	640.0		
	2.25			690.0	710.0	750.0	692.0		
	4.00			716.0	740.0	790.0	760.0		
	6.25			733.0	755.0	809.0	770.0		
	9.00			739.0	764.0	825.0	785.0		
	16.00			758.0	780.0	832.0	796.0		
	25.00			763.0	790.0	847.0	800.0		
	36.00			770.0	794.0	849.0	803.0		
	49.00			778.0	800.0	860.0	806.0		
	60.00			781.0	806.0	888.0	808.0		
75.00	781.0	807.0	889.0	809.0					
18/4/2019 21:00	90.00	8,000.0	3.951	782.0	807.0	890.0	810.0	822.25	8.223
18/4/2019 21:02	0.00	9,500.0	4.691	-	-	-	-	1067.00	10.670
	1.00			918.0	930.0	1003.0	909.0		
	2.25			950.0	979.0	1032.0	978.0		
	4.00			986.0	1010.0	1065.0	1008.0		
	6.25			995.0	1017.0	1076.0	1017.0		
	9.00			1004.0	1027.0	1082.0	1023.0		
	16.00			1012.0	1034.0	1091.0	1031.0		
	25.00			1017.0	1042.0	1096.0	1039.0		
	36.00			1024.0	1049.0	1105.0	1045.0		
	49.00			1030.0	1057.0	1115.0	1053.0		
	60.00			1033.0	1059.0	1117.0	1054.0		
75.00	1033.0	1060.0	1118.0	1055.0					
18/4/2019 22:32	90.00	9,500.0	4.691	1034.0	1060.0	1119.0	1055.0	1067.00	10.670

Time	Time Intervals	Pressure gauge reading	Intensity of load w.r.t. plate size	SETTLEMENT				Average Dial reading	Settlement
				Dial Gauge Reading					
[d/m/y hh:mm]	[min]	[kg]	[kg/cm <sup>2</sup> ]	1	2	3	4		[mm]
18/4/2019 22:33	0.00	11,000.0	5.432	-	-	-	-	1336.50	13.365
	1.00			1150.0	1190.0	1240.0	1170.0		
	2.25			1177.0	1210.0	1278.0	1195.0		
	4.00			1197.0	1229.0	1289.0	1217.0		
	6.25			1211.0	1243.0	1301.0	1226.0		
	9.00			1221.0	1253.0	1316.0	1233.0		
	16.00			1246.0	1277.0	1336.0	1262.0		
	25.00			1266.0	1297.0	1366.0	1281.0		
	36.00			1290.0	1319.0	1378.0	1305.0		
	49.00			1296.0	1326.0	1384.0	1312.0		
	60.00			1303.0	1331.0	1390.0	1317.0		
	75.00			1304.0	1332.0	1391.0	1318.0		
	90.00			1304.0	1332.0	1392.0	1318.0		
19/4/2019 0:05	0.00	13,000.0	6.420	-	-	-	-	1789.75	17.898
	1.00			1490.0	1500.0	1590.0	1530.0		
	2.25			1560.0	1595.0	1678.0	1590.0		
	4.00			1630.0	1675.0	1737.0	1640.0		
	6.25			1660.0	1700.0	1760.0	1669.0		
	9.00			1672.0	1712.0	1773.0	1682.0		
	16.00			1683.0	1726.0	1787.0	1694.0		
	25.00			1703.0	1746.0	1806.0	1726.0		
	36.00			1727.0	1766.0	1828.0	1738.0		
	49.00			1738.0	1779.0	1838.0	1746.0		
	60.00			1750.0	1792.0	1853.0	1760.0		
	75.00			1751.0	1792.0	1853.0	1761.0		
	90.00			1751.0	1793.0	1853.0	1762.0		
19/4/2019 1:37	0.00	16,200.0	8.000	0.0	0.0	0.0	0.0	(Re-set)	
	1.00			520.0	540.0	549.0	515.0		
	2.25			590.0	650.0	660.0	638.0		
	4.00			640.0	665.0	675.0	660.0		
	6.25			670.0	695.0	696.0	675.0		
	9.00			698.0	726.0	720.0	699.0		
	16.00			723.0	750.0	737.0	721.0		
	25.00			743.0	767.0	756.0	739.0		
	36.00			780.0	775.0	773.0	759.0		
	49.00			800.0	820.0	819.0	800.0		
	60.00			814.0	846.0	828.0	810.0		
	75.00			824.0	855.0	840.0	824.0		
	90.00			831.0	860.0	846.0	830.0		
19/4/2019 3:37	105.00	16,200.0	8.000	840.0	866.0	854.0	840.0	851.25	26.410
	120.00			842.0	867.0	855.0	841.0		
19/4/2019 3:38	0.00	13,000.0	6.420	-	-	-	-	(Un-load)	
	1.00			834.0	858.0	845.0	833.0		
	2.25			834.0	858.0	845.0	832.0		
	4.00			832.0	858.0	844.0	832.0		
	6.25			832.0	858.0	844.0	832.0		
	9.00			832.0	858.0	844.0	832.0		
	16.00			832.0	858.0	844.0	832.0		
19/4/2019 4:03	25.00	13,000.0	6.420	832.0	858.0	844.0	832.0	841.50	26.313

Time	Time Intervals	Pressure gauge reading	Intensity of load w.r.t. plate size	SETTLEMENT					Settlement
				Dial Gauge Reading				Average Dial reading	
[d/m/y hh:mm]	[min]	[kg]	[kg/cm <sup>2</sup> ]	1	2	3	4		[mm]
19/4/2019 4:05	0.00	9,500.0	4.691	-	-	-	-	819.50	26.093
	1.00			812.0	833.0	832.0	814.0		
	2.25			810.0	832.0	830.0	812.0		
	4.00			810.0	831.0	830.0	812.0		
	6.25			809.0	830.0	830.0	812.0		
	9.00			809.0	830.0	830.0	812.0		
	16.00			809.0	829.0	830.0	812.0		
	25.00			808.0	829.0	830.0	811.0		
19/4/2019 4:31	0.00	6,500.0	3.210	-	-	-	-	783.00	25.728
	1.00			773.0	790.0	793.0	790.0		
	2.25			771.0	789.0	793.0	790.0		
	4.00			770.0	788.0	790.0	789.0		
	6.25			770.0	788.0	789.0	788.0		
	9.00			770.0	788.0	788.0	788.0		
	16.00			770.0	787.0	788.0	787.0		
	25.00			770.0	787.0	788.0	787.0		
19/4/2019 4:57	0.00	3,500.0	1.728	-	-	-	-	737.75	25.275
	1.00			726.0	740.0	757.0	756.0		
	2.25			723.0	738.0	752.0	750.0		
	4.00			720.0	738.0	752.0	748.0		
	6.25			720.0	737.0	751.0	747.0		
	9.00			720.0	737.0	751.0	747.0		
	16.00			719.0	735.0	751.0	747.0		
	25.00			718.0	735.0	751.0	747.0		
19/4/2019 5:25	0.00	1,400.0	0.691	-	-	-	-	688.50	24.783
	1.00			674.0	690.0	703.0	707.0		
	2.25			671.0	689.0	701.0	705.0		
	4.00			670.0	688.0	700.0	703.0		
	6.25			670.0	688.0	700.0	702.0		
	9.00			669.0	687.0	698.0	700.0		
	16.00			669.0	687.0	698.0	700.0		
	25.00			669.0	687.0	698.0	700.0		
19/4/2019 5:51	0.00	0.0	0.000	-	-	-	-	459.50	22.493
	1.00			520.0	548.0	560.0	526.0		
	2.25			495.0	516.0	539.0	498.0		
	4.00			453.0	476.0	497.0	468.0		
	6.25			448.0	470.0	490.0	461.0		
	9.00			442.0	465.0	490.0	454.0		
	16.00			440.0	462.0	490.0	450.0		
	25.00			439.0	462.0	489.0	449.0		
19/4/2019 6:27	36.00	0.0	0.000	439.0	462.0	489.0	448.0	459.50	22.493

**Location** : N 3027895.5, E 728304.9

**Test Start Date** : 18.04.19

**Test No.** : PLT-1

**Test End Date** : 19.04.19

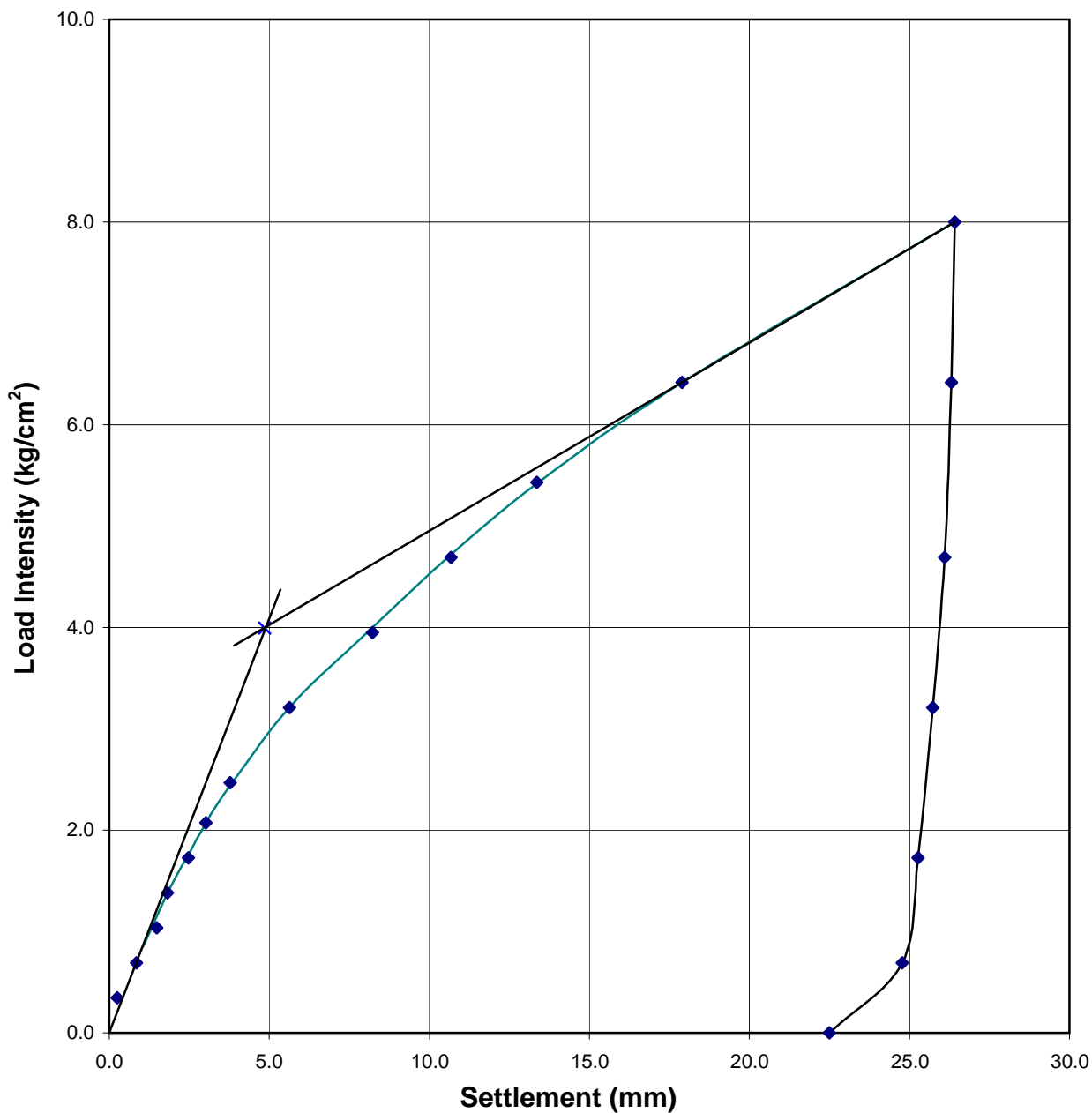
**Plate Size** : 45cm x 45cm

**Ground Elevation** : +118.1 m

**Depth** : 3.50m b.g.l.

**Ground Water Level** : Not Encountered

### ARITHMETIC PLOT



**Project** : Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

**Job No.**  
CCPL/19021175

**Fig. No.**  
1/1

**Location** : N 3027895.5, E 728304.9

**Test Start Date** : 18.04.19

**Test No.** : PLT-1

**Test End Date** : 19.04.19

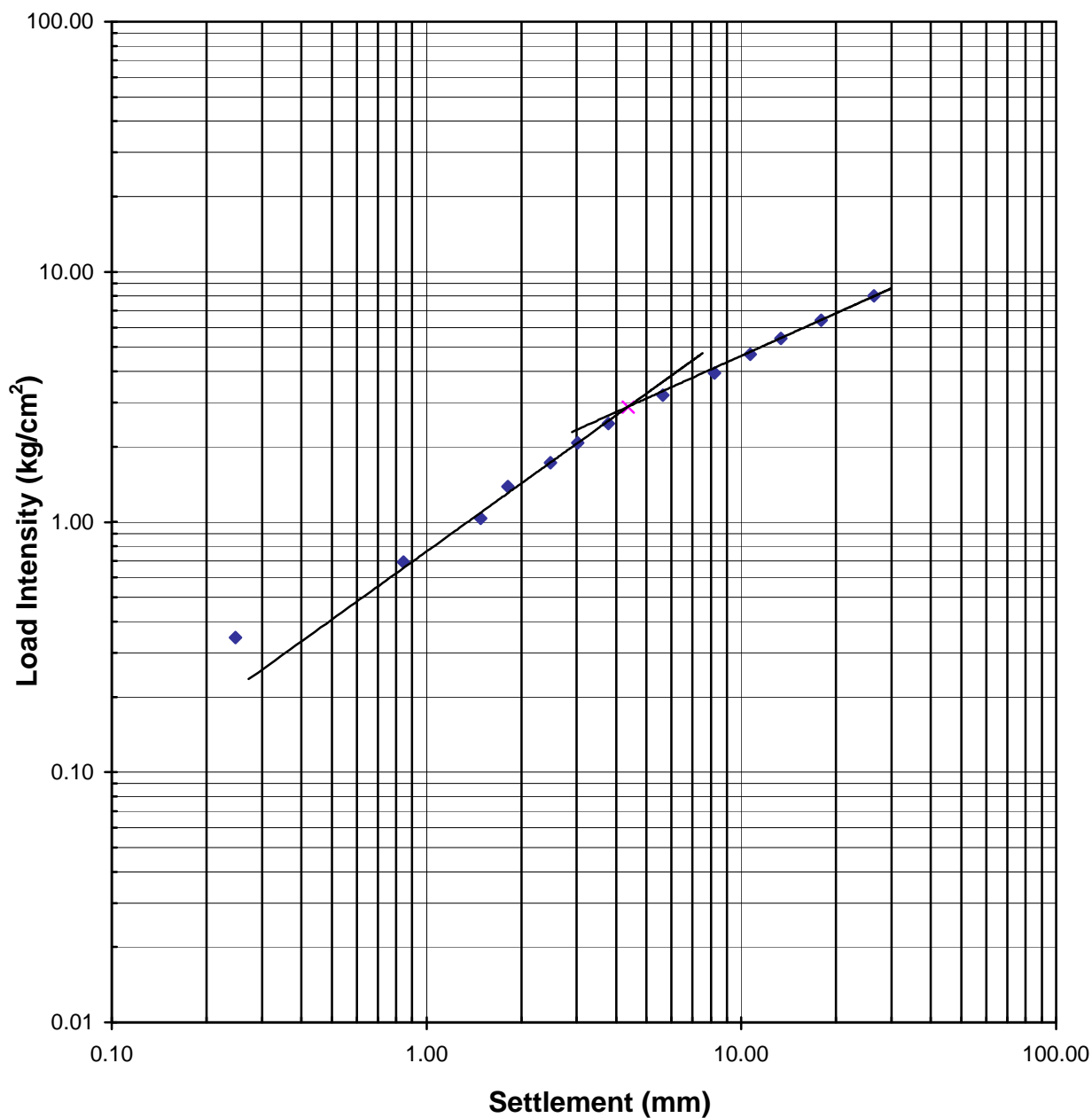
**Plate Size** : 45cm x 45cm

**Ground Elevation** : +118.1 m

**Depth** : 3.50m b.g.l.

**Ground Water Level** : Not Encountered

### LOGARITHMIC PLOT



**Project :** Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

**Job No.**  
CCPL/19021175

**Fig. No.**  
1/2

BLOCK VIBRATION TEST

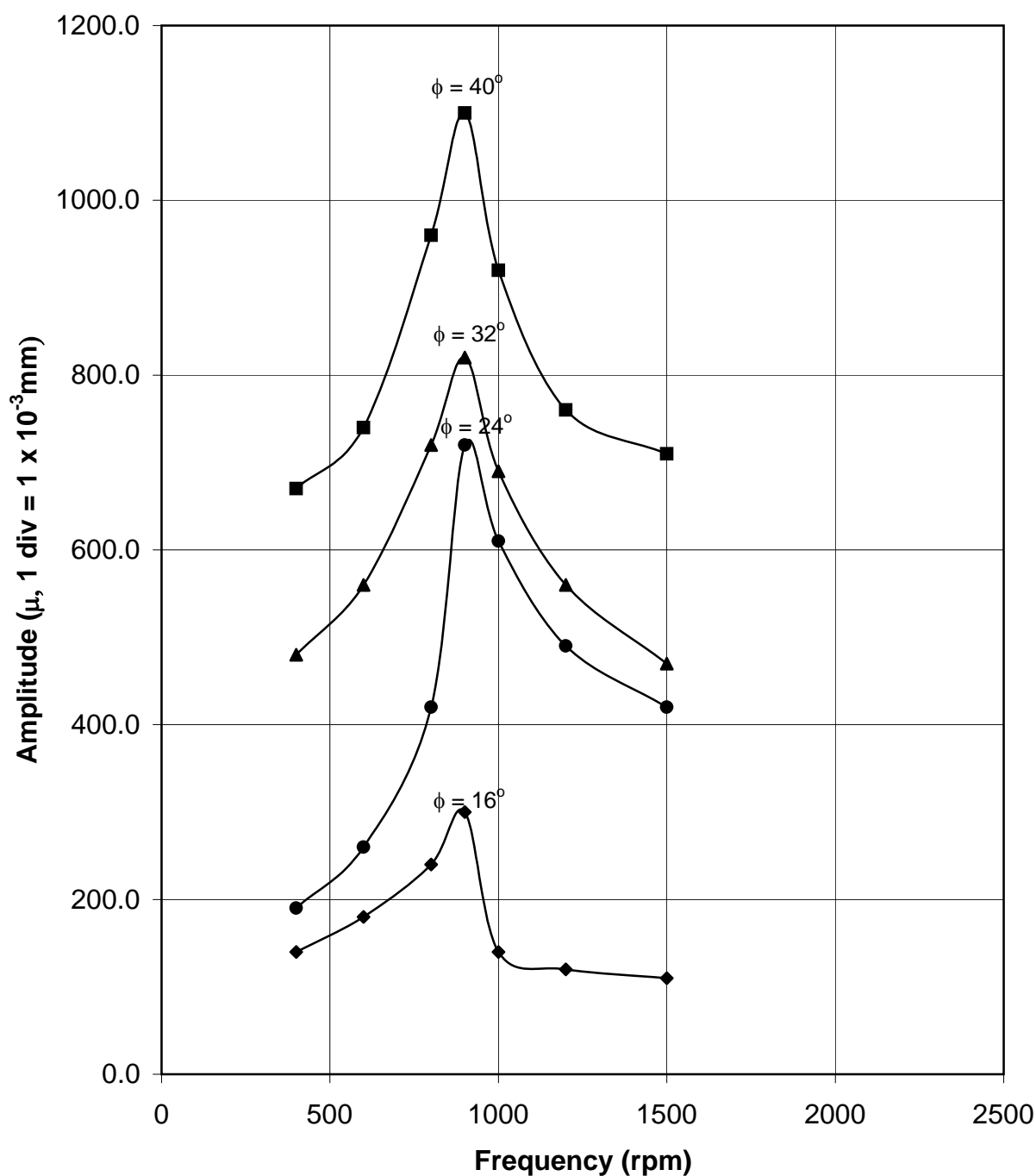
Project	: Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam	Test Number	: BVT-1
Location	: N 3027794.4; E 728348.2	Block Size	: 0.75m x 0.75m x 1.50m
Pit Size	: 3.00m x 6.00m	Ground Elevation	: +118.2m
Pit Condition	: Wet	Test Level	: +114.7m
Soil Type	: Silty sand	Date of Test	: 29.04.2019

Eccentric Angle, $\phi$ (degree)	Frequency (rpm)	Acceleration (m/sec <sup>2</sup> )	Amplitude ( $\mu$ )	Resonant Frequency (rpm)	Amplitude at Resonant Frequency ( $\mu$ )	Damping Ratio ( $\xi$ )
16	400	0.06	140.00	900	300.0	0.13
	600	0.11	180.00			
	800	0.16	240.00			
	900	0.21	300.00			
	1000	0.17	140.00			
	1200	0.14	120.00			
	1500	0.11	110.00			
24	400	0.09	190.00	900	720.0	0.18
	600	0.11	260.00			
	800	0.21	420.00			
	900	0.26	720.00			
	1000	0.17	610.00			
	1200	0.15	490.00			
	1500	0.11	420.00			
32	400	0.13	480.00	900	820.0	0.29
	600	0.17	560.00			
	800	0.25	720.00			
	900	0.39	820.00			
	1000	0.32	690.00			
	1200	0.26	560.00			
	1500	0.21	470.00			
40	400	0.18	670.00	900	1100.0	0.29
	600	0.25	740.00			
	800	0.42	960.00			
	900	0.49	1100.00			
	1000	0.41	920.00			
	1200	0.29	760.00			
	1500	0.21	710.00			



