

Request for Selection (RfS) Document for setting up of 40 MW/80MWh Standalone Battery Energy Storage Systems in Kolkata under Tariff-Based Competitive Bidding

RfS No. ED(PM)/2025-26/266 dated 30.07.2025

**Issued By:
CESC Limited
CESC House, Chowringhee Square,
Kolkata-700001)**

Addendum-13

Date: 04.11.2025

Part -1: Revised Timeline

Part-2: Report on Geotechnical investigation for CESC's 40MW/80MWh BESS project

Part -1

Activity	Timeline	Revised Timeline
Date of issuance of RfS	30.07.2025 (No Change)	30.07.2025 (No Change)
Site Visit	from 02.08.2025 to 25.09.2025	from 02.08.2025 to 25.09.2025
Date of pre-bid meeting	09.09.2025 at 11:30Hrs	09.09.2025 at 11:30Hrs
Technical clarifications	25.09.2025	25.09.2025
Response to Technical Clarification/Queries	26.09.2025	26.09.2025
Bid submission deadline	10.11.2025 by 17:00Hrs	12.11.2025 by 17:00Hrs
Issuance of Letter of Award (LoA)	On or before 10.12.2025	On or before 12.12.2025
Submission of documents for verification in terms of clause 18.3 of RfS	No change	No change
Signing of the BESPA and Right to Use Agreement with respect to Project land	No change	No change
Financial Closure	No change	No change
Schedule Commissioning Date	No change	No change

Part -2

Report on Geotechnical investigation for CESC's 40MW/80MWh BESS project

Note:

- The report is for reference only.
- As mentioned in RfS (clause 8.6 of Annexure A), soil test is in BESSD's scope.

**Report
On
Geotechnical Investigation
For
Proposed Battery Energy
Storage Station
At
Pre. No. - 28, Jheel Road,
Kolkata - 700 002.**

*(W.O. No. - EST / ORD / 25 - 26 / 1241; Dated: 09.09.2025)
&
(W.O. No. - EST / ORD / 25 - 26 / 1508; Dated: 16.10.2025)*

Name of Client

CESC LIMITED
Estates Department (3rd Floor)
4, Sashi Sekhar Bose Row,
Kolkata - 700 025.

Name of Testing Agency

GEOTEST ENGINEERS PVT. LTD.

(An ISO 9001 : 2015 Certified Company)

Soil Investigators, Foundation Consultants & Land Surveyors

6A, Milan Park, Kolkata - 700 084.

Phone : 91-33-2430-3494 / 8103 / 9717

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REPORT NO. : GT / CL / 102 / 2025 - 2026



REPORT
ON
GEOTECHNICAL INVESTIGATION
FOR
PROPOSED BATTERY ENERGY STORAGE STATION
AT
PRE. NO. - 28, JHEEL ROAD, KOLKATA - 700 002.
(REPORT NO.: GT/CL/102/2025 - 2026)

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REPORT SHEET



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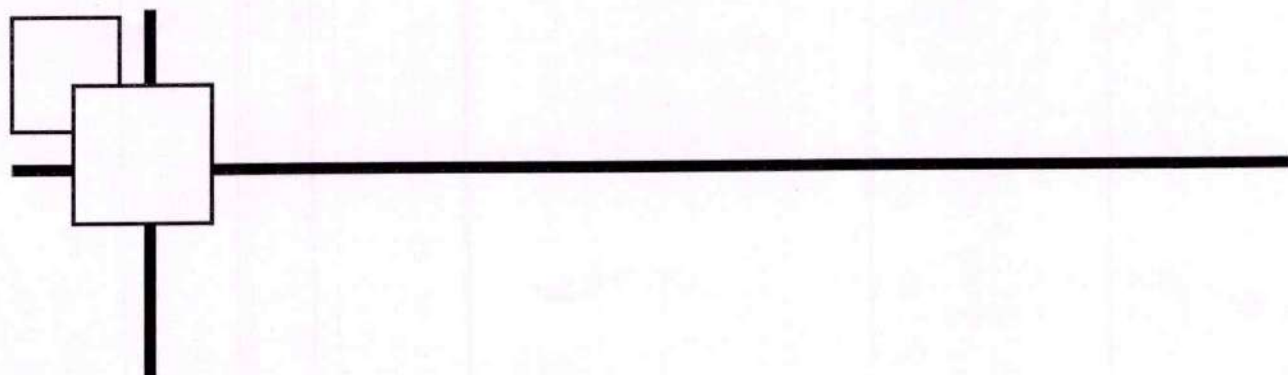
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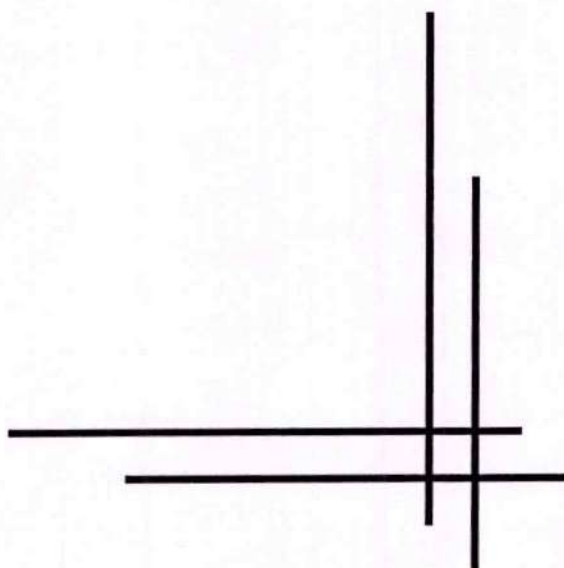
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A. TEXT





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1. INTRODUCTION

The work of sub-soil exploration for the Proposed Battery Energy Storage Station at Pre. No.- 28, Jheel Road, Kolkata – 700 002, was awarded to M/S. GEOTEST ENGINEERS PRIVATE LIMITED of 6A, Milan Park, Kolkata - 700 084 by the Client M/S. CESC LIMITED of Estates Department (3rd Floor), 4, Sashi Sekhar Bose Row, Kolkata - 700 025. The sub-soil investigation purpose for the proposed Battery Energy Storage Station at the aforesaid site was to determine the sub-soil condition and to ascertain the foundation types that would be suitable for the proposed battery energy storage station. The Fieldwork was done in the month of September, 2025. Laboratory tests were conducted on soil samples at our own laboratory, for the analysis of sub-soil condition at the site.

2. SCOPE OF INVESTIGATION

In an attempt for optimization in the design of foundations for the proposed battery energy storage station, geotechnical investigation programme had been divided mainly into two parts, like, field works part unfurling the sub-surface deposit types and their states of occurrences in-situ and laboratory tests part which would help to determine the relevant physical and the geotechnical properties of the sub-surface deposits leading to finalization of foundation type and foundation design bearing capacity with particular reference to the sub-surface deposit types and their strength parameters and settlement potentials in-situ. The scope is summarized as follows: -

- (a) Sinking 6 (six) numbers of 150 mm. & 76 mm. dia., exploratory boreholes, all with termination depths of about 25.00 m. below E.G.L., at prefixed location at the site. The borehole numbers, depths & locations were finalized & fixed by the **Soil Investigation Agency**. For location of the exploratory boreholes please refer 'Borehole Location Plan' at the **ANNEXURE** of this report.
- (b) Collection of representative 100 mm dia. undisturbed soil samples as per the provisions as laid down in IS: 2132 (1986) as well as representative disturbed soil samples from the exploratory boreholes for carrying out detailed laboratory analysis which would help adoption of strength, settlement and other relevant parameters of the sub-surface deposits



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for finalization of foundation type and thereafter for design of foundations for the proposed battery energy storage station.

- (c) *Carrying out standard penetration tests as per the provisions laid down in IS: 2131 (2025) in all the boreholes and subsequently maintaining penetration chart, depth-wise, upto the test depth in all the exploratory boreholes at this site.*

After completion of the above mentioned field works, the appropriate laboratory tests, as were applicable to the sub-surface deposit types which were encountered at the explored location, were conducted to determine the physical and the relevant geotechnical properties of the sub-surface deposits and subsequently to finalize type and thereafter for design of foundation for the proposed battery energy storage station to be constructed at this site under investigation.

3. FIELD WORK

A brief description of boring method, field tests, sample collection etc. and type of equipment, are furnished below.

3.1 Rig

The entire fieldwork was done by deploying single number of rig.

3.2 Boring

Boring through the soil was carried out by combination of Shell & Auger boring technique (as per clause 5.4.2 of IS1892:2021) & Rotary boring Technique (as per clause 5.4.4 of IS 1892:2021) upto their termination depths below E.G.L. in all the boreholes, by using Mechanically Power-Driven Winch.

3.3 Representative Sample

Representative samples were collected from auger, S.P.T. sampler and cutting shoe of undisturbed sampling assembly. This was done to maintain a continuous record of strata encountered. The samples were labeled and placed in airtight polythene bags and shifted to the laboratory for testing and classification.



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3.4 Standard Penetration Test (S.P.T.)

This test was conducted at the boring points at suitable intervals. The number of blows required for last 30.00 cm penetration of split spoon sampler out of a total penetration of 45.00 cm driven by a 63.50 kg hammer falling freely through a height of 75.00 cm was recorded as 'N' values. The sample from split spoon were collected after each test and were labeled and placed in air-tight polythene bags before sending to the laboratory for identification and testing. The test procedure was performed to IS: 2131 : 2025. The Split Spoon Sampler was as per I.S. 9640:1980 (Reaffirmed 1987).

3.5 Undisturbed Samples

Undisturbed samples were collected as per I.S.2132 (1986) by means of a two-tier 100.00 mm I.D. open driven sampling assembly having area ratio of 15%. The sampling assembly (as per I.S. 11594: 1985) was driven to the required depth manually with the help of jarring link. Samples collected in the lower tube were retained, labeled and waxed at all ends before sending it to the laboratory.

3.6 Ground Water Level

Ground water level observation was made during boring in all the boreholes after 24 hours of completion of boreholes.

It was observed that the Ground Water Table was at an average depth of about 0.50 m. below Avg. E.G.L. (During the period of fieldwork, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level) from 18.09.2025 to 26.09.2025.



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4. LABORATORY INVESTIGATION

For proper identification and classification of the sub-surface deposits and for deriving adequate information regarding its relevant physical and the geotechnical properties at the site under investigation, most or all of the following laboratory tests pertaining to the actual soil types, occurring at this site, were conducted on the representative soil samples, collected from all the exploratory borehole.

- (a) Grain size analysis.
 - (i) Hydrometer analysis for cohesive soil samples.
 - (ii) Sieve analysis for cohesionless soil samples.
- (b) Liquid limit and plastic limit for cohesive soil samples.
- (c) Specific Gravity.
- (d) Natural moisture content.
- (e) Natural density and dry density.
- (f) Triaxial shear tests in unconsolidated undrained condition on cohesive soil samples for determination of strength parameter values like, cohesion, C_{uu} , and angle of internal friction, ϕ_{uu} .
- (g) Consolidation tests on cohesive soil samples for determination of settlement potentials.
- (h) Void ratio.

All or most of the above-mentioned laboratory tests on the representative soil samples were conducted as per the relevant provisions as laid down in the different sections of IS: 2720.

The result after the relevant laboratory tests on the representative soil samples have been presented in tabular form in 'Laboratory Test Result Sheet' at the ANNEXURE of this report.

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5. SUB-SOIL STRATIFICATION

The sub-soil investigation work has been done by sinking 6 (six) number boreholes explored upto a maximum depth of 25.95 m. below the existing ground level at specified locations.

The ground water level as encountered in the boreholes during the period of field work is shown in respective bore logs. The laboratory test results are tabulated in ANNEXURE of the Report. The bore hole location plan is shown in ANNEXURE of the Report. The sub soil formation as revealed by the bore holes are shown in ANNEXURE of the Report. The grain size distribution curves are shown in ANNEXURE of the Report. Average engineering properties of all the boreholes were provided in TABLE 1.

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TABLE - 1
Average Engineering Properties

Strata	Brief Description	Average Thickness (m.)	Avg. Field 'N' value	Corrected Avg. Field 'N' Value	Bulk Unit Weight (kN/m ³)	Dry Unit Weight (kN/m ³)	NMC %	LL%	PL%	Plasticity Index (%)	Cohesion kN/m ²	Angle of shear resistance in degree	Specific Gravity 'G'	Initial Void Ratio 'e ₀ '	Grain Size Analysis				LS CLASSIFICATION
															GRAVEL	SAND	SILT	CLAY	
I	Reclaimed top fill of loose dark grey fly ash with brickpieces, underlain by F.C.C., R.C.C. and	3.40	3	4	-	-	23.42	NP	NP	-	-	-	-	-	1	47	52		SM
II	Soft / firm brownish grey / grey silty clay / clayey silt with traces of kankars.	4.17	5	5	18.59	14.30	29.99	47	22	25	31.00	8	2.66	0.704	1	8	63	28	CI - MI
III	Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium percent) of decomposed wood.	5.65	3	3	16.71	11.43	46.71	77	27	50	20.00	0	2.54	1.176	-	2	58	40	CH - OH
IV	Stiff / very stiff bluish grey / mottled brown silty clay / clayey silt with traces of rusty brown silt spots.	> 12.32	15	15	19.32	15.38	25.58	54	22	32	70.00	1	2.67	0.733	1	7	59	33	CH - MH

* Combined % of silt and clay.
** From corrected SPT value.
NOTE : As per clause 5.6.3 & 5.6.4 of I.S. 2131 - 2025, overburden & dilatancy corrections would not be applicable in cohesive soil. Hence in present case, field 'N' values of cohesive stratum have not been corrected.



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6. BEARING CAPACITY & PROBABLE SETTLEMENT VALUES OF CONVENTIONAL SHALLOW OPEN FOUNDATIONS & RIGID RAFT FOUNDATION

6.1.1 Computation of net safe bearing capacities for shallow foundations

For computation of net safe bearing capacity values for design of shallow foundations, ultimate net bearing capacity formula as per "Code of Practice for Determination of Bearing Capacity of Shallow Foundations (First Revision)", IS: 6403 (1981) will be used.

As per the clause 5.1.2 of IS: 6403 (1981), the ultimate net bearing capacity of shallow foundations in case of general shear failure,

$$q_d = C_u N_c S_c d_{c i_c} + q(N_q - 1) S_q d_{q i_q} + 0.5 B \gamma N_\gamma d_\gamma S_\gamma i_\gamma w'$$

and the same in case of local shear failure,

$$q_d = 2/3 C_u N'_c S'_c d_{c i_c} + q(N'_q - 1) S'_q d_{q i_q} + 0.5 B \gamma N'_\gamma d'_\gamma S'_\gamma i_\gamma w'$$

where, N_c , N_q , N_γ and N'_c , N'_q , N'_γ are the bearing capacity factors in case of general shear and local shear failure conditions respectively.

S_c , S_q and S_γ are the shape factors.

d_c , d_q and d_γ are the depth factors.

i_c , i_q and i_γ are the inclination factors.

B is the least dimension of the foundation in metre.

q is the effective surcharge at the base level of foundation in kN/m^2 .

γ is the bulk unit weight of foundation soil in kN/m^3 .

w' is the correction factor for location of water table.

In case of foundations resting on cohesive soils, as the rate of gradual building up of load intensity at the foundation level will be more than the rate of dissipation of excess pore water pressure from the cohesive soil due to low to very low range of co-efficient of permeability values of the same, the computation of net safe bearing capacity values for foundations resting on cohesive foundation medium will be governed by undrained analysis, i.e. $\phi = 0^\circ$ analysis will prevail.

Computation of net safe bearing capacity values for shallow open foundations resting on cohesive stratum, at 4.50 m. depth below Avg. E.G.L. (During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level) the following formula will be used.

$$q_{ns} = q_d / F.O.S. = C_u N_c S_c d_{c i_c} / F.O.S.$$



6.1.2 Foundation Settlement

Settlement is calculated on the basis of the following formulae

Immediate Settlement (S_i) = $q_{ns} B (1 - \mu^2) I_f / E$ as per the clause 9.2.3.2 of IS : 8009 (Part 1) 1976 (Reaffirmed 2003).

Where, q_{ns} = Net foundation pressure.
 B = Width of footing.
 μ = Poisson's Ratio of soil.
 I_f = Influence Factor.
 E = Modulus of Elasticity.

Corrected immediate settlement, $S_{ic} = S_i C_c$

Where, C_c = Depth correction factor as per fig.12 of I.S.8009 (Part 1) 1976 (Reaffirmed 2003).

Consolidation settlement

Assuming the influence zone for 20% stress contour, upto twice the width of footing, the total consolidation settlement is given by

$S_c = \Sigma m_v \Delta P H$ as per IS: 8009 (Part I)

Where, m_v = Coefficient of volume change.
 ΔP = Pressure increment at centre of the layer.
 H = Thickness of the stratum.

Corrected consolidation settlement, $S_{cc} = S_c C_b C_c$

Where, C_b = Pore Pressure correction factor as per Table 1 of I.S. 8009 (Part 1) 1976, Reaffirmed 2003]

C_c = Depth correction factor as per fig.12 of I.S.8009 (Part 1) 1976. (Reaffirmed 2003)

SBC & Probable Settlement values calculations are shown in chapter 9 of ANNEXURE.



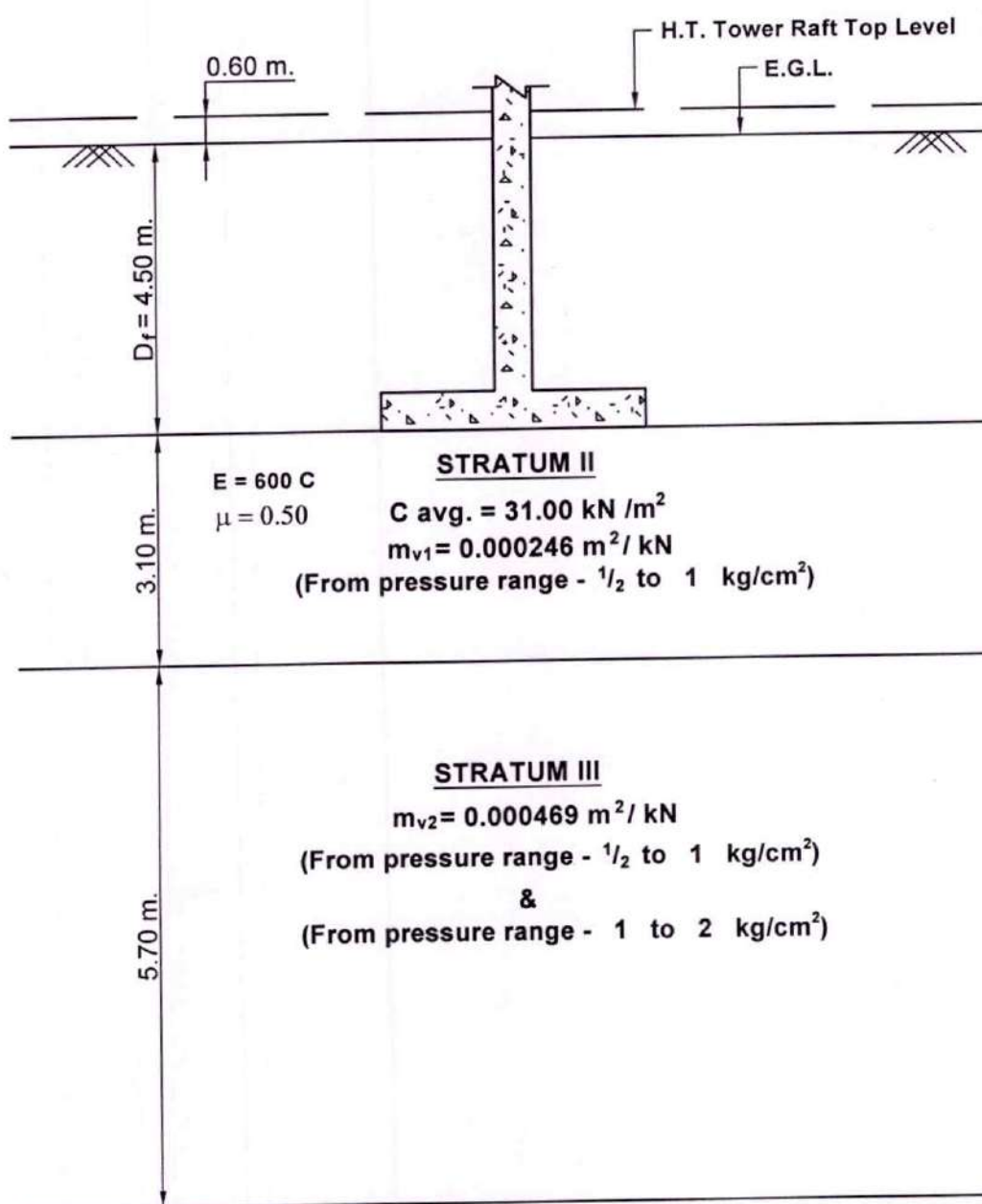
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FOUNDATION DESIGN MODEL FOR SHALLOW OPEN FOUNDATION

DEPTH OF FOUNDATION = 4.50 M. BELOW AVG. E.G.L.

(During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level)

(DRAWING NOT TO SCALE)



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TABLE 2(A)

Shallow Foundation : Bearing Capacity and Probable Settlement Values

Depth of foundation = 4.50 m. below Avg. E.G.L.

(During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level)

Factor of Safety in shear = 2.50

Type of footing	Size of footing (m x m)	Net safe bearing capacity in shear (kN/m ²)	Total expected settlement (mm)	Net allowable bearing pressure to restrict settlement within *75.00 mm (i.e. safe both in shear and settlement) (kN/m ²)
ISOLATED SQUARE	1.50 x 1.50	83.00	13.00	83.00
	2.00 x 2.00	83.00	20.00	83.00
	2.50 x 2.50	83.00	27.00	83.00
	3.00 x 3.00	83.00	35.00	83.00
	3.50 x 3.50	83.00	42.00	83.00
	4.00 x 4.00	83.00	50.00	83.00
RECTANGULAR	1.50 x 3.00	70.00	15.00	70.00
	2.00 x 4.00	70.00	23.00	70.00
	2.50 x 5.00	70.00	31.00	70.00
	3.00 x 6.00	70.00	39.00	70.00
	3.50 x 7.00	70.00	47.00	70.00
	4.00 x 8.00	70.00	57.00	70.00
SINGLE DIRECTION CONTINUOUS STRIP	1.50 m. wide	64.00	18.00	64.00
	2.00 m. wide	64.00	26.00	64.00
	2.50 m. wide	64.00	36.00	64.00
	3.00 m. wide	64.00	49.00	64.00
	3.50 m. wide	64.00	60.00	64.00

*As per Table – 1 of I.S.1904 (2021) for isolated foundation for R.C. Structure in plastic clay, like in present case.

Note: - In present case, depth factor (d_c) in bearing capacity calculations, has not been considered, to be on safe side.



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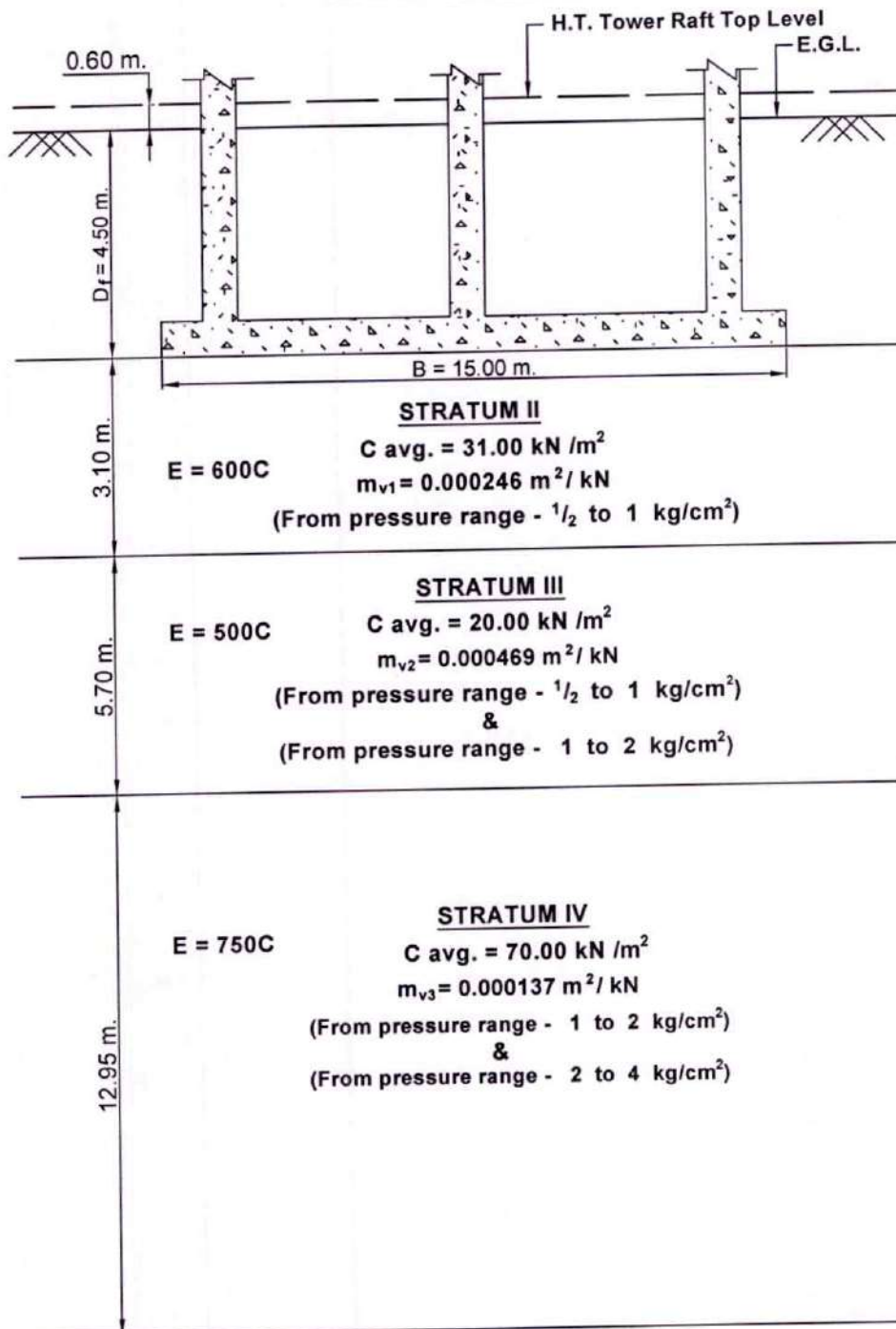
FOUNDATION DESIGN MODEL

FOR SHALLOW FOUNDATION AS RIGID RAFT

DEPTH OF FOUNDATION = 4.50 M. BELOW AVG. E.G.L.