## BLOCK VIBRATION TEST

BVT-1



**Project:** Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

**Job No.**  
CCPL/19021175

**Fig. No.**  
E/1

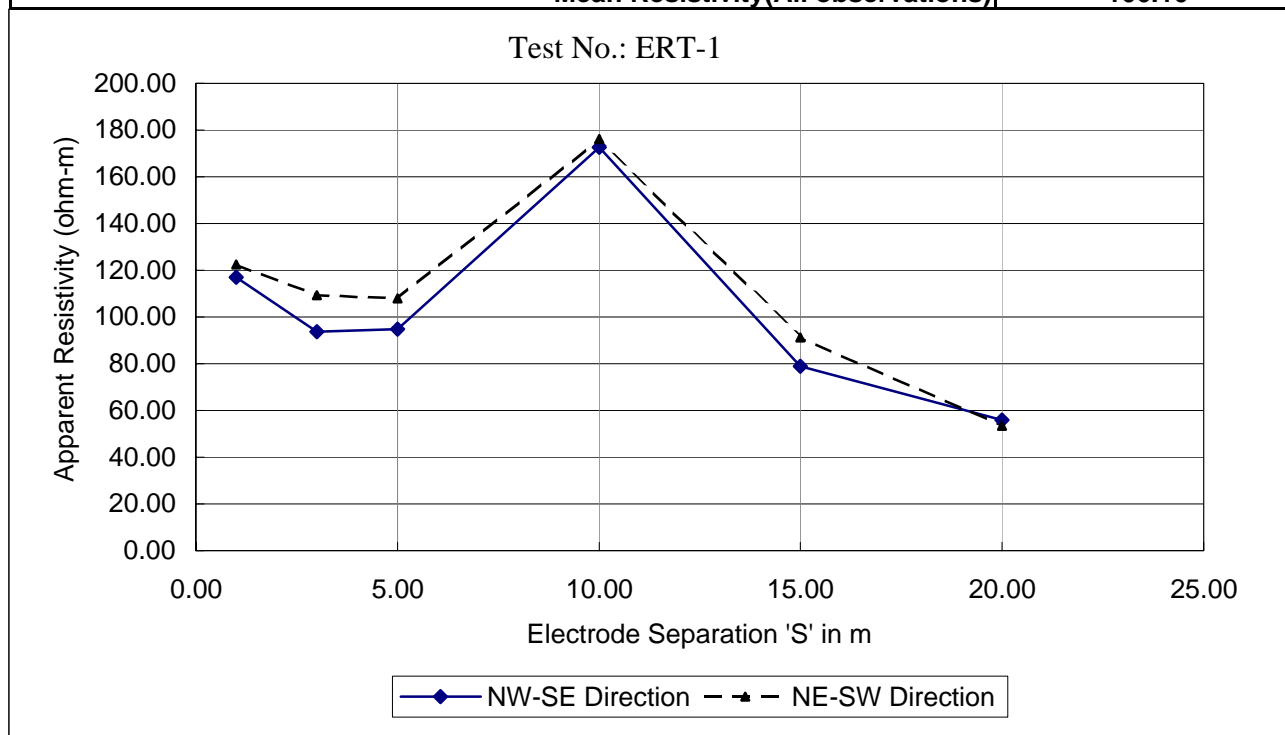
### EARTH RESISTIVITY DATA SHEET

Project : Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam Test Number : ERT-1

Location (Co-ordinate) : N 3027822.9 Ground elevation : +118.3m  
E 728358.4 Ground condition : Wet

Date of measurement : 14.04.19 Temperature [°C] : 30.4

Sl. No.	Electrode spacing 'S' [metres]	Depth of Burial 'e' [metres]	Geometric factor [metres]	Resistance		Average Apparent Resistivity	
				NW-SE Direction [Ohms]	NE-SW Direction [Ohms]	NW-SE Direction [Ohm-m]	NE-SW Direction [Ohm-m]
1.	1.00	0.15	6.52	17.9360	18.7780	116.98	122.47
2.	3.00	0.15	18.85	4.9667	5.8063	93.62	109.45
3.	5.00	0.15	31.42	3.0149	3.4360	94.72	107.95
4.	10.00	0.15	62.83	2.7465	2.8039	172.57	<b>176.17</b>
5.	15.00	0.15	94.25	0.8360	0.9691	78.79	91.34
6.	20.00	0.15	125.66	0.4442	0.4242	55.82	<b>53.31</b>
Mean Resistivity						<b>102.08</b>	<b>110.11</b>
Mean Resistivity(All observations)						<b>106.10</b>	



**FIELD C.B.R. TEST DATA SHEET**

Project	: Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam	Depth	: 0.80m
Location	: N 3027819.9 , E 728327.1	R.L.	: 118.1
Sample No.	: CBR-1	Surcharge wt.used	: 15kg
Test condition	: Soaked	Date of test	: 25/4/2019
Description	: Grey silty clay with traces of sand		

**Water Content and Dry Density Data**

Wt. Wet Soil + Mould	(gm)	8198.0
Wt. Mould	(gm)	3291.0
Wt. Wet Soil	(gm)	4907.0
Vol. Soil	(cc)	2780.9
Wet Density	(gms/cc)	1.765
Water Content	(%)	23.4
Dry Density	(gms/cc)	1.430

**Penetration Data**

Proving Ring Used : 5000 kg

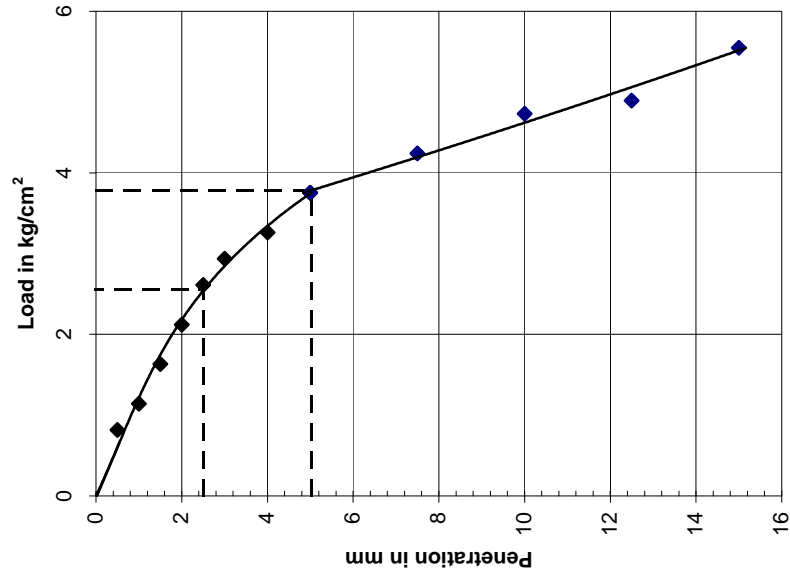
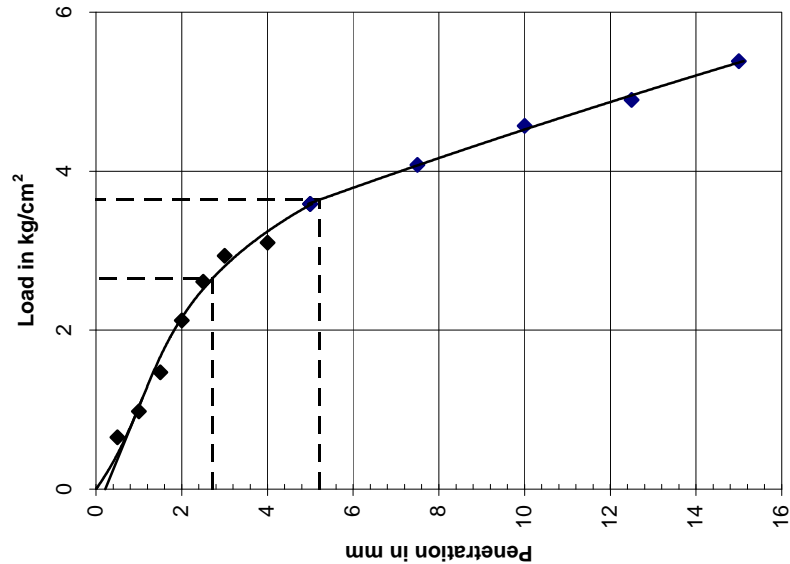
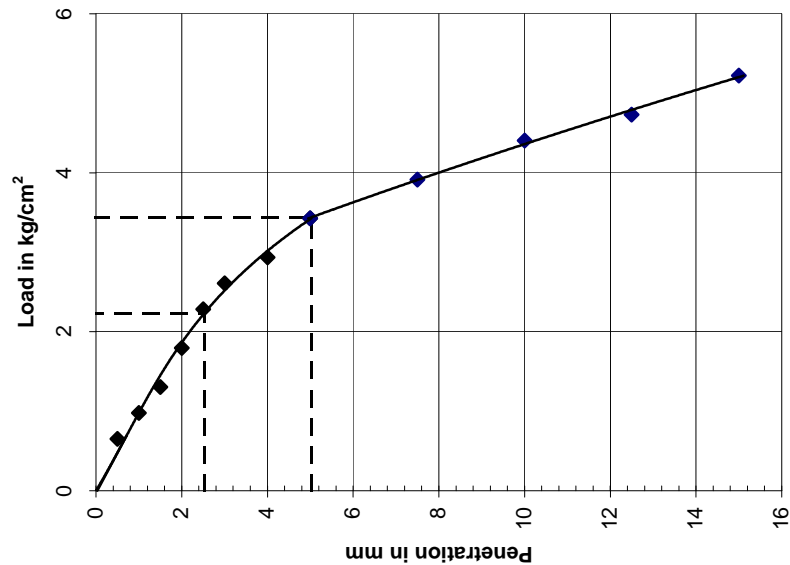
Penetration (mm)	TEST LOAD						Standard Load (Kg/cm <sup>2</sup> )	Corrected Load (Kg/cm <sup>2</sup> )			CBR (%)		
	Dial Gauge Reading			In Kg/cm <sup>2</sup>									
0.5	2.0	2.0	2.5	0.7	0.7	0.8							
1.0	3.0	3.0	3.5	1.0	1.0	1.1							
1.5	4.0	4.5	5.0	1.3	1.5	1.6							
2.0	5.5	6.5	6.5	1.8	2.1	2.1	70	2.2	2.6	2.6	3.2	3.8	3.6
2.5	7.0	8.0	8.0	2.3	2.6	2.6							
3.0	8.0	9.0	9.0	2.6	2.9	2.9							
4.0	9.0	9.5	10.0	2.9	3.1	3.3	105	3.4	3.6	3.8	3.3	3.5	3.6
5.0	10.5	11.0	11.5	3.4	3.6	3.8							
7.5	12.0	12.5	13.0	3.9	4.1	4.2							
10.0	13.5	14.0	14.5	4.4	4.6	4.7							
12.5	14.5	15.0	15.0	4.7	4.9	4.9							
15.0	16.0	16.5	17.0	5.2	5.4	5.5							

Load Penetration Curve of Laboratory C.B.R. Test

Sample No.: CBR-1 (Soaked,.)  
Penetration (mm)      CBR (%)  
2.5                      3.2  
5.0                      3.3

Sample No.: CBR-1 (Soaked,.)  
Penetration (mm)      CBR (%)  
2.5                      3.8  
5.0                      3.5

Sample No.: CBR-1 (Soaked,.)  
Penetration (mm)      CBR (%)  
2.5                      3.6  
5.0                      3.6



Geotechnical investigation work at Duliujan Power Station of Oil India Limited in Dibrugarh, Assam

Job No.:  
CCPL/19021175

Fig. No.: G/1

**FIELD C.B.R. TEST DATA SHEET**

Project : Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam  
 Location : N 3027743.0 , E 728332.0 Depth : 0.50m  
 Sample No. : CBR-2 R.L. : 118.1  
 Test condition : Soaked Surcharge wt.used : 15kg  
 Description : Brownish / yellowish grey silty clay with traces of sand Date of test : 24/4/2019

**Water Content and Dry Density Data**

Wt. Wet Soil + Mould (gm) 7727.0  
 Wt. Mould (gm) 3128.0  
 Wt. Wet Soil (gm) 4599.0  
 Vol. Soil (cc) 2720.9  
 Wet Density (gms/cc) 1.690  
 Water Content (%) 23.9  
 Dry Density (gms/cc) 1.364

**Penetration Data**

Proving Ring Used : 5000 kg

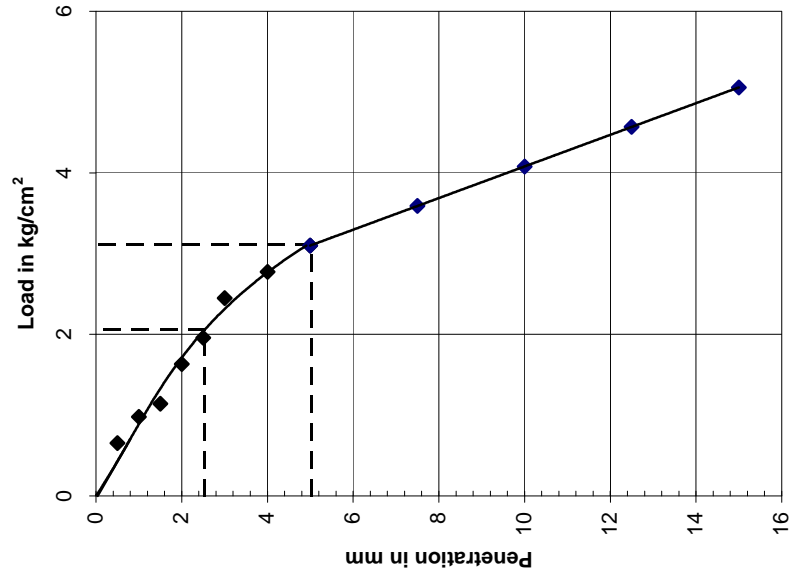
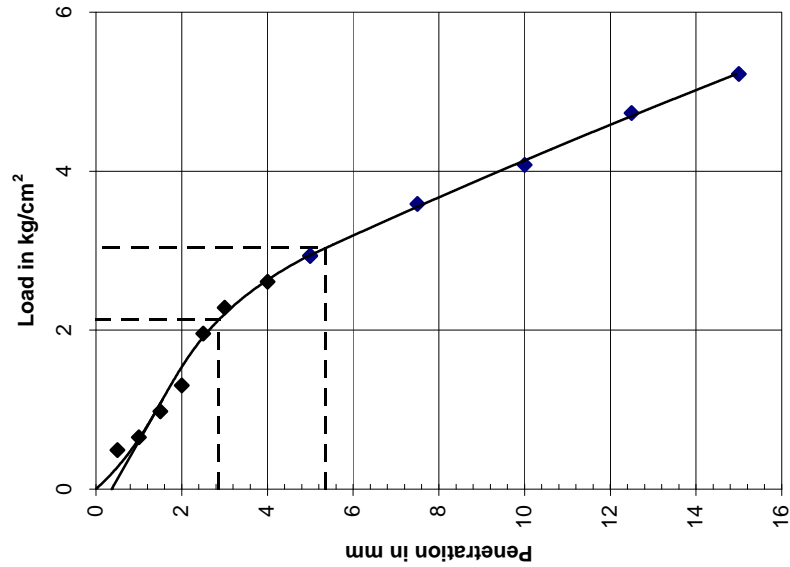
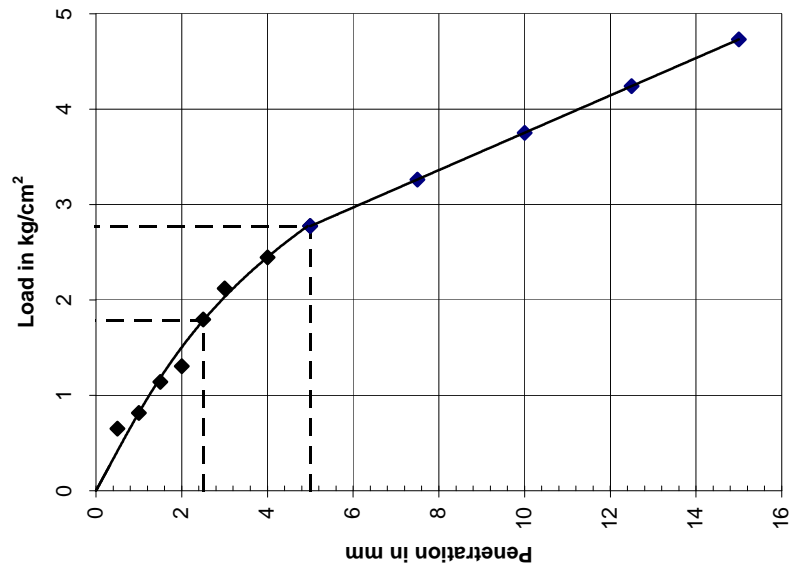
Penetration (mm)	TEST LOAD						Standard Load (Kg/cm <sup>2</sup> )	Corrected Load (Kg/cm <sup>2</sup> )			CBR (%)		
	Dial Gauge Reading			In Kg/cm <sup>2</sup>									
0.5	2.0	1.5	2.0	0.7	0.5	0.7							
1.0	2.5	2.0	3.0	0.8	0.7	1.0							
1.5	3.5	3.0	3.5	1.1	1.0	1.1							
2.0	4.0	4.0	5.0	1.3	1.3	1.6	70	1.8	2.1	2.1	2.5	3.0	2.9
2.5	5.5	6.0	6.0	1.8	2.0	2.0							
3.0	6.5	7.0	7.5	2.1	2.3	2.4							
4.0	7.5	8.0	8.5	2.4	2.6	2.8	105	2.8	3.0	3.1	2.6	2.9	3.0
5.0	8.5	9.0	9.5	2.8	2.9	3.1							
7.5	10.0	11.0	11.0	3.3	3.6	3.6							
10.0	11.5	12.5	12.5	3.8	4.1	4.1							
12.5	13.0	14.5	14.0	4.2	4.7	4.6							
15.0	14.5	16.0	15.5	4.7	5.2	5.1							

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

Sample No.: CBR-2 (Soaked, )  
Penetration (mm)      CBR (%)  
2.5                      2.5  
5.0                      2.6

Sample No.: CBR-2 (Soaked, )  
Penetration (mm)      CBR (%)  
2.5                      3.0  
5.0                      2.9

Sample No.: CBR-2 (Soaked, )  
Penetration (mm)      CBR (%)  
2.5                      2.9  
5.0                      3.0



Geotechnical investigation work at Duliujan Power Station of Oil India Limited in Dibrugarh, Assam

Job No.:  
CCPL/19021175

Fig. No.: G/2

Bore Hole Number	Depth below G.L. in 'm'	Description	Standard Penetration Resistance 'N' Value	Corrected 'N' Value	Grain Size Analysis				Density and Moisture Test			Atterberg Limits			Shear Strength Parameters			Specific Gravity $G_s$	Consolidation Characteristics		
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gms/cc)	Dry Density (gms/cc)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	C (kPa)	$\phi$ (degrees)		$C_c$	$\frac{C_c}{1+e_0}$	Void Ratio, $e_0$
BH-1		Brick soling followed by brownish grey sandy silty clay with brick pieces 0.60m																			
	1.50	Firm brownish yellow silty clay / clayey silt with traces of sand	-	-	-	12.1	75.9	12.0	25.0	1.855	1.484	32.8	22.5	10.3	UU	33	5.0	2.67	0.2253	0.1252	0.7992
	2.00		7	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.00	3.00m	-	-	-	76.5	*23.5		24.4	1.830	1.471	Non-plastic			DS	0	31.0	2.65	-	-	-
	3.50	Medium dense / dense greyish brown / grey silty sand	10	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5.00		16	16	0.5	81.3	*18.2		-	-	-	Non-plastic			-	-	-	-	-	-	-
	6.50		36	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8.00		42	28	-	89.6	*10.4		21.6	\$2.009	1.652	Non-plastic			DS <sub>R</sub>	0	36.0	2.67	-	-	-
	9.50		52	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11.00		66	37	0.4	86.9	*12.7		-	-	-	Non-plastic			-	-	-	-	-	-	-
	12.50		94	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14.00		100	49	-	81.0	*19.0		19.0	\$2.036	1.711	Non-plastic			DS <sub>R</sub>	0	35.5	2.66	-	-	-
	15.50		86	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17.00		77	37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	18.50		80	37	-	87.0	*13.0		-	-	-	Non-plastic			-	-	-	-	-	-	-
					\$ Remoulded density																
					*Combined percentage of silt & clay																
Abbreviations used : (i) UU = Unconsolidated Undrained Triaxial Test (ii) DS = Direct shear test on undisturbed sample (iii) DS <sub>R</sub> = Direct Shear test on remoulded sample																					
Bore hole data and Laboratory test results for Duliajan Power Station of Oil India Limited in Dibrugarh, Assam																JOB NO.: CCPL/19021175			TABLE NO.: H/1-1		



Bore Hole Number	Depth below G.L. in 'm'	Description	Standard Penetration Resistance 'N' Value	Corrected 'N' Value	Grain Size Analysis				Density and Moisture Test			Atterberg Limits			Shear Strength Parameters			Specific Gravity G <sub>s</sub>	Consolidation Characteristics		
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gms/cc)	Dry Density (gms/cc)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	C (kPa)	φ (degrees)		C <sub>c</sub>	$\frac{C_c}{1+e_0}$	Void Ratio, e <sub>0</sub>
BH-1	20.00	Medium dense / dense greyish brown / grey silty sand	93	41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	21.50		102	43	0.6	86.4	*13.0	20.5	\$2.017	1.674	Non-plastic			DS <sub>R</sub>	0	35.5	2.67	-	-	-	
	23.00		94	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	24.50		63	28	-	90.0	*10.0	-	-	-	Non-plastic			-	-	-	-	-	-	-	
	26.00		68	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	27.50		70	30	-	86.0	*14.0	19.6	\$2.020	1.689	Non-plastic			DS <sub>R</sub>	0	35.0	2.65	-	-	-	
	29.00		78	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	30.63		102	38	-	91.0	*9.0	-	-	-	Non-plastic			-	-	-	-	-	-	-	
					\$ Remoulded density																
					*Combined percentage of silt & clay																
Abbreviations used : (i) UU = Unconsolidated Undrained Triaxial Test (ii) DS = Direct shear test on undisturbed sample (iii) DS <sub>R</sub> = Direct Shear test on remoulded sample																					
Bore hole data and Laboratory test results for Duliajan Power Station of Oil India Limited in Dibrugarh, Assam																JOB NO.: CCPL/19021175			TABLE NO.: H/1-2		





Bore Hole Number	Depth below G.L. in 'm'	Description	Standard Penetration Resistance 'N' Value	Corrected 'N' Value	Grain Size Analysis				Density and Moisture Test			Atterberg Limits			Shear Strength Parameters			Specific Gravity $G_s$	Consolidation Characteristics		
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gms/cc)	Dry Density (gms/cc)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	C (kPa)	$\phi$ (degrees)		$C_c$	$\frac{C_c}{1+e_0}$	Void Ratio, $e_0$
BH-2		Fill consisting of dark grey sandy silty clay with gravels																			
	1.50	0.30m Firm / stiff brownish yellow silty clay with traces of sand	-	-	-	11.6	69.5	18.9	23.7	1.879	1.519	37.2	21.5	15.7	UU	39	4.0	2.68	0.2263	0.1283	0.7643
	2.00		9	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.00	3.00m	-	-	-	85.1	*14.9		25.6	1.895	1.509	Non-plastic			DS	0	32.5	2.65	-	-	-
	3.50	Medium dense / dense yellowish grey / grey silty sand / sand ; very stiff / hard grey silty clay (high silt content) observed from 23.00m to 25.00m depth	20	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5.00		27	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6.50		31	23	-	83.8	*16.2		-	-	-	Non-plastic			-	-	-	-	-	-	-
	8.00		37	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9.50		38	25	-	88.8	*11.2		22.0	\$1.975	1.619	Non-plastic			DS <sub>R</sub>	0	34.5	2.67	-	-	-
	11.00		47	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	12.50		67	36	-	88.4	*11.6		-	-	-	Non-plastic			-	-	-	-	-	-	-
	14.00		89	45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15.50		78	39	-	96.7	*3.3		-	-	-	Non-plastic			-	-	-	-	-	-	-
	17.00		66	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	18.50		55	28	-	75.8	*24.2		21.6	\$2.000	1.645	Non-plastic			DS <sub>R</sub>	0	34.0	2.65	-	-	-
						\$ Remoulded density															
						*Combined percentage of silt & clay															
Abbreviations used : (i) UU = Unconsolidated Undrained Triaxial Test (ii) DS = Direct shear test on undisturbed sample (iii) DS <sub>R</sub> = Direct Shear test on remoulded sample																					
Bore hole data and Laboratory test results for Duliajan Power Station of Oil India Limited in Dibrugarh, Assam																	JOB NO.: CCPL/19021175			TABLE NO.: H/2-1	



Bore Hole Number	Depth below G.L. in 'm'	Description	Standard Penetration Resistance 'N' Value	Corrected 'N' Value	Grain Size Analysis				Density and Moisture Test			Atterberg Limits			Shear Strength Parameters			Specific Gravity $G_s$	Consolidation Characteristics											
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gms/cc)	Dry Density (gms/cc)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	C (kPa)	$\phi$ (degrees)		$C_c$	$\frac{C_c}{1+e_0}$	Void Ratio, $e_0$									
BH-2	20.00	Medium dense / dense yellowish grey / grey silty sand / sand ; very stiff / hard grey silty clay (high silt content) observed from 23.00m to 25.00m depth	66	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-									
	21.50		69	32	-	74.8	*25.2	-	-	-	Non-plastic			-	-	-	-	-	-	-										
	23.00		40	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
	24.50		31	31	-	2.0	82.5	15.5	-	-	-	32.6	21.0	11.6	-	-	-	-	-	-										
	25.00		-	-	-	75.6	*24.4	22.0	2.007	1.645	Non-plastic			DS	0	35.5	2.67	-	-	-										
	27.50		75	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
	29.00		85	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
	30.39		95	36	-	72.8	*27.2	-	-	-	Non-plastic			-	-	-	-	-	-	-										
					\$ Remoulded density																									
					*Combined percentage of silt & clay																									
Abbreviations used : (i) UU = Unconsolidated Undrained Triaxial Test (ii) DS = Direct shear test on undisturbed sample (iii) DS <sub>R</sub> = Direct Shear test on remoulded sample																														
Bore hole data and Laboratory test results for Duliajan Power Station of Oil India Limited in Dibrugarh, Assam																JOB NO.: CCPL/19021175		TABLE NO.: H/2-2												



Bore Hole Number	Depth below G.L. in 'm'	Description	Standard Penetration Resistance 'N' Value	Corrected 'N' Value	Grain Size Analysis				Density and Moisture Test			Atterberg Limits			Shear Strength Parameters			Specific Gravity $G_s$	Consolidation Characteristics		
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gms/cc)	Dry Density (gms/cc)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	C (kPa)	$\phi$ (degrees)		$C_c$	$\frac{C_c}{1+e_0}$	Void Ratio, $e_0$
BH-3		Fill consisting of dark grey sandy silty clay with gravels , brick pieces etc. 0.70m																			
	1.50	Firm / stiff yellowish grey silty clay / clayey silt with traces of sand	-	-	-	15.3	72.6	12.1	22.0	1.906	1.562	30.0	19.7	10.3	UU	46	4.5	2.68	0.2080	0.1213	0.7154
	2.00		11	11	-	15.7	75.6	8.7	-	-	-	31.7	22.0	9.7	-	-	-	-	-	-	-
	3.00	3.00m																			
	3.00	Medium dense / dense grey / yellowish grey silty sand / sand	-	-	-	80.0	*20.0		25.0	1.845	1.476	Non-plastic			DS	0	31.5	2.65	-	-	-
	3.50		14	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5.00		26	21	-	84.5	*15.5		24.4	\$1.930	1.551	Non-plastic			DS <sub>R</sub>	0	33.5	2.65	-	-	-
	6.50		25	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8.00		31	23	-	86.8	*13.2		-	-	-	Non-plastic			-	-	-	-	-	-	-
	9.50		42	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11.00		47	29	-	88.4	*11.6		20.7	\$2.017	1.671	Non-plastic			DS <sub>R</sub>	0	35.0	2.67	-	-	-
	12.50		70	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	14.00		66	35	-	93.4	*6.6		-	-	-	Non-plastic			-	-	-	-	-	-	-
	15.50		68	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
\$ Remoulded density *Combined percentage of silt & clay																					
Abbreviations used : (i) UU = Unconsolidated Undrained Triaxial Test (ii) DS = Direct shear test on undisturbed sample (iii) DS <sub>R</sub> = Direct Shear test on remoulded sample																					
Bore hole data and Laboratory test results for Duliajan Power Station of Oil India Limited in Dibrugarh, Assam																JOB NO.: CCPL/19021175			TABLE NO.: H/3-1		



Bore Hole Number	Depth below G.L. in 'm'	Description	Standard Penetration Resistance 'N' Value	Corrected 'N' Value	Grain Size Analysis				Density and Moisture Test			Atterberg Limits			Shear Strength Parameters			Specific Gravity $G_s$	Consolidation Characteristics												
					Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gms/cc)	Dry Density (gms/cc)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	C (kPa)	$\phi$ (degrees)		$C_c$	$\frac{C_c}{1+e_0}$	Void Ratio, $e_0$										
BH-3	17.00	Medium dense / dense grey / yellowish grey silty sand / sand	79	38	-	95.8	*4.2		-	-	-	Non-plastic			-	-	-	-	-	-	-										
	18.50		81	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
	20.00		78	36	-	78.6	*21.4		21.0	\$2.031	1.679	Non-plastic			DS <sub>R</sub>	2	36.0	2.66	-	-	-										
	21.50		80	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
	23.00		75	33	-	77.4	*22.6		-	-	-	Non-plastic			-	-	-	-	-	-	-										
	24.50		69	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
	26.00		64	28	-	76.8	*23.2		20.4	\$2.009	1.669	Non-plastic			DS <sub>R</sub>	0	35.5	2.67	-	-	-										
	27.50		68	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
	29.00		77	31	-	75.9	*24.1		-	-	-	-	Non-plastic			-	-	-	-	-	-	-									
	30.86		89	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
					\$ Remoulded density																										
					*Combined percentage of silt & clay																										
Abbreviations used : (i) UU = Unconsolidated Undrained Triaxial Test (ii) DS = Direct shear test on undisturbed sample (iii) DS <sub>R</sub> = Direct Shear test on remoulded sample																															
Bore hole data and Laboratory test results for Duliajan Power Station of Oil India Limited in Dibrugarh, Assam																JOB NO.: CCPL/19021175			TABLE NO.: H/3-2												

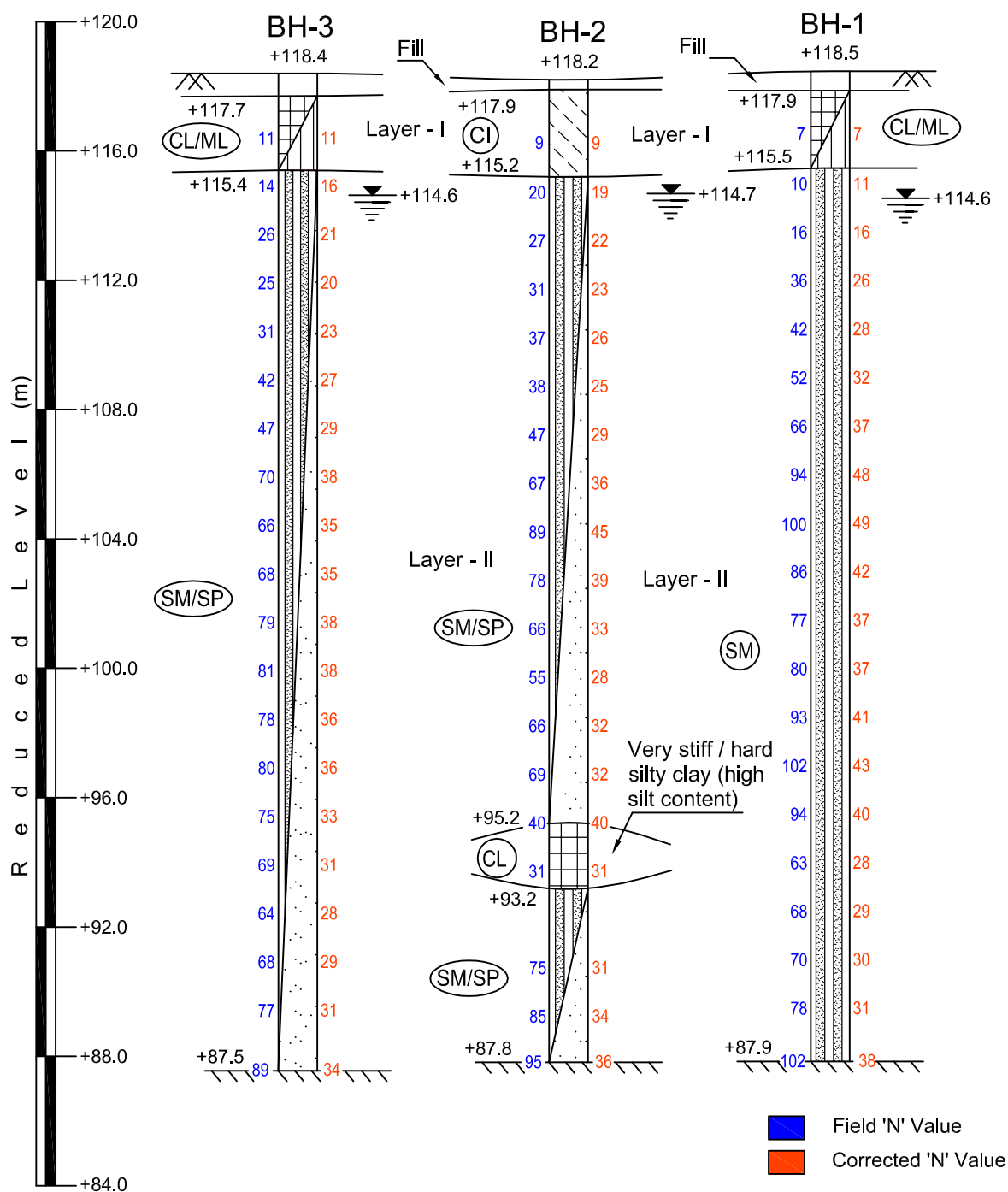




Bore Hole No.	Depth (m)	pH	Chloride (%)	Sulphate (%)
BH-3	1.50	7.20 (at 31°C)	0.0292	0.0033
Laboratory Test Results of Chemical Analysis of Soil Sample			JOB NO.: CCPL/19021175	TABLE NO.: H/4



Bore Hole No.	pH	Chloride (mg/l)	Sulphate (mg/l)
BH-2	7.71 (at 31°C)	70.02	51.04
Laboratory Test Results of Chemical Analysis of Water Sample		JOB NO.: CCPL/19021175	TABLE NO.: H/5



Fill : Consisting of sandy silty clay with gravels / brick pieces / brick soling etc.  
 Layer - I : Firm / stiff silty clay / clayey silt with traces of sand  
 Layer - II : Medium dense / dense silty sand / sand

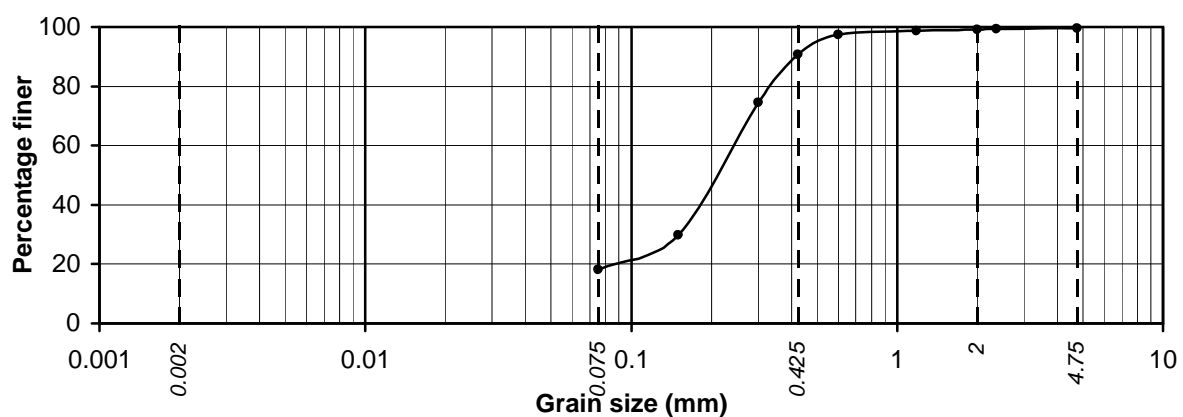
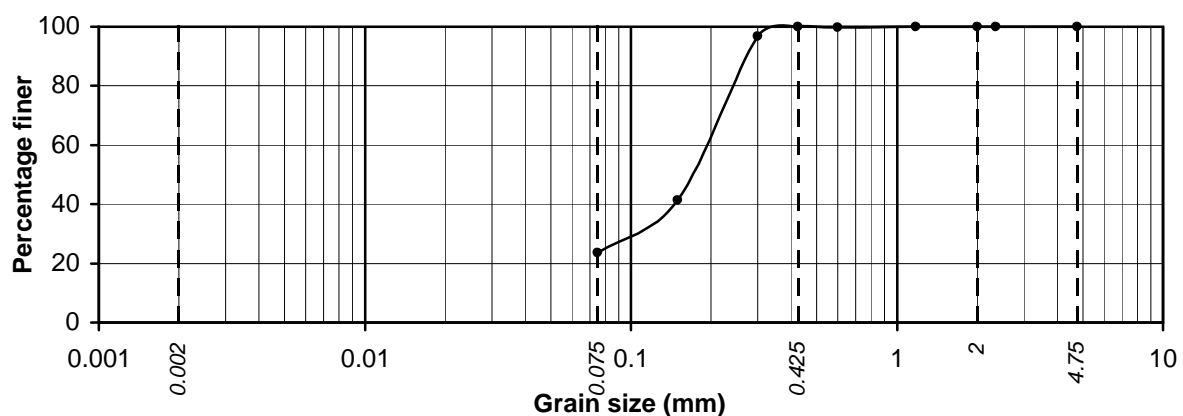
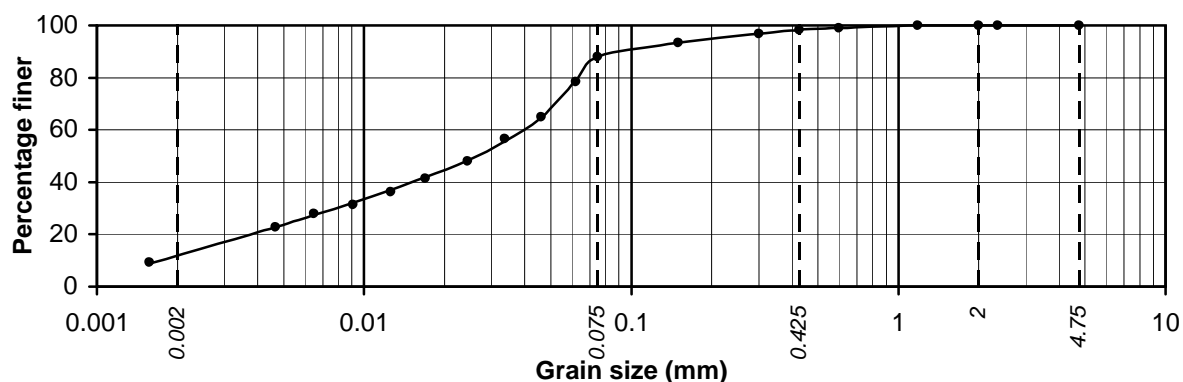
### Generalised Soil Profile for Duliajan Power Station of Oil India Limited (OIL) in Dibrugarh, Assam

Job No.:  
CCPL/19021175

Scale:- Vertical : 1:200  
Horizontal : 1:1250

Figure No.: I/1

### GRAIN SIZE DISTRIBUTION CURVES



\*Silt & Clay

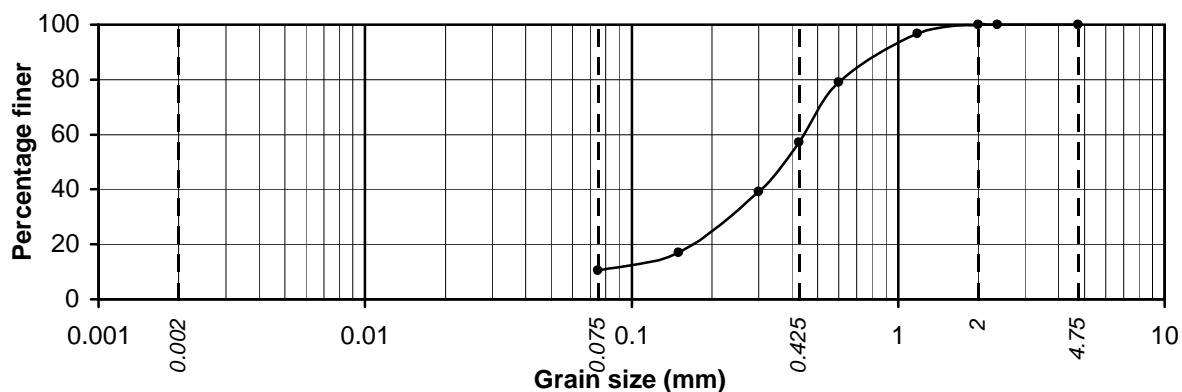
Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

**Job No.**  
CCPL/19021175

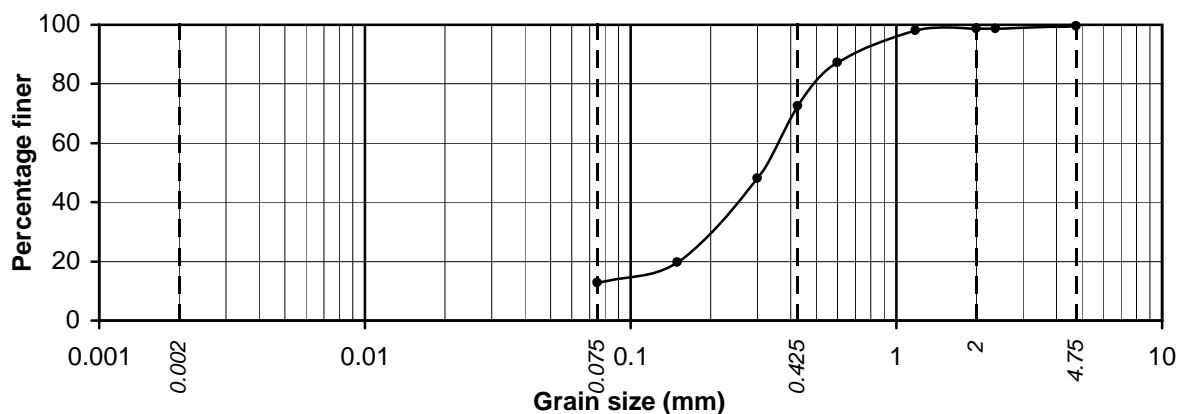
**Fig. No.**  
J/1



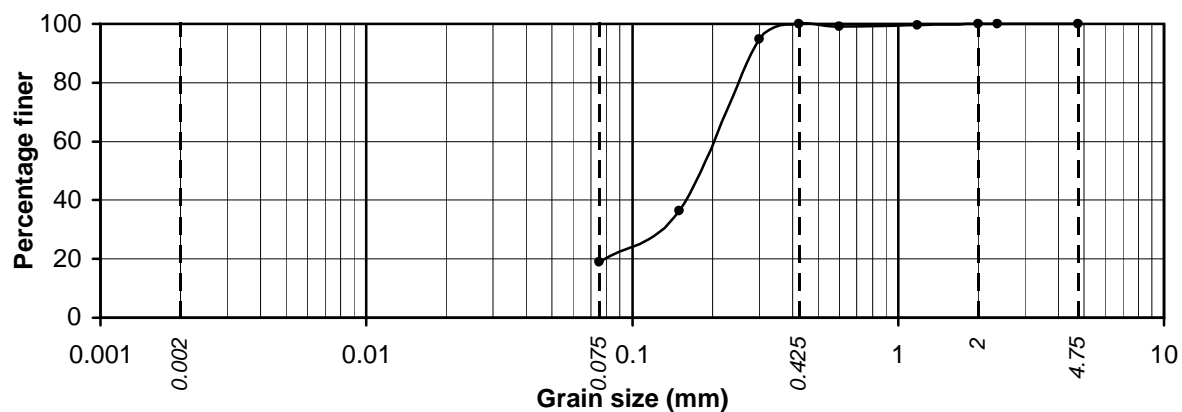
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-1, 8.00m		*10.4	46.7	42.9	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-1, 11.00m		*12.7	59.8	26.2	0.9	0.4



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-1, 14.00m		*19.0	81.0	0.0	0.0	0.0