(During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level)

(DRAWING NOT TO SCALE)



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TABLE - 2(B)

Shallow Rigid Raft Foundation:

Bearing Capacity and Probable Settlement Value

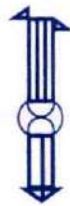
Depth of foundation = 4.50 m. below Avg. E.G.L.

(During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level)

Factor of Safety in shear = 2.50

Type of Footing	Tentative Size (m x m)	Net Safe bearing capacity from shear criterion (kN/m ²)	Estimated Total Settlement corresponding to Net Safe bearing pressure from shear criterion (mm)	Net Allowable bearing pressure for a total settlement of *125.00 mm (kN/m ²)	Design Net Allowable bearing pressure (least among shear and settlement criteria i.e., safe both in shear and settlement) (kN/m ²)
RIGID RAFT	15.00 x 20.00	76.00	150.00	63.00	63.00

*As per Table - 1 of I.S.1904 (2021) for Raft foundation for R.C. Structure in plastic clay, like in present case.



7. RECOMMENDATIONS

From the information as supplied by the client, it is known that there is a proposal for the Construction of Battery Storage Station at the site. However, whatever be the type, height and nature of the structure, its foundation design should satisfy two basic criteria. They are as follows:

- (a) There must be adequate factor of safety against shear failure.*
- (b) The settlement of footings must be within permissible limits as defined in IS: 1904 (2021).*

*Considering the above-mentioned criteria & subsoil condition as encountered in the entire site, it is suggested to try to resort to shallow open foundations in the form of isolated & or combined & or one-way continuous strip footings or a judicious combination of some or all of them depending on column position and spacing, to be designed with the bearing capacity values as given in **TABLE 2(A)** of previous chapter, for foundation design purposes.*

*If this bearing capacity of **TABLE 2(A)** falls short, for providing adequate footing area, without overlapping, then, shallow open foundation in the form of Rigid Raft Foundation can be tried out, with the bearing capacity values as provided in **TABLE 2(B)** of the previous chapter.*

For conventional shallow footings if provided, they should be properly connected in all directions by suitable tie-beams to arrest / check differential settlement.

Ground water level during the period of fieldwork was observed at an average depth of about 0.50 m. below Avg. E.G.L. (During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level). Since the fieldwork was done in the month of September, it can be considered as moderately high water table location, which can be normally expected

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to go down in dry seasons. So, it is envisaged that, constant pumping will be necessary to keep the excavation water free, due to the position of water table much above the founding depth. However, situation may be worsened if foundation excavation is done in heavy and continuous monsoon, when water table may merge with E.G.L. and constant and continuous dewatering might be necessary to keep foundation trenches water free.

*No local information regarding highest position of ground water table during Monsoon was available from the site. However, for design purposes, it is advisable to consider the worst possible condition of standing water level to merge with E.G.L., which has been done in present case. Hence our results of bearing capacity of conventional shallow open foundation & Rigid Raft Foundation as given in **TABLE 2(A) & TABLE 2(B)** respectively, will not be affected by fluctuation of Ground Water Table position, since those were determined under worst condition.*

Last but not the least, due considerations should be given to open excavation of any sort. All sorts of precautionary measures like earth retainment by any suitable method, are to be adopted to avoid excessive ground settlement and damage to adjoining structures.

*For and on behalf of **GEOTEST ENGINEERS PVT. LTD.***

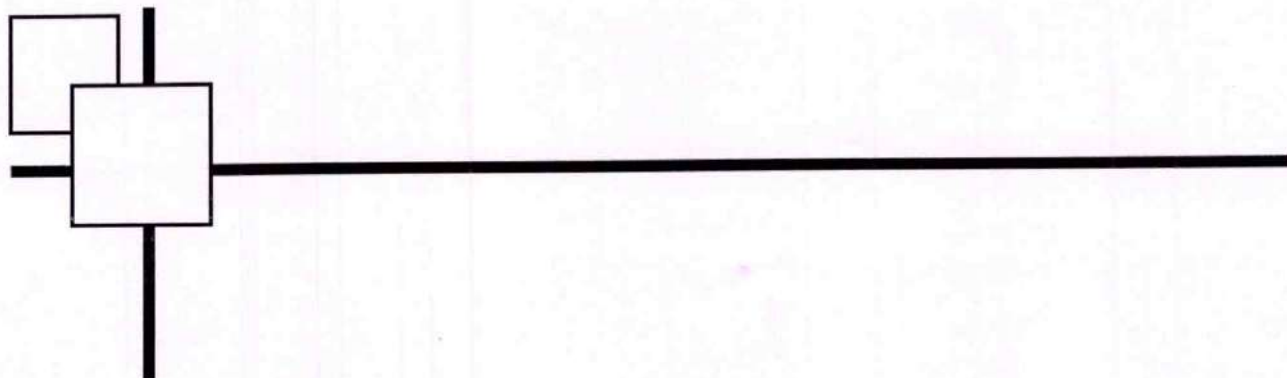
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B.E. (CIVIL), MCE (SOIL MECH. and FOUNDN. ENGG.)

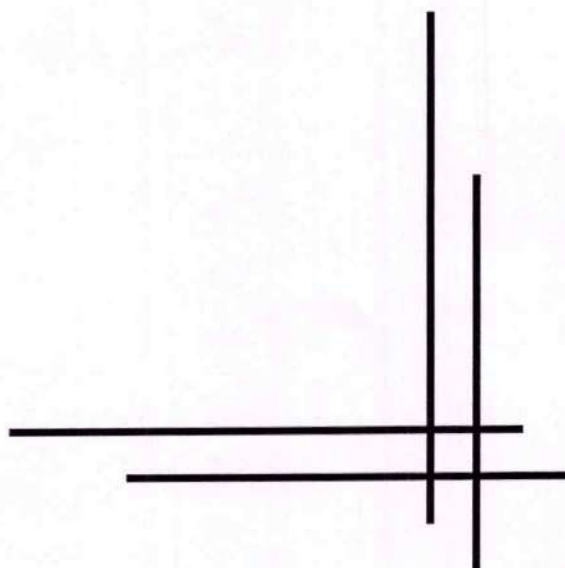
MASCE, MIE, MIGS, M.I.P.H.E., M.A.C.I. (I), C. Eng. (I)

Chartered Engineer (I), Reg. No. M128469 – 4.

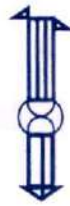
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B. ANNEXURE



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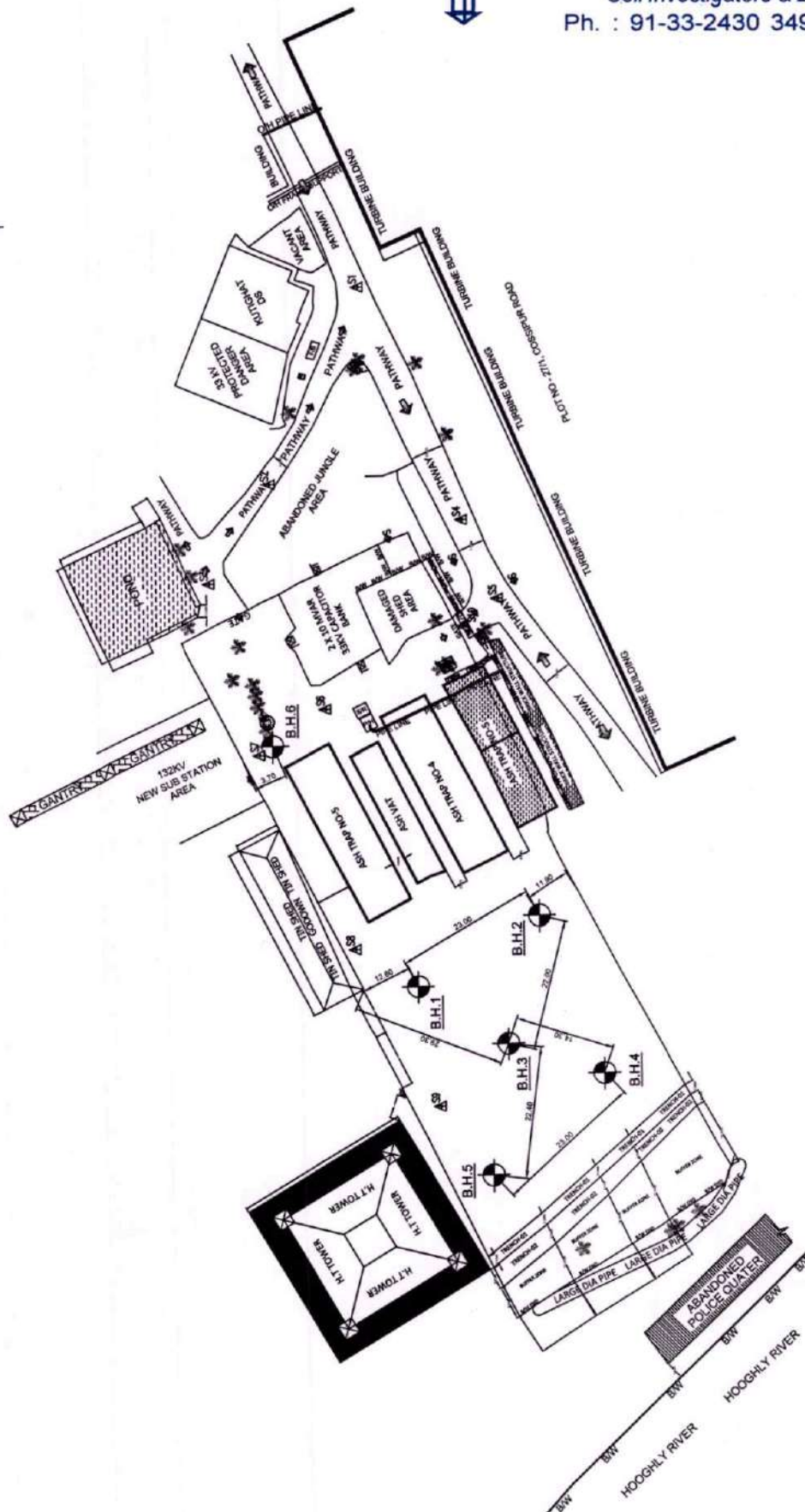
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1. BOREHOLE LOCATION PLAN

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6A, Milan Park, Kolkata -700 084



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NOTE

i) Drawing not to scale.

ii) All dimensions are in m.

<u>BOREHOLE</u>	<u>B.H.</u>	
<u>LEGEND</u>		

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BORE LOG DATA SHEET

Type of boring	Shell and Auger	Rotary Boring	Drilling	Report No.: GT / CL / 102 / 2025 - 2026		B.H.1	
Dia of Hole	150 mm.	--	76 mm.	Coordination Sext Angles	As per Borehole Location Plan.		
Depth	22.35 m	--	3.10 m.	Ground Bed RL	About 0.40 m. below H.T. Tower Raft Top Level (approx.)		
Commenced on: 18.09.25		Completed on: 19.09.25		Location:	Jheel Road, Kolkata.		
Ground Water Table: 0.70 m. below E.G.L.							
Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES	Depth in 'M'
		From	To			Type	
Reclaimed top fill of loose grey fly ash upto 1.40 m., underlain by P.C.C. over B.F.S upto 4.50 m. NOTE :- HX drilling done from 1.40 m. to 4.50 m., to puncture the P.C.C.	SM	0.00	4.50	4.50	-- 02 -- -- --	D P D Concrete Concrete	0.00 0.50 - 0.95 1.40 1.40 - 2.90 (4% Core Recovery) 2.90 - 4.50 (6% Core Recovery)
Soft / firm brownish grey / grey clayey silt with traces of kankars and silt spots.	CI - MI	4.50	8.50	4.00	04 -- 09	P U P	4.50 - 4.95 6.00 - 6.45 7.50 - 7.95
Very soft / soft grey / dark grey silty clay / clayey silt with varying percentage (traces to medium percent) of decomposed wood.	CH - OH	8.50	13.70	5.20	-- 02 -- *04	U P U P	9.00 - 9.45 10.50 - 10.95 12.00 - 12.45 13.50 - 13.95
Stiff / very stiff bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots. • Color changes to mottled brown from 21.00 m.	CH - MH	13.70	25.45		-- 10 -- 11 -- 18 -- 15	U P U P U P P	15.00 - 15.45 16.50 - 16.95 18.00 - 18.45 19.50 - 19.95 21.00 - 21.45 22.50 - 22.95 24.00 - 24.45 25.00 - 25.45
Borehole Terminated.							
S. S.: Chanchal Roy / M.P.							
D - Disturbed Sample		U - Undisturbed Sample			P - Standard Penetration Test		
Page No.: 19							

*S.P.T. lies in interface zone between two different layers.

REPORT SHEET



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BORE LOG DATA SHEET

Type of boring	Shell and Auger	Rotary Boring	Drilling	Report No.: GT / CL / 102 / 2025 - 2026		B.H.2	
Dia of Hole	150 mm.	--	76 mm.	Coordination Sext Angles	As per Borehole Location Plan.		
Depth	21.95 m.	--	3.50 m.	Ground Bed RL	About 0.50 m. below H.T. Tower Raft Top Level (approx.)		
Commenced on: 19.09.25		Completed on: 20.09.25		Location:	Jheel Road, Kolkata.		
Ground Water Table: 0.60 m. below E.G.L.							
Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES	Depth in 'M'
		From	To			Type	
Reclaimed top fill of loose dark grey fly ash upto 1.00 m., underlain by R.C.C. upto 4.50 m. NOTE :- HX drilling done from 1.00 m. to 4.50 m., to puncture the R.C.C. bed.	SM	0.00	4.50	4.50	-- -- -- --	D U Concrete Concrete	0.00 0.50 – 0.95 1.00 – 3.00 (15% Core Recovery) 3.00 – 4.50 (17% Core Recovery)
Soft / firm brownish grey / grey silty clay / clayey silt with kankars and rusty brown silt spots.	CI – MI	4.50	7.30	2.80	-- 05	U P	4.50 – 4.95 6.00 – 6.45
Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium percent) of decomposed wood.	CH – OH	7.30	13.20	5.90	-- 03 -- 02	U P U P	7.50 – 7.95 9.00 – 9.45 10.50 – 10.95 12.00 – 12.45
Stiff / very stiff bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots	CH – MH	13.20	25.45		-- 09 -- 17 -- 19 -- 15 --	U P U P U P U	13.50 – 13.95 15.00 – 15.45 16.50 – 16.95 18.00 – 18.45 19.50 – 19.95 21.00 – 21.45 22.50 – 22.95 24.00 – 24.45 25.00 – 25.45
Borehole Terminated.							
S. S.: Chanchal Roy / M.P.							
D – Disturbed Sample		U – Undisturbed Sample		P – Standard Penetration Test			
						Page No.: 20	

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BORE LOG DATA SHEET

Type of boring	Shell and Auger	Rotary Boring	Drilling	Report No.: GT / CL / 102 / 2025 - 2026		B.H.3	
Dia of Hole	150 mm.	--	76 mm.	Coordination Sext Angles	As per Borehole Location Plan.		
Depth	22.95 m.	--	2.50 m.	Ground Bed RL	About 0.70 m. below H.T. Tower Raft Top Level(approx.)		
Commenced on: 20.09.25		Completed on: 21.09.25		Location:	Jheel Road, Kolkata.		
Ground Water Table: 0.20 m. below E.G.L.							
Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES	Depth in 'M'
		From	To			Type	
Reclaimed top fill of loose dark grey fly ash upto 0.50 m., underlain by P.C.C. <u>NOTE :-</u> HX drilling done from 0.50 m. to 3.00 m.	SM	0.00	3.00	3.00	--	D	0.00
--		Concrete			0.50 – 2.00		
--		Concrete			2.00 – 3.00 (8% Core Recovery)		
Soft / firm brownish grey / grey clayey silt with traces kankars and rusty brown silt spots.	CI – MI	3.00	7.80	4.80	04	P	3.00 – 3.45
--		U			4.50 – 4.95		
07		P			6.00 – 6.45		
--		U slip			7.50 – 7.95		
Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium percent) of decomposed wood.	CH – OH	7.80	13.20	5.40	02	P	8.00 – 8.45
--		U			9.50 – 9.95		
03		P			11.00 – 11.45		
--		U			12.50 – 12.95		
Stiff / very stiff bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty yellow silt spots.	CH – MH	13.20	25.45		09	P	14.00 – 14.45
--		U			15.50 – 15.95		
11		P			17.00 – 17.45		
--		U			18.50 – 18.95		
15		P			20.00 – 20.45		
--		U			21.50 – 21.95		
19		P			23.00 – 23.45		
--		U			25.00 – 25.45		
Borehole Terminated.							
S. S.: Chanchal Roy / M.P.							
D – Disturbed Sample		U – Undisturbed Sample		P – Standard Penetration Test		Page No.: 21	

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Type of boring	Shell and Auger	Rotary Boring	Drilling	Report No.: GT / CL / 102 / 2025 - 2026	B.H.4		
Dia of Hole	150 mm.	--	76 mm.	Coordination Sext Angles	As per Borehole Location Plan.		
Depth	23.45 m.	--	2.00 m.	Ground Bed RL	About 0.70 m. below H.T. Tower Raft Top Level(approx.)		
Commenced on: 21.09.25		Completed on: 22.09.25		Location:	Jheel Road, Kolkata.		
Ground Water Table: 0.60 m. below E.G.L.							
Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES	Depth in 'M'
		From	To			Type	
Reclaimed top fill of loose dark grey fly ash upto 0.50 m., underlain by R.C.C. & P.C.C. upto 2.50m. <u>NOTE</u> :- HX drilling done from 0.50 m. to 2.50 m.	SM	0.00	2.50	2.50	-- -- --	D Concrete Concrete	0.00 0.50 – 1.50 (12% Core Recovery) 1.50 – 2.50 (16% Core Recovery)
Soft / firm brownish grey / grey clayey silt with traces kankars and silt spots.	CI - MI	2.50	7.50	5.00	04 -- 05 --	P U P U	2.50 – 2.95 4.00 – 4.45 5.50 – 5.95 7.00 – 7.45
Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium percent) of decomposed wood.	CH - OH	7.50	12.80	5.30	02 -- 03	P U P	8.50 – 8.95 10.00 – 10.45 11.50 – 11.95
Stiff / very stiff bluish grey / mottled brown silty clay / clayey silt with traces of rusty brown silt spots.	CH - MH	12.80	25.45		-- 10 -- 12 -- 19 -- 23 --	U P U P U P U P U	13.00 – 13.45 14.50 – 14.95 16.00 – 16.45 17.50 – 17.95 19.00 – 19.45 20.50 – 20.95 22.00 – 22.45 23.50 – 23.95 25.00 – 25.45
Borehole Terminated.							
S. S.: Chanchal Roy / M.P.							
D – Disturbed Sample		U – Undisturbed Sample		P – Standard Penetration Test		Page No.: 22	

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Type of boring	Shell and Auger	Rotary Boring	Drilling	Report No.: GT / CL / 102 / 2025 - 2026		B.H.5	
Dia of Hole	150 mm.	--	76 mm.	Coordination Sext Angles	As per Borehole Location Plan.		
Depth	23.75 m.	--	2.20 m.	Ground Bed RL	About 0.70 m. below H.T. Tower Raft Top Level(approx.)		
Commenced on: 22.09.25		Completed on: 24.09.2025		Location:	Jheel Road, Kolkata.		
Ground Water Table: 0.40 m. below E.G.L.							
Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES	Depth in 'M'
		From	To			Type	
Reclaimed top fill of loose dark grey fly ash with brickpieces upto 0.50 m., underlain by R.C.C. and B.F.S. upto 2.70 m. <u>NOTE</u> :- HX drilling done from 0.50 m. to 2.70 m.	SM	0.00	2.70	2.70	-- -- --	D Concrete Concrete	0.00 0.50 – 1.50 (12% Core Recovery) 1.50 – 2.70 (17% Core Recovery)
Soft / firm brownish grey / grey silty clay / clayey silt with traces of kankars.	CI - MI	2.70	7.00	4.30	-- 05 --	U P U	3.00 – 3.45 4.50 – 4.95 6.00 – 6.45
Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium percent) of decomposed wood.	CH - OH	7.00	13.00	6.00	03 -- 02 --	P U P U	7.50 – 7.95 9.00 – 9.45 10.50 – 10.95 12.00 – 12.45
Stiff / very stiff bluish grey / mottled brown silty clay / clayey silt with traces of rusty brown silt spots.	CH - MH	13.00	25.45		08 -- 12 -- 16 -- 18 -- 22	P U P U P U P U P	13.50 – 13.95 15.00 – 15.45 16.50 – 16.95 18.00 – 18.45 19.50 – 19.95 21.00 – 21.45 22.50 – 22.95 24.00 – 24.45 25.00 – 25.45
Borehole Terminated.							
S. S.: Chanchal Roy / M.P.							
D – Disturbed Sample		U – Undisturbed Sample		P – Standard Penetration Test			
Page No.: 23							

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BORE LOG DATA SHEET

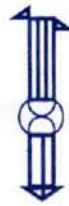
Type of boring	Shell and Auger	Rotary Boring	Drilling	Report No.: GT / CL / 102 / 2025 - 2026	B.H.6
Dia of Hole	150 mm.	--	76 mm.	Coordination Sext Angles	As per Borehole Location Plan.
Depth	23.25 m.	--	2.20 m.	Ground Bed RL	About 0.50 m. below H.T. Tower Raft Top Level(approx.)
Commenced on: 24.09.25		Completed on: 26.09.25		Location:	Jheel Road, Kolkata.
Ground Water Table: 0.70 m. below E.G.L.					

Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES Type	Depth in 'M'
		From	To				
Reclaimed top fill of loose dark grey fly ash upto 1.00 m., underlain by R.C.C. & P.C.C upto 3.20 m. <u>NOTE:-</u> HX drilling done from 1.00 m. to 3.20 m.	SM	0.00	3.20	3.20	-- 03 -- --	D P Concrete Concrete	0.00 0.50 - 0.95 1.00 - 2.00 (20% Core Recovery) 2.00 - 3.20 (22% Core Recovery)
Soft / firm brownish grey / grey silty clay / clayey silt with traces kankars and silt spots.	CI - MI	3.20	7.30	4.10	04 -- 07	P U P	3.50 - 3.95 5.00 - 5.45 6.50 - 6.95
Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium percent) of decomposed wood.	CH - OH	7.30	13.40	6.10	-- 03 -- 02	U P U P	8.00 - 8.45 9.50 - 9.95 11.00 - 11.45 12.50 - 12.95
Stiff / very stiff bluish grey / mottled brown silty clay / clayey silt with traces of rusty brown silt spots.	CH - MH	13.40	25.45		-- 09 -- 13 -- 16 -- 20	P U P U P U P U	14.00 - 14.45 15.50 - 15.95 17.00 - 17.45 18.50 - 18.95 20.00 - 20.45 21.50 - 21.95 23.00 - 23.45 25.00 - 25.45

Borehole Terminated.

S. S.: Chanchal Roy / M.P.		
D - Disturbed Sample	U - Undisturbed Sample	P - Standard Penetration Test
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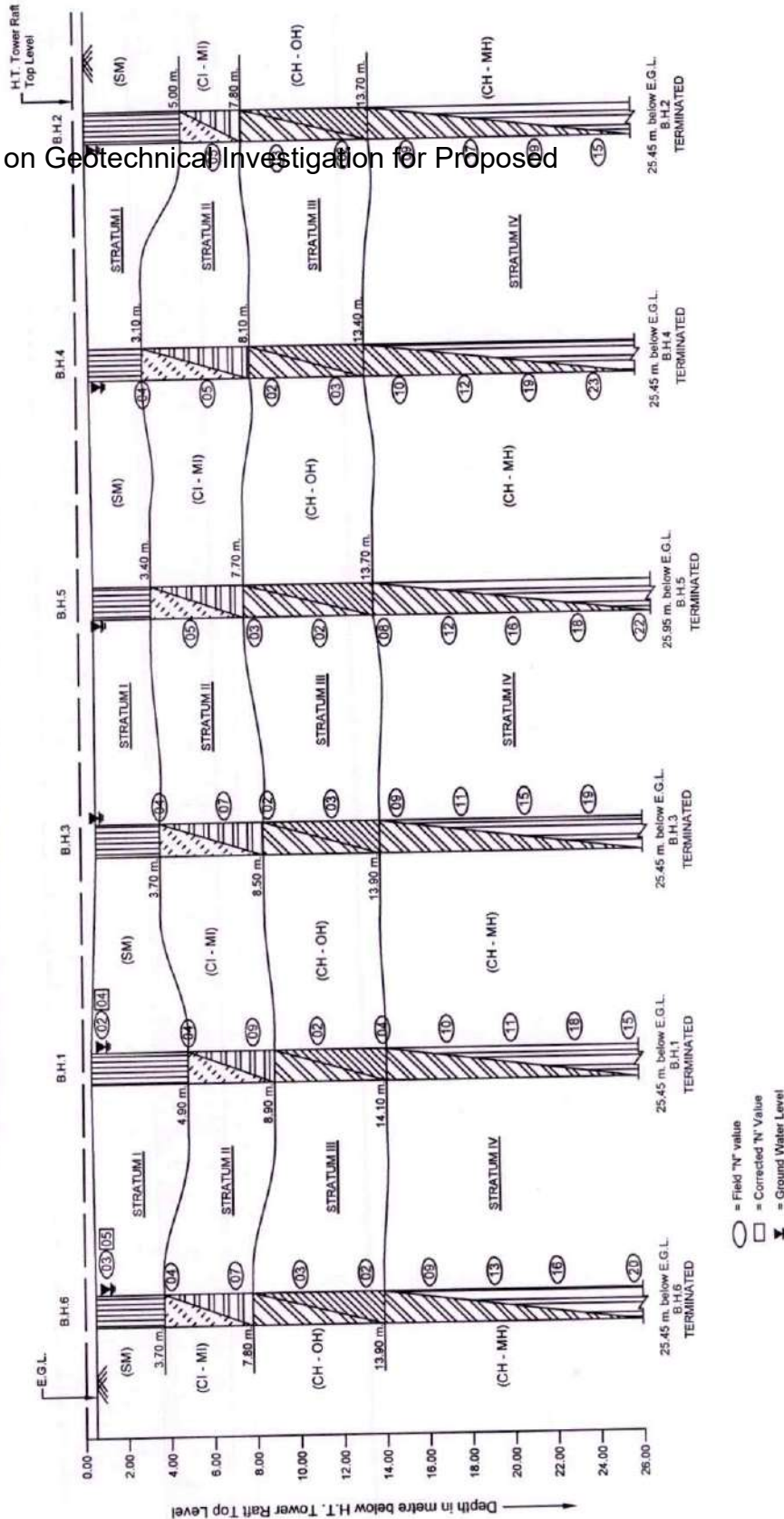
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3. Sub-Soil Profile with Field 'N' Values & Corrected 'N' Values



LEGEND :-

STRATUM I Reclaimed top fill of loose dark grey fly ash with brickpieces, underlain by P.C.C., R.C.C. and B.F.S.
STRATUM II Soft / firm brownish grey / grey silty clay / clayey silt with traces of kankars.
STRATUM III Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium percent) of decomposed wood.
STRATUM IV Stiff / very stiff bluish grey / mottled brown silty clay / clayey silt with traces of rusty brown silt spots.