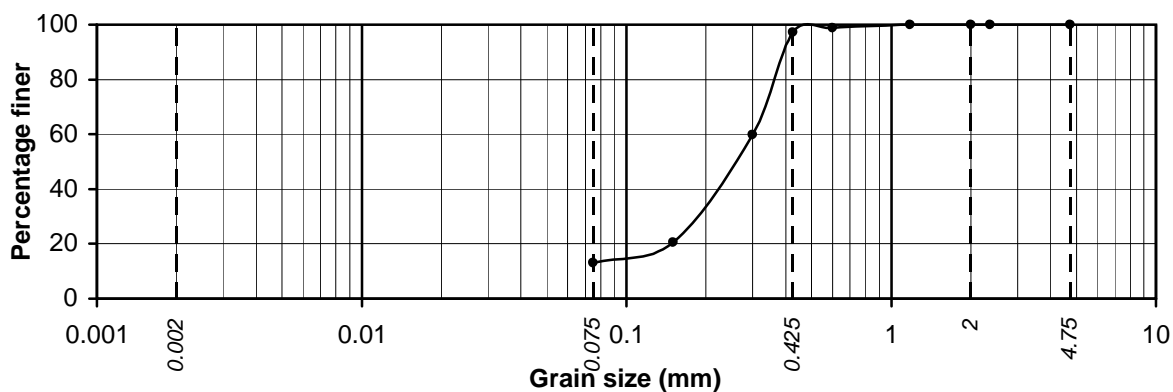
\*Silt & Clay

Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

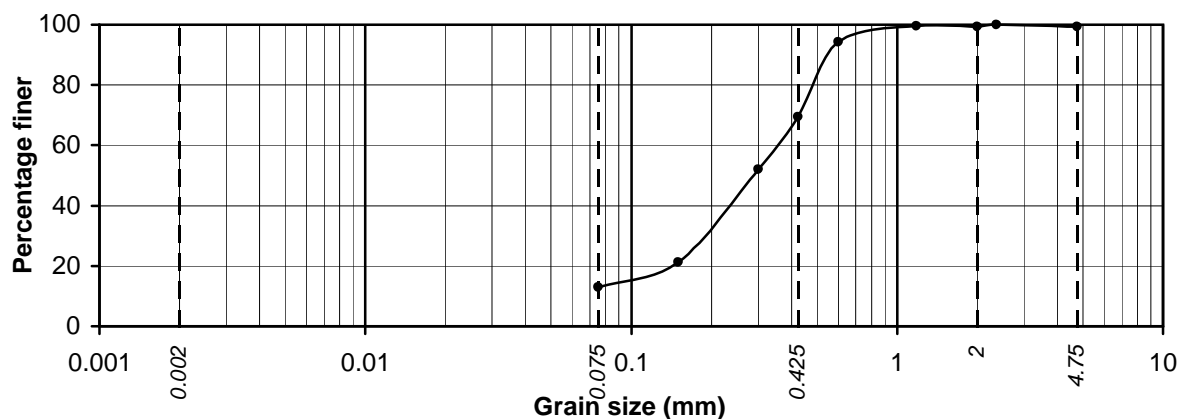
**Job No.**  
CCPL/19021175

**Fig. No.**  
J/2

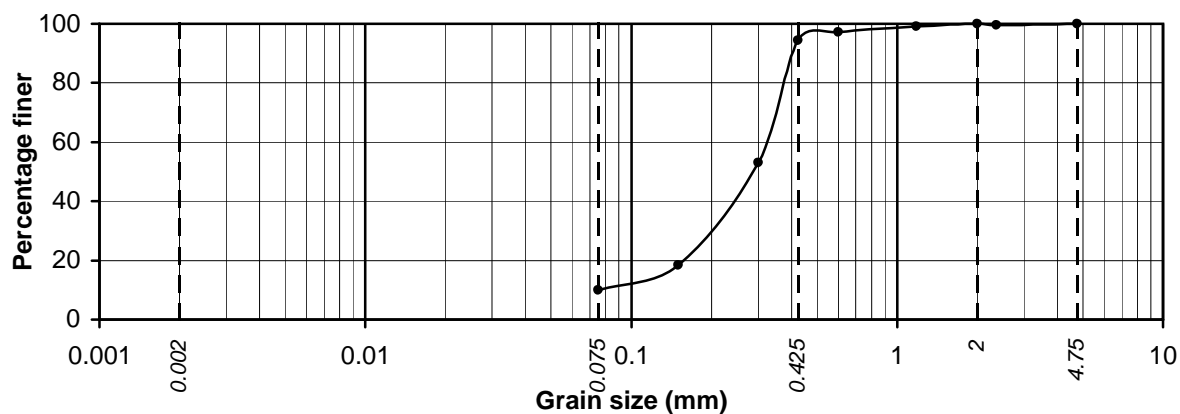
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-1, 18.50m		*13.0	84.2	2.8	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-1, 21.50m		*13.0	56.4	30.0	0.0	0.6



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-1, 24.50m		*10.0	84.4	5.5	0.1	0.0

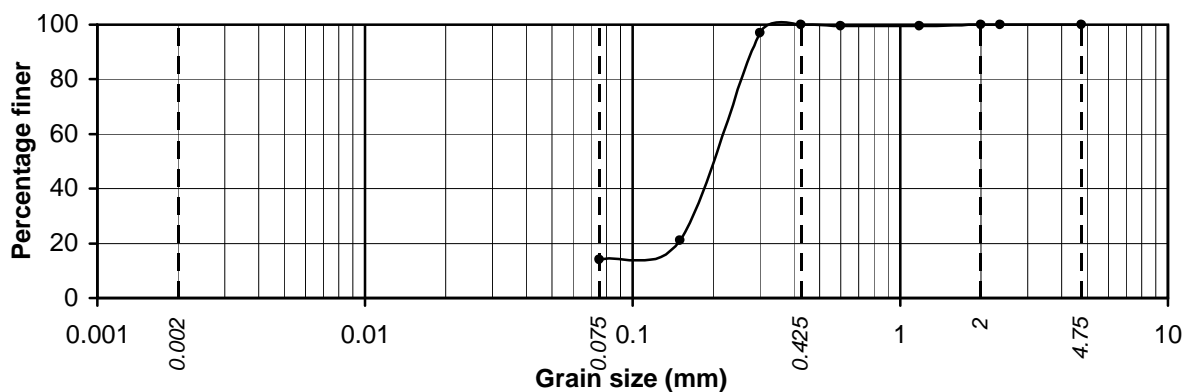
\*Silt & Clay

Geotechnical investigation work at Duliayan Power Station of Oil India Limited in Dibrugarh, Assam

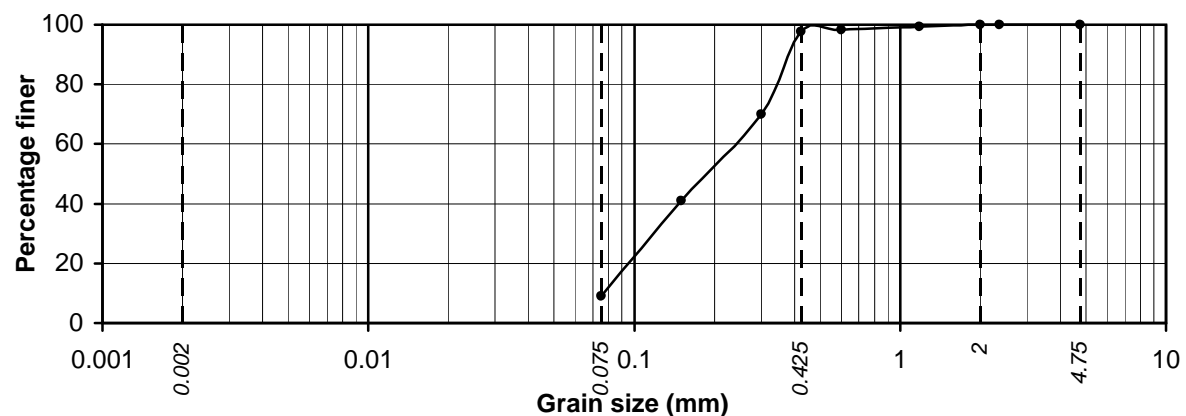
**Job No.**  
CCPL/19021175

**Fig. No.**  
J/3

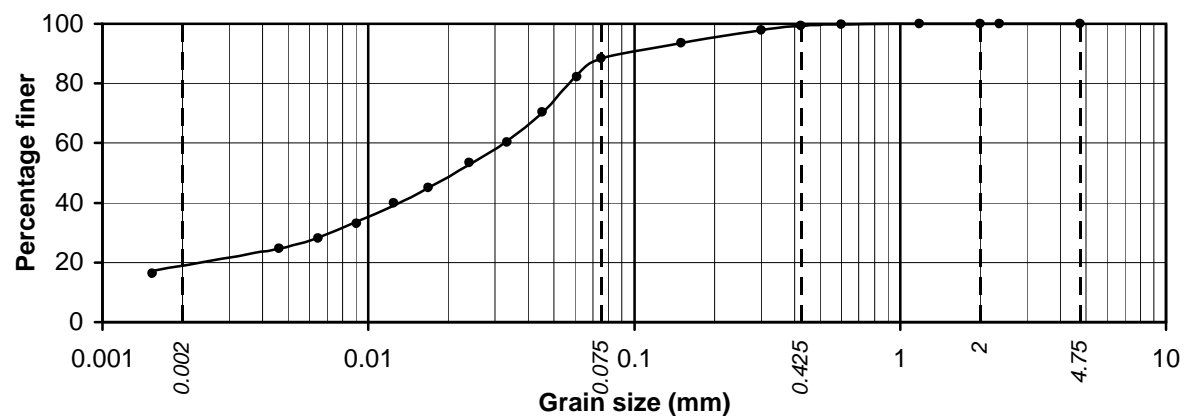
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-1, 27.50m		*14.0	86.0	0.0	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-1, 30.63m		*9.0	88.6	2.4	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-2, 1.50m	18.9	69.5	11.1	0.5	0.0	0.0

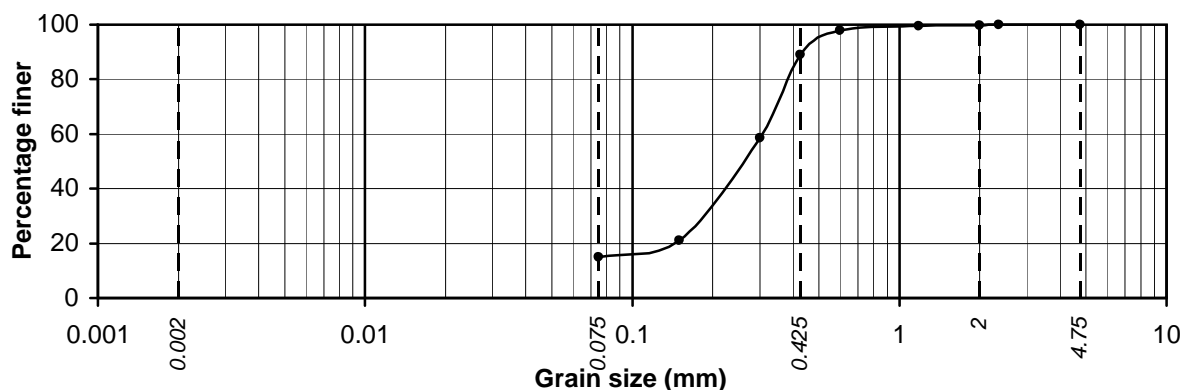
\*Silt & Clay

Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

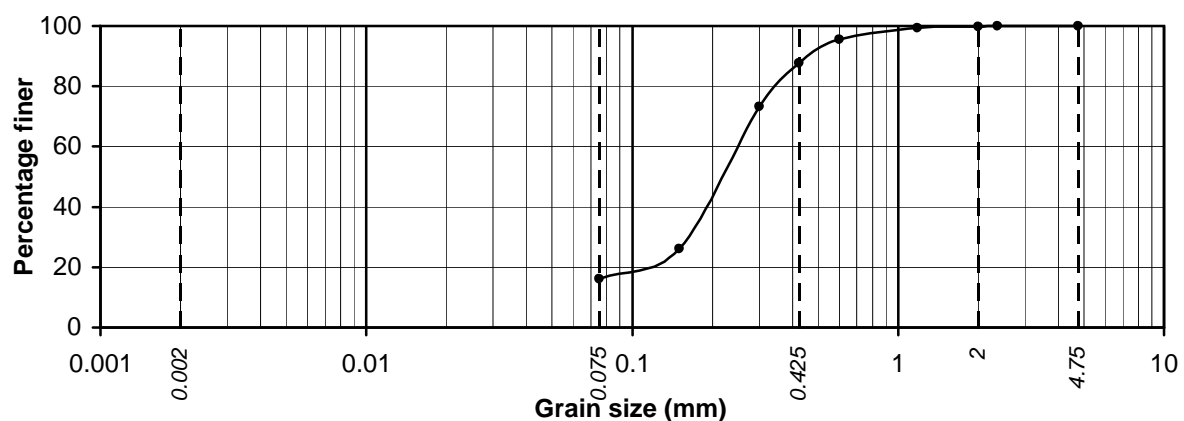
**Job No.**  
CCPL/19021175

**Fig. No.**  
J/4

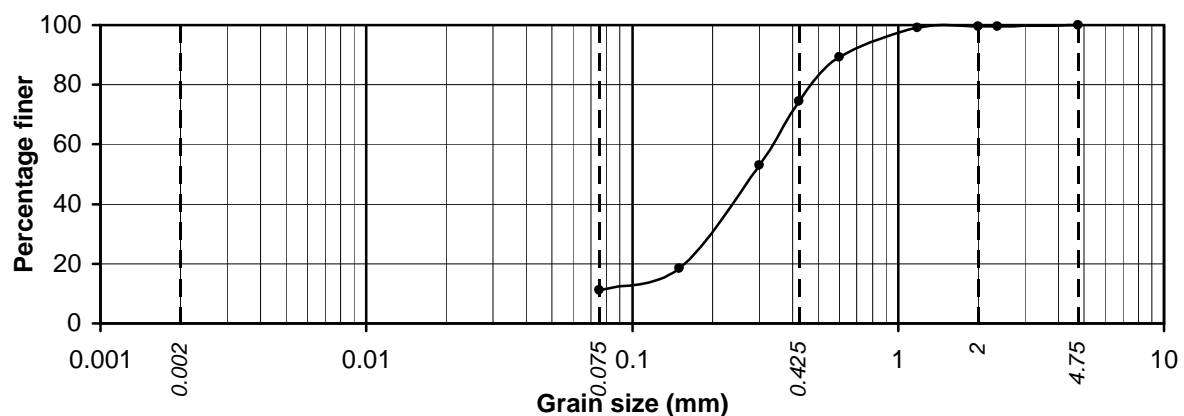
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-2, 3.00m		*14.9	74.2	10.7	0.2	0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-2, 6.50m		*16.2	71.4	12.1	0.3	0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-2, 9.50m		*11.2	63.3	25.1	0.4	0.0

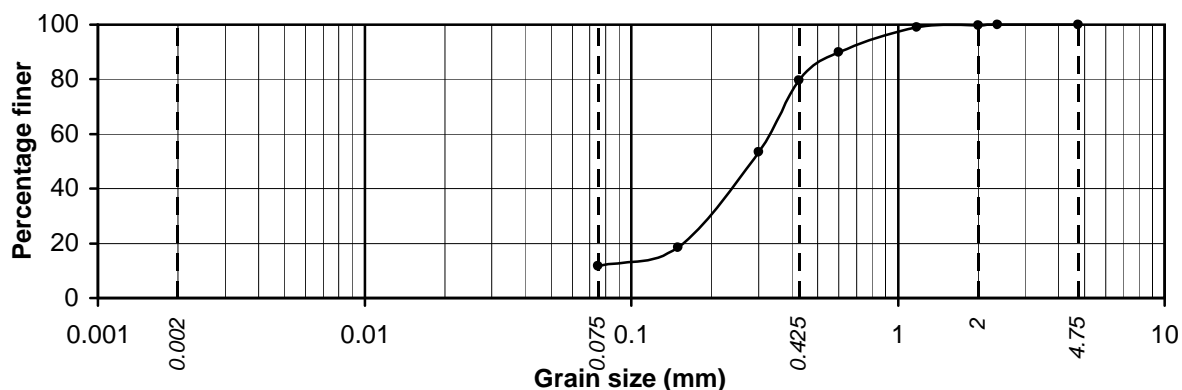
\*Silt & Clay

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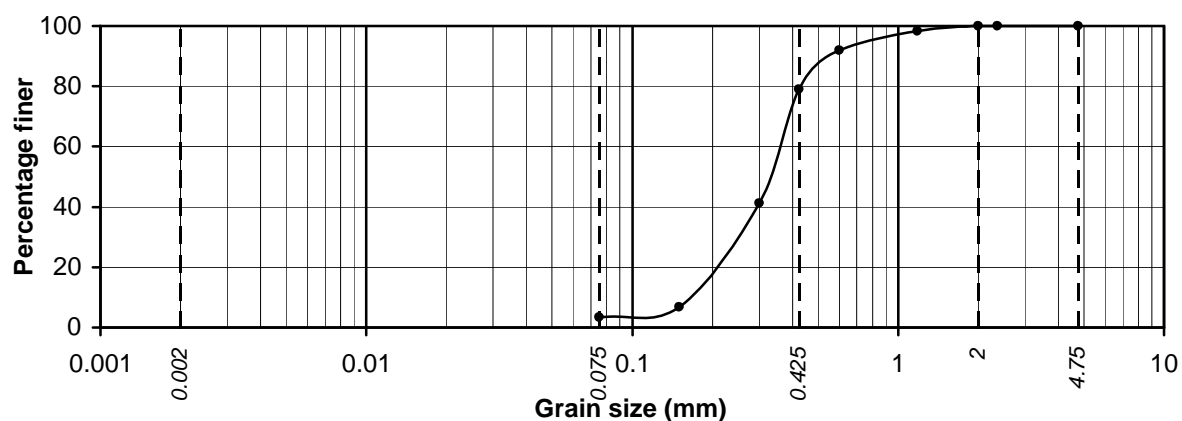
**Job No.**  
CCPL/19021175

**Fig. No.**  
J/5

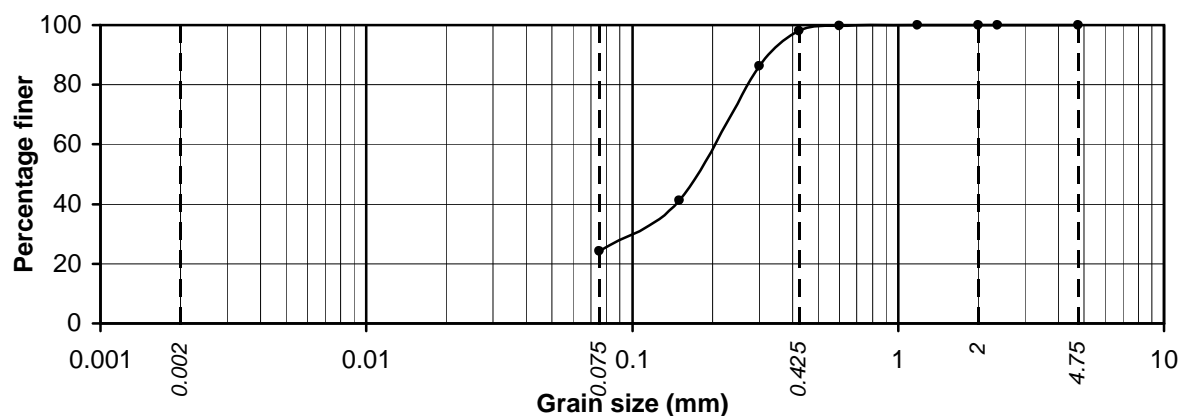
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-2, 12.50m		*11.6	68.0	20.3	0.1	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-2, 15.50m		*3.3	75.6	21.1	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-2, 18.50m		*24.2	73.9	1.9	0.0	0.0

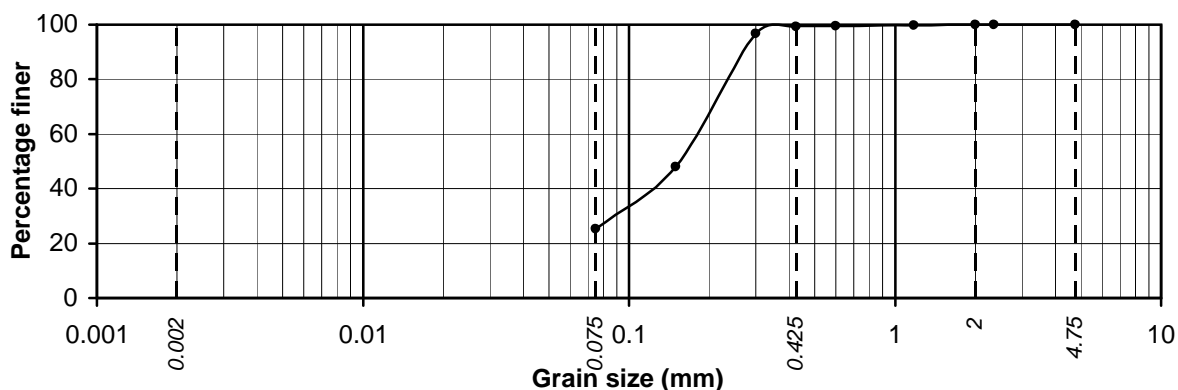
\*Silt & Clay

Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

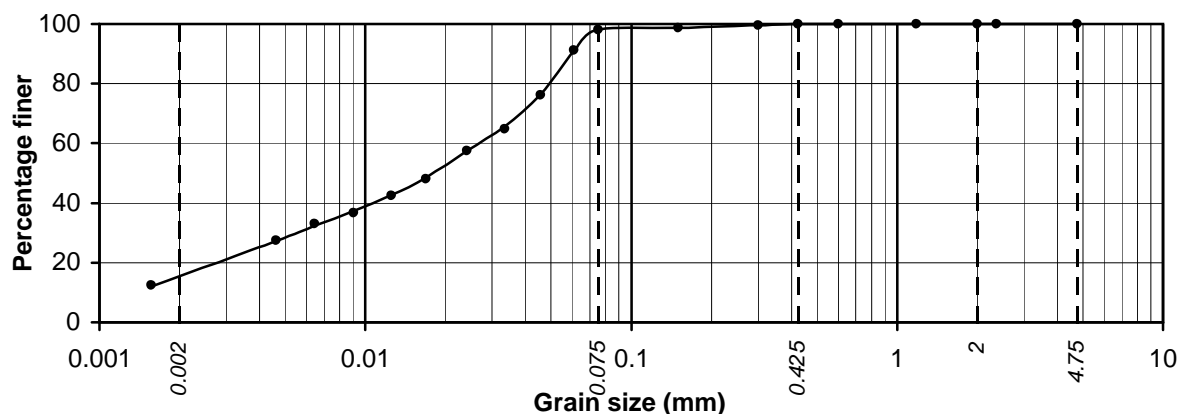
**Job No.**  
CCPL/19021175

**Fig. No.**  
J/6

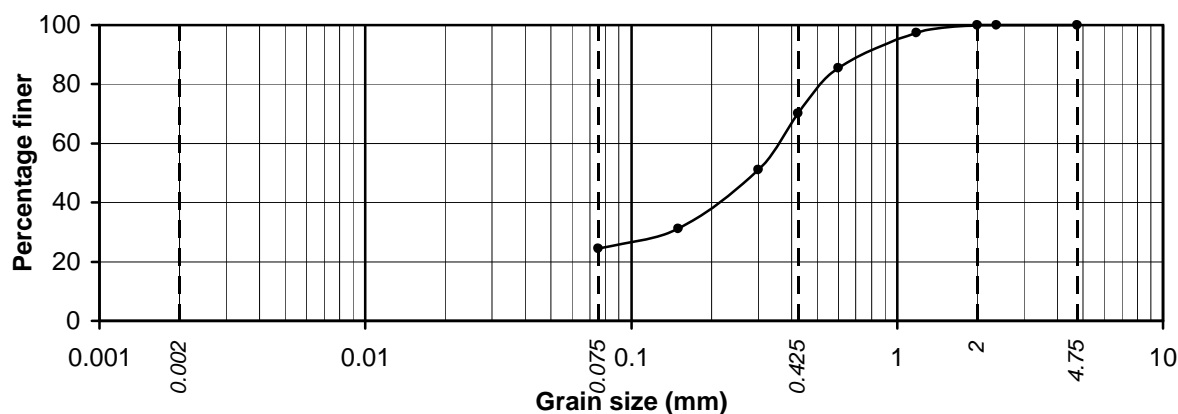
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-2, 21.50m		*25.2	74.0	0.8	0.0	0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-2, 24.50m	15.5	82.5	2.0	0.0	0.0	0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-2, 25.00m		*24.4	45.7	29.9	0.0	0.0

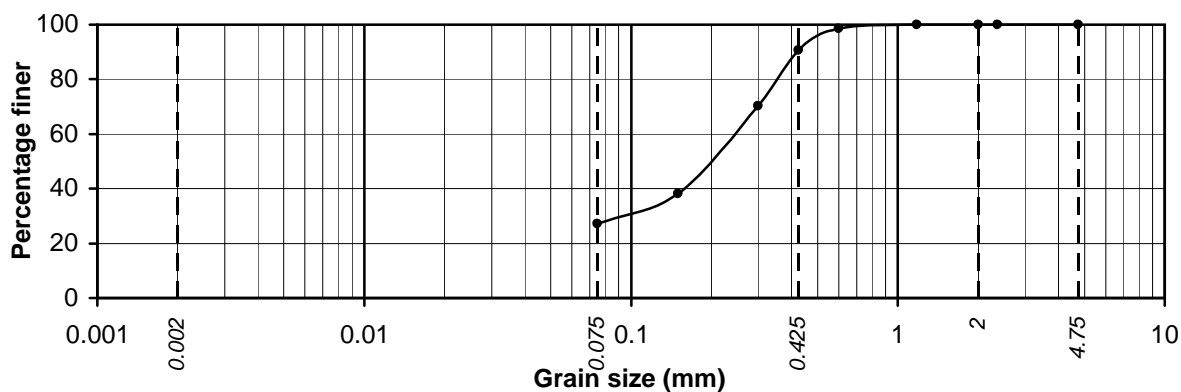
\*Silt & Clay

Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

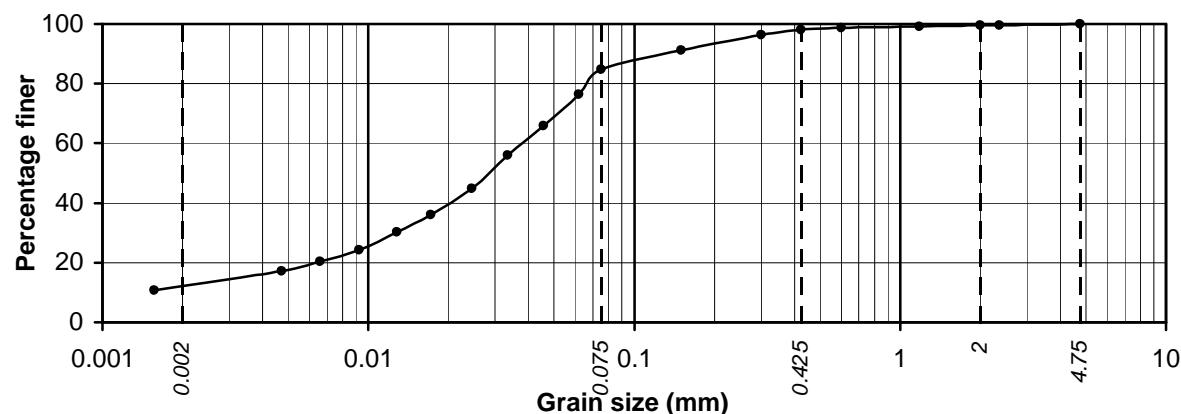
Job No.  
CCPL/19021175

Fig. No.  
J/7

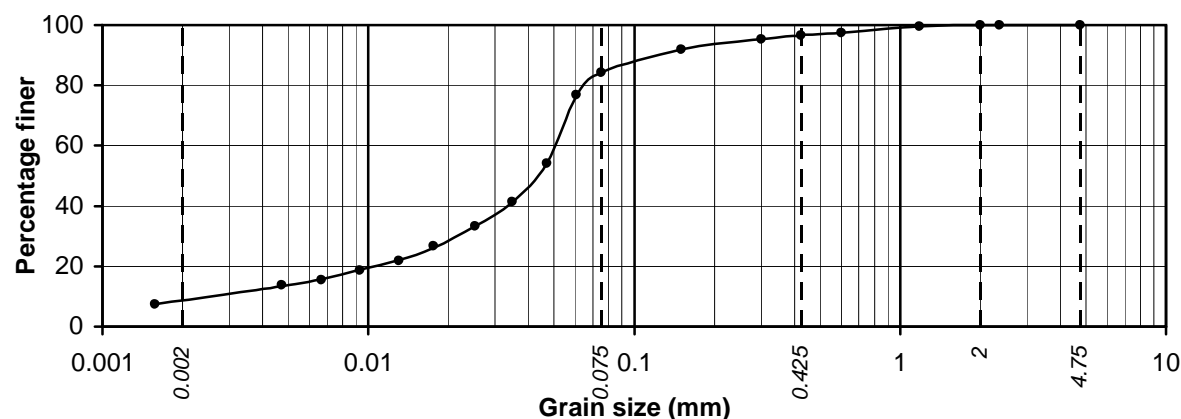
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-2, 30.39m		*27.2	63.4	9.4	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-3, 1.50m	12.1	72.6	13.5	1.3	0.5	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-3, 2.00m	8.7	75.6	12.4	3.3	0.0	0.0

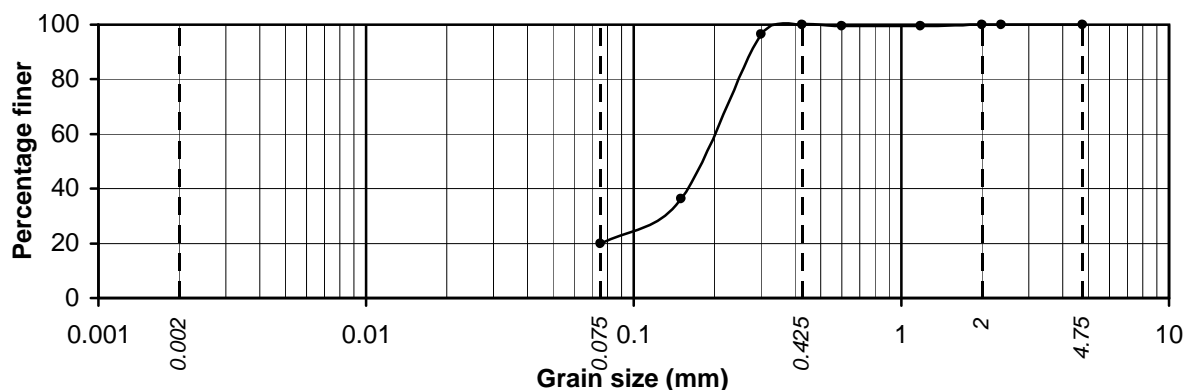
\*Silt & Clay

Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

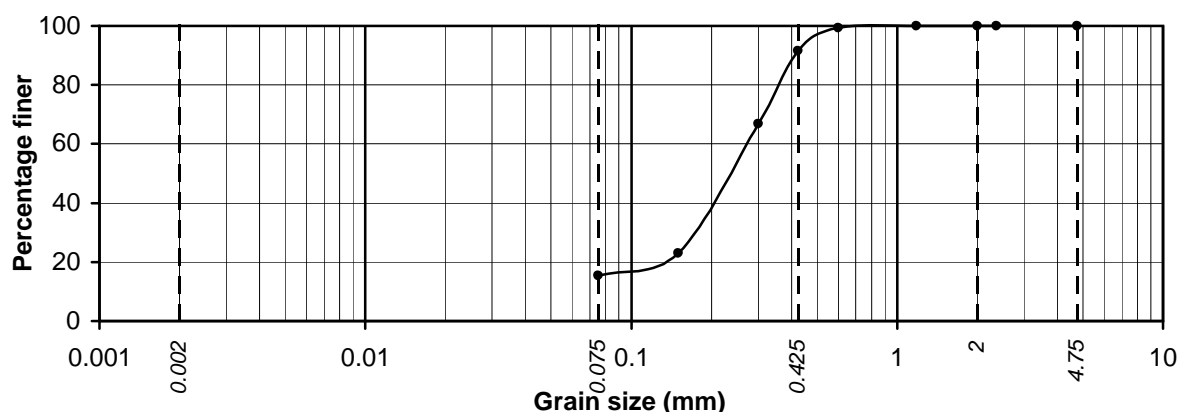
Job No.  
CCPL/19021175

Fig. No.  
J/8

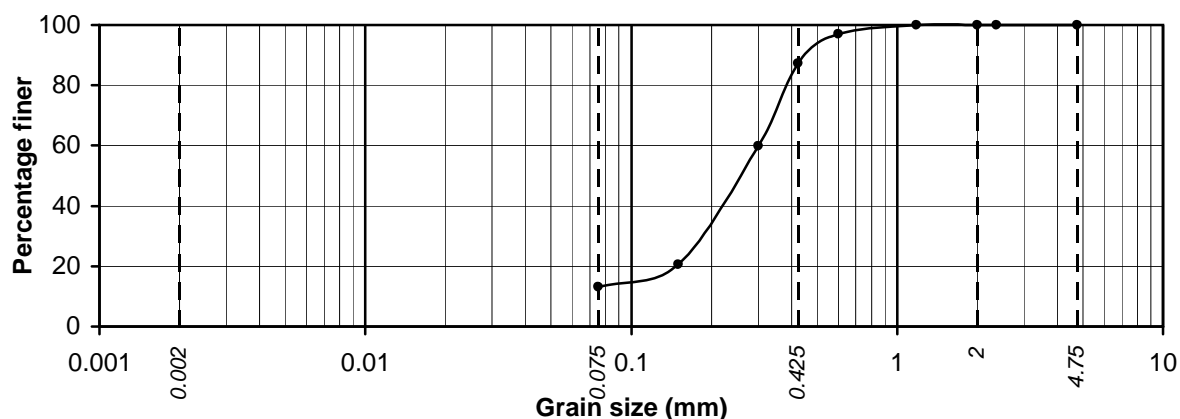
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-3, 3.00m		*20.0	80.0	0.0	0.0	0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-3, 5.00m		*15.5	76.0	8.5	0.0	0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-3, 8.00m		*13.2	74.0	12.8	0.0	0.0
*Silt & Clay						

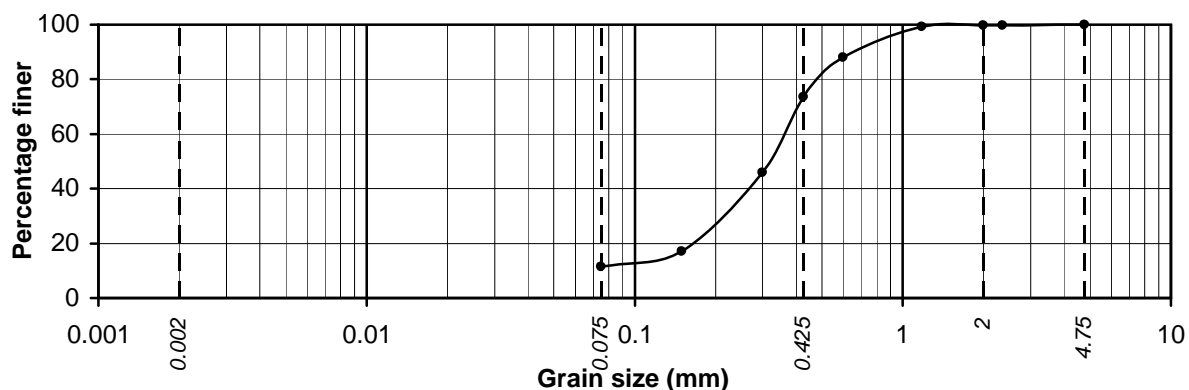
Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

**Job No.**  
CCPL/19021175

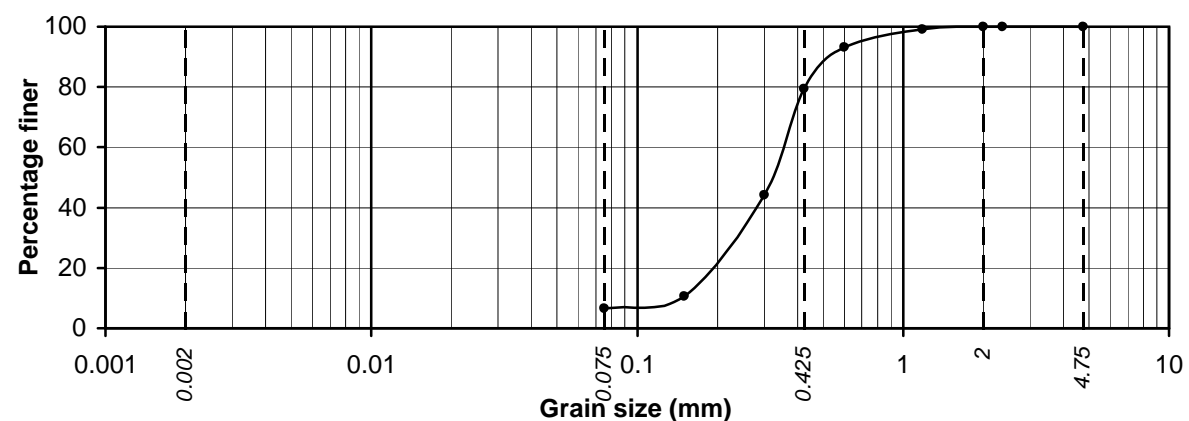
**Fig. No.**  
J/9



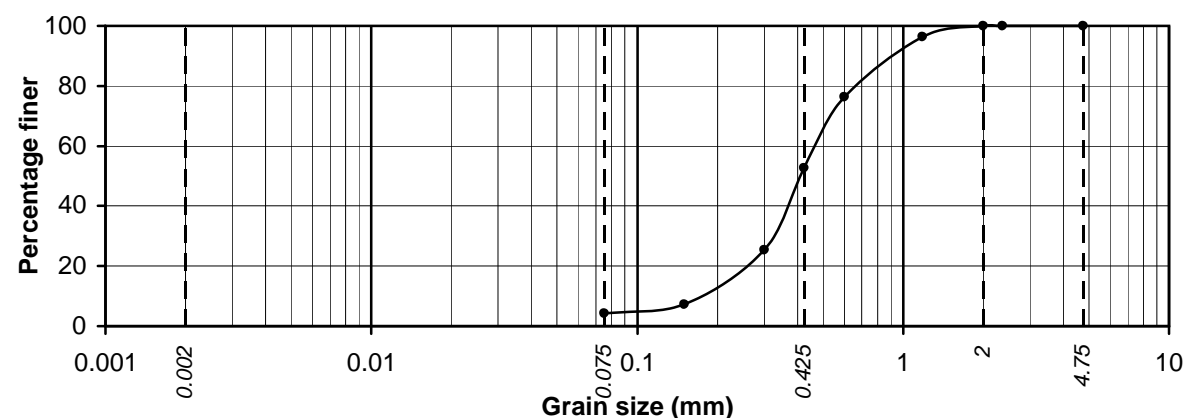
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-3, 11.00m		*11.6	61.9	26.3	0.2	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-3, 14.00m		*6.6	72.8	20.6	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-3, 17.00m		*4.2	48.4	47.4	0.0	0.0

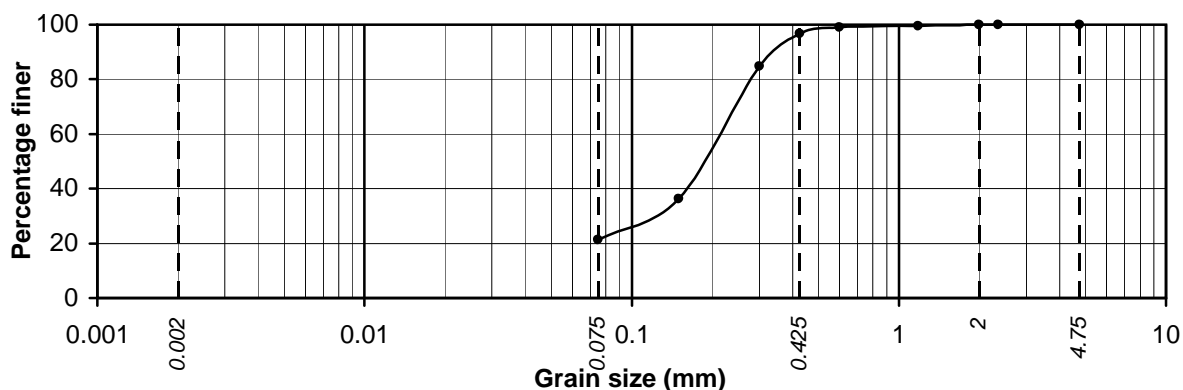
\*Silt & Clay

Geotechnical investigation work at Duliagan Power Station of Oil India Limited in Dibrugarh, Assam

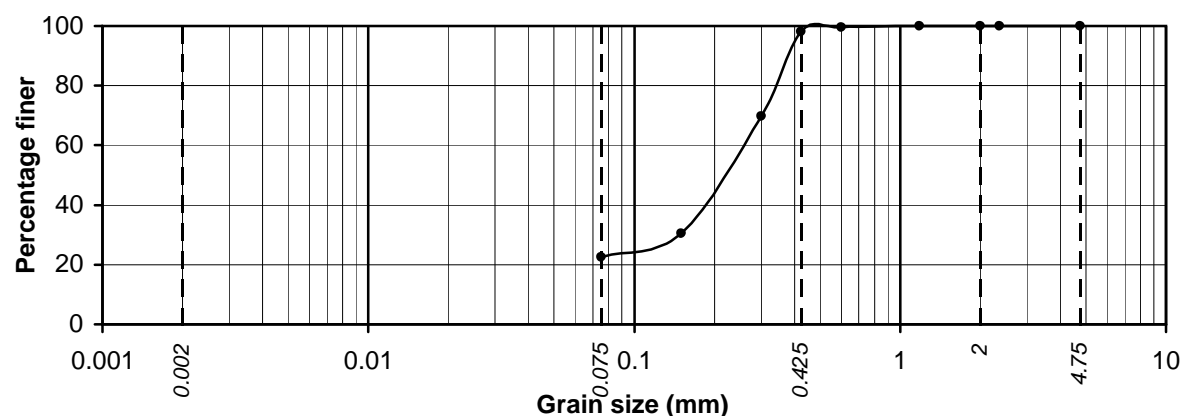
**Job No.**  
CCPL/19021175

**Fig. No.**  
J/10

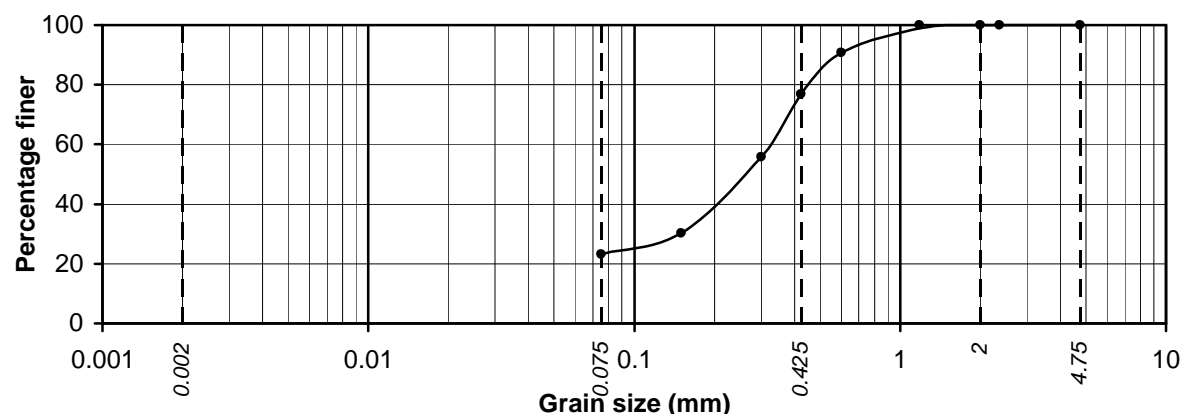
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-3, 20.00m		*21.4	75.3	3.3	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-3, 23.00m		*22.6	75.4	2.0	0.0	0.0



Grain size (mm)	<0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	>4.75 Gravel (%)
Sample No.						
BH-3, 26.00m		*23.2	53.7	23.1	0.0	0.0