During fieldwork, E.G.L. was about 0.40 m., 0.50 m., 0.70 m., 0.60 m., 0.70 m. & 0.50 m. below H.T. Tower Raft Top Level in B.H.1, B.H.2, B.H.3, B.H.4, B.H.5 & B.H.6 respectively.

NOTE : For Average Engineering Properties of each stratum, refer Page No. 9 of TEXT.
As per clause 5.6.3 & 5.6.4 of I.S. 2131 - 2025, overburden & distance corrections would not be applicable in cohesive soil. Hence in present case, field 'N' values of cohesive stratum have not been corrected.

Report on Geotechnical Investigation for Proposed

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6A, Milan Park , Kolkata - 700 084.

4. Laboratory Test Results

Location: Jheel Road, Kolkata.

Bore Hole Number	Type of Sample	Sample Depth (m)	Description	Grain Size Analysis					Natural Moisture Content (%)	Bulk Unit Weight (kN/m ³)	Dry Unit Weight (kN/m ³)	Atterberg Limits			Shear Strength Parameters			Specific Gravity G _s	Initial Void Ratio, e ₀
				Type of Test	Gravel (%)	Sand (%)	Silt (%)	Clay (%)				Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion, C (kN/m ²)	φ (degrees)		
P - 1		0.50	Fly ash mixed with kankars and brick pieces.	S.A.	1	27	72	72	-	-	-	Non-plastic			-	-	-	-	-
P - 2		4.50	P.C.C over B.F.S from 1.40 m. to 4.50 m.	H.A.	-	8	64	28	-	-	-	45	22	23	-	-	-	-	-
U - 1		6.00	Brownish grey / grey clayey silt with rusty brown silt spots and traces of mica.	H.A.	-	5	65	30	32.45	18.44	13.92	50	23	27	UCS	30.00	-	2.65	0.737
P - 3		7.50	8.50	H.A.	-	8	68	24	-	-	-	45	21	24	-	-	-	-	-
U - 2		9.00	Grey silty clay / clayey silt with traces to medium percentage of decomposed wood.	H.A.	-	2	58	40	53.91	16.36	10.63	80	27	53	UCS	18.00	-	2.49	1.292
U - 3		12.00	Top:- Grey silty clay / clayey silt with traces of decomposed wood.	H.A.	-	3	60	37	46.36	16.54	11.30	-	-	-	UCS	20.00	-	-	-
P - 5		13.50	Bottom:- Bluish grey silty clay / clayey silt with rusty brown silt spots.	H.A.	-	5	59	36	-	-	-	60	24	36	-	-	-	-	-
U - 4		15.00	Bluish grey / mottled brown silty clay / clayey silt with rusty brown silt spots.	H.A.	-	6	59	35	28.71	19.21	14.93	54	22	32	UCS	53.00	-	2.66	0.729
U - 5		18.00		-	-	-	-	-	25.73	19.48	15.49	-	-	-	UU	56.00	6	-	-
P - 7		19.50		H.A.	-	7	63	30	-	-	-	50	21	29	-	-	-	-	-
U - 6		21.00		H.A.	-	6	60	34	24.32	19.23	15.47	56	22	34	UU	88.00	0	2.67	-
U - 7		24.00		-	-	-	-	-	24.14	19.06	15.35	-	-	-	UU	76.00	0	-	-
P - 9		25.00		H.A.	-	5	60	35	-	-	-	58	23	35	-	-	-	-	-

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* Combined % of Silt and Clay.

Abbreviations used : H.A = Hydrometer Analysis, UU = Unconsolidated Undrained Triaxial Test, UCS = Unconfined Compressive Strength Test, S.A = Sieve Analysis, U = Undisturbed Sample, P = Standard Penetration Test Sample.

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Request for Selection (RfS) Document for setting up of 40 MW/80MWh Standalone Battery Energy Storage Systems in Kolkata under Tariff-Based Competitive Bidding

RfS No. ED(PM)/2025-26/266 dated 30.07.2025

Addendum-13

Date:04.11.2025

Report on Geotechnical

Geotest Engineers Pvt.Ltd. 6A, Milan Park, Kolkata - 700 084.														
Location: Jheel Road, Kolkata.														
Bore Hole Number	Type of Sample	Sample Depth (m)	Description	Grain Size Analysis					Natural Moisture Content (%)	Bulk Unit Weight (kN/m ³)	Dry Unit Weight (kN/m ³)	Atterberg Limits		
				Type of Test	Gravel (%)	Sand (%)	Silt (%)	Clay (%)				Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
B.H.2	U - 1	0.50	Cinder.	S.A.	-	84	16	23.42	-	-	-	-	-	-
	U - 2	4.50	P.C.C over B.F.S from 1.00 m. to 4.50 m.	H.A.	-	7	64	29	23.98	14.88	14.48	22	23	22
	P - 1	6.00	Brownish grey / grey silty clay / clayey silt with rusty brown silt spots.	H.A.	-	4	66	30	-	-	-	45	24	26
	U - 3	7.50	Grey silty clay with traces to medium percentage of decomposed wood.	H.A.	-	1	55	44	49.20	16.54	11.09	82	28	54
	U - 4	10.50		-	-	-	-	-	38.54	17.40	12.56	-	-	-
	P - 3	12.00		H.A.	-	3	60	37	-	-	-	70	25	45
	U - 5	13.50	13.20	H.A.	-	6	60	34	28.84	19.02	14.76	59	24	35
	U - 6	16.50	Bluish grey / mottled brown silty clay / clayey silt with rusty brown silt spots.	-	-	-	-	-	26.32	19.53	15.46	-	-	0
	U - 7	19.50		H.A.	-	7	61	32	25.20	19.21	15.34	56	23	33
U - 8		22.50		-	-	-	-	-	24.95	18.96	15.17	-	-	-
U - 9		25.00		H.A.	-	8	62	30	24.41	19.42	15.61	52	21	31
* Combined % of Silt and Clay.														
Abbreviations used : H.A = Hydrometer Analysis, UU = Unconsolidated Undrained Triaxial Test, UCS = Unconfined Compressive Strength Test, S.A = Sieve Analysis, U = Undisturbed Sample, P = Standard Penetration Test Sample.														
													Page No.- 27	

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Addendum-13

Date:04.11.2025

Report on Geotechnical In

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Soil Investigators & Land Surveyors

Report on Geotechnical Investigation for

Geotest Engineers Pvt.Ltd.
6A, Milan Park , Kolkata - 700 084.

Location: Jheel Road, Kolkata.

Bore Hole Number	Type of Sample	Sample Depth (m)	Description	Grain Size Analysis					Natural Moisture Content (%)	Bulk Unit Weight (kN/m ³)	Dry Unit Weight (kN/m ³)	Atterberg Limits			Shear Strength Parameters		Specific Gravity G _s	Initial Void Ratio, e ₀	
				Type of Test	Gravel (%)	Sand (%)	Silt (%)	Clay (%)				Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion, C (kN/m ²)	φ (degrees)		
B.H.4	P - 1	2.50	Fly ash mixed with kankars and brick pieces. R.C.C and P.C.C from 0.50 m. to 2.50	H.A.	-	9	64	27	-	-	-	44	22	22	-	-	-	-	-
	U - 1	4.00		H.A.	-	6	65	29	31.52	18.62	14.16	48	23	25	UCS	31.00	-	2.65	0.785
	U - 2	7.00		H.A.	-	10	66	24	25.69	18.54	14.75	40	21	19	UU	33.00	8	2.66	-
	P - 3	8.50	Grey silty clay with traces to medium percentage of decomposed wood. 7.50	H.A.	-	1	54	45	-	-	-	84	29	55	-	-	-	-	-
	U - 3	10.00		H.A.	-	2	58	40	44.52	16.38	11.33	80	27	53	UCS	20.00	-	2.50	1.185
	P - 4	11.50		H.A.	-	1	55	44	-	-	-	83	28	55	-	-	-	-	-
	U - 4	13.00	Bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots. 12.80	H.A.	2	6	58	34	28.92	19.02	14.75	-	-	-	UCS	50.00	-	2.66	0.702
	U - 5	16.00		-	-	-	-	-	26.88	19.34	15.24	-	-	-	UU	56.00	0	-	-
	U - 6	19.00		H.A.	-	8	64	28	25.54	19.11	15.22	43	21	22	UU	61.00	0	2.67	-
	U - 7	22.00		-	-	-	-	-	24.69	19.36	15.53	-	-	-	UCS	91.00	-	-	-
U - 8	U - 8	25.00	25.45	H.A.	-	7	60	33	24.24	19.06	15.34	55	22	33	UCS	108.00	-	2.68	0.783

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Abbreviations used : H.A = Hydrometer Analysis, UU = Unconsolidated Undrained Triaxial Test, UCS = Unconfined Compressive Strength Test, U = Undisturbed Sample, P = Standard Penetration Test Sample.

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 Geotest Engineers Pvt.Ltd. 6A, Milan Park , Kolkata - 700 084.														
Location: Jheel Road, Kolkata.														
Bore Hole Number	Type of Sample	Sample Depth (m)	Description	Grain Size Analysis					Natural Moisture Content (%)	Bulk Unit Weight (kN/m ³)	Dry Unit Weight (kN/m ³)	Atterberg Limits		
				Type of Test	Gravel (%)	Sand (%)	Silt (%)	Clay (%)				Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
B.H.5			Fly ash mixed with kankars and brick pieces.											
			R.C.C. and P.C.C. from 0.50 m. to 2.70 m.						Filled up Soil					
	U - 1	3.00	2.70 ————— Brownish grey / grey silty clay / clayey silt with rusty brown silt spots and traces of mica.	H.A.	-	6	64	30	32.12	18.52	14.02	51	24	27
	U - 2	6.00	————— Brownish grey / grey silty clay / clayey silt with rusty brown silt spots and traces of mica.	H.A.	-	7	65	28	30.02	18.66	14.35	49	22	27
	P - 2	7.50	7.00 ————— Grey silty clay with traces to medium percentage of decomposed wood.	H.A.	-	3	59	38	-	-	-	-	-	-
	U - 3	9.00	————— Grey silty clay with traces to medium percentage of decomposed wood.	-	-	-	-	-	52.63	16.35	10.71	-	-	-
	U - 4	12.00	————— Grey silty clay with traces to medium percentage of decomposed wood.	H.A.	-	1	53	46	52.30	16.26	10.68	82	28	54
	P - 4	13.50	13.00 ————— Bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots.	H.A.	2	7	56	35	-	-	-	55	22	33
	U - 5	15.00	————— Bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots.	-	-	-	-	-	26.82	19.39	15.29	-	-	-
	U - 6	18.00	————— Bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots.	H.A.	-	8	64	28	25.27	19.21	15.33	48	21	27
	U - 7	21.00	————— Bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots.	-	-	-	-	-	24.78	19.63	15.73	-	-	-
	U - 8	24.00	————— Bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots.	H.A.	-	6	59	35	24.76	19.27	15.45	49	22	27
	P - 8	25.50	25.95 ————— Bluish grey / mottled brown silty clay / clayey silt with traces of kankars and rusty brown silt spots.	H.A.	-	7	63	30	-	-	-	50	22	28
														Page No.- 30

Abbreviations used : H.A = Hydrometer Analysis, UU = Unconsolidated Undrained Triaxial Test, UCS = Unconfined Compressive Strength Test, U = Undisturbed Sample, P = Standard Penetration Test Sample.

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Ph. : 91-33-2430 3494 / 8103 / 9717

Geotest Engineers Pvt.Ltd. 6A, Milan Park , Kolkata - 700 084.														
Location:		Jheel Road, Kolkata.												
Bore Hole Number	Type of Sample	Sample Depth (m)	Description	Grain Size Analysis				Natural Moisture Content (%)	Bulk Unit Weight (kN/m ³)	Dry Unit Weight (kN/m ³)	Atterberg Limits			Initial Void Ratio, e ₀
				Type of Test	Gravel (%)	Sand (%)	Silt (%)				Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	
B.H.6	P - 1	0.50	Fly ash mixed with kankars and brick pieces.	S.A.	3	30	*67	-	-	-	Non-plastic			-
			P.C.C. over B.F.S from 1.00 m. to 3.20 m.					Filled up Soil						
	P - 2	3.50	Brownish grey / grey silty clay / clayey silt with traces of kankars and rusty brown silt spots.	H.A.	2	5	58	35	-	-	62	24	38	-
	U - 1	5.00		H.A.	2	7	63	28	18.65	14.46	46	21	25	0.593
	P - 3	6.50		H.A.	-	8	68	24	-	-	40	22	18	-
	U - 2	8.00	Grey silty clay with traces to medium percentage of decomposed wood.	H.A.	-	3	60	37	17.65	12.99	70	25	45	0.905
	U - 3	11.00		-	-	-	-	-	16.25	10.60	-	-	-	-
	P - 5	12.50		H.A.	-	2	58	40	-	-	78	27	51	-
	U - 4	14.00	Bluish grey / mottled brown silty clay / clayey silt with rusty brown silt spots.	H.A.	2	6	57	35	19.36	15.18	57	22	35	0.789
	U - 5	17.00		-	-	-	-	-	19.60	15.63	-	-	-	-
	U - 6	20.00		H.A.	-	7	64	29	19.23	15.45	50	22	28	-
	U - 7	23.00		-	-	-	-	-	19.73	15.90	-	-	-	-
	P - 9	25.00		H.A.	-	8	59	33	23.85	-	54	21	33	-
														Page No. - 31

Abbreviations used : H.A = Hydrometer Analysis, UU = Unconsolidated Undrained Triaxial Test, UCS = Unconfined Compressive Strength Test, S.A = Sieve Analysis, U = Undisturbed Sample, P = Standard Penetration Test Sample.

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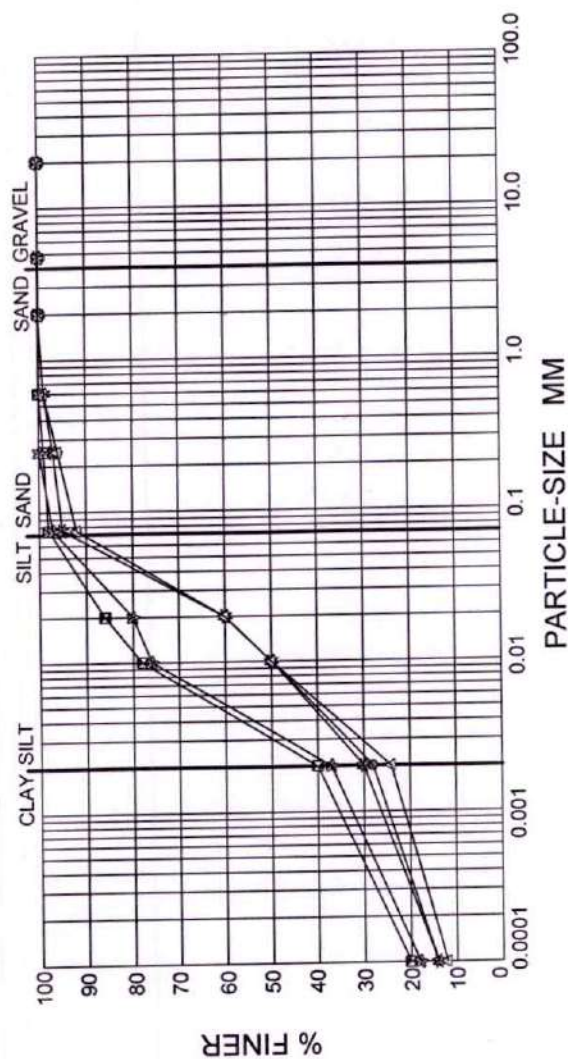
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Soil Investigators & Land Surveyors

Ph. : 91-33-2430 3494 / 8103 / 9717

5. PARTICLE - SIZE DISTRIBUTION CURVES a. HYDROMETER ANALYSIS

Location : Jheel Road, Kolkata.



CLAY %		SILT %		SAND %		GRAVEL %	
FINE	COARSE	FINE	COARSE	FINE	COARSE	FINE	COARSE

LEGEND

B.H. NO.	DEPTH	CLAY %	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE	GRAVEL %
1.	4.50 m.	28	64	08	05	08	02	03	03	03	03
1.	6.00 m.	30	65	05	08	02	03	03	03	03	03
1.	7.50 m.	24	68	08	02	03	03	03	03	03	03
1.	9.00 m.	40	58	02	03	03	03	03	03	03	03
1.	13.50 m. (Top)	37	60	03	03	03	03	03	03	03	03

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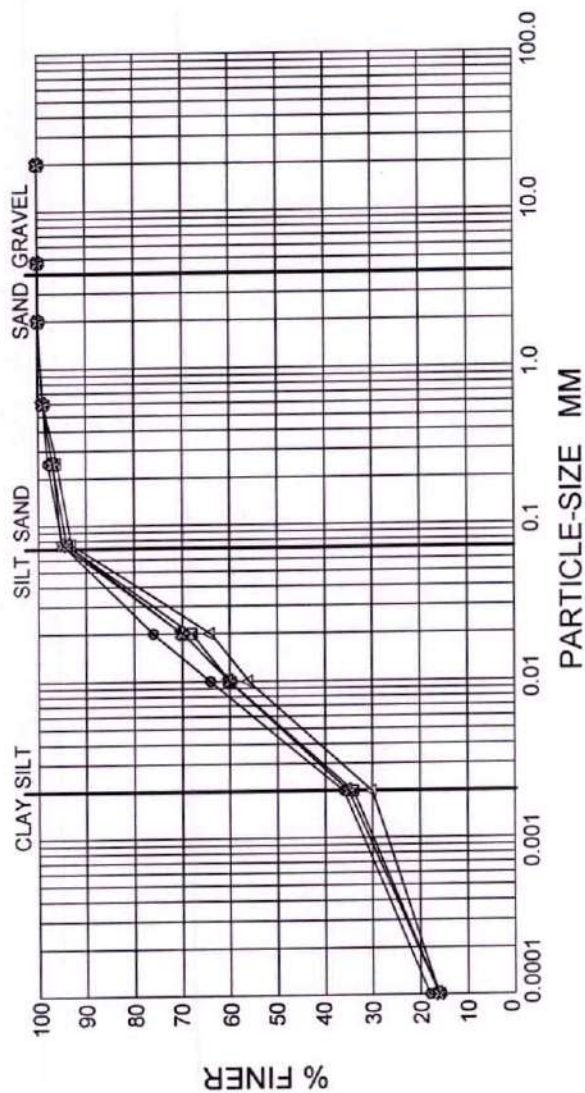
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PARTICLE - SIZE DISTRIBUTION CURVES

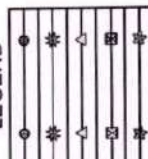
Location : Jheel Road, Kolkata.



CLAY %		SILT %		SAND %		GRAVEL %	
FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE

B.H. NO.	DEPTH	CLAY %	FINE	MEDIUM	COARSE	SILT %	FINE	MEDIUM	COARSE	SAND %	FINE	COARSE	GRAVEL %
1.	13.50 m (Bottom)	36				59				05			--
1.	15.00 m.	35				59				06			--
1.	19.50 m.	30				63				07			--
1.	21.00 m.	34				60				06			--
1.	25.00 m.	35				60				05			--

LEGEND



PAGE NO. : 33

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Request for Selection (RfS) Document for setting up of 40 MW/80MWh Standalone Battery Energy Storage Systems in Kolkata under Tariff-Based Competitive Bidding

RfS No. ED(PM)/2025-26/266 dated 30.07.2025

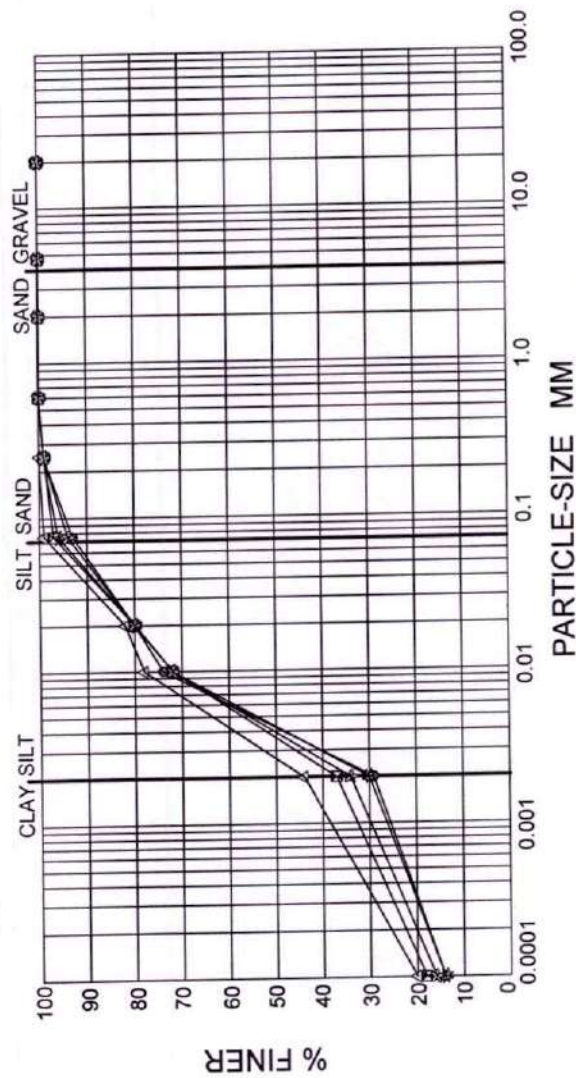
Addendum-13

Date:04.11.2025

Report on Geotechnical In

PARTICLE - SIZE DISTRIBUTION CURVES

Location : Jheel Road, Kolkata.



CLAY %			SILT %			SAND %			GRAVEL %	
FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE

LEGEND

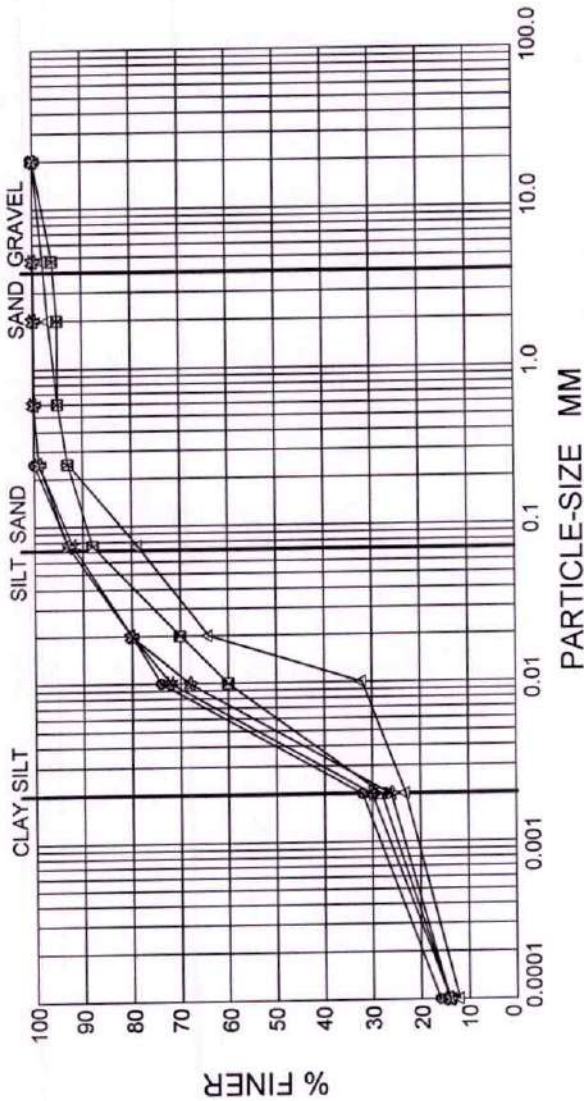
B.H. NO.	DEPTH	CLAY %	FINE SILT %	MEDIUM SILT %	COARSE SILT %	FINE SAND %	MEDIUM SAND %	COARSE SAND %	FINE GRAVEL %	COARSE GRAVEL %
2.	4.50 m.	29	64	07	00	00	00	00	00	00
2.	6.00 m.	30	66	04	00	00	00	00	00	00
2.	7.50 m.	44	55	01	00	00	00	00	00	00
2.	12.00 m.	37	60	03	00	00	00	00	00	00
2.	13.50 m.	34	60	06	00	00	00	00	00	00

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PARTICLE - SIZE DISTRIBUTION CURVES

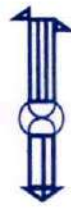
Location : Jheel Road, Kolkata.



CLAY %		SILT %		SAND %		GRAVEL %	
FINE	COARSE	FINE	COARSE	FINE	COARSE	FINE	COARSE

B.H. NO.	DEPTH	CLAY %		SILT %		SAND %		GRAVEL %		LEGEND
		FINE	COARSE	FINE	COARSE	FINE	COARSE	FINE	COARSE	
2.	19.50 m.	32		61		07		--		●
2.	25.00 m.	30		62		08		--		■
3.	3.00 m.	23		56		19		02		▲
3.	4.50 m.	28		60		08		04		□
3.	6.00 m.	26		67		07		--		■

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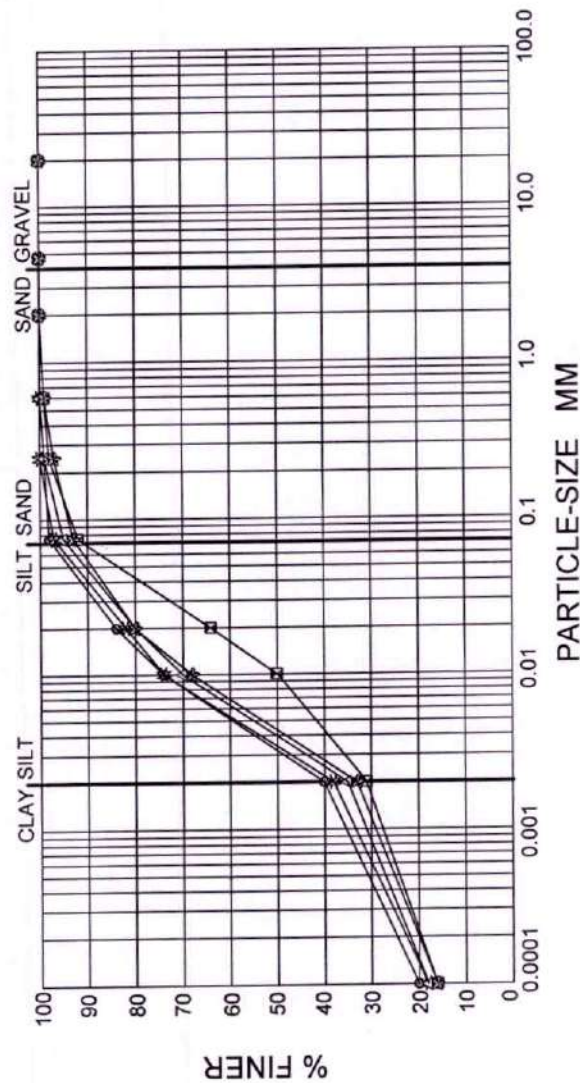
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Ph. : 91-33-2430 3494 / 8103 / 9717

PARTICLE - SIZE DISTRIBUTION CURVES

Location : Jheel Road, Kolkata.



CLAY %	SILT %		SAND %		GRAVEL %	
	FINE	COARSE	FINE	COARSE	FINE	COARSE

LEGEND

B.H. NO.	DEPTH	CLAY %	FINE SILT %	COARSE SILT %	FINE SAND %	COARSE SAND %	FINE GRAVEL %	COARSE GRAVEL %
3.	8.00 m.	40	58	02	--	--	--	--
3.	12.50 m.	38	59	03	--	--	--	--
3.	14.00 m.	35	60	05	--	--	--	--
3.	18.50 m.	31	61	08	--	--	--	--
3.	25.00 m.	33	60	07	--	--	--	--

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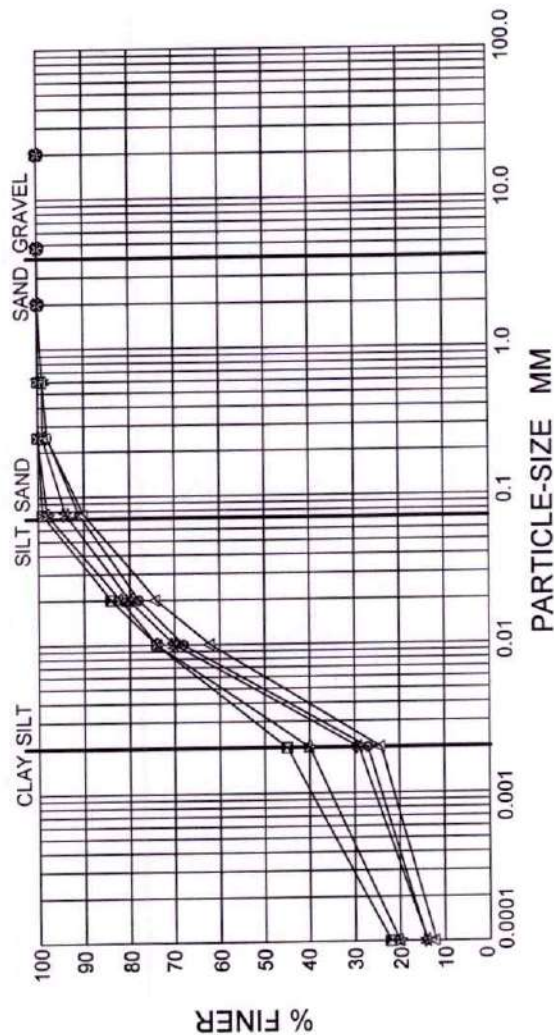
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Report on Geotechnical Investigation for Proposed

PARTICLE - SIZE DISTRIBUTION CURVES

Location : Jheel Road, Kolkata.



CLAY %			SILT %			SAND %			GRAVEL %	
FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE

B.H. NO.	DEPTH	CLAY %	FINE	MEDIUM	COARSE	SILT %	FINE	MEDIUM	COARSE	SAND %	FINE	COARSE	GRAVEL %	LEGEND
4.	2.50 m.	27				64				09			--	●
4.	4.00 m.	29				65				06			--	★
4.	7.00 m.	24				66				10			--	△
4.	8.50 m.	45				54				01			--	□
4.	10.00 m.	40				58				02			--	☆

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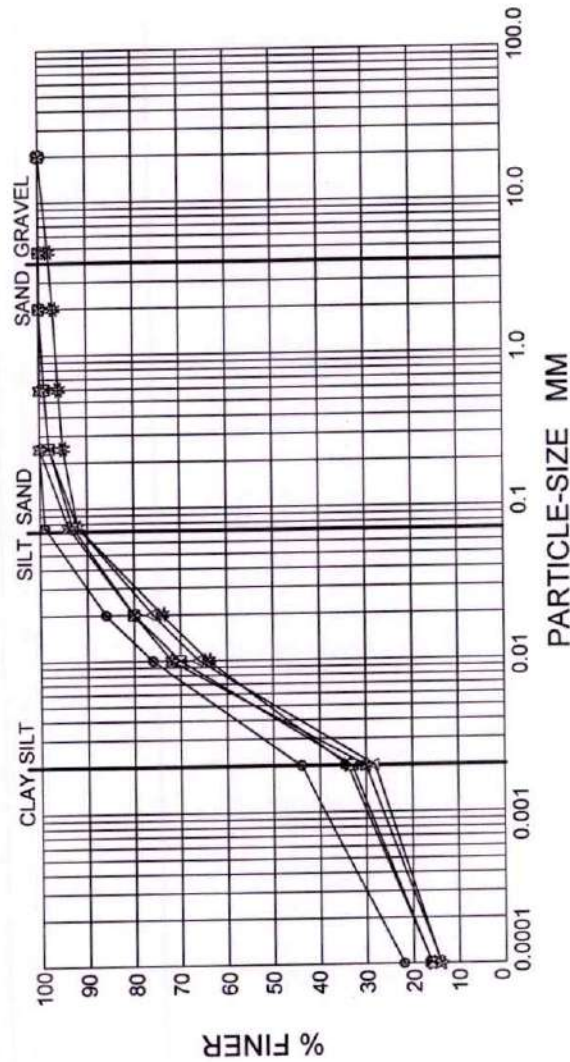
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PARTICLE - SIZE DISTRIBUTION CURVES

Location : Jheel Road, Kolkata.



CLAY %			SILT %			SAND %			GRAVEL %	
FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE

LEGEND

B.H. NO.	DEPTH	CLAY %	FINE	MEDIUM	COARSE	SILT %	FINE	MEDIUM	COARSE	SAND %	FINE	MEDIUM	COARSE	GRAVEL %
4.	11.50 m.	44				55				01				--
4.	13.00 m.	34				58				06				02
4.	19.00 m.	28				64				08				--
4.	25.00 m.	33				60				07				--
5.	3.00 m.	30				64				06				--

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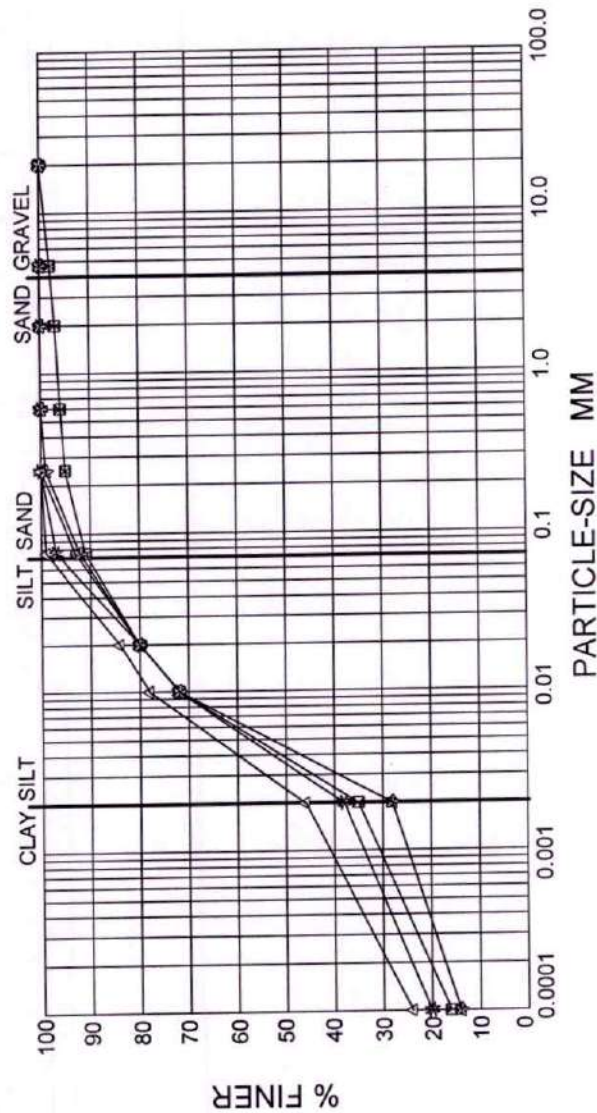
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PARTICLE - SIZE DISTRIBUTION CURVES

Location : Jheel Road, Kolkata.



CLAY %		SILT %		SAND %		GRAVEL %	
FINE	COARSE	FINE	COARSE	FINE	COARSE	FINE	COARSE

B.H. NO.	DEPTH	CLAY %	FINE	MEDIUM	COARSE	SILT %	FINE	MEDIUM	COARSE	SAND %	FINE	COARSE	GRAVEL %
5.	6.00 m.	28				65				07			--
5.	7.50 m.	38				59				03			--
5.	12.00 m.	46				53				01			--
5.	13.50 m.	35				56				07			02
5.	18.00 m.	28				64				08			--

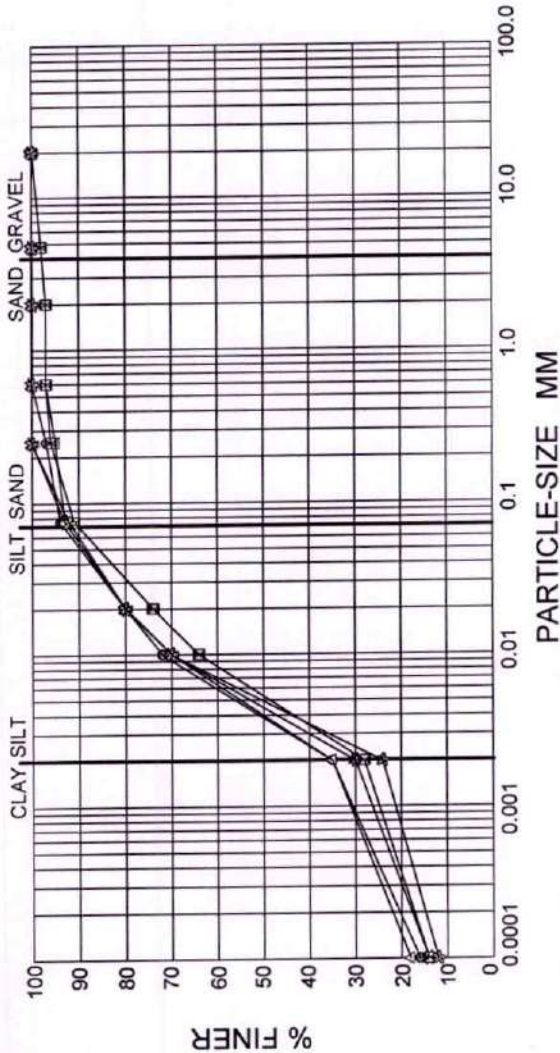
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PAGE NO. : 39



PARTICLE - SIZE DISTRIBUTION CURVES

Location : Jheel Road, Kolkata.



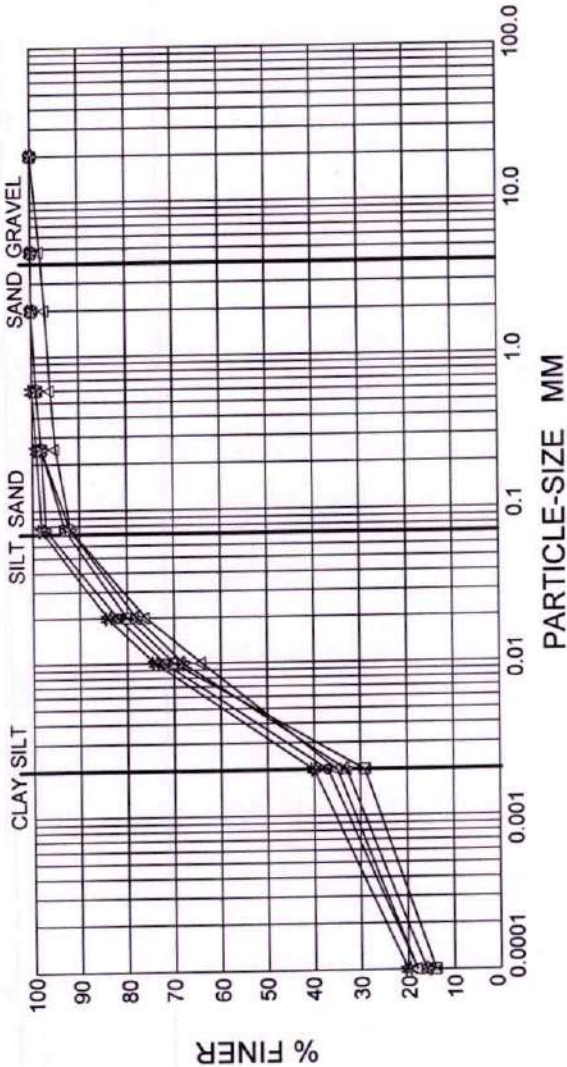
CLAY %		FINE SILT %		MEDIUM SAND %		FINE GRAVEL %	
FINE	COARSE	FINE	COARSE	FINE	COARSE	FINE	COARSE

B.H. NO.	DEPTH	CLAY %	FINE SILT %	MEDIUM SAND %	FINE GRAVEL %	LEGEND
5.	24.00 m.	35	59	06	--	●
5.	25.50 m.	30	63	07	--	■
6.	3.50 m.	35	58	05	02	△
6.	5.00 m.	28	63	07	02	□
6.	6.50 m.	37	60	03	--	×



PARTICLE - SIZE DISTRIBUTION CURVES

Location : Jheel Road, Kolkata.



CLAY %			SILT %			SAND %			GRAVEL %	
FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE

B.H. NO.	DEPTH	CLAY %	FINE	MEDIUM	COARSE	SILT %	FINE	MEDIUM	COARSE	SAND %	FINE	COARSE	GRAVEL %	LEGEND
6.	8.00 m.	37				60				03			--	●
6.	12.50 m.	40				58				02			--	●
6.	14.00 m.	35				57				06			02	△
6.	20.00 m.	29				64				07			--	■
6.	25.00 m.	33				59				08			--	■

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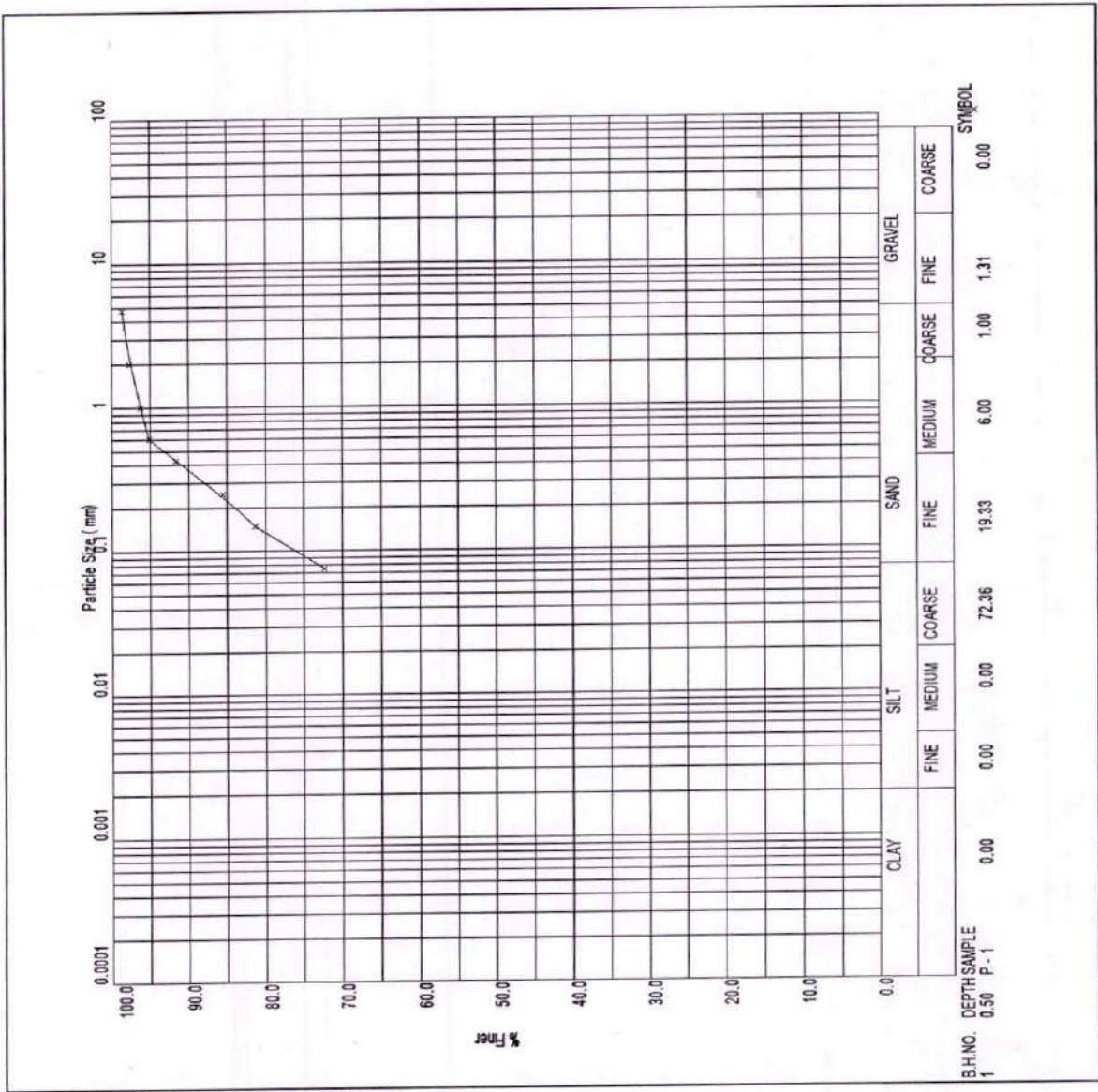
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5.b. Sieve Analysis

Project: Jheel Road, Kolkata.



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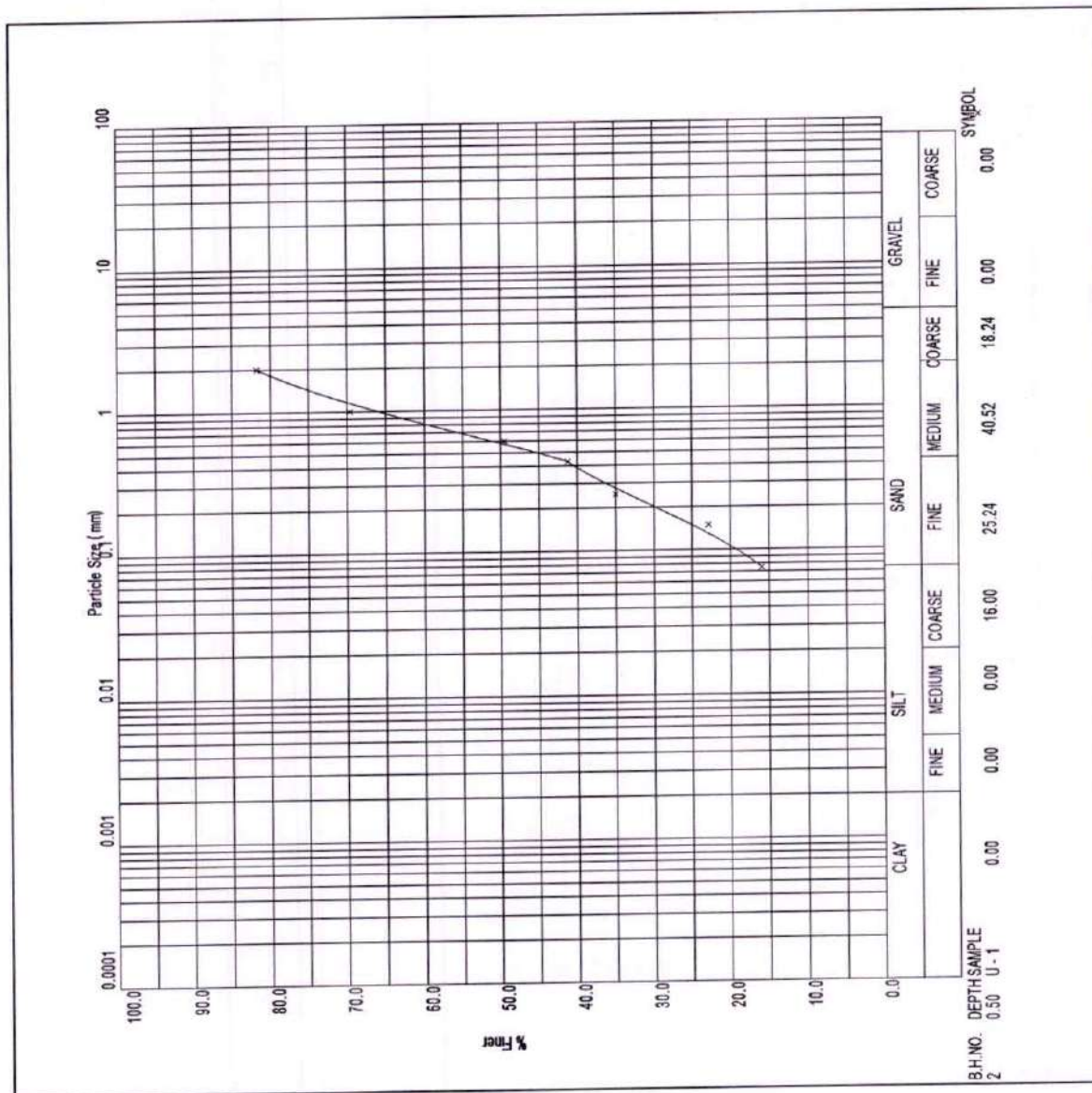
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Project: Jheel Road, Kolkata.



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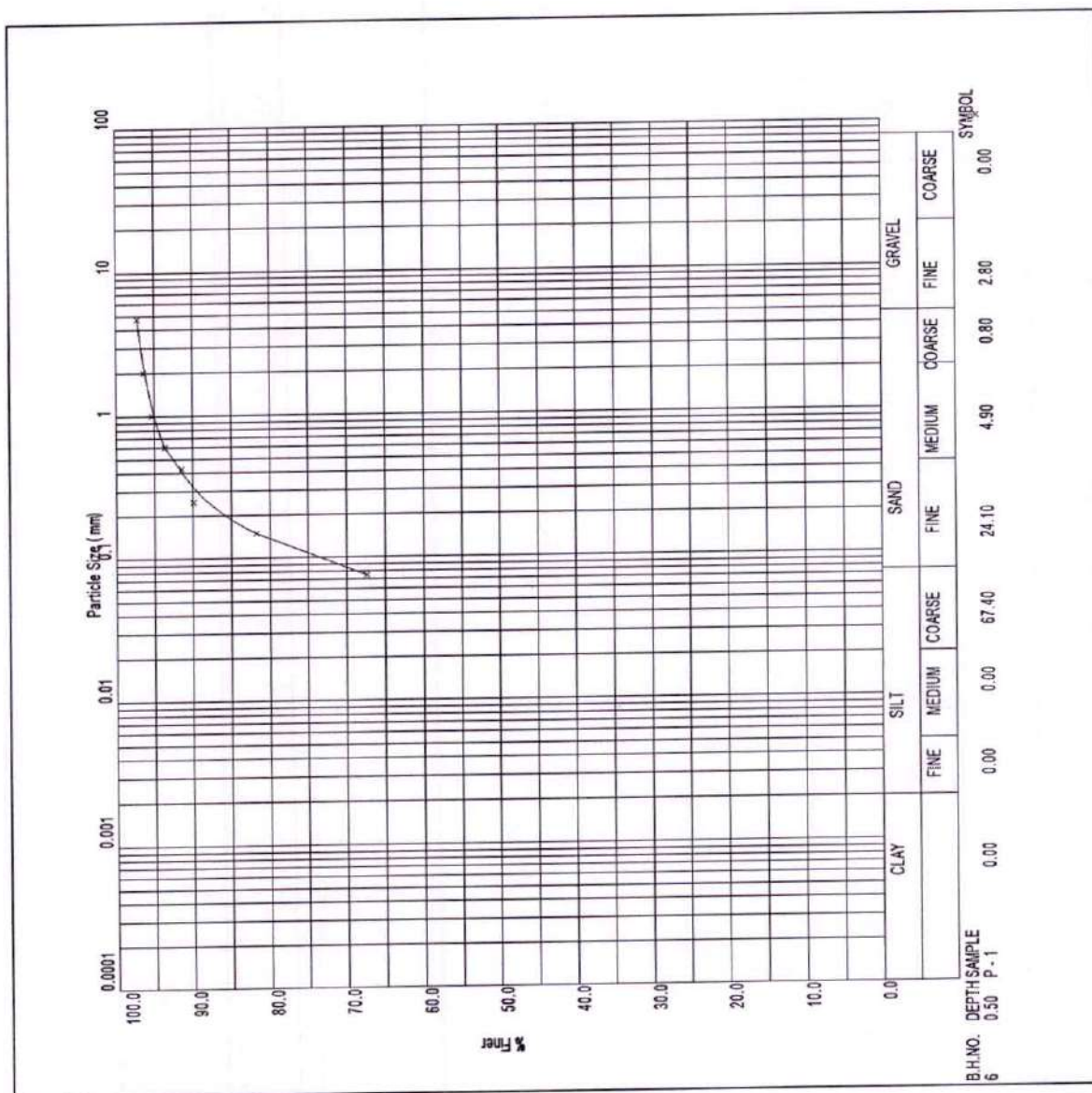
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Project: Jheel Road, Kolkata.