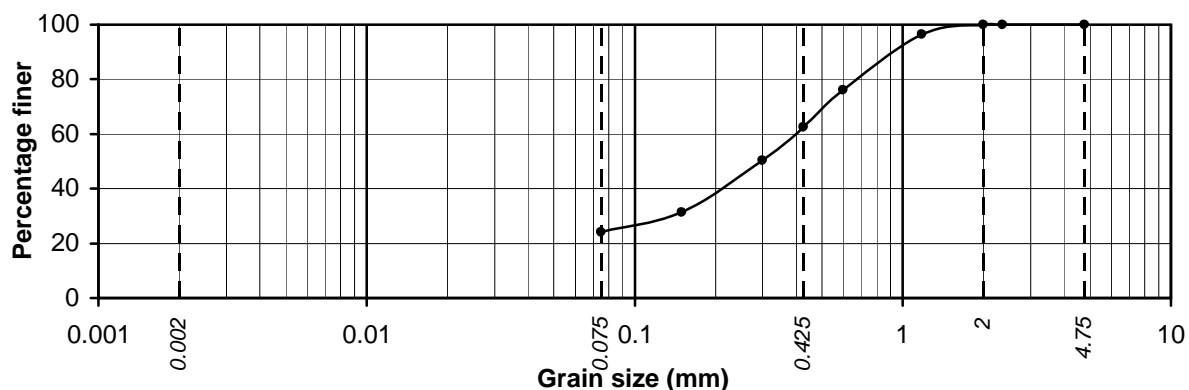
\*Silt & Clay

Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

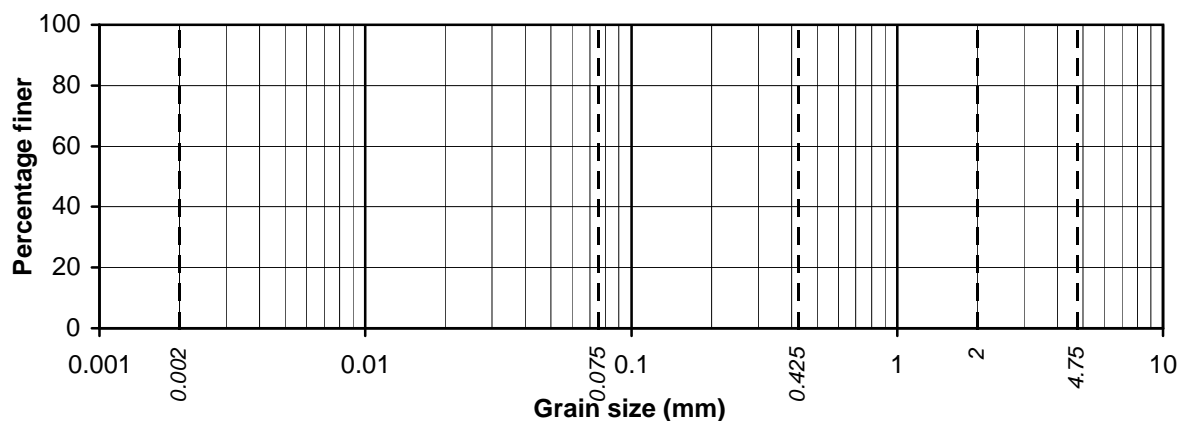
**Job No.**  
CCPL/19021175

**Fig. No.**  
J/11

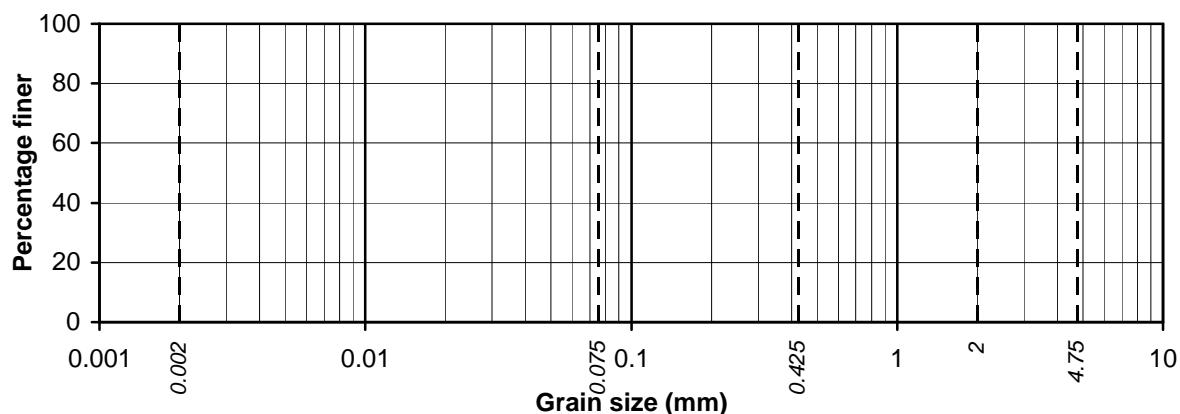
### GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)
BH-3, 29.00m		*24.1	38.3	37.6	0.0	0.0



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)



Grain size (mm)	<0.002	0.002-0.075	0.075-0.425	0.425-2.0	2.0-4.75	>4.75
Sample No.	Clay (%)	Silt (%)	Fine sand (%)	Medium sand (%)	Coarse sand (%)	Gravel (%)

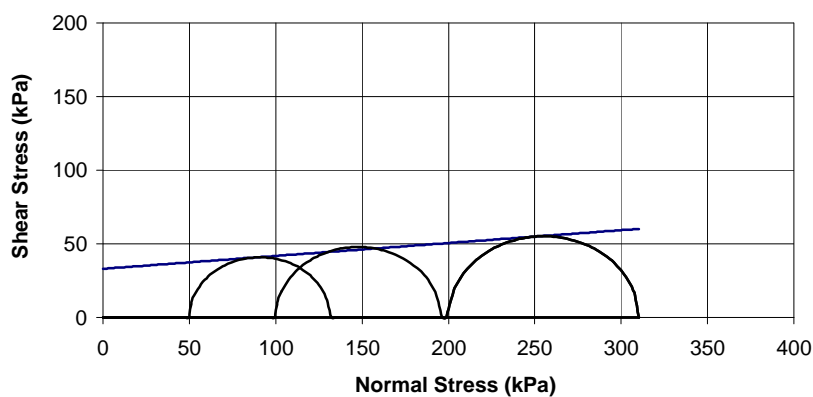
\*Silt & Clay

Geotechnical investigation work at Duliayan Power Station of Oil India Limited in Dibrugarh, Assam

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**Fig. No.**  
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### Mohr-Diagram

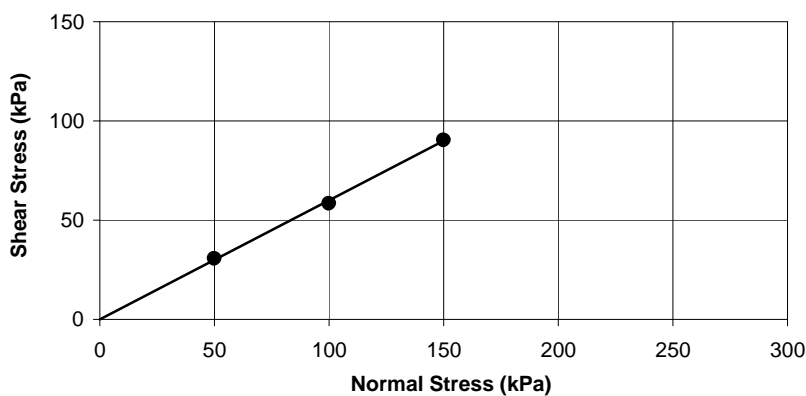


BH No.: BH-1  
Depth: 1.50 m

Test Type: UU

c : 33 kPa  
 $\phi$  : 5.0°

### Direct Shear Test

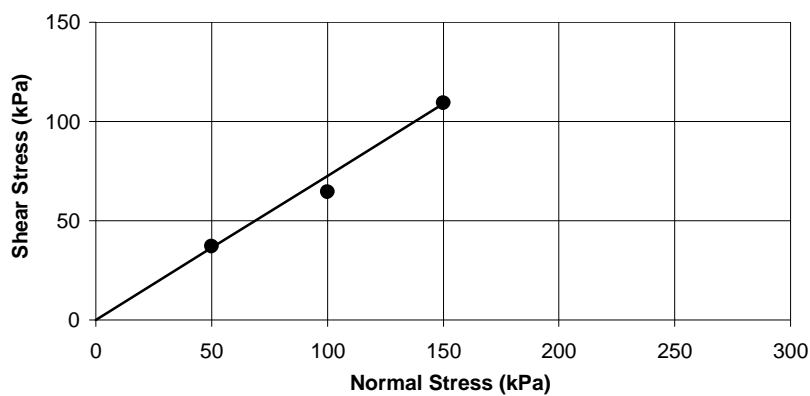


BH No.: BH-1  
Depth: 3.00 m

Test Type: DS

c : 0 kPa  
 $\phi$  : 31.0°

### Direct Shear Test



BH No.: BH-1  
Depth: 8.00 m

Test Type: DS<sub>R</sub>

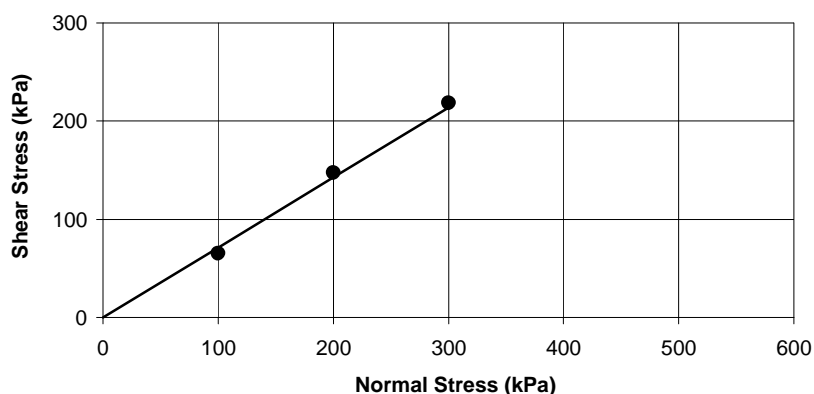
c : 0 kPa  
 $\phi$  : 36.0°

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**Direct Shear Test**

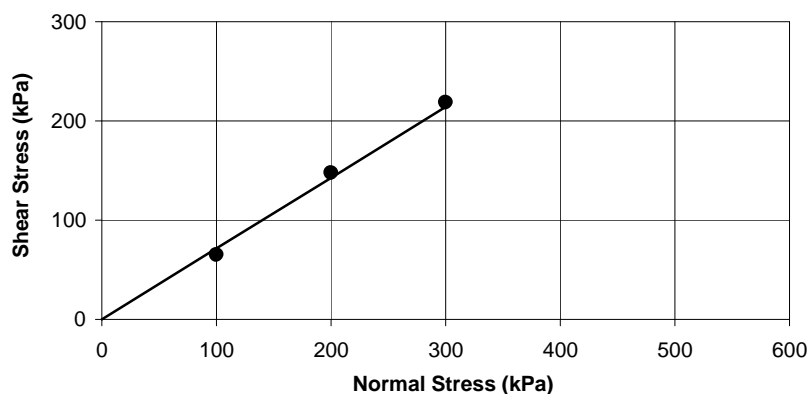


BH No.: BH-1  
Depth: 14.00 m

Test Type:  $DS_R$

$c$  : 0 kPa  
 $\phi$  :  $35.5^\circ$

**Direct Shear Test**

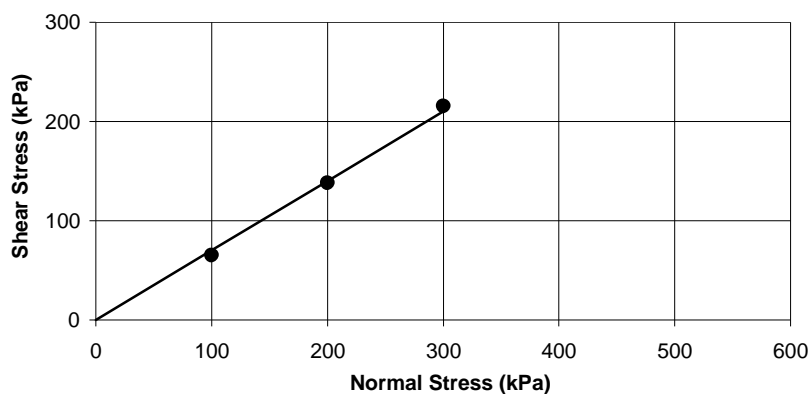


BH No.: BH-1  
Depth: 21.50 m

Test Type:  $DS_R$

$c$  : 0 kPa  
 $\phi$  :  $35.5^\circ$

**Direct Shear Test**



BH No.: BH-1  
Depth: 27.50 m

Test Type:  $DS_R$

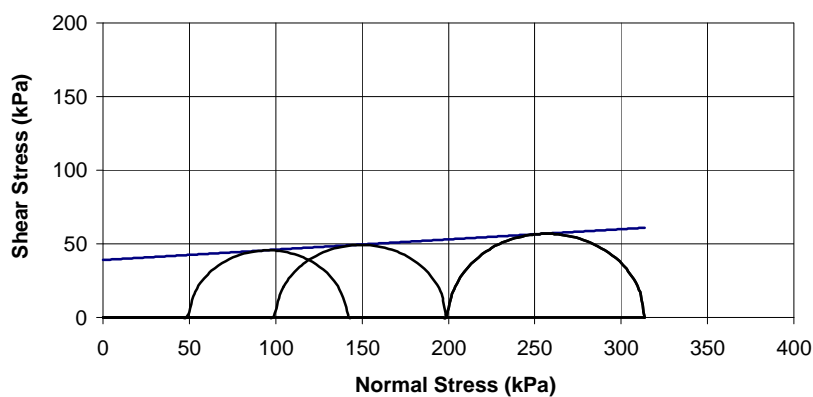
$c$  : 0 kPa  
 $\phi$  :  $35.0^\circ$

Geotechnical investigation work at Duliayan Power Station of Oil India Limited in Dibrugarh, Assam

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CCPL/19021175

**Fig. No.**  
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**Mohr-Diagram**

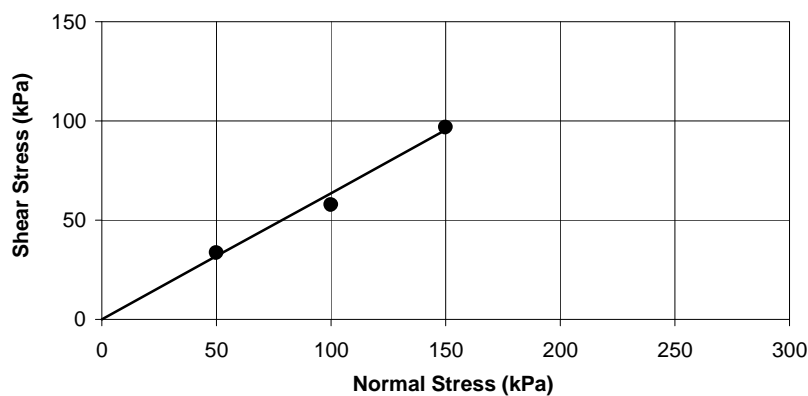


BH No.: BH-2  
Depth: 1.50 m

**Test Type: UU**

$c : 39 \text{ kPa}$   
 $\phi : 4.0^\circ$

**Direct Shear Test**

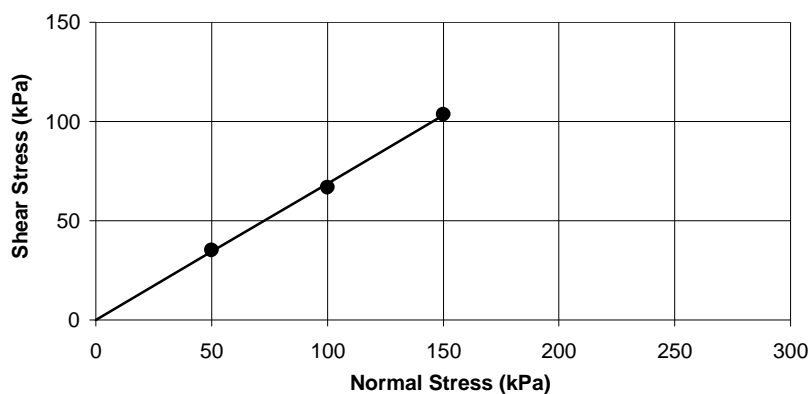


BH No.: BH-2  
Depth: 3.00 m

**Test Type: DS**

$c : 0 \text{ kPa}$   
 $\phi : 32.5^\circ$

**Direct Shear Test**



BH No.: BH-2  
Depth: 9.50 m

**Test Type: DS<sub>R</sub>**

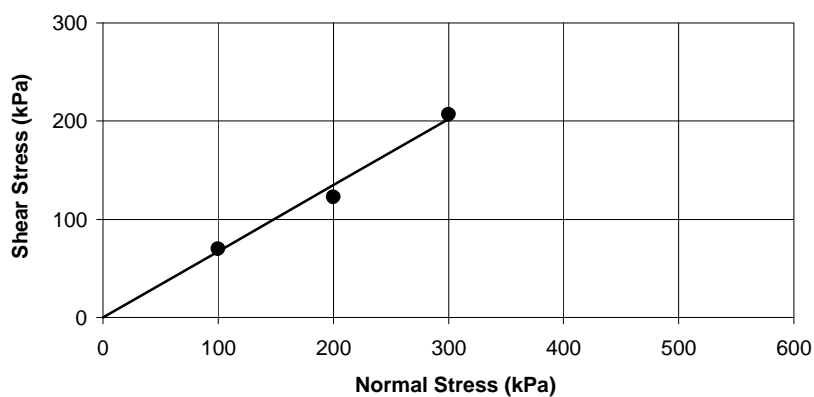
$c : 0 \text{ kPa}$   
 $\phi : 34.5^\circ$

Geotechnical investigation work at Duliajan Power Station of Oil India Limited in  
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**Job No.**  
CCPL/19021175

**Fig. No.**  
J/15

### Direct Shear Test

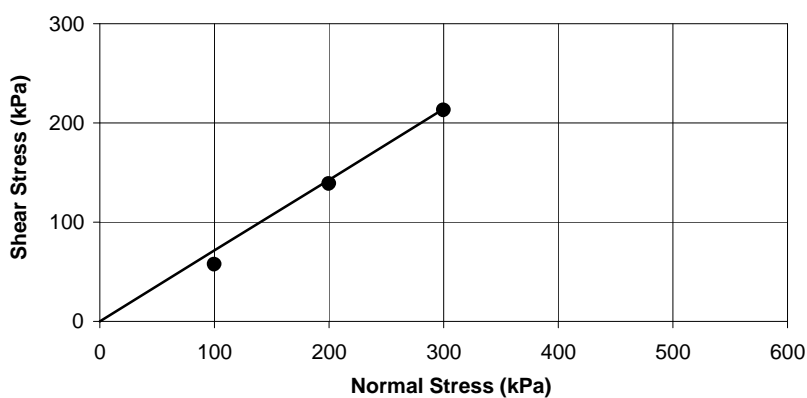


BH No.: BH-2  
Depth: 18.50 m

Test Type:  $DS_R$

$c$  : 0 kPa  
 $\phi$  :  $34.0^\circ$

### Direct Shear Test

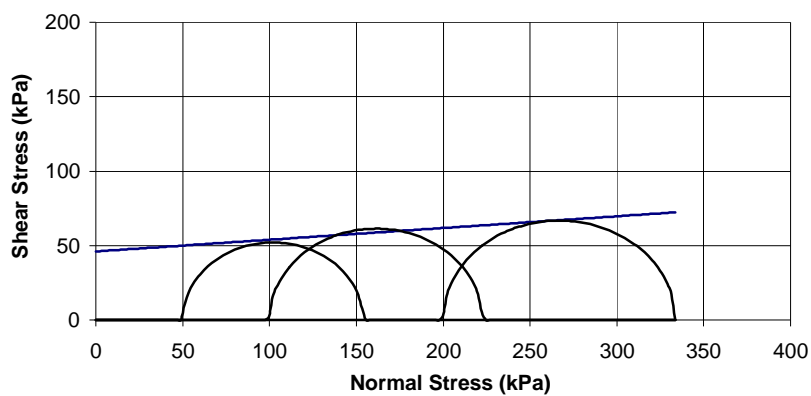


BH No.: BH-2  
Depth: 25.00 m

Test Type:  $DS_R$

$c$  : 0 kPa  
 $\phi$  :  $35.5^\circ$

### Mohr-Diagram



BH No.: BH-3  
Depth: 1.50 m

Test Type:  $UU$

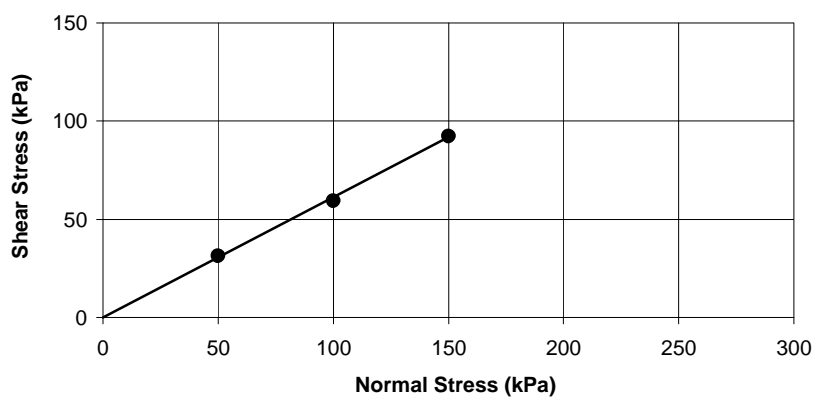
$c$  : 46 kPa  
 $\phi$  :  $4.5^\circ$

Geotechnical investigation work at Duliagan Power Station of Oil India Limited in Dibrugarh, Assam

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Fig. No.  
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**Direct Shear Test**

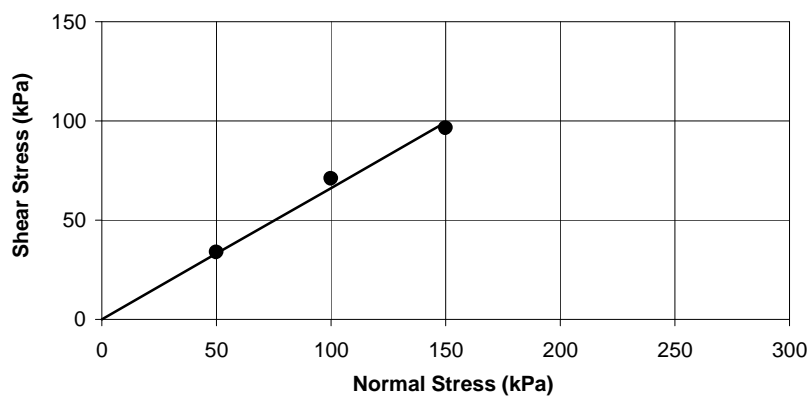


BH No.: BH-3  
Depth: 3.00 m

**Test Type: DS**

$c : 0 \text{ kPa}$   
 $\phi : 31.5^\circ$

**Direct Shear Test**

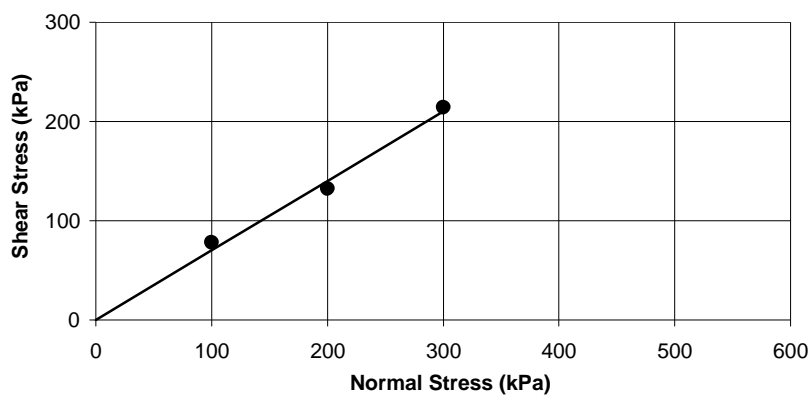


BH No.: BH-3  
Depth: 5.00 m

**Test Type: DS<sub>R</sub>**

$c : 0 \text{ kPa}$   
 $\phi : 33.5^\circ$

**Direct Shear Test**



BH No.: BH-3  
Depth: 11.00 m

**Test Type: DS<sub>R</sub>**

$c : 0 \text{ kPa}$   
 $\phi : 35.0^\circ$

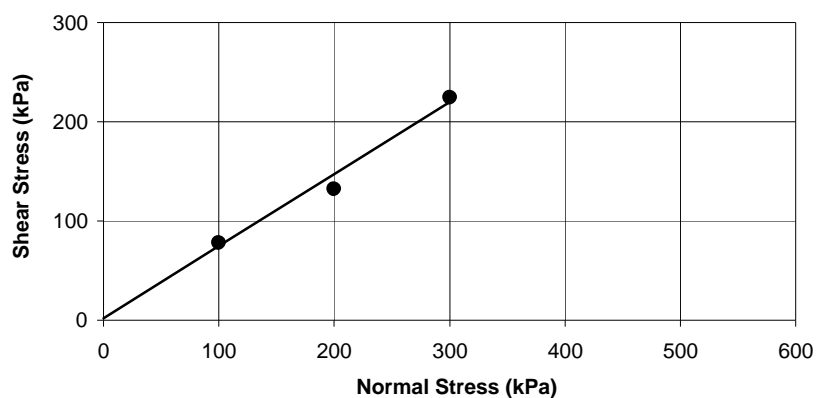
Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam

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CCPL/19021175

**Fig. No.**  
J/17



### Direct Shear Test

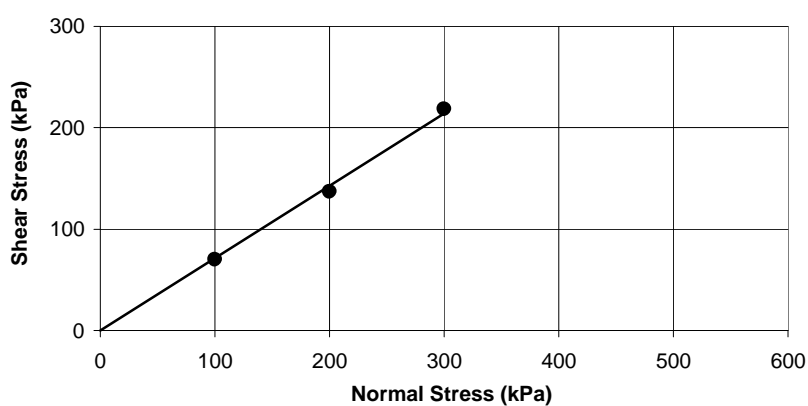


BH No.: BH-3  
Depth: 20.00 m

Test Type:  $DS_R$

$c$  : 2 kPa  
 $\phi$  :  $36.0^\circ$

### Direct Shear Test



BH No.: BH-3  
Depth: 26.00 m

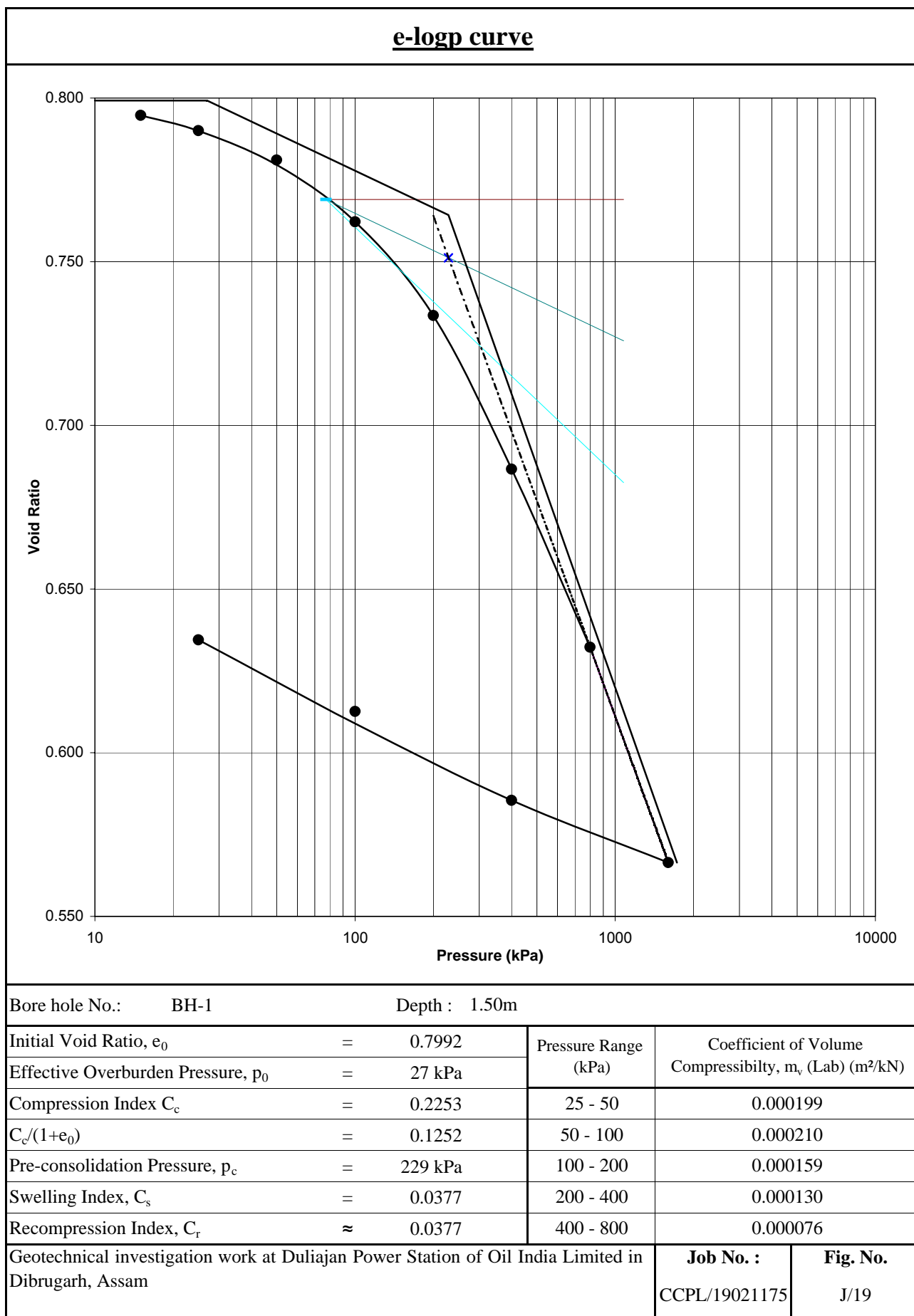
Test Type:  $DS_R$

$c$  : 0 kPa  
 $\phi$  :  $35.5^\circ$

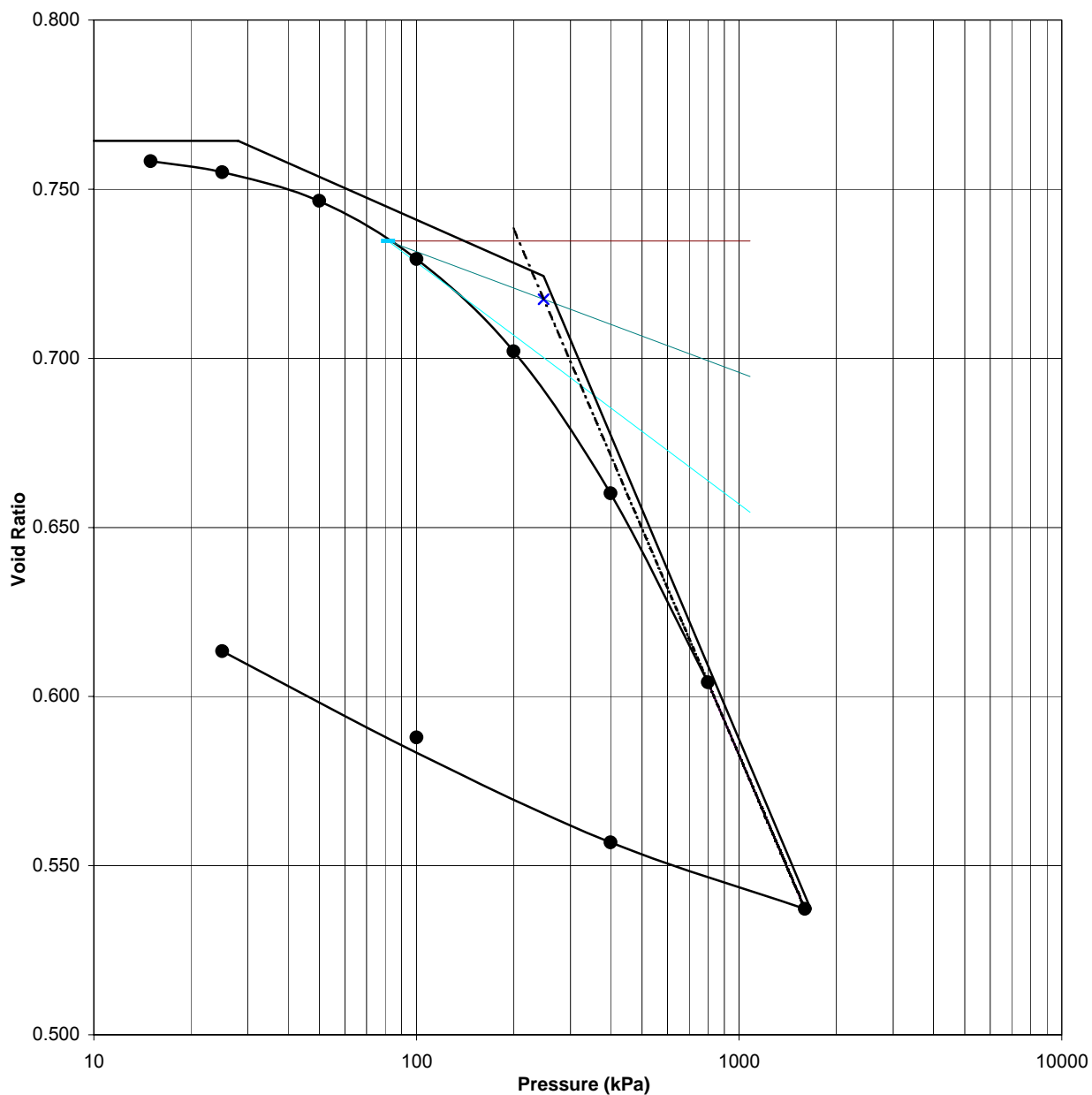
Geotechnical investigation work at Duliayan Power Station of Oil India Limited in  
Dibrugarh, Assam

**Job No.**  
CCPL/19021175

**Fig. No.**  
J/18

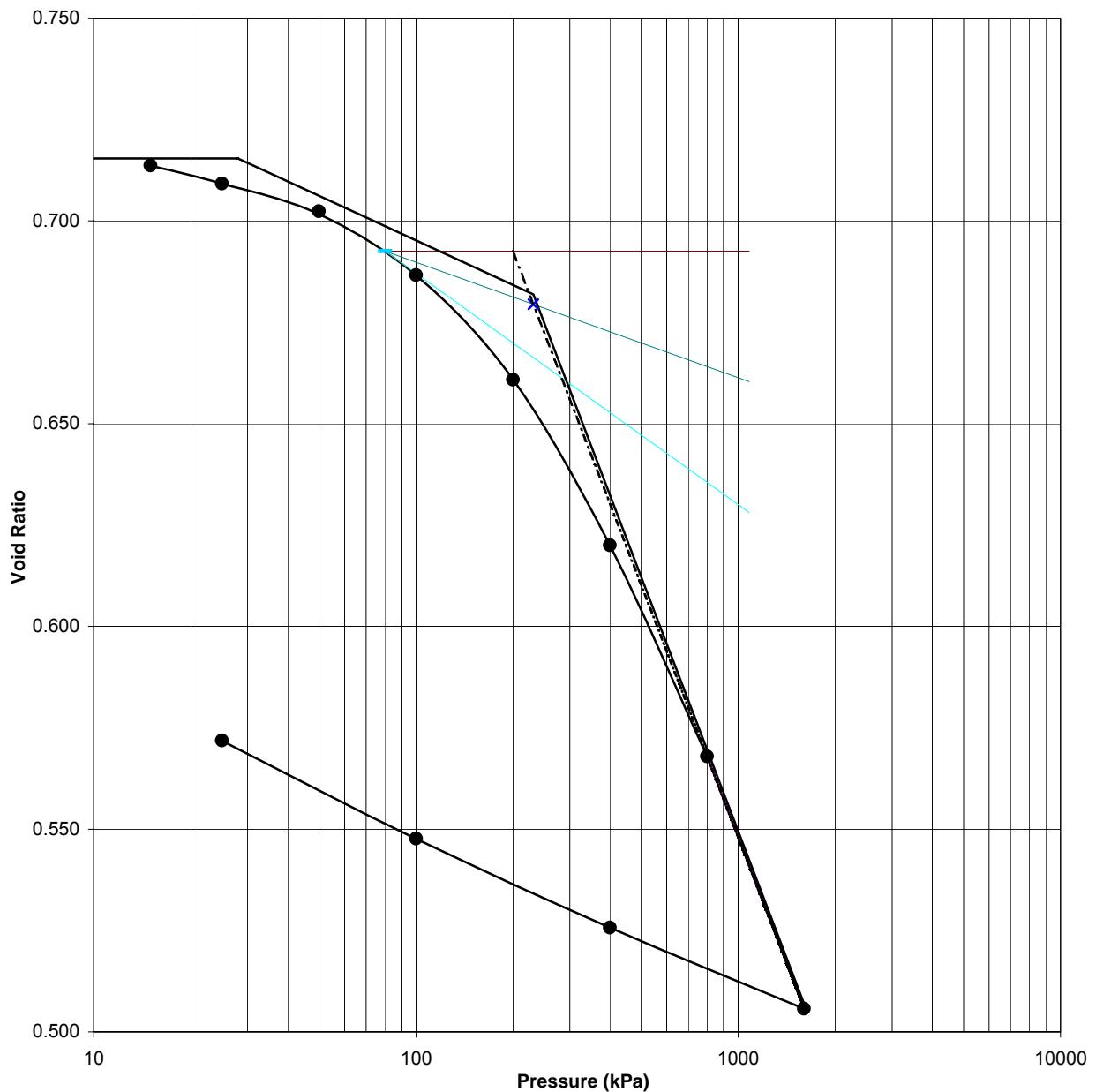


**e-logp curve**



Bore hole No.: BH-2		Depth : 1.50m	
Initial Void Ratio, $e_0$	= 0.7643	Pressure Range (kPa)	Coefficient of Volume Compressibility, $m_v$ (Lab) ( $m^2/kN$ )
Effective Overburden Pressure, $p_0$	= 28 kPa		
Compression Index $C_c$	= 0.2263	25 - 50	0.000192
$C_c/(1+e_0)$	= 0.1283	50 - 100	0.000195
Pre-consolidation Pressure, $p_c$	= 248 kPa	100 - 200	0.000154
Swelling Index, $C_s$	= 0.0422	200 - 400	0.000119
Recompression Index, $C_r$	$\approx$ 0.0422	400 - 800	0.000079
Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam			<div>Job No. : CCPL/19021175</div> <div>Fig. No. J/20</div>

**e-logp curve**



Bore hole No.: BH-3		Depth : 1.50m	
Initial Void Ratio, $e_0$	= 0.7154	Pressure Range (kPa)	Coefficient of Volume Compressibility, $m_v$ (Lab) ( $m^2/kN$ )
Effective Overburden Pressure, $p_0$	= 28 kPa		
Compression Index $C_c$	= 0.2080	25 - 50	0.000159
$C_c/(1+e_0)$	= 0.1213	50 - 100	0.000184
Pre-consolidation Pressure, $p_c$	= 231 kPa	100 - 200	0.000150
Swelling Index, $C_s$	= 0.0366	200 - 400	0.000119
Recompression Index, $C_r$	≈ 0.0366	400 - 800	0.000076
Geotechnical investigation work at Duliajan Power Station of Oil India Limited in Dibrugarh, Assam			<div>Job No. : CCPL/19021175</div> <div>Fig. No. J/21</div>

Job No. : CCPL/19021175

Ref. Location: BH-1

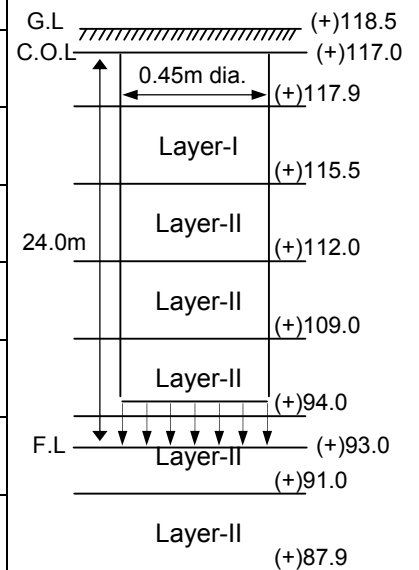
**DESIGN DATA:**

Pile diameter, D (m): 0.45  
Pile cut-off level (m): (+)117.0  
Pile founding level (m): (+)93.0  
Pile type: Bored Cast-in-situ

Existing ground level (m): (+)118.5  
Formation level (m): -  
Ground water table: At G.L.  
Factor of safety, FOS : 2.5

**SOIL DATA FOR CAPACITY CALCULATIONS**

Sl. No.	Layer ID	Description of Layers			SPT value N	Bulk density $\gamma$ (t/m <sup>3</sup> )	Cohesion c (t/m <sup>2</sup> )	Angle of internal friction $\phi$ (°)
		Starting RL (m)	Ending RL (m)	Thickness (m)				
1	—	(+)118.5	(+)117.9	0.6	-	1.800	-	-
2	I	(+)117.9	(+)115.5	2.4	7	1.855	3.3	-
3	II	(+)115.5	(+)112.0	3.5	14	1.830	-	31.0
4	II	(+)112.0	(+)109.0	3.0	27	2.000	-	34.5
5	II	(+)109.0	(+)94.0	15.0	41	2.070	-	36.0
6	II	(+)94.0	(+)91.0	3.0	29	2.010	-	35.0
7	II	(+)91.0	(+)87.9	3.1	34	2.030	-	35.5



**SAFE VERTICAL CAPACITY UNDER COMPRESSION**

[Refer to IS: 2911(Part I/Sec 2)-2010]

**Shaft Resistance**

$Q_s = \sum (\alpha_i c_i + K_i P_{di} \tan \delta_i) A_{si}$  where,  $\alpha_i$ : Adhesion factor;  $A_{si}$ : Area of shaft =  $\pi D L_i$ ;

$L_i$ : Length of pile in  $i^{th}$  layer;  $K_i$ : Earth pressure coefficient (varying between 1 to 1.5 for  $\phi$  30° to 40°);

$P_{di}$ : Effective overburden pressure;  $\delta_i$ : Angle of wall friction between pile and soil (in degree) for  $i^{th}$  layer

Sl. No.	Layer ID	$L_i$ (m)	R.L.* (m)	$P_d^{*1}$ (t/m <sup>2</sup> )	c (t/m <sup>2</sup> )	$\alpha$	$\phi$ (°)	$\delta$ (°)	K	$Q_s$ (t)	$\Sigma Q_s$ (t)
2	I	1.5	(+)116.3	1.9	3.3	1.000	-	-	-	7.0	169.5
3	II	3.5	(+)113.8	4.0	-	-	31.0	31.0	1.05	12.4	
4	II	3.0	(+)111.4	6.0	-	-	34.5	34.5	1.23	21.6	
5	II	15.0	(+)111.4	6.0	-	-	36.0	36.0	1.30	121.0	
6	II	1.0	(+)111.4	6.0	-	-	35.0	35.0	1.25	7.5	

\*: R.L./Depth where effective overburden pressure ( $P_d$ ) is computed

\*1: Effective overburden pressure restricted to a depth of 15D for  $\phi \leq 30^\circ$  and increasing to 20D for  $\phi \geq 40^\circ$ , when relevant depth exceeds such limit

Weighted average of  $\phi$  = 31.6      Overburden pressure restriction = 15.79D

### End Bearing Capacity

$$Q_b = A_p(cN_c + 0.5\gamma'DN_\gamma + P_dN_q)$$

where,  $\alpha_i$ : Adhesion factor;  $\gamma'$ : Effective unit weight of soil;

$A_p$ : Cross-sectional area of pile toe  $= \pi D^2/4$

$N_c$ ,  $N_q$  and  $N_\gamma$ : Bearing capacity factors

Founding level (m)	c (t/m <sup>2</sup> )	$\phi$ (degree)	$\gamma$ (t/m <sup>3</sup> )	$P_d$ (t/m <sup>2</sup> )	$N_c$	$N_q$	$N_\gamma$	$Q_b$ (t)
(+)93.0	-	35.0	2.010	6.0	-	50.0	48.0	<b>49.8</b>