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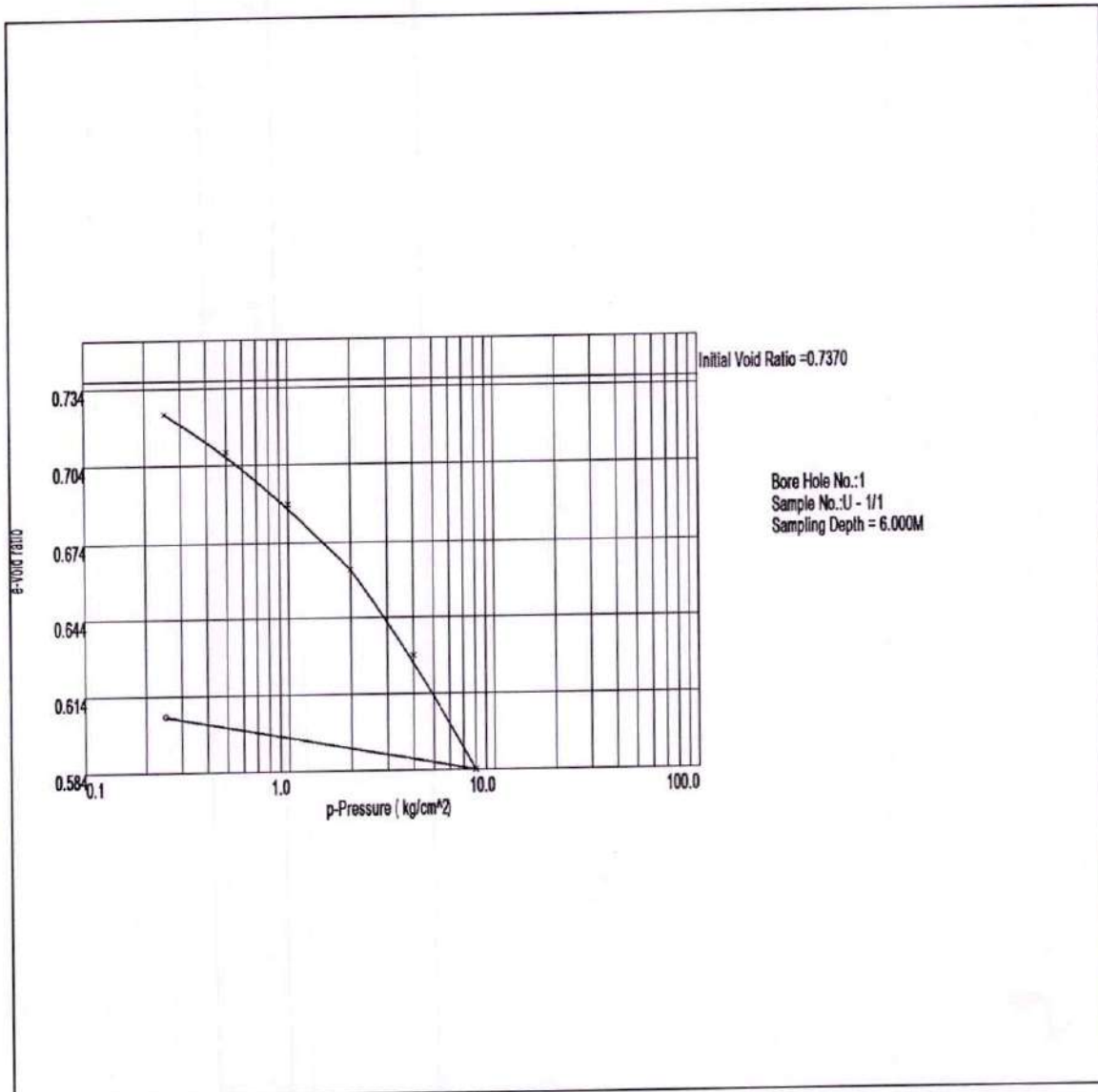
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6. Consolidation Test

a. $e - \log_{10} P$ Curves

Project: Jheel Road, Kolkata.



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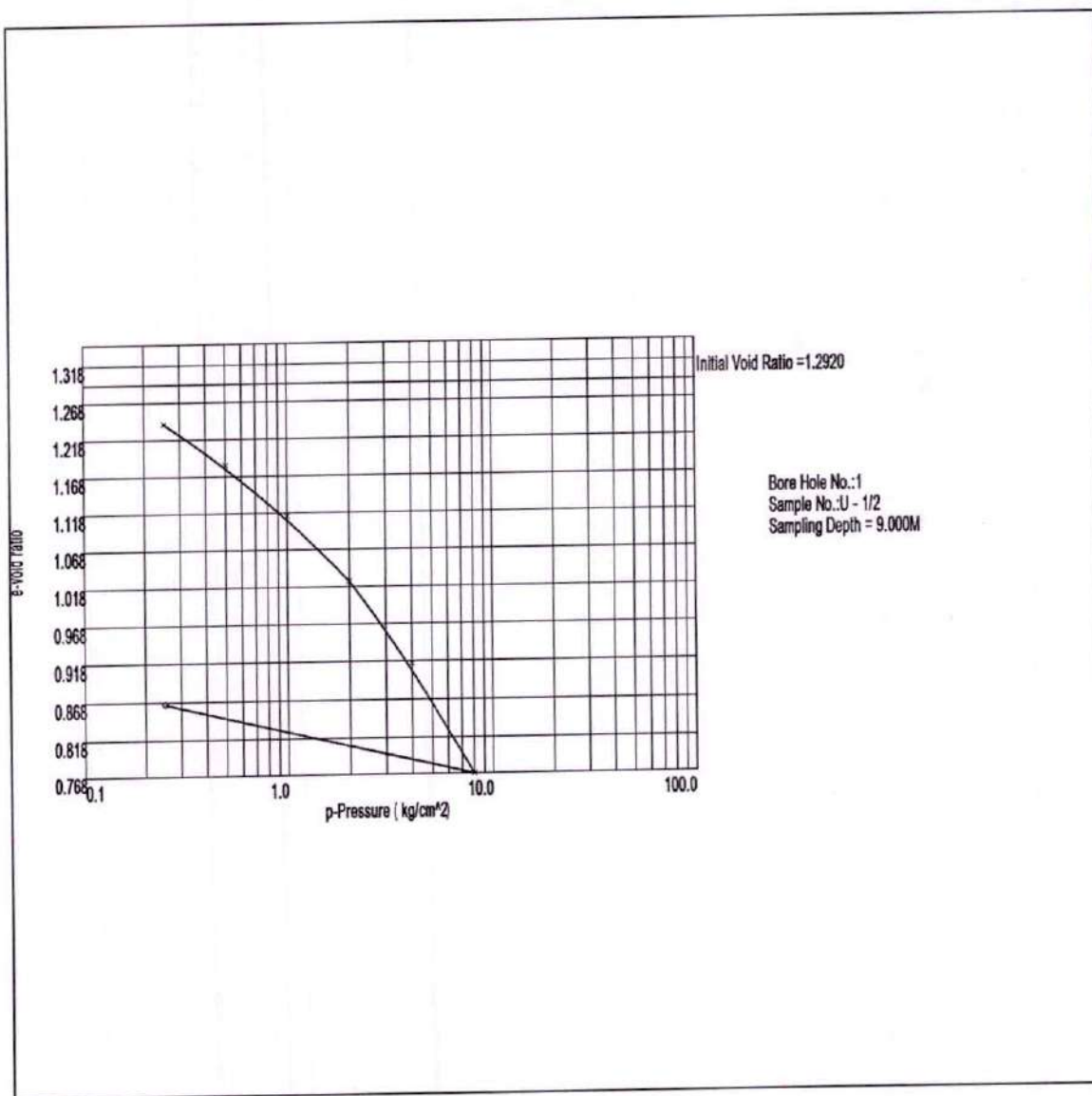
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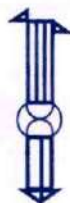
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Project: Jheel Road, Kolkata.



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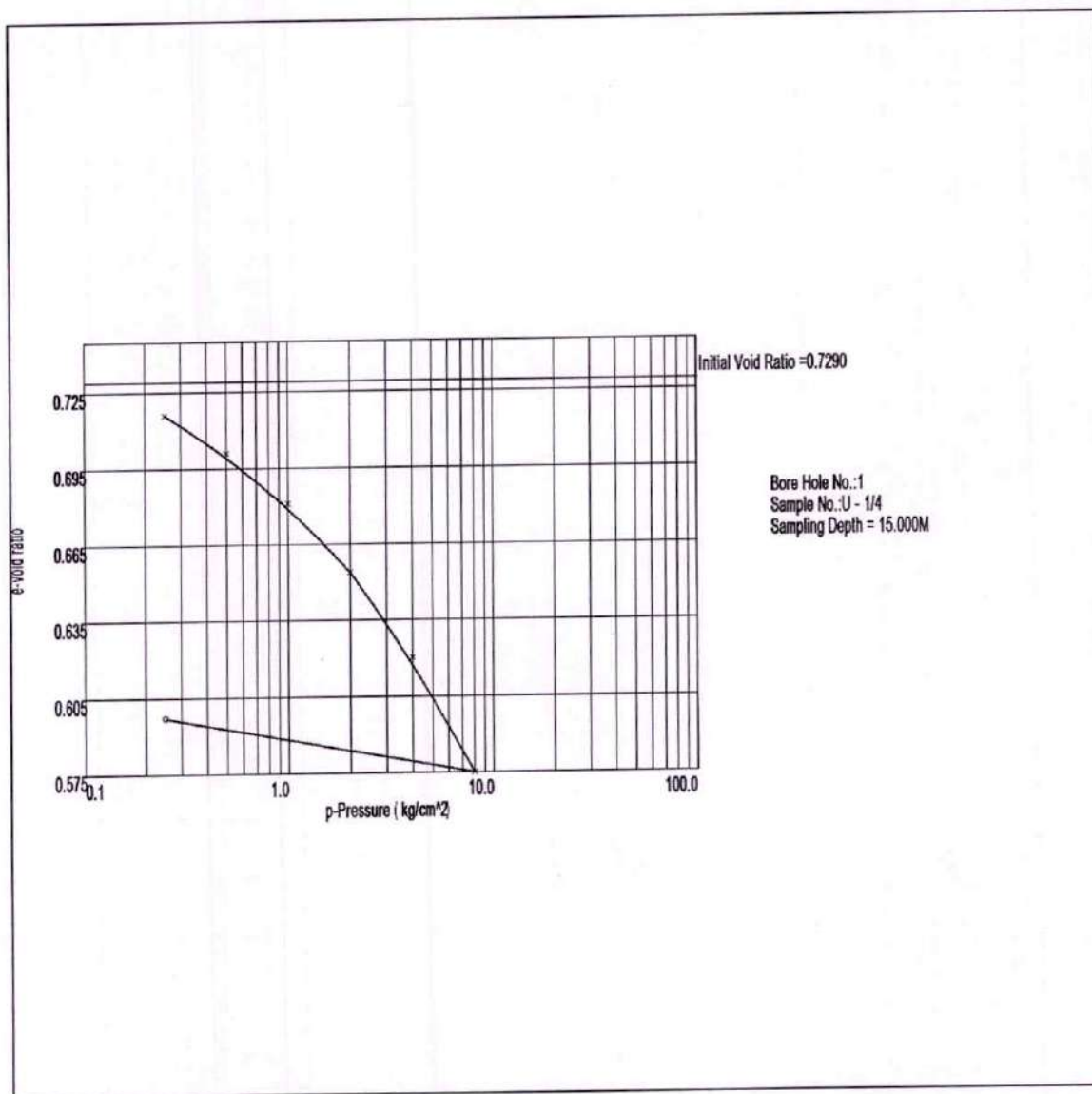
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Project: Jheel Road, Kolkata.



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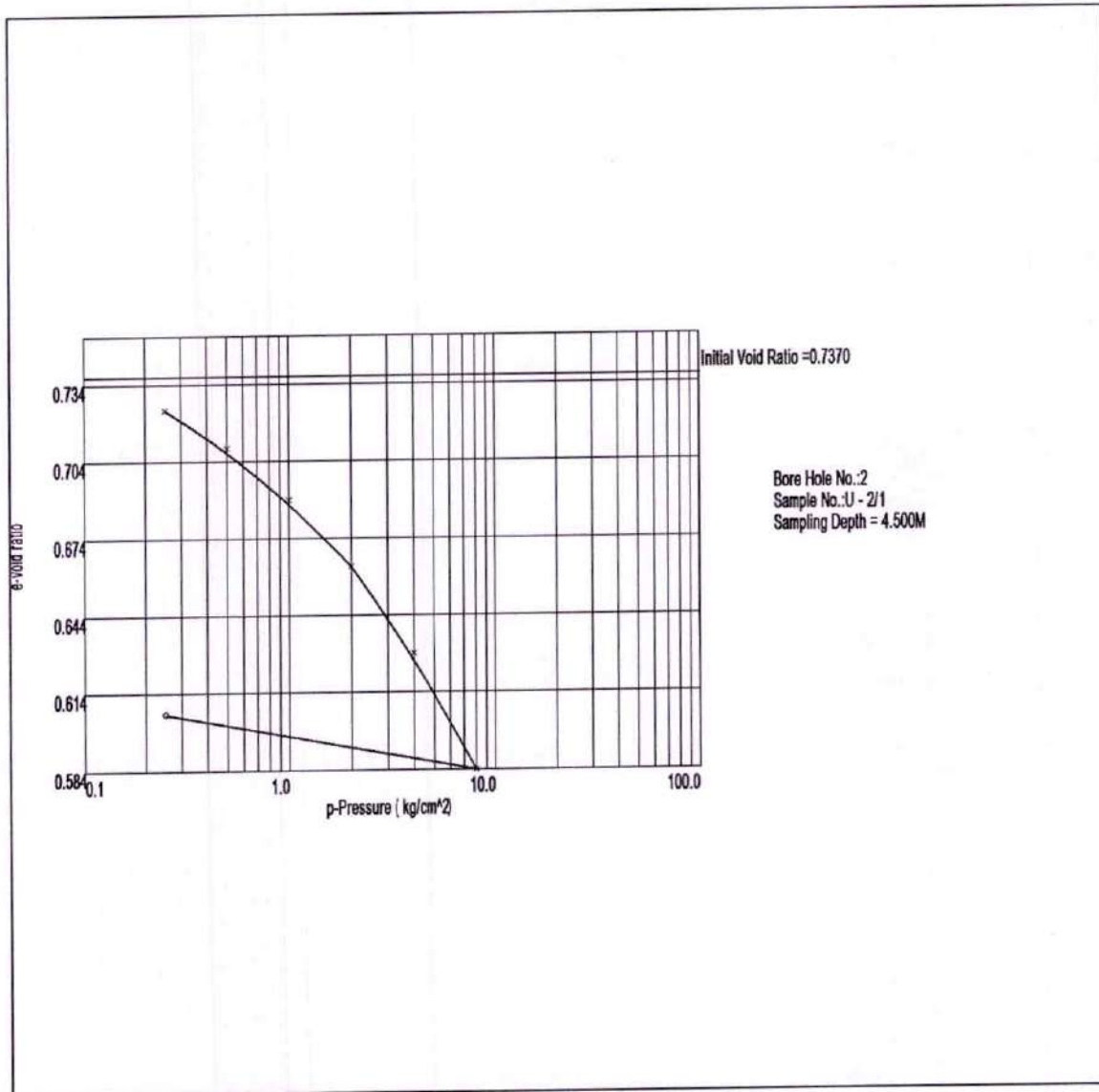
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Project: Jheel Road, Kolkata.



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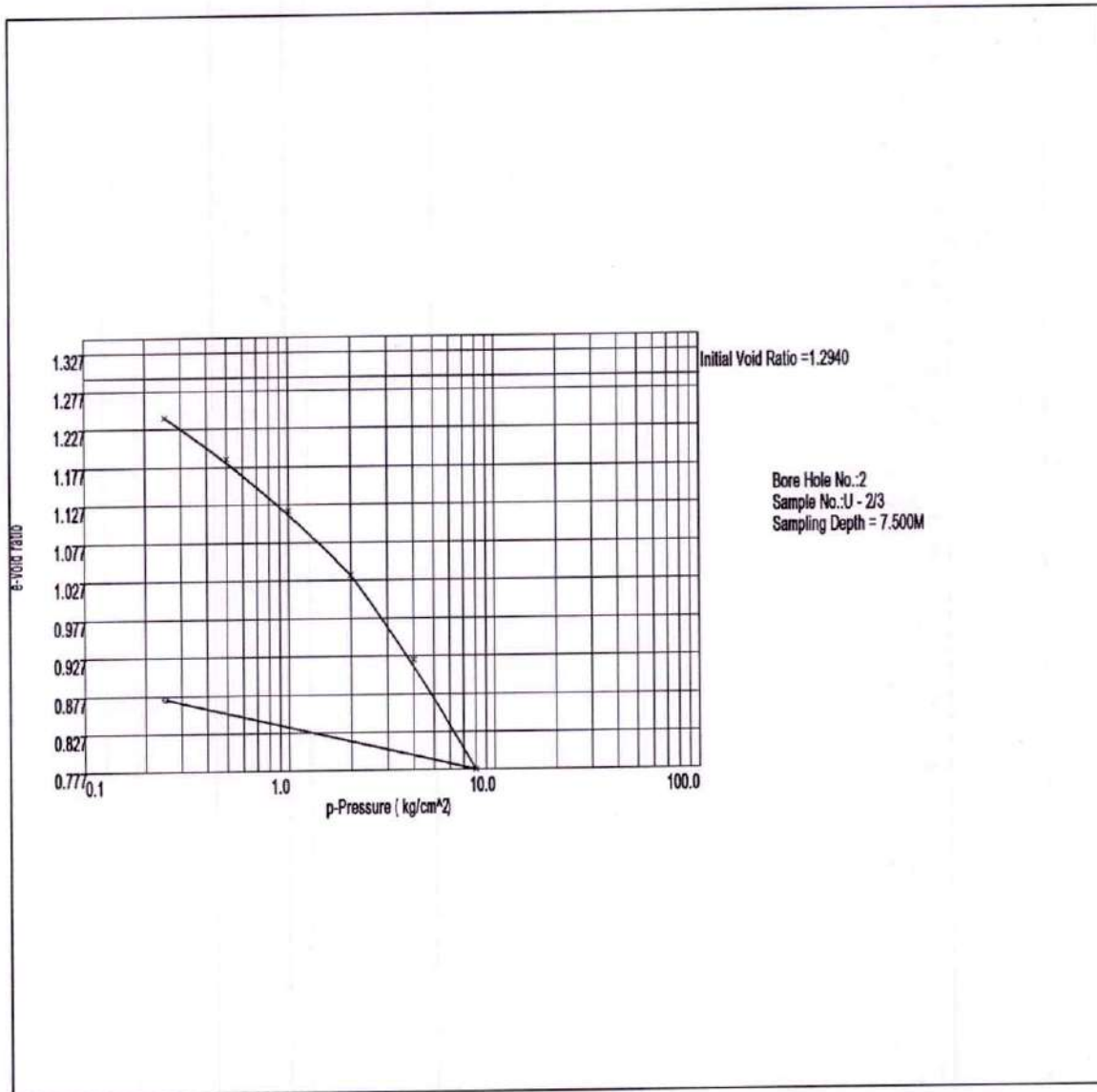
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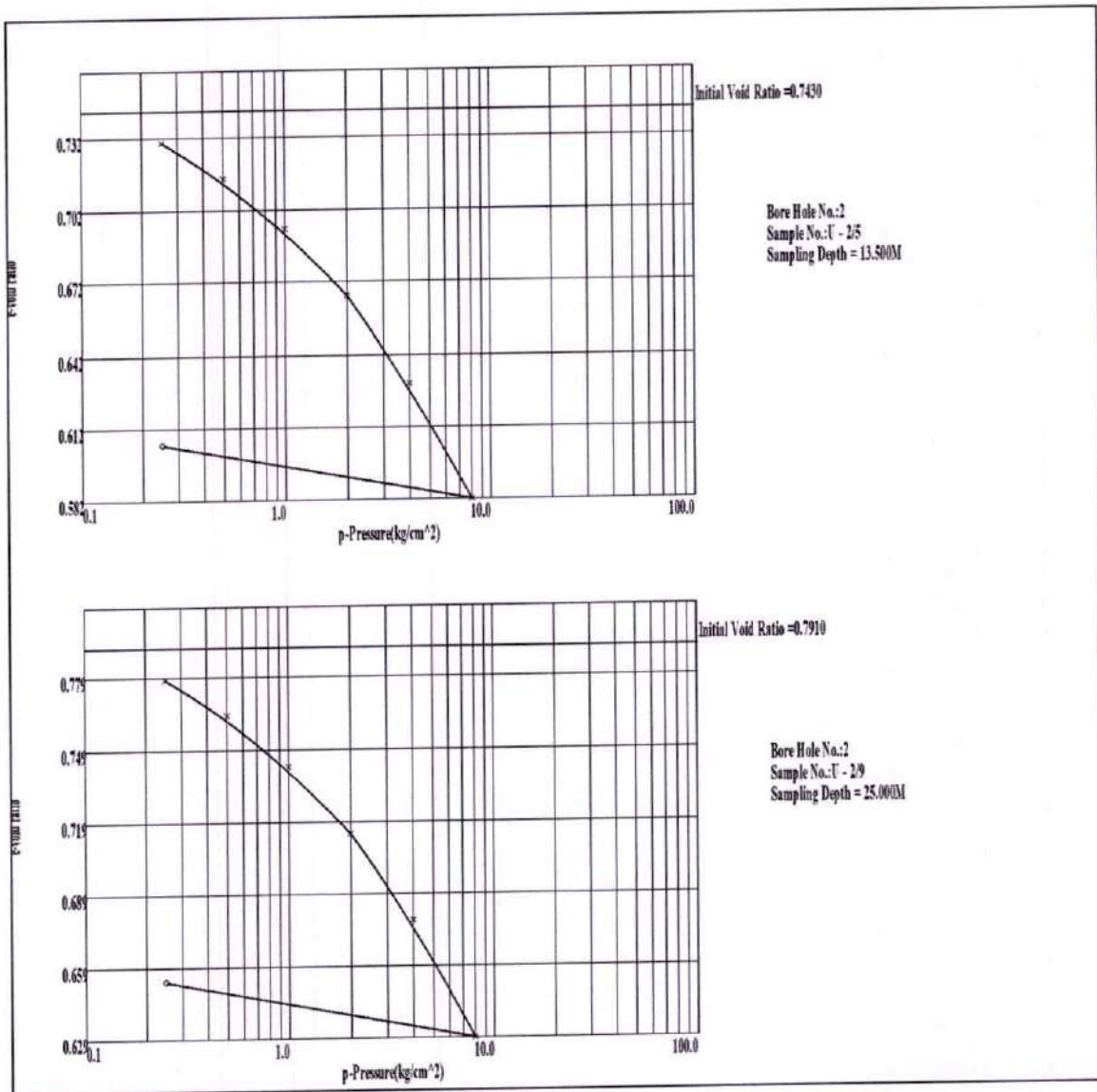
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Project: Jheel Road, Kolkata.