### Meyerhof correction [1976]<sup>#</sup>

Layer ID	End Bearing capcities at various Notional Founding Level								$Q_{bf}^{**4}$ (t)
	[above actual founding level]				[below actual founding level]				
	R.L.** (m)	$d_{abv'}^{**1}$ (m)	$Q_{bi}^{**2}$ (t)	$Q_{bint}^{**3}$ (t)	R.L.** (m)	$d_{blw'}^{**1}$ (m)	$Q_{bi}^{**2}$ (t)	$Q_{bint}^{**3}$ (t)	
—	-	-	-	-	-	-	-	-	49.8
I	-	-	-	-	-	-	-	-	
II	-	-	-	-	-	-	-	-	
II	-	-	-	-	-	-	-	-	
II	(+)97.5	3.5	59.9	49.8	-	-	-	-	
II	(+)94.0	1.0	59.9	57.6	(+)91.0	2.0	54.6	52.4	
II	-	-	-	-	(+)88.5	2.5	54.6	49.8	
	10D = $\Sigma$	4.5			10D = $\Sigma$	4.5			

<sup>#</sup>: Recommended if thickness of founding layer above and/ below pile tip is less than 10D;

<sup>\*\*</sup>: R.L. / Depth of respective strata above / below pile toe (within 10D from pile toe);

<sup>\*\*1</sup>: Thickness of respective strata above / below pile toe (within 10D from pile toe);

<sup>\*\*2</sup>: End bearing capacity if pile base were at the interface of respective layers (within 10D from pile toe);

<sup>\*\*3</sup>: End bearing capacity interpolated between  $Q$  and  $Q_{bi}$  in the ratio of depth of penetration;

<sup>\*\*4</sup>: End bearing capacity is minimum of  $Q$  and  $Q_{bint}$  obtained through interpolation in the zone of 10D above and below pile toe

### Effective self weight of pile over existing soil surcharge

$$Q_{self} = \pi D^2/4 \times \Sigma [L_i \times (\gamma_c - \gamma_i)] = 1.9 \text{ t}$$

where,  $\gamma_c$  = unit weight of reinforced concrete = 2.5 t/m<sup>3</sup>

$$\text{Safe vertical pile capacity} = [\Sigma Q_s + Q_{bf}] / \text{FOS} - Q_{self} = 85.8 \text{ t}$$

**Suggested Vertical Capacity of Pile is 85t**

### UPLIFT CAPACITY

[Refer to IRC: 78: 2014]

$$\text{Safe uplift capacity} = \frac{R_s \cdot x r_d}{F \cdot S} + W = (169.5 \times 0.7) / 2.5 + 1.9 = 49.3t$$

Where  $R_s = \Sigma Q_s$  = Skin friction = 169.5t

$r_d$  = Reduction factor = 0.7

F.S. = Factor of safety = 2.5

W = Effective Self Weight of pile = 1.9 t

**Suggested Uplift Capacity of Pile is 45t**

### LATERAL LOAD CAPACITY (FIXED HEAD PILE)

[Refer to IS: 2911(Part I/Sec 2)-2010]

Sl No.	Layer ID	R.L. (m)		Thick-ness (m)	$\eta_h$ (t/m <sup>3</sup> )	$k_1$ (t/m <sup>3</sup> )	K (t/m <sup>3</sup> )	Stiffness factor		Equivalent Stiffness factor
		From	To					T (m)	R (m)	T (m)
1	I	**(+117.0	(+115.5	1.5	80	-	-	2.3	-	2.1
2	II	(+115.5	(+112.6	2.9	198	-	-	1.9	-	
			Total =	4.4			-	-	-	

\*\*Cut-off-level

Here, embedded length of pile  $L = [(+117.0 - (+)93.0)] = 24.0m > 4 \times T$

Therefore, pile is treated as long pile

$$\text{where } T = \sqrt[5]{\frac{EI}{\eta_h}}, R = \sqrt[4]{\frac{EI}{KB}}, I = \frac{\pi d^4}{64}, K = \frac{k_1}{1.5} \times \frac{0.3}{B}$$

In which E = Young's modulus of pile material =  $5000 \times 30^{0.5} \text{ N/mm}^2 = 2.74 \times 10^6 \text{ t/m}^2$   
assuming grade of concrete M30

#### **Assuming fixed-head pile, equivalent length of pile**

$$L_f = 2.18 \times 2.1 = 4.6m \quad (\text{thickness of soil layer considered to assess } T)$$

$$L_1 = 0$$

Where  $L_1$  = Length of pile above Ground level / Scour level

Therefore, lateral load-carrying capacity of pile,  $Q = [12 \times 2740000 \times 0.002 \times 0.0045] / 97.3 = 3.1t$

$$\text{where } Q = \frac{12 \times E \times I \times \Delta}{(L_1 + L_f)^3} = \text{for fixed head pile}$$

$\Delta$  = maximum allowable lateral deflection at cut-off level of pile = 4.5mm (1% of pile dia.)

**[As per Article 709.3.5 of IRC:78, 2014]**

Now for maximum allowable lateral deflection at cut-off level of pile = 5.0mm

$$Q = [12 \times 2740000 \times 0.002 \times 0.005] / 97.3 = 3.4t$$

Now for maximum allowable lateral deflection at cut-off level of pile = 12.0mm

$$Q = [12 \times 2740000 \times 0.002 \times 0.012] / 97.3 = 8.2t$$

Therefore Final load = 50% of 8.2 = 4.1t

**However lateral load capacity capacity of pile shall be taken as the least of the above three:**

**[As per IS:2911 (Part 4)- 2010]**

**Suggested Lateral Capacity of Pile is 3.0t**

**LATERAL LOAD CAPACITY (FREE HEAD PILE)**

[Refer to IS: 2911(Part I/Sec 2)-2010]

Sl No.	Layer ID	R.L. (m)		Thick-ness (m)	$\eta_h$ (t/m <sup>3</sup> )	$k_1$ (t/m <sup>3</sup> )	$K$ (t/m <sup>3</sup> )	Stiffness factor		Equivalent Stiffness factor
		From	To					T (m)	R (m)	T (m)
1	I	**(+117.0	(+115.5	1.5	80	-	-	2.3	-	2.1
2	II	(+115.5	(+113.0	2.5	198	-	-	1.9	-	
			Total =	4.0			-	-	-	

\*\*Cut-off-level

Here, embedded length of pile  $L = [(+117.0 - (+)93.0)] = 24.0\text{m} > 4 \times T$

Therefore, pile is treated as long pile

$$\text{where } T = \sqrt[5]{\frac{EI}{\eta_h}}, R = \sqrt[4]{\frac{EI}{KB}}, I = \frac{\pi d^4}{64}, K = \frac{k_1}{1.5} \times \frac{0.3}{B}$$

In which  $E$  = Young's modulus of pile material =  $5000 \times 30^{0.5} \text{ N/mm}^2 = 2.74 \times 10^6 \text{ t/m}^2$   
assuming grade of concrete M30

**Assuming free-head pile, equivalent length of pile**

$$L_f = 1.92 \times 2.1 = 4.0\text{m} \quad (\text{thickness of soil layer considered to assess } T)$$

$$L_1 = 0$$

Where  $L_1$  = Length of pile above Ground level / Scour level

Therefore, lateral load-carrying capacity of pile,  $Q = [3 \times 2740000 \times 0.002 \times 0.0045] / 64 = 1.2\text{t}$

$$\text{where } Q = \frac{3 \times E \times I \times \Delta}{(L_1 + L_f)^3} = \text{for free head pile}$$

$\Delta$  = maximum allowable lateral deflection at cut-off level of pile = 4.5mm (1% of pile dia.)

**[As per Article 709.3.5 of IRC:78, 2014]**

Now for maximum allowable lateral deflection at cut-off level of pile = 5.0mm

Therefore, lateral load-carrying capacity of pile,  $Q = [3 \times 2740000 \times 0.002 \times 0.005] / 64 = 1.3\text{t}$

Now for maximum allowable lateral deflection at cut-off level of pile = 12.0mm

Therefore, lateral load-carrying capacity of pile,  $Q = [3 \times 2740000 \times 0.002 \times 0.012] / 64 = 3.1\text{t}$

Therefore Final load = 50% of 3.1 = 1.6t

**However lateral load capacity capacity of pile shall be taken as the least of the above three:**

**[As per IS:2911 (Part 4)- 2010]**

**Suggested Lateral Capacity of Pile is 1.2t**



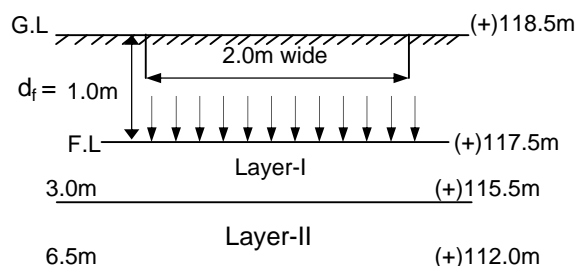
### Sample Calculation for Shallow Foundation

Job No.: CCPL/19021175  
Location : -  
Borehole No.: BH-1  
Depth of Water : 0.00m (Worst Condition)  
Factor of Safety: 2.5

Width/Diameter: 2.00 m  
Length: -  
Depth of Foundation : 1.00 m  
Allowable Settlement: 75 mm

#### SOIL DATA FOR CAPACITY CALCULATIONS

Layer ID	Starting Depth (m)	Ending Depth (m)	Thickness	SPT value	Bulk Density (t/m <sup>3</sup> )	c (t/m <sup>2</sup> )	φ (degrees)
—	0.0	0.6	0.6	-	1.800	-	-
I	0.6	3.0	2.4	7	1.855	3.3	-
II	3.0	6.5	3.5	14	1.830	-	31.0



Surcharge,  $q = (1.800-1) \times 0.6 + (1.855-1) \times 0.4 = 0.822 \text{ t/sq.m}$

c (t/m <sup>2</sup> )	N <sub>c</sub>	S <sub>c</sub>	d <sub>c</sub>	i <sub>c</sub>	q <sub>d</sub> (t/m <sup>2</sup> )	q <sub>net</sub> (t/m <sup>2</sup> )
3.3	5.14	1.00	1.10	1.00	18.7	7.5

$q_d = cN_c S_c d_c i_c$  where  $q_d$  : Net ultimate bearing capacity,  $q_{net}$  : Net safe bearing capacity

#### SOIL DATA FOR SETTLEMENT CALCULATIONS

Layer ID	mv (cm <sup>2</sup> /kg)					Relevant e-logp curve	Pore Pressure factor	Rigidity factor	Depth factor
	0.25-0.50	0.50-1.00	1.00-2.00	2.00-4.00	4.00-8.00				
I	0.0174	0.0174	0.0174	0.0174	0.0174	*mv	1.0	1.0	0.949
II	-	-	-	-	-	-	-		

\*mv - Estimated from fig.5.15 (Page-175) of Pile Design and construction practice (Fourth Edition) by M.J. Tomlinson

#### SETTLEMENT FOR SUPERIMPOSED LOAD INTENSITY, $p = 7.5 \text{ t/m}^2$

Layer ID	Mid Depth (m)	H (m)	p <sub>0</sub> (kg/cm <sup>2</sup> )	Influence factor Δ	p <sub>0</sub> +Δp (kg/cm <sup>2</sup> )	m <sub>v</sub> × Δp (0.25-0.5)	m <sub>v</sub> × Δp (0.5-1.0)	m <sub>v</sub> × Δp (1.0-2.0)	m <sub>v</sub> × Δp (2.0-4.0)	m <sub>v</sub> × Δp (4.0-8.0)	Consolidation Settlement = m <sub>v</sub> ΔpH (mm)	*Settlement in Sand (mm)	**Total corrected settlement (mm)
I	2.00	2.0	0.17	0.8183	0.78	0.0058	0.0048	-	-	-	21.2	-	20.1
II	4.00	2.0	0.34	0.3947	0.63	-	-	-	-	-	-	-	

\*Referring to IS : 8009 Part-1-1976 Cl. 9.1.4 ; \*\*Total settlement is corrected by depth, rigidity & pore pressure factor

Therefore, Estimated Net Allowable Bearing Capacity is  $7.5 \text{ t/m}^2$



### **Sample Calculation for Block Vibration Test**

a) Calculation for  $C_u$  for BVT-1

$$\text{Area of Block} = 75 \times 75 = 5625 \text{ cm}^2$$

$$\text{Wt. of Block} = 2.5 \times 0.75 \times 0.75 \times 1.50 = 2.11 \text{ t.}$$

$$\text{Wt. of Motor} + \text{Wt. of Oscillator} + \text{Wt. of Plates} + \text{Wt. of Bolts}$$

$$= 63.95 + 42.50 + (23.50 + 10.00) + 4.50 = 144.45 \text{ kg} = 0.14 \text{ t}$$

$$\text{Total Wt} = 2.11 + 0.14 = 2.25 \text{ t}$$

$$\therefore \text{Total mass } M = \frac{2250}{980.7} = 2.30 \text{ Kgf. sec}^2/\text{cm}$$

$$\text{Co-efficient of Elastic Uniform Compression } (C_u) = \frac{4\pi^2 f_{nz}^2 M}{A} \quad [\text{Cl. 5.4.2 of IS 5249:1992}]$$

where, M = Mass of the block, Oscillator, Motor etc.

A = Contact area of the block with the soil

$f_{nz}$  = Natural frequency

$$\therefore C_u = \frac{4\pi^2 \times 2.30}{75 \times 75} f_{nz}^2 \text{ kg/cm}^3 = 0.016 f_{nz}^2 \text{ kg/cm}^3$$

From relevant frequency-amplitude curve  $f_{nz} = 900 / 60 = 15 \text{ cps}$  [Fig. 2]

$$\therefore C_u = 0.016 \times 15^2 = 3.60 \text{ kg/cm}^3$$

b) Calculation for Young's modulus (E) & Shear modulus (G)

$$C_u = \frac{1.13E}{1 - \varepsilon^2} \times \frac{1}{\sqrt{A}} \quad (\text{refer to Annex - D, IS 5249: 1992})$$

$$\therefore E = \frac{(1 - \varepsilon^2) \times \sqrt{A}}{1.13} C_u, \text{ where } \varepsilon = \text{Poisson's ratio of soil} = 0.35 \text{ (assumed)}$$

$$= \frac{(1 - 0.35^2) \sqrt{75 \times 75}}{1.13} \times C_u$$

$$= 58.24 C_u = 58.24 \times 3.60 = 209.66 \text{ kg/cm}^2$$



$$G = \frac{E}{2(1 + \varepsilon)} = \frac{E}{2 \times (1 + 0.35)} = 0.37 \times E = 0.37 \times 209.66 = 77.65 \text{ kg/cm}^2$$

c) Calculation for correction of  $C_u$  for confining pressure and area

The mean effective confining pressure  $\overline{\sigma_o}$  at depth of one and half the width below the

$$\text{base of the Block } \overline{\sigma_o} = \overline{\sigma_v} \left( \frac{1 + 2K_o}{3} \right)$$

where  $\overline{\sigma_v} = \overline{\sigma_{v_1}} + \overline{\sigma_{v_2}}$  = Effective overburden pressure at one half the width of the  
block + increase in vertical pressure due to Wt. of Block,  
Motor etc.

$$\text{Now } \overline{\sigma_{v_1}} = 1.950 \times \left( 3.5 + \frac{0.75}{2} \right) = 7.56 \text{ t/m}^2,$$

where unit weight of overburden =  $1.950 \text{ t/m}^3$  (assumed) and depth of test = 3.5 m

$$\overline{\sigma_{v_2}} = I \times q \text{ where } q = 2.25 / (0.75 \times 0.75) = 4.00 \text{ t/m}^2 \text{ and } I = \text{Influence co-efficient} = 0.70$$

$$= 0.70 \times 2.76 \text{ t/m}^2 = 2.80 \text{ t/m}^2$$

$$\therefore \overline{\sigma_v} = 7.56 + 2.80 = 10.36 \text{ t/m}^2$$

$$\text{Now } K_o = \frac{\varepsilon}{1 - \varepsilon} = \frac{0.35}{1 - 0.35} = 0.54$$

$$\therefore \overline{\sigma_o} = 10.36 \times \frac{1 + 2 \times 0.54}{3} = 7.18 \text{ t/m}^2$$

Now the correction factor for area and confining pressure on  $C_u$ ,  $E$  and  $G$  is given by the relation:

$$\frac{(C_u)_{actual}}{(C_u)_{test}} = \frac{(E)_{actual}}{(E)_{test}} = \frac{(G)_{actual}}{(G)_{test}} = \left( \frac{\overline{\sigma_{o_{actual}}}}{\overline{\sigma_{o_{test}}}} \right)^{0.5} \times \left( \frac{A_{test}}{A_{actual}} \right)^{0.5}$$



Now considering actual area =  $10 \text{ m}^2$   
and reference confining pressure  $(\sigma_o)_{actual} = 10 \text{ t/m}^2$ .

$$\frac{(C_u)_{actual}}{(C_u)_{test}} = \frac{(E)_{actual}}{(E)_{test}} = \frac{(G)_{actual}}{(G)_{test}} = \left( \frac{10}{7.18} \right)^{0.5} \times \left( \frac{0.75 \times 0.75}{10} \right)^{0.5} = 0.28$$

After correction,

$$C_u = 3.60 \times 0.28 = 1.01 \text{ kg/cm}^3;$$

$$E = 58.24 \text{ C}_u = 58.24 \times 1.01 = 58.82 \text{ kg/cm}^2$$

$$G = 0.37E = 0.37 \times 58.82 = 21.76 \text{ kg/cm}^2$$

d) Calculation for damping co-efficient

$$\text{Damping co-efficient } \xi = \frac{f_2 - f_1}{2f_{nz}} \quad [\text{Cl. 5.4.3 of IS 5249: 1992}]$$

where  $f_2, f_1$  = Two frequencies at which the amplitude is equal to  $\frac{X_m}{\sqrt{2}}$

$X_m$  = Maximum amplitude

and  $f_{nz}$  = Frequency at which amplitude is maximum (resonant frequency)

From amplitude – frequency curve of BVT-1 for  $\phi = 16^\circ$ ,  $X_m = 300\mu$  and  $f_{nz} = 900 \text{ r.p.m.}$  which gives  $f_2 = 948 \text{ rpm}$ ,  $f_1 = 713 \text{ rpm}$  corresponding to

$$\frac{X_m}{\sqrt{2}} = 212.1\mu$$

$$\therefore \text{for } \phi = 16^\circ, \xi = \frac{948 - 713}{2 \times 900} = 0.13$$

Similarly for  $\phi = 24^\circ$ ,  $\xi = 0.18$ ,  $\phi = 32^\circ$ ,  $\xi = 0.29$ ,  $\phi = 40^\circ$ ,  $\xi = 0.29$

$$\therefore \text{For BVT-1, } \xi = \frac{0.13 + 0.18 + 0.29 + 0.29}{4} = 0.22$$



e) Calculation for Horizontal Properties with area correction

$$\text{Co-efficient of Elastic Uniform Shear } (C_{\tau}) = \frac{C_u}{1.75} = 1.01 / 1.75 = 0.58 \text{ kg/cm}^3$$

$$\text{Co-efficient of Elastic Non-uniform Compression } (C_{\phi}) = 3.46 C_{\tau} = 3.46 \times 0.58 = 2.01 \text{ kg/cm}^3$$

$$\text{Co-efficient of Elastic Non-uniform Shear } (C_{\psi}) = 1.5 C_{\tau} = 1.5 \times 0.58 = 0.87 \text{ kg/cm}^3$$

## Sample calculation for shear modulus level wise

### BH-3

#### A) For Silty Clay/Clayey Silt/ Sandy Silt formation

From RL +117.7 to RL +115.4, N=11

Calculation for Young's modulus (E) :

[Refer Table 5.6 of Foundation Analysis and Design, Fifth edition by J. E. Bowles]

$$\begin{aligned} E &= 300 \times (N+6), \text{ Where } N = \text{Corrected SPT value} \\ &= 300 \times (11+6) \\ &= 51000 \text{ Kpa} \\ &= 51 \text{ kg/cm}^2 \end{aligned}$$

Calculation for Shear modulus (G) :

[Refer Sec 2-14, equation (a) of Foundation Analysis and Design, Fifth edition by J. E. Bowles]

$$G = \frac{E_{av}}{2(1 + \varepsilon)} = \frac{E_{av}}{2 \times (1 + 0.25)} = 20.40 \text{ kg/cm}^2$$

$\varepsilon$  = Poisson's ratio of Clayey soil = 0.25 (assumed)

#### B) Similarly for sandy soil (Normally consolidated)

From RL +115.4 to +113.4, N=16

Calculation for Young's modulus (E) & Shear modulus (G)

$$\begin{aligned} E &= 500 \times (N+15) \\ &= 500 \times (16+15) \\ &= 15500 \text{ Kpa} \\ &= 155 \text{ kg/cm}^2 \end{aligned}$$

$$G = \frac{E_{av}}{2(1 + \varepsilon)} = \frac{E_{av}}{2 \times (1 + 0.35)} = 57.41 \text{ kg/cm}^2$$

$\varepsilon$  = Poisson's ratio of Sandy soil = 0.35 (assumed)

**Land Survey & Geotechnical Investigation work at Duliajan Power Station Dibrugarh, Assam, inside the existing power plant of Oil India Limited (OIL)**



**BH-1**



**BH-2**



**BH-3**

**FIELD WORK IN PROGRESS**



**Land Survey & Geotechnical Investigation work at Duliajan Power Station Dibrugarh, Assam, inside the existing power plant of Oil India Limited (OIL)**



SCPT - 1



SCPT – 2

**FIELD WORK IN PROGRESS**



**Land Survey & Geotechnical Investigation work at Duliajan Power Station Dibrugarh,  
Assam, inside the existing power plant of Oil India Limited (OIL)**



**PLT – 1**

**FIELD WORK IN PROGRESS**

**Land Survey & Geotechnical Investigation work at Duliajan Power Station Dibrugarh,  
Assam, inside the existing power plant of Oil India Limited (OIL)**



**ERT - 1**

**FIELD WORK IN PROGRESS**



**Land Survey & Geotechnical Investigation work at Duliajan Power Station Dibrugarh,  
Assam, inside the existing power plant of Oil India Limited (OIL)**



**CBR - 2**

**FIELD WORK IN PROGRESS**