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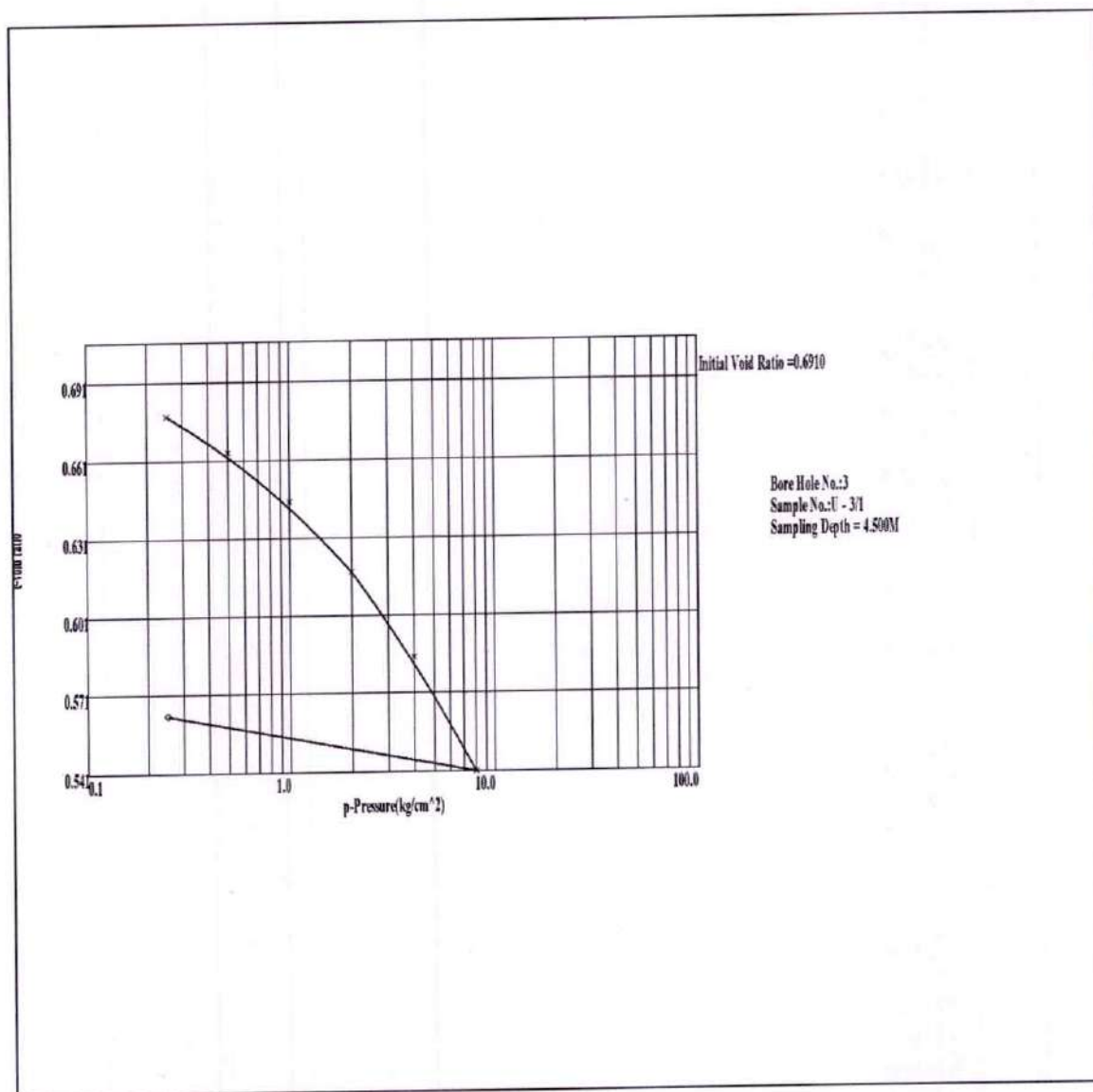
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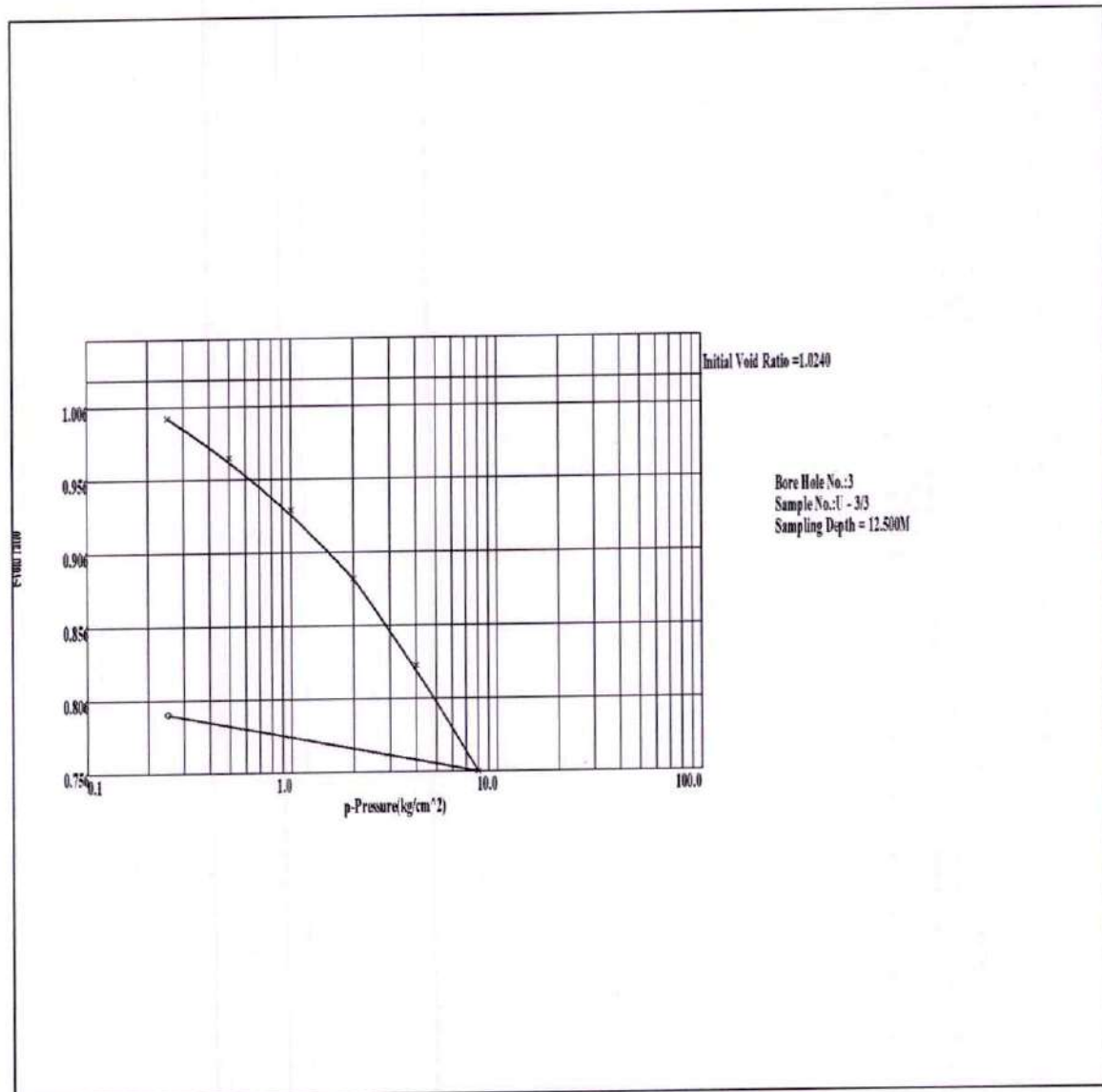
(An ISO 9001 : 2015 Certified Company)

Soil Investigators & Land Surveyors

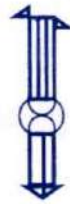
Ph. : 91-33-2430 3494 / 8103 / 9717

:: 52 ::

Project: Jheel Road, Kolkata.



REPORT SHEET



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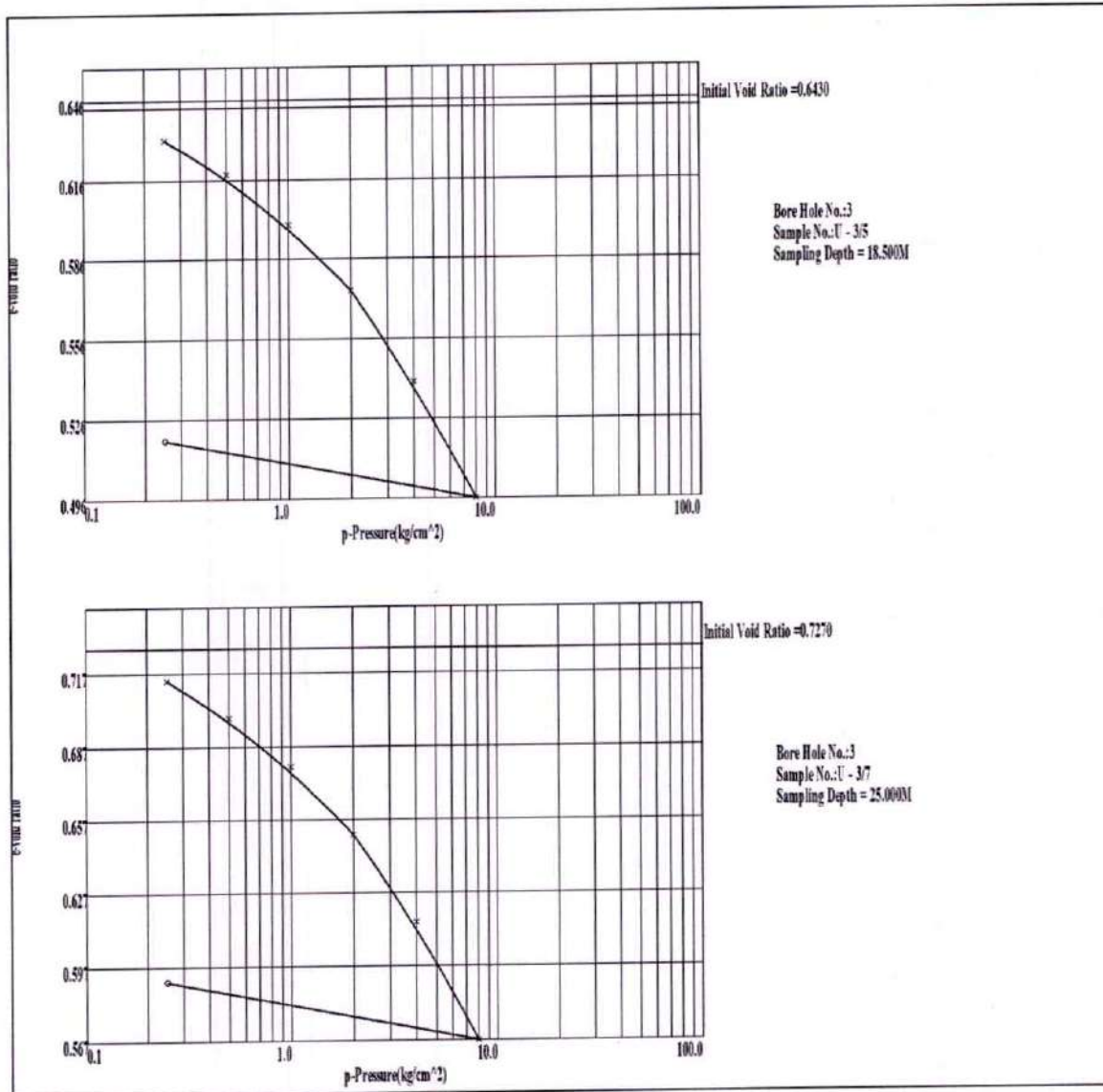
(An ISO 9001 : 2015 Certified Company)

Soil Investigators & Land Surveyors

Ph. : 91-33-2430 3494 / 8103 / 9717

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Project: Jheel Road, Kolkata.



REPORT SHEET



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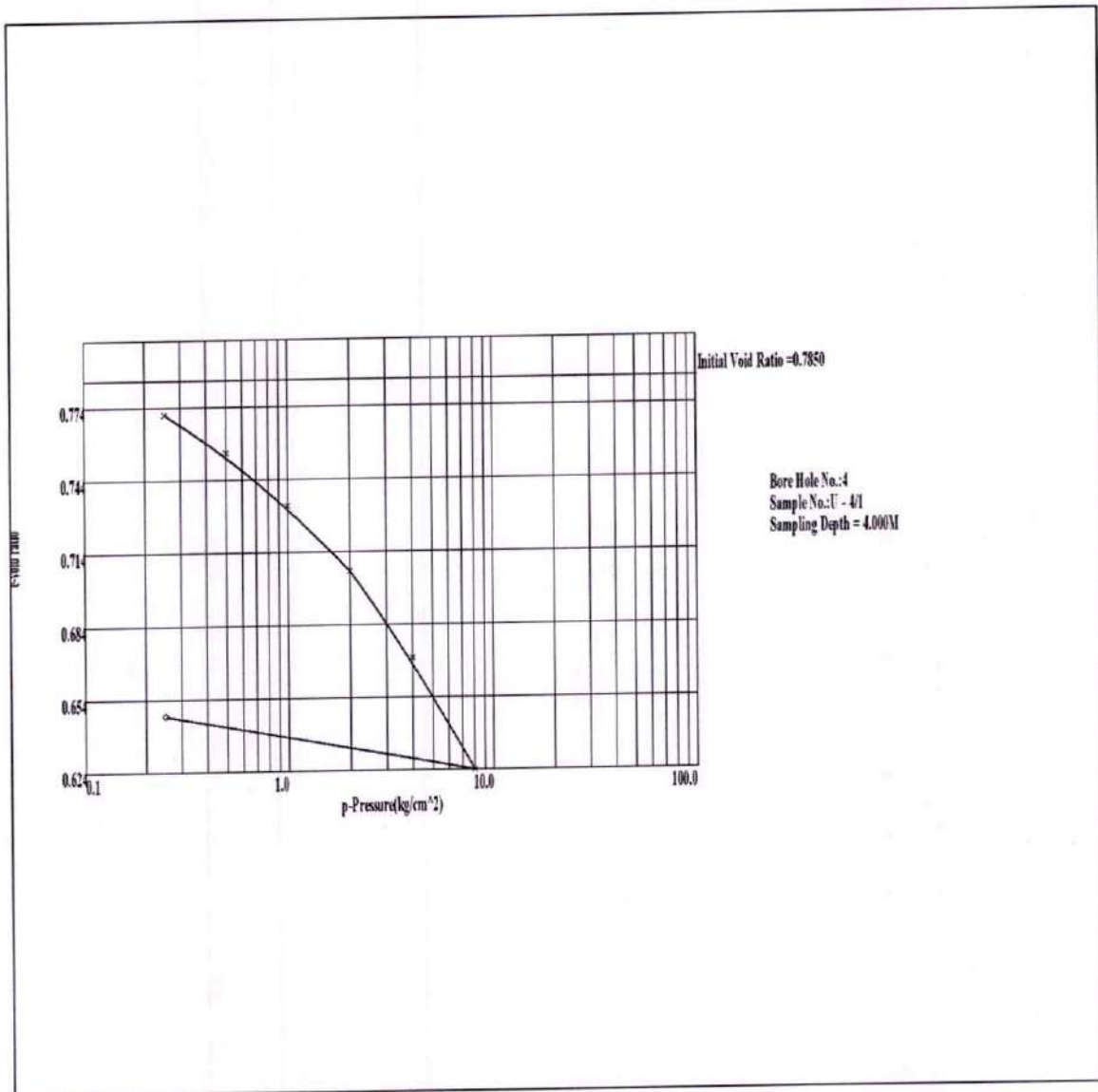
(An ISO 9001 : 2015 Certified Company)

Soil Investigators & Land Surveyors

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Project: Jheel Road, Kolkata.



REPORT SHEET



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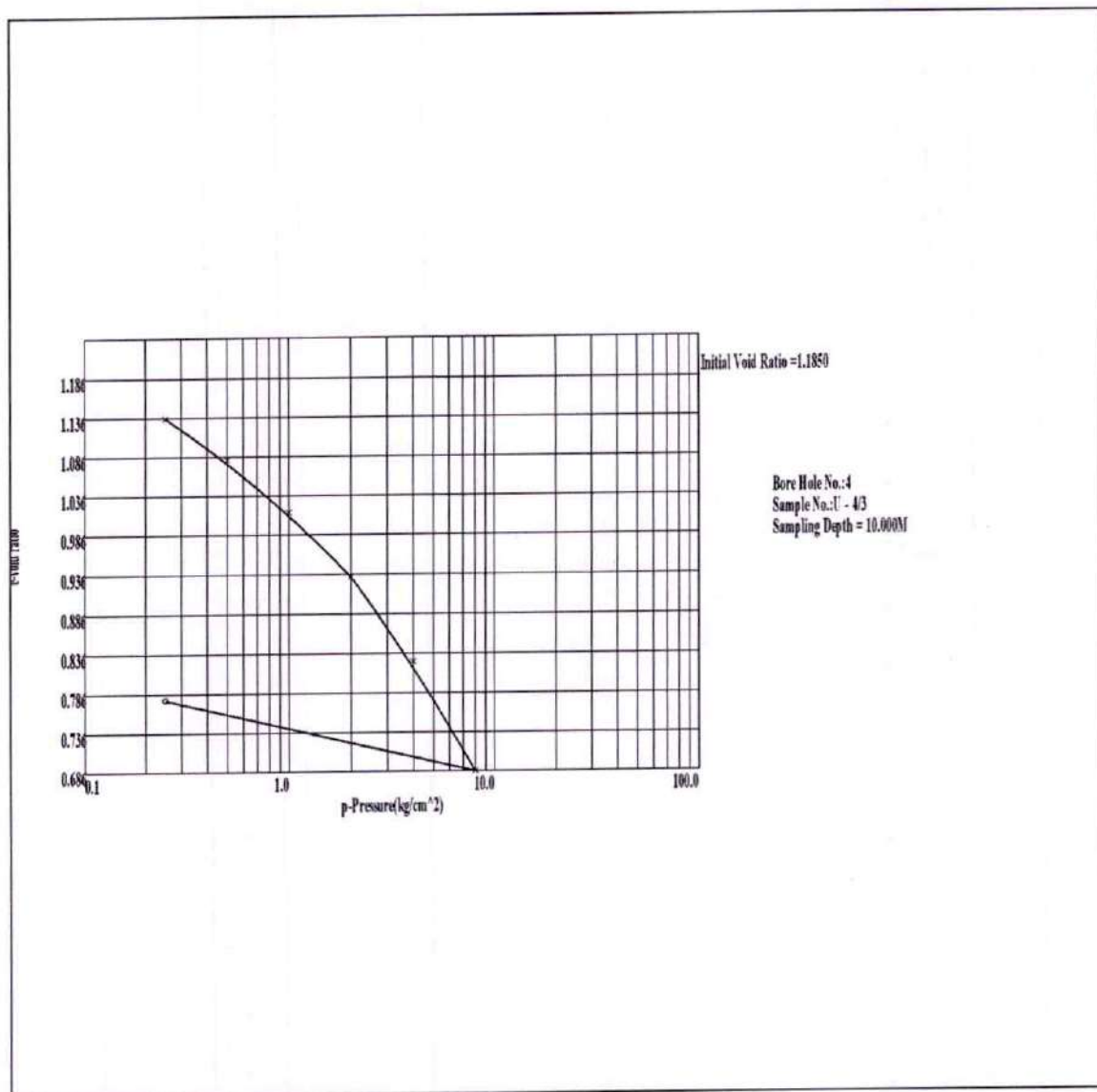
(An ISO 9001 : 2015 Certified Company)

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:: 55 ::

Project: Jheel Road, Kolkata.



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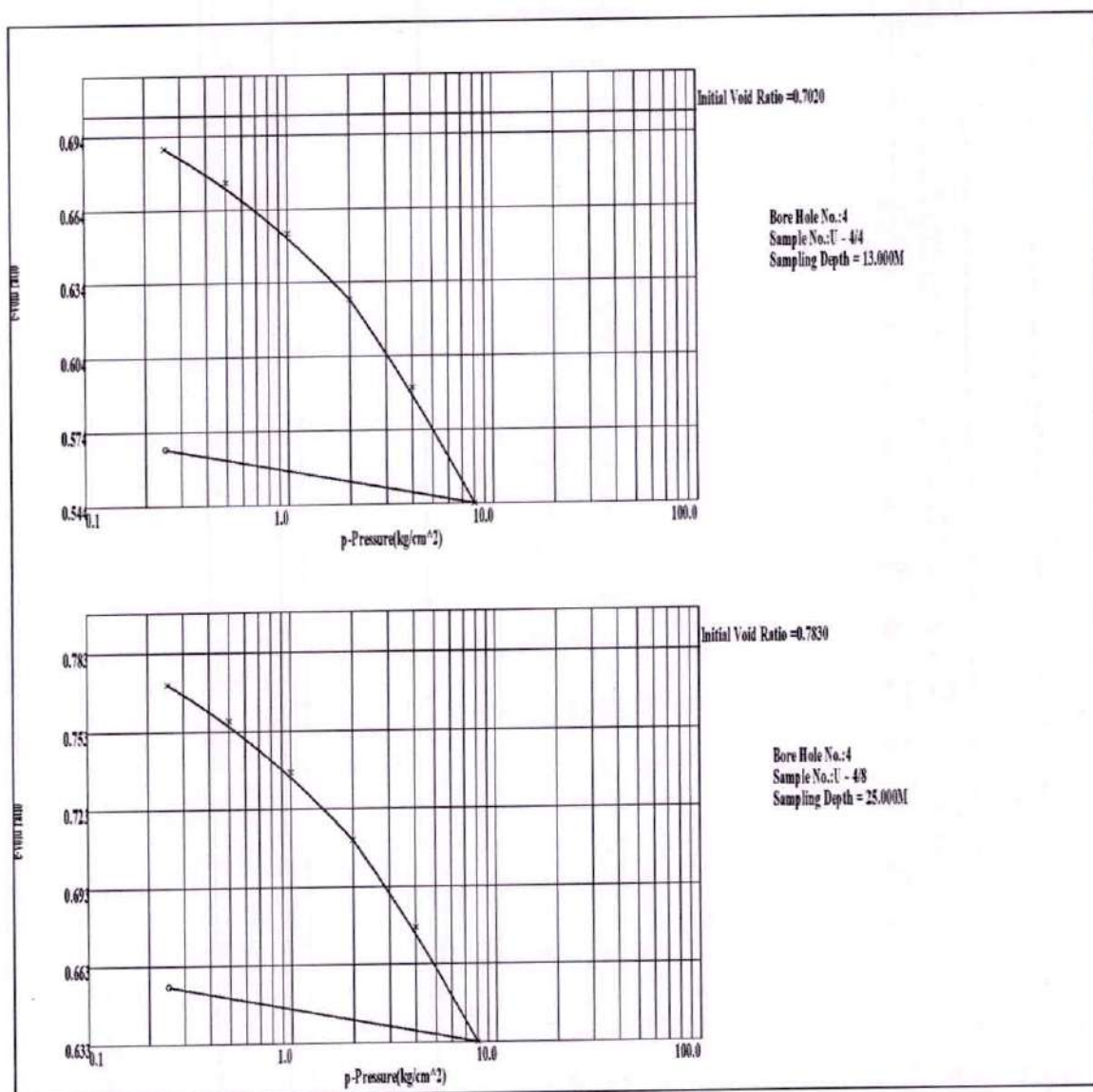
(An ISO 9001 : 2015 Certified Company)

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:: 56 ::

Project: Jheel Road, Kolkata.



REPORT SHEET



geotest
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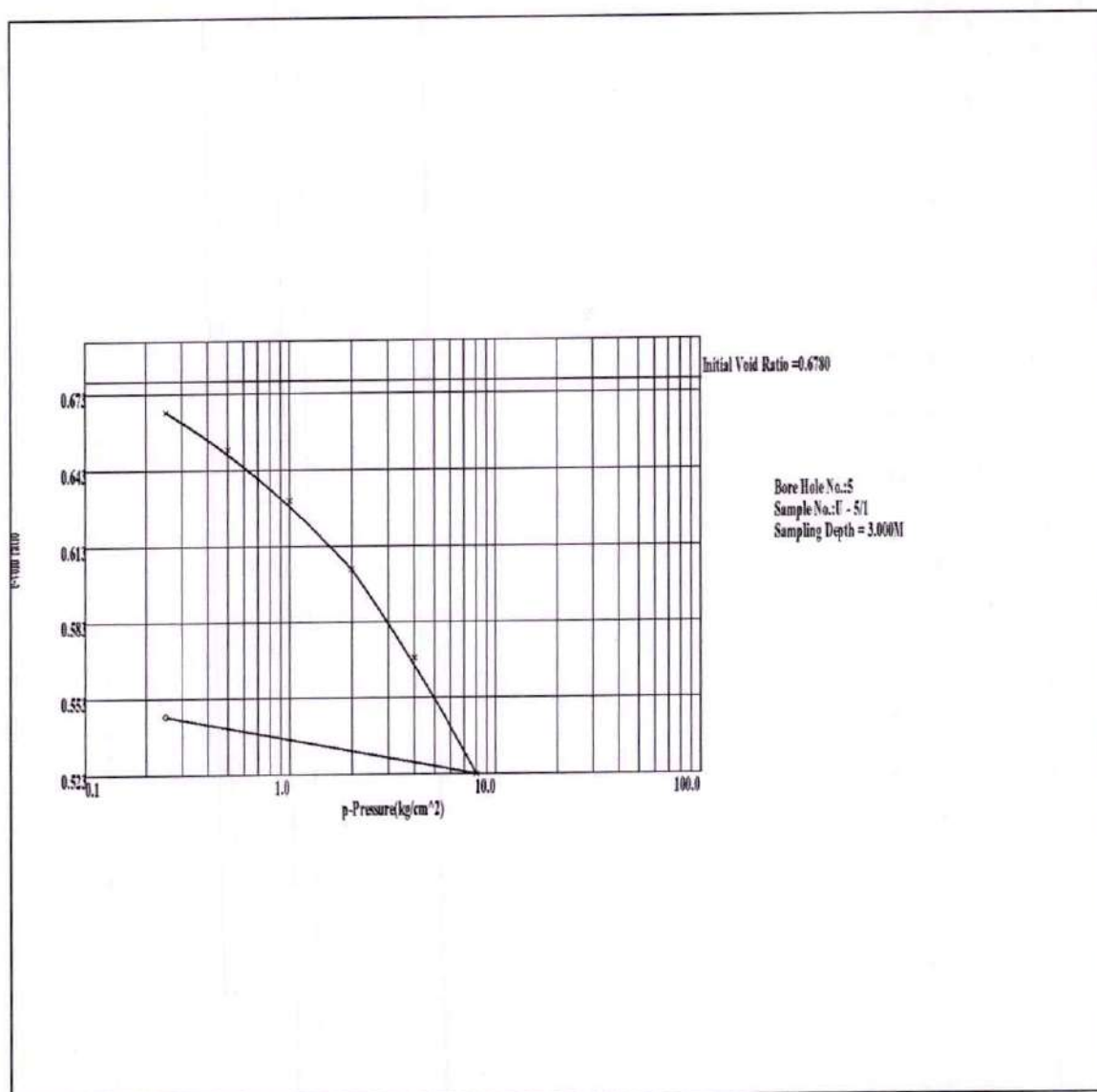
(An ISO 9001 : 2015 Certified Company)

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:: 57 ::

Project: Jheel Road, Kolkata.



REPORT SHEET



geotest
ENGINEERS PVT. LTD.

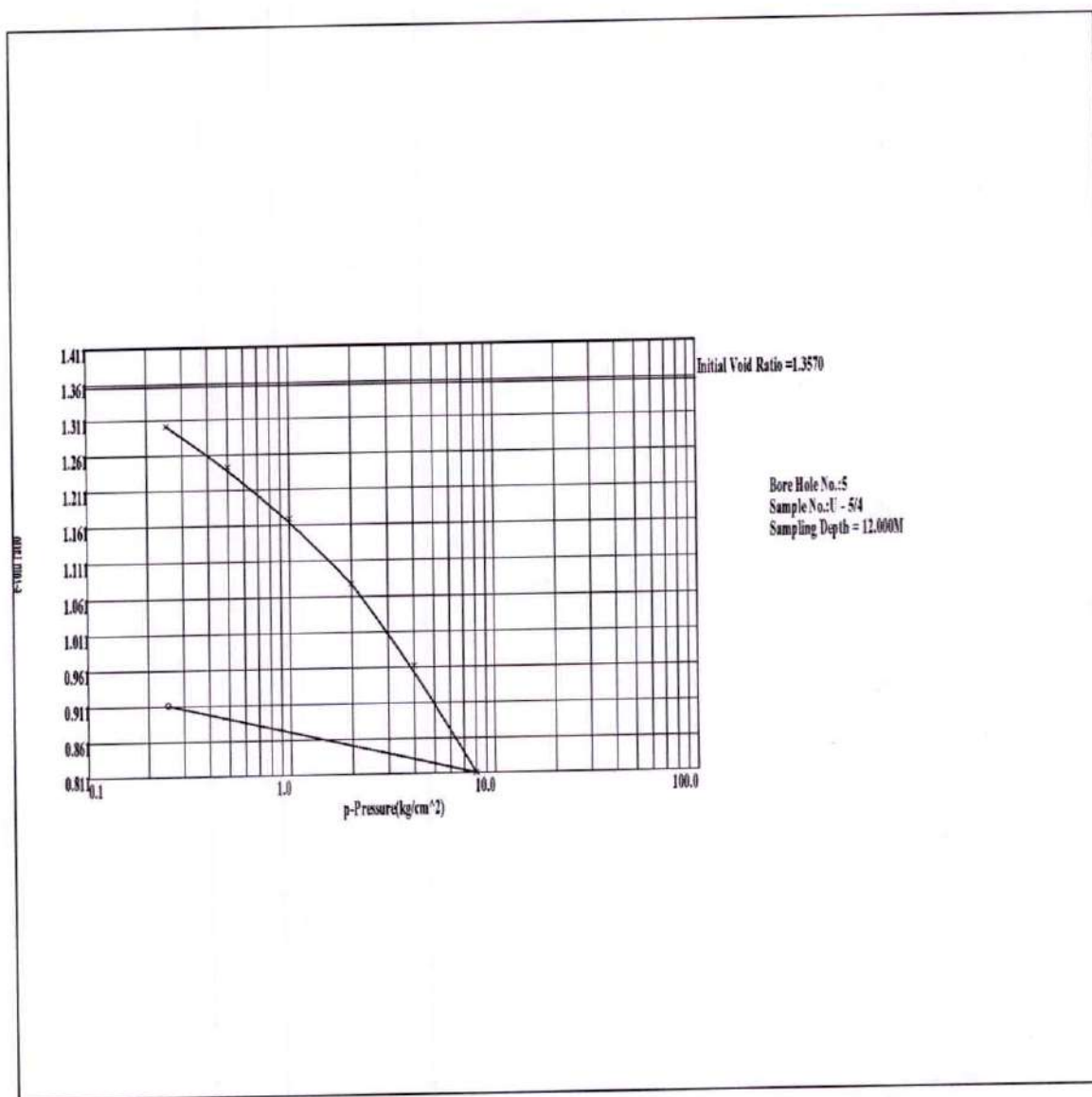
(An ISO 9001 : 2015 Certified Company)

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:: 58 ::

Project: Jheel Road, Kolkata.



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ENGINEERS PVT. LTD.

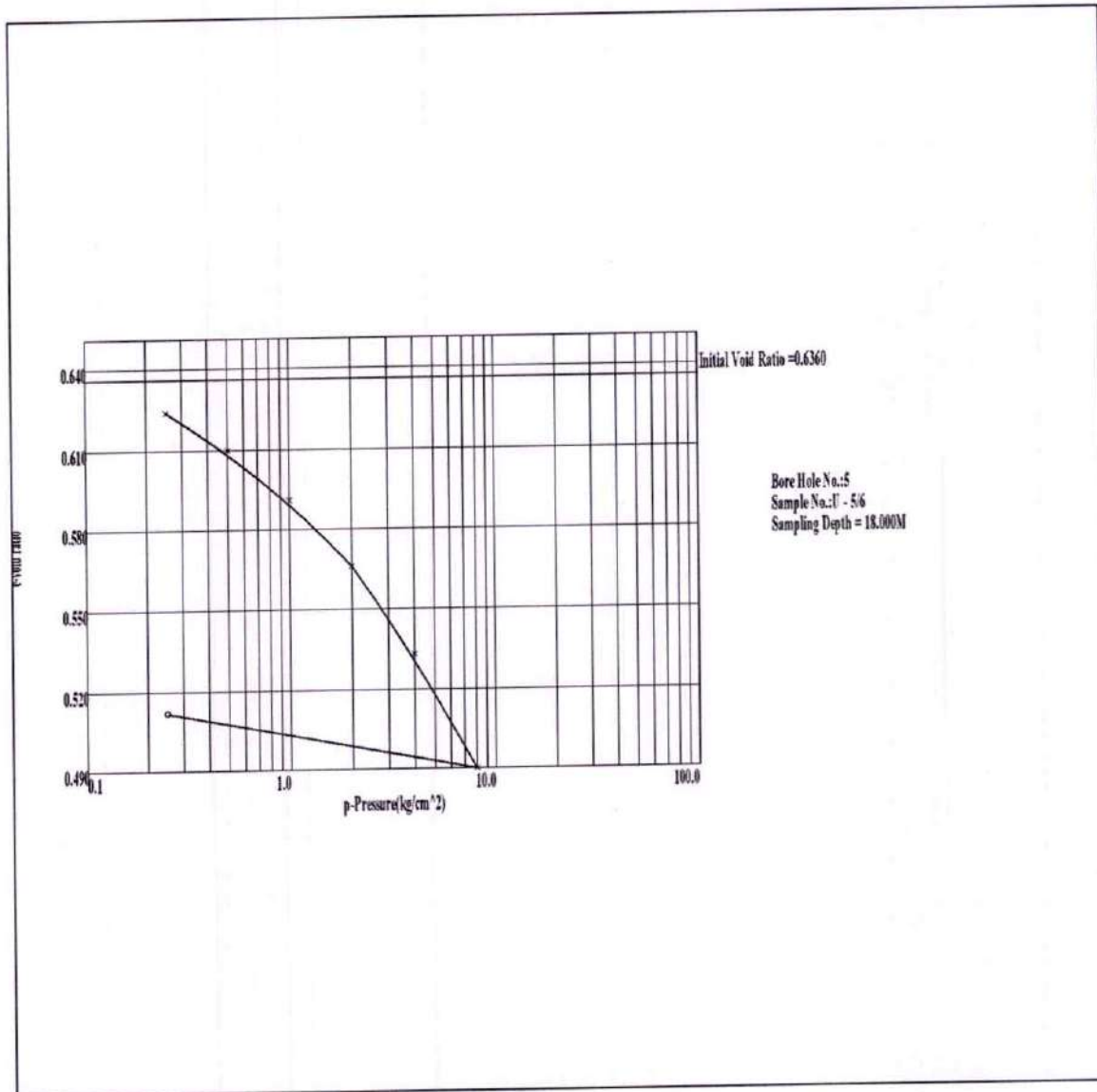
(An ISO 9001 : 2015 Certified Company)

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:: 59 ::

Project: Jheel Road, Kolkata.



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ENGINEERS PVT. LTD.

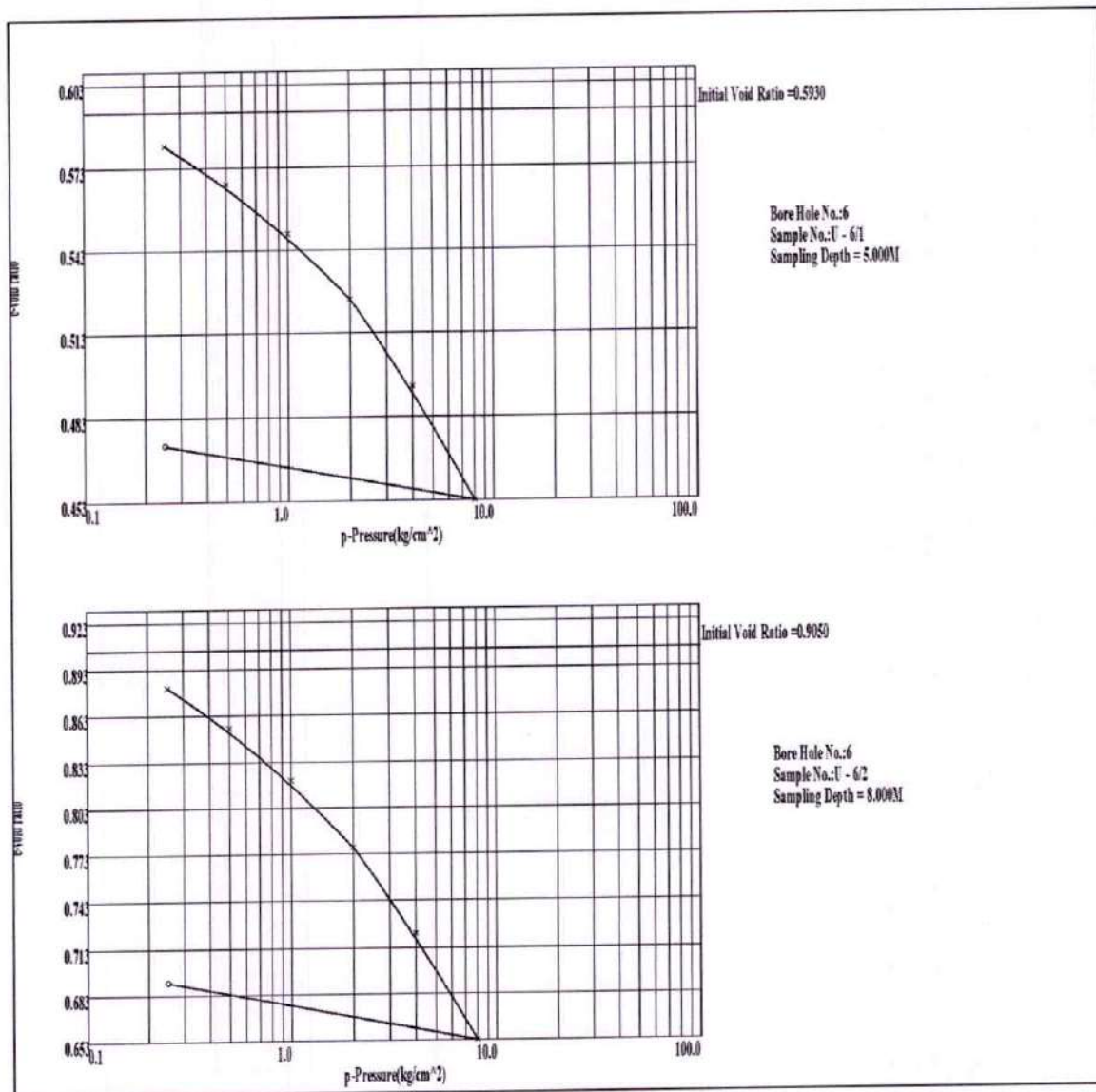
(An ISO 9001 : 2015 Certified Company)

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:: 60 ::

Project: Jheel Road, Kolkata.



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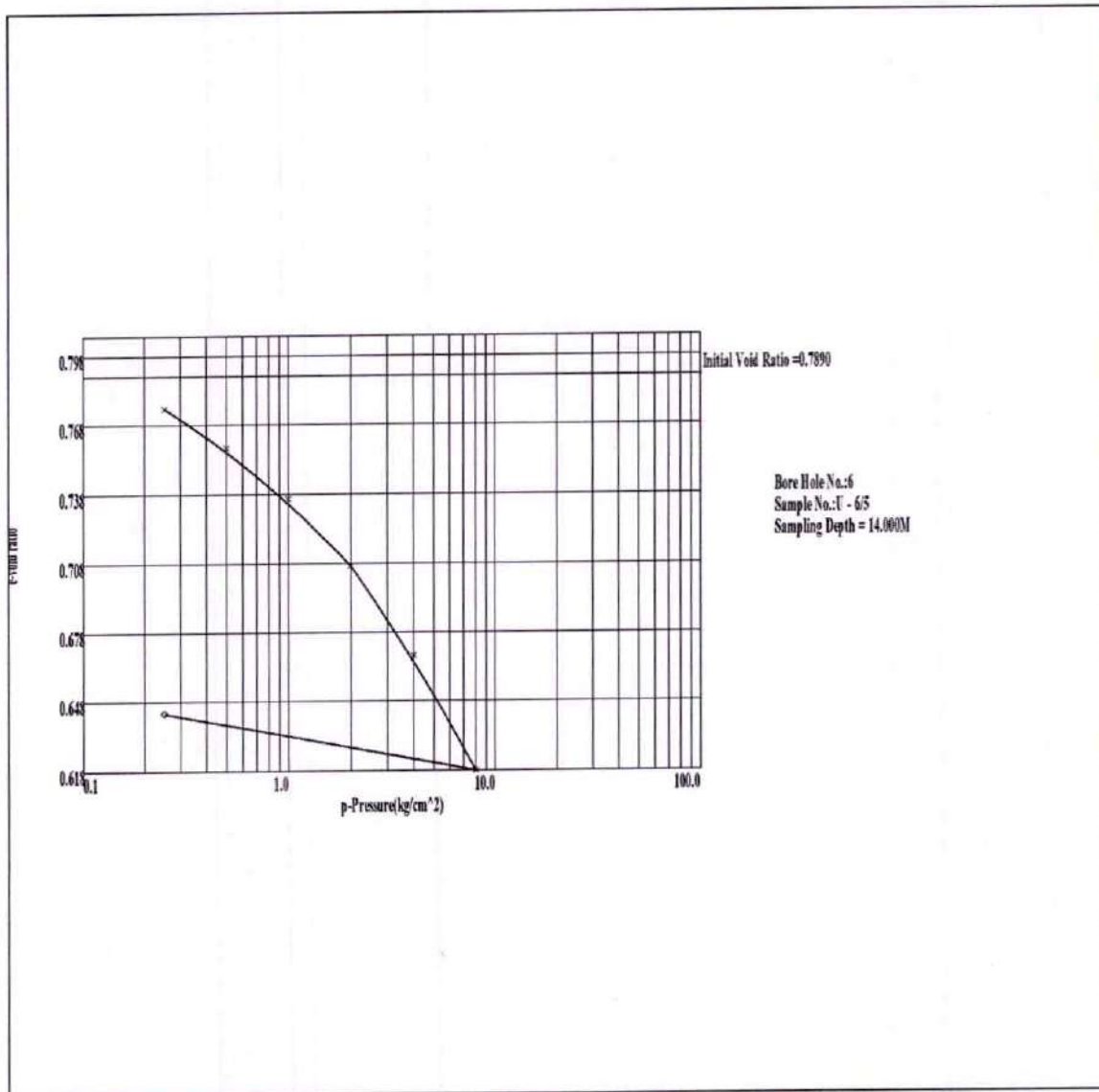
(An ISO 9001 : 2015 Certified Company)

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Project: Jheel Road, Kolkata.



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5.b. Chart for 'mv' Values
Site: Jheel Road, Kolkata.

TABLE - 3

Stratum	Sample No.	Depth in metre below E.G.L.	'mv' (cm ² / kg) Pressure Range in kg / cm ²					
			0 - 1/4	1/4 - 1/2	1/2 - 1	1 - 2	2 - 4	4 - 8
II	U - 1/1	6.00 - 6.45	0.0304	0.0358	0.0239	0.0158	0.0104	0.0072
III	U - 1/2	9.00 - 9.45	0.0942	0.1029	0.0662	0.0430	0.0290	0.0207
IV	U - 1/4	15.00 - 15.45	0.0303	0.0332	0.0228	0.0162	0.0107	0.0071
II	U - 2/1	4.50 - 4.95	0.0301	0.0348	0.0246	0.0157	0.0104	0.0070
III	U - 2/3	7.50 - 7.95	0.0921	0.1007	0.0650	0.0423	0.0286	0.0205
IV	U - 2/5	13.50 - 13.95	0.0302	0.0336	0.0247	0.0168	0.0112	0.0076
IV	U - 2/9	25.00 - 25.45	0.0300	0.0324	0.0235	0.0161	0.0109	0.0074

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Continued ...

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Ph. : 91-33-2430 3494 / 8103 / 9717

Site: Jheel Road, Kolkata.

TABLE - 3

Stratum	Sample No.	Depth in metre below E.G.L.	'm _v ' (cm ² / kg) Pressure Range in kg / cm ²					
			0 - 1/4	1/4 - 1/2	1/2 - 1	1 - 2	2 - 4	4 - 8
II	U - 3/1	4.50 - 4.95	0.0303	0.0357	0.0246	0.0162	0.0107	0.0071
III	U - 3/3	12.50 - 12.95	0.0506	0.0566	0.0376	0.0247	0.0160	0.0105
IV	U - 3/5	18.50 - 18.95	0.0280	0.0323	0.0234	0.0162	0.0109	0.0074
IV	U - 3/7	25.00 - 25.45	0.0301	0.0325	0.0227	0.0168	0.0112	0.0076
II	U - 4/1	4.00 - 4.45	0.0323	0.0369	0.0255	0.0162	0.0107	0.0071
III	U - 4/3	10.00 - 10.45	0.0942	0.1029	0.0662	0.0430	0.0290	0.0207
IV	U - 4/4	13.00 - 13.45	0.0301	0.0342	0.0236	0.0167	0.0112	0.0076
IV	U - 4/8	25.00 - 25.45	0.0282	0.0322	0.0226	0.0151	0.0101	0.0068

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Continued ...

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Site: Jheel Road, Kolkata.

TABLE - 3

Stratum	Sample No.	Depth in metre below E.G.L.	'm _v ' (cm ² / kg) Pressure Range in kg / cm ²					
			0 - 1/4	1/4 - 1/2	1/2 - 1	1 - 2	2 - 4	4 - 8
II	U-5/1	3.00 - 3.45	0.0301	0.0345	0.0246	0.0167	0.0112	0.0076
III	U-5/4	12.00 - 12.45	0.0963	0.1051	0.0674	0.0436	0.0294	0.0210
IV	U-5/6	18.00 - 18.45	0.0302	0.0336	0.0237	0.0162	0.0107	0.0071
II	U-6/1	5.00 - 5.45	0.0301	0.0349	0.0246	0.0157	0.0104	0.0070
III	U-6/2	8.00 - 8.45	0.0506	0.0564	0.0388	0.0246	0.0160	0.0105
IV	U-6/5	14.00 - 14.45	0.0323	0.0342	0.0238	0.0173	0.0115	0.0077

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REPORT SHEET



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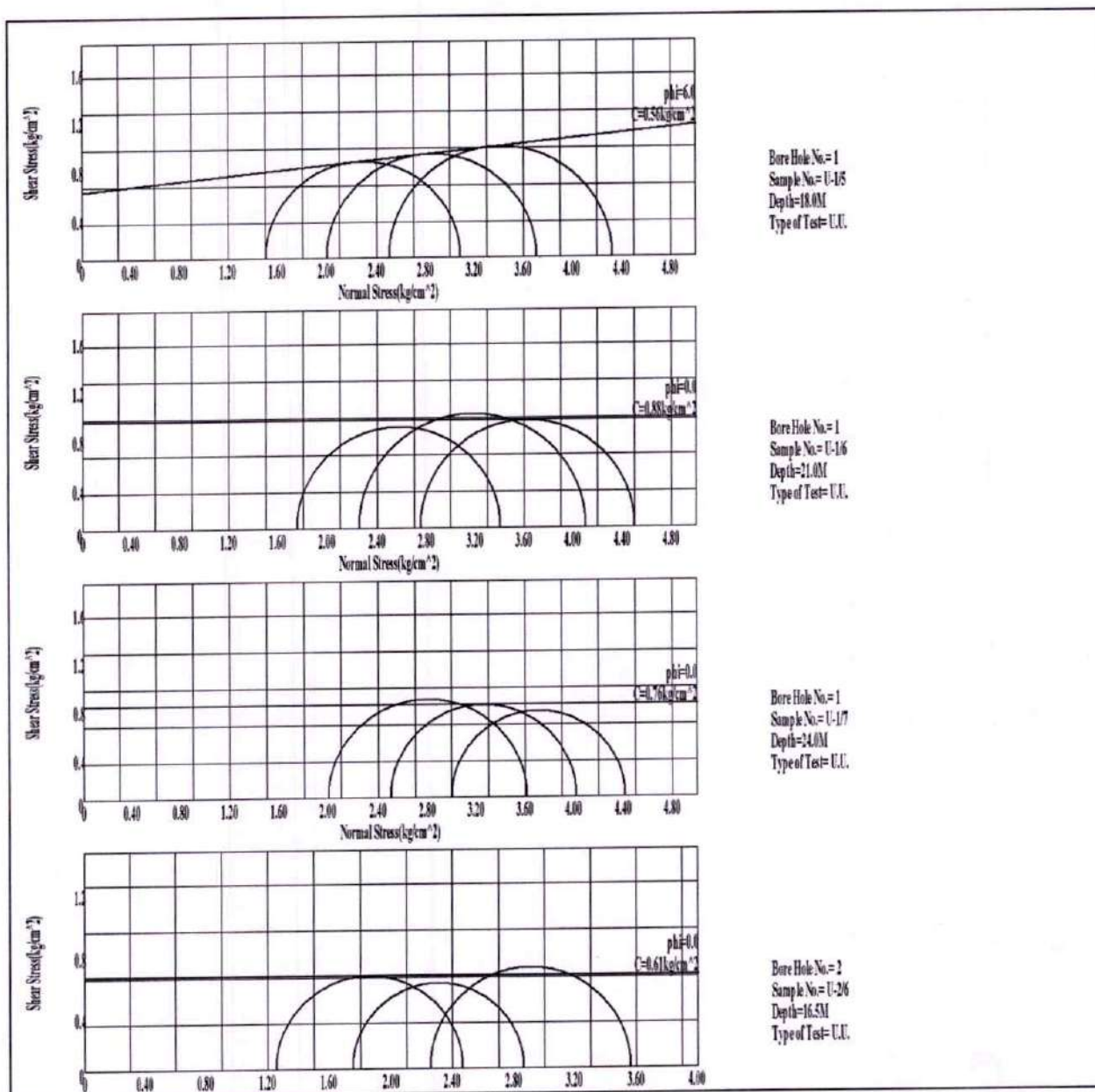
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7. Mohr's Circles

Project: Jheel Road, Kolkata.



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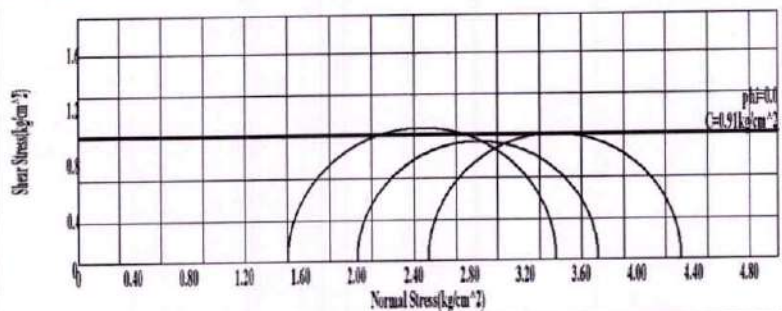
(An ISO 9001 : 2015 Certified Company)

Soil Investigators & Land Surveyors

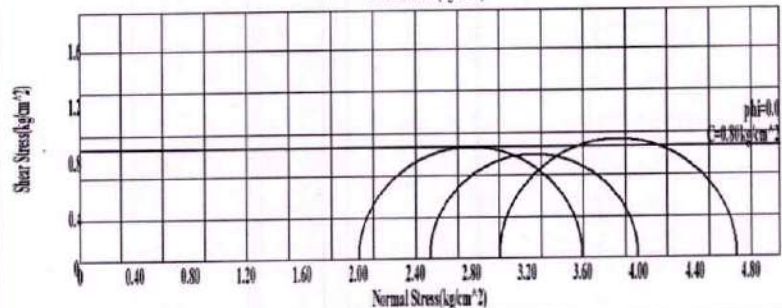
Ph. : 91-33-2430 3494 / 8103 / 9717

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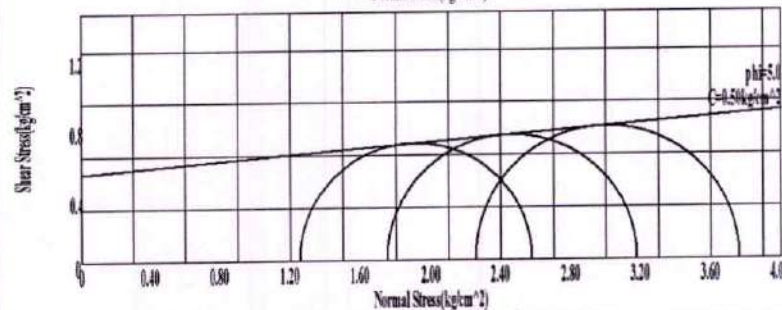
Project: Jheel Road, Kolkata.



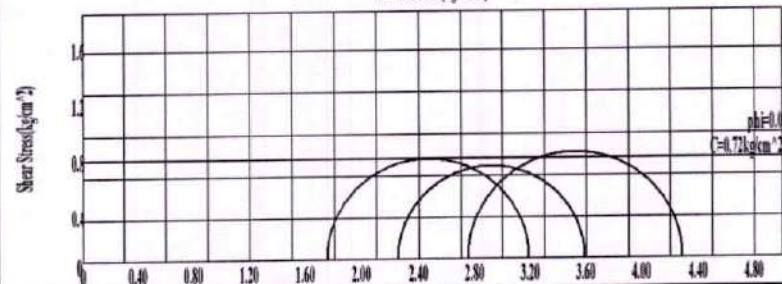
Bore Hole No.= 2
Sample No.= U-27
Depth=19.5M
Type of Test= U.U.



Bore Hole No.= 2
Sample No.= U-29
Depth=19.0M
Type of Test= U.U.



Bore Hole No.= 3
Sample No.= U-34
Depth=15.5M
Type of Test= U.U.



Bore Hole No.= 3
Sample No.= U-36
Depth=21.5M
Type of Test= U.U.

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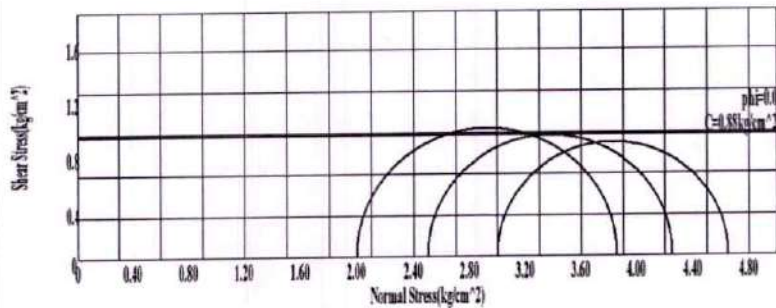
(An ISO 9001 : 2015 Certified Company)

Soil Investigators & Land Surveyors

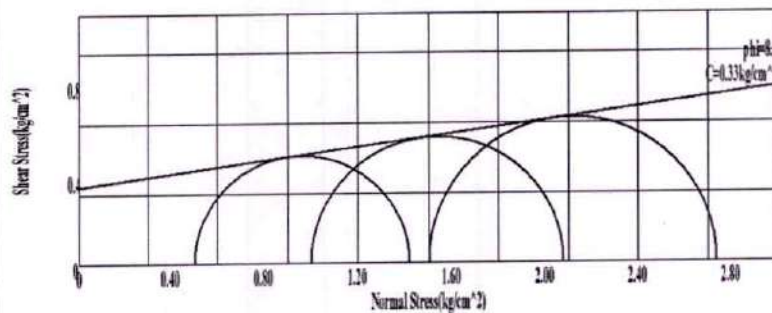
Ph. : 91-33-2430 3494 / 8103 / 9717

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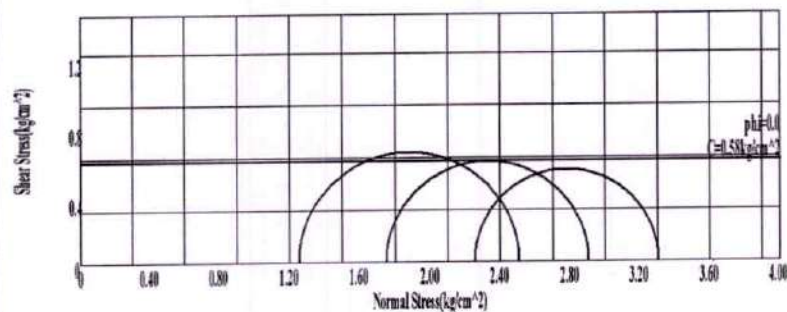
Project: Jheel Road, Kolkata.



Bore Hole No.= 3
Sample No.= U-37
Depth=25.0M
Type of Test= U.U.

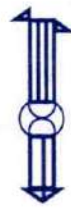


Bore Hole No.= 4
Sample No.= U-42
Depth=7.0M
Type of Test= U.U.



Bore Hole No.= 4
Sample No.= U-45
Depth=16.0M
Type of Test= U.U.

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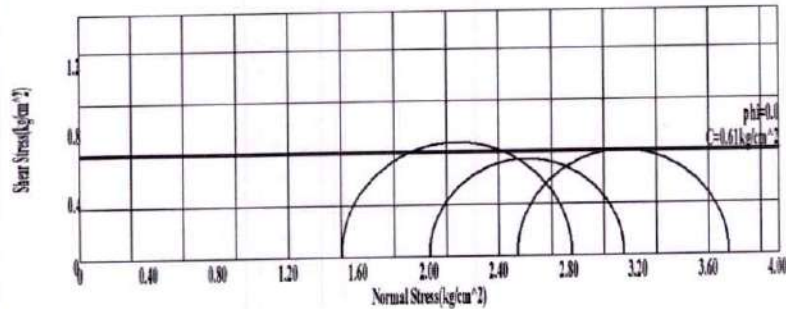
(An ISO 9001 : 2015 Certified Company)

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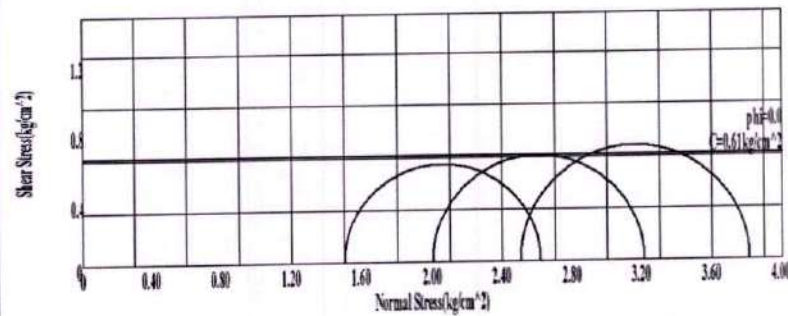
Ph. : 91-33-2430 3494 / 8103 / 9717

:: 68 ::

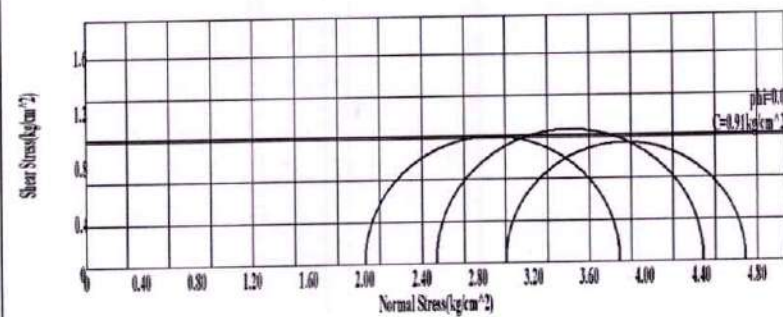
Project: Jheel Road, Kolkata.



Bore Hole No.= 4
Sample No.= U-46
Depth=13.0M
Type of Test= U.U.



Bore Hole No.= 5
Sample No.= U-56
Depth=18.0M
Type of Test= U.U.



Bore Hole No.= 5
Sample No.= U-58
Depth=24.0M
Type of Test= U.U.

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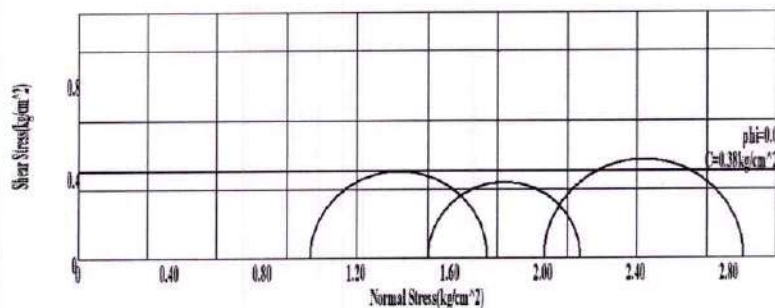
(An ISO 9001 : 2015 Certified Company)

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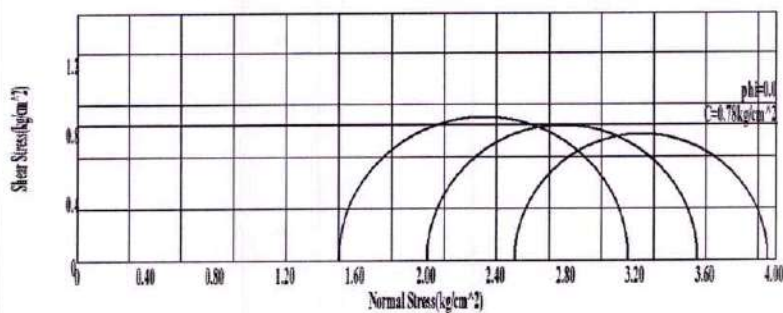
Ph. : 91-33-2430 3494 / 8103 / 9717

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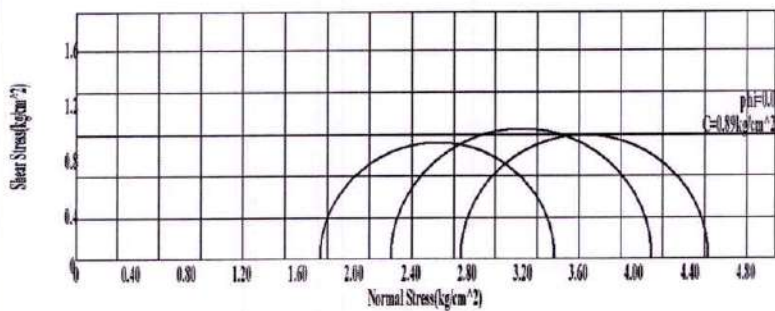
Project: Jheel Road, Kolkata.



Bore Hole No. = 6
Sample No. = U-6/4
Depth = 14.0M
Type of Test = U.U.



Bore Hole No. = 6
Sample No. = U-6/6
Depth = 20.0M
Type of Test = U.U.



Bore Hole No. = 6
Sample No. = U-6/7
Depth = 23.0M
Type of Test = U.U.

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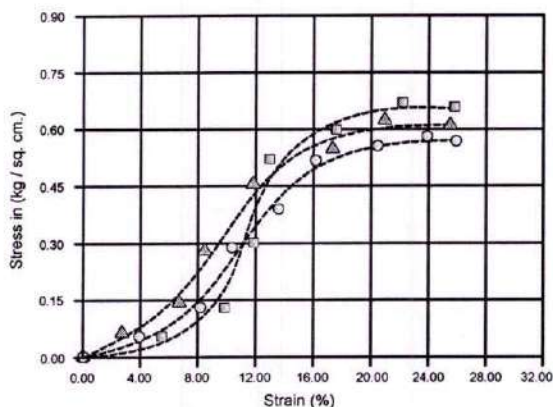
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:: 70 ::

8. STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



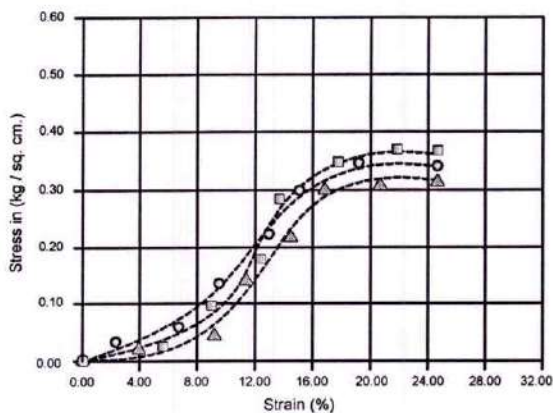
SAMPLE - 1 ○

SAMPLE - 2 ▲

SAMPLE - 3 ■

B.H. No: 1

Sample Depth: 6.00 m. - 6.45 m.



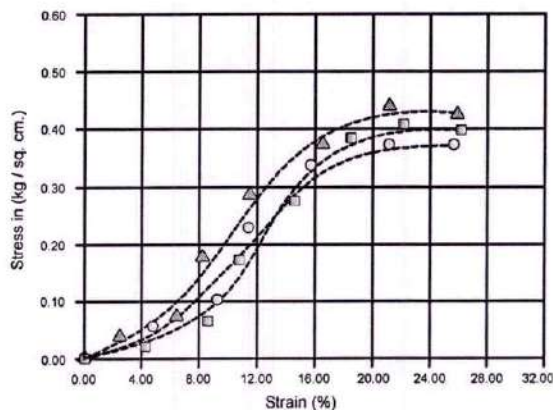
SAMPLE - 1 ○

SAMPLE - 2 ▲

SAMPLE - 3 ■

B.H. No: 1

Sample Depth: 9.00 m. - 9.45 m.



SAMPLE - 1 ○

SAMPLE - 2 ▲

SAMPLE - 3 ■

B.H. No: 1

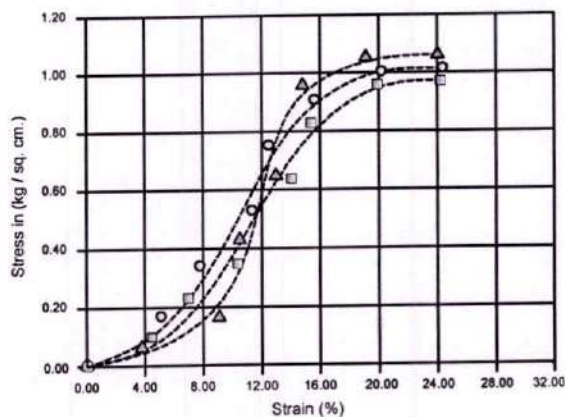
Sample Depth: 12.00 m. - 12.45 m.



:: 71 ::

STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



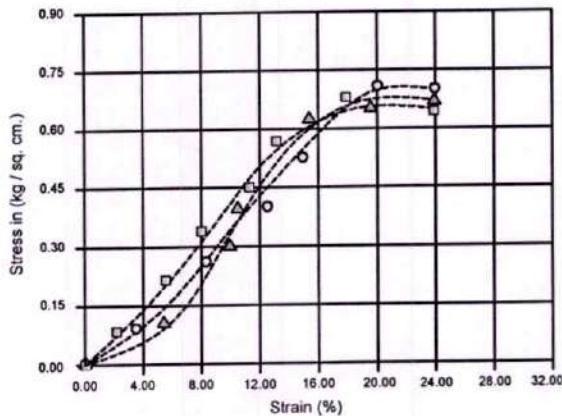
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 1

Sample Depth: 15.00 m. - 15.45 m.



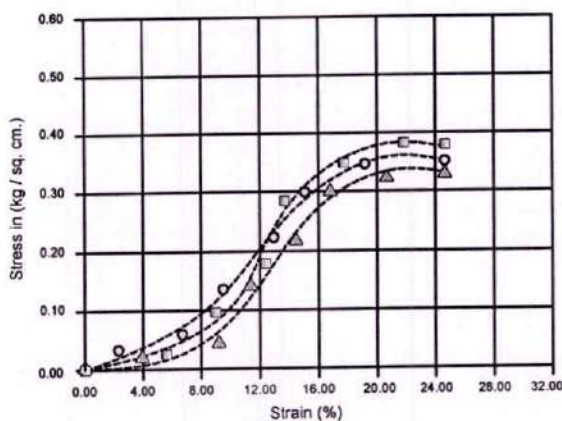
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 2

Sample Depth: 4.50 m. - 4.95 m.



SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 2

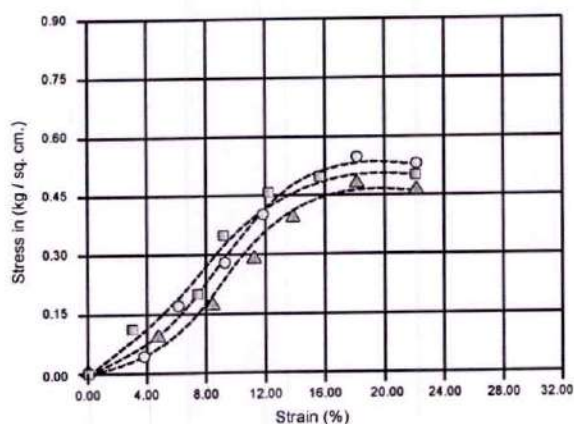
Sample Depth: 7.50 m. - 7.95 m.



:: 72 ::

STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



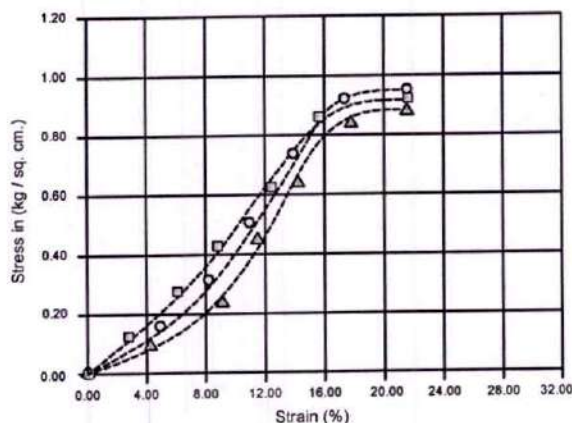
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 2

Sample Depth: 10.50 m. - 10.95 m.



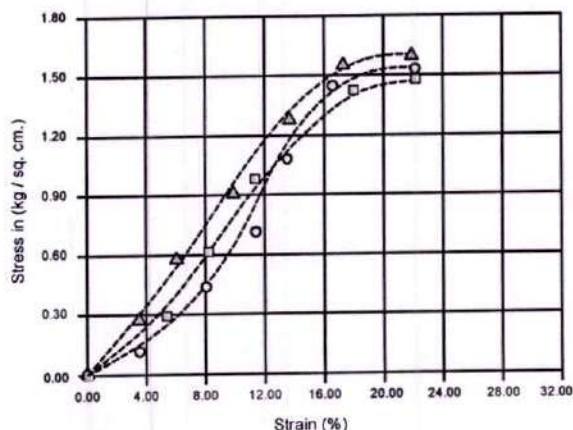
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 2

Sample Depth: 13.50 m. - 13.95 m.



SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 2

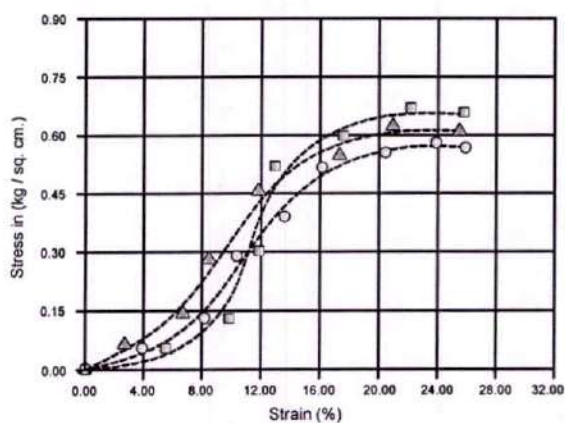
Sample Depth: 22.50 m. - 22.95 m.



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STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



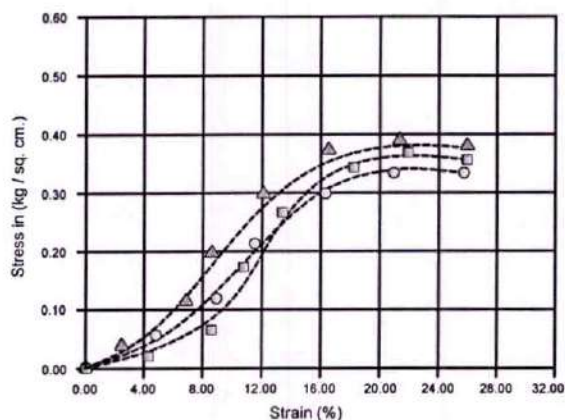
SAMPLE - 1 ○

SAMPLE - 2 ▲

SAMPLE - 3 ■

B.H. No: 3

Sample Depth: 4.50 m. - 4.95 m.



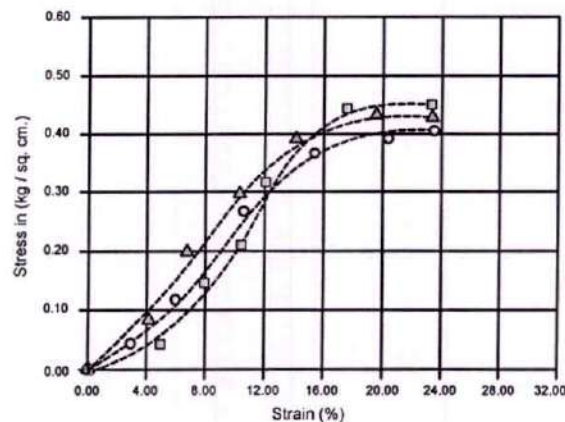
SAMPLE - 1 ○

SAMPLE - 2 ▲

SAMPLE - 3 ■

B.H. No: 3

Sample Depth: 9.50 m. - 9.95 m.



SAMPLE - 1 ○

SAMPLE - 2 ▲

SAMPLE - 3 ■

B.H. No: 3

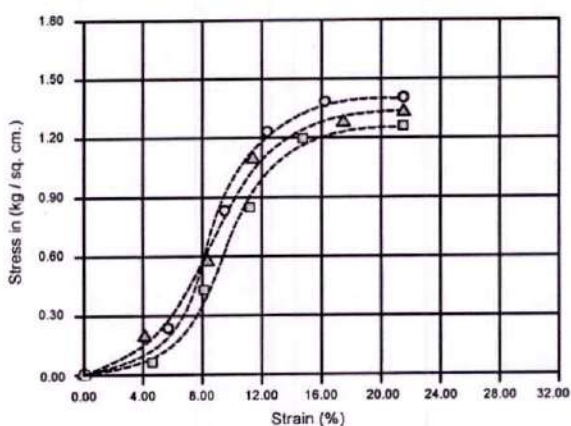
Sample Depth: 12.50 m. - 12.95 m.



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STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



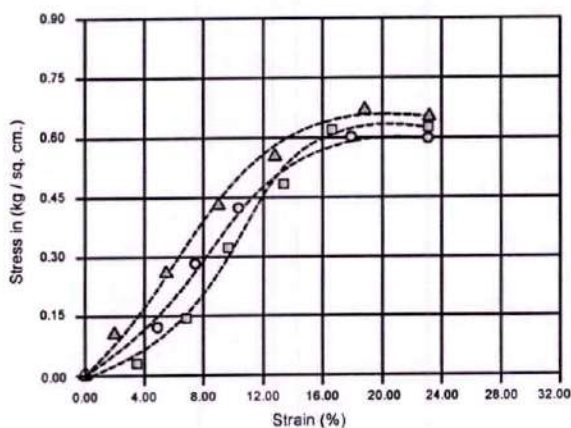
SAMPLE - 1 ○

SAMPLE - 2 ▲

SAMPLE - 3 □

B.H. No: 3

Sample Depth: 18.50 m. - 18.95 m.



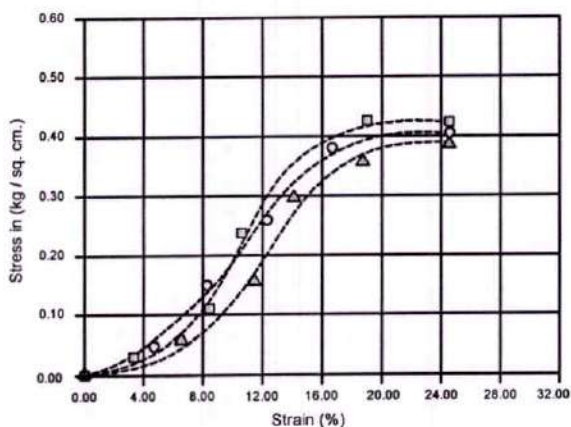
SAMPLE - 1 ○

SAMPLE - 2 ▲

SAMPLE - 3 □

B.H. No: 4

Sample Depth: 4.00 m. - 4.45 m.



SAMPLE - 1 ○

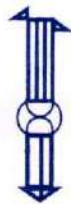
SAMPLE - 2 ▲

SAMPLE - 3 □

B.H. No: 4

Sample Depth: 10.00 m. - 10.45 m.

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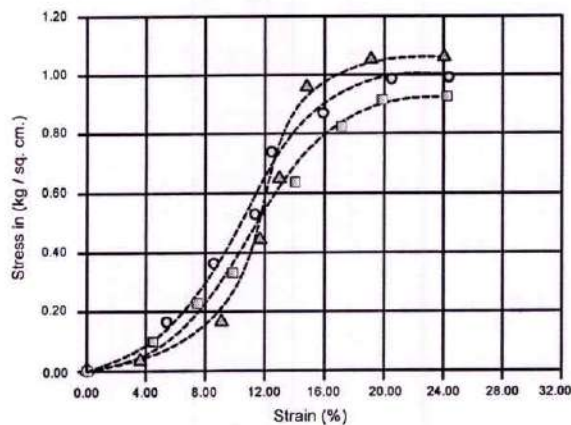
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STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



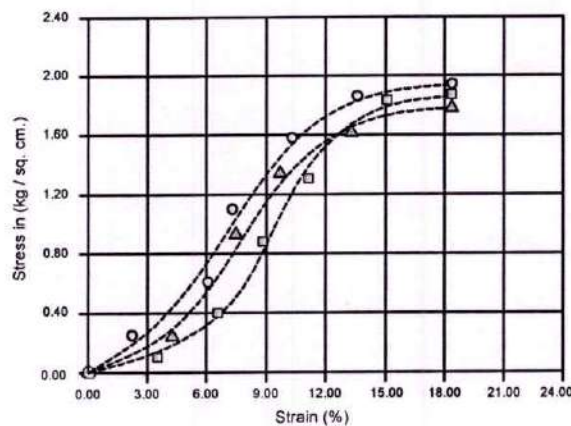
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 4

Sample Depth: 13.00 m. - 13.45 m.



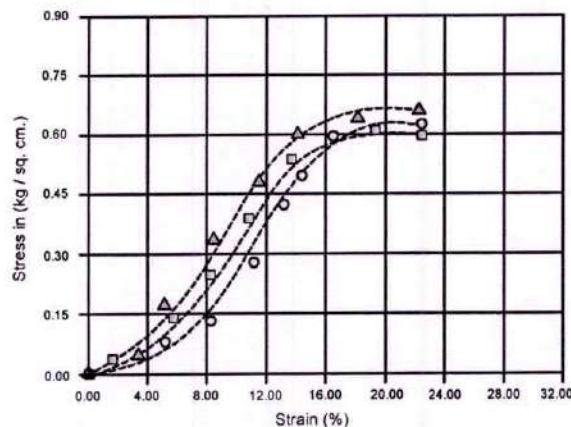
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 4

Sample Depth: 22.00 m. - 22.45 m.



SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 5

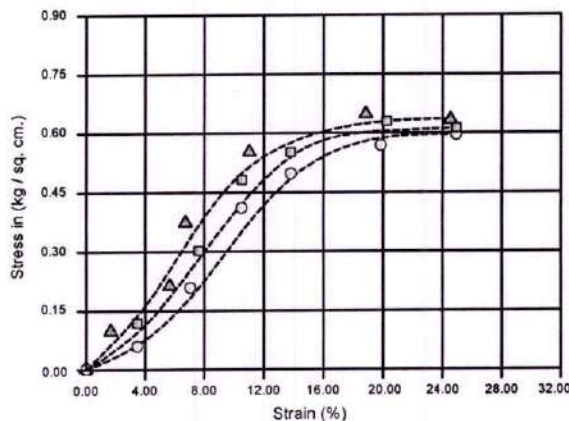
Sample Depth: 3.00 m. - 3.45 m.



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STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



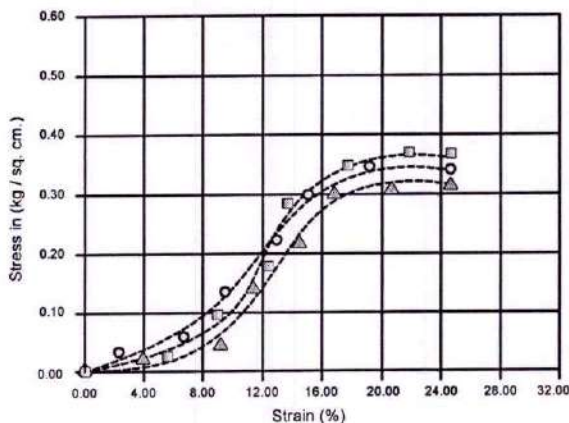
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 5

Sample Depth: 6.00 m. - 6.45 m.



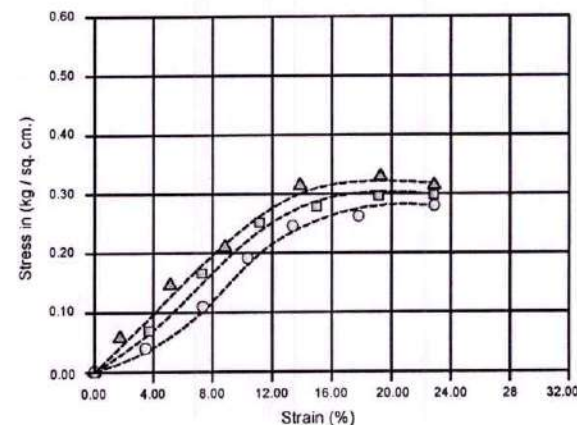
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 5

Sample Depth: 9.00 m. - 9.45 m.



SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 5

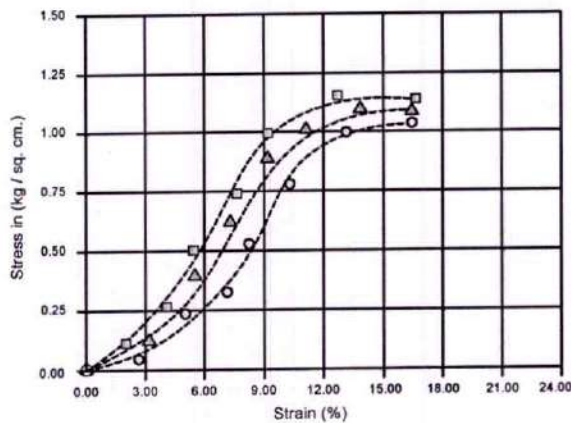
Sample Depth: 12.00 m. - 12.45 m.



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STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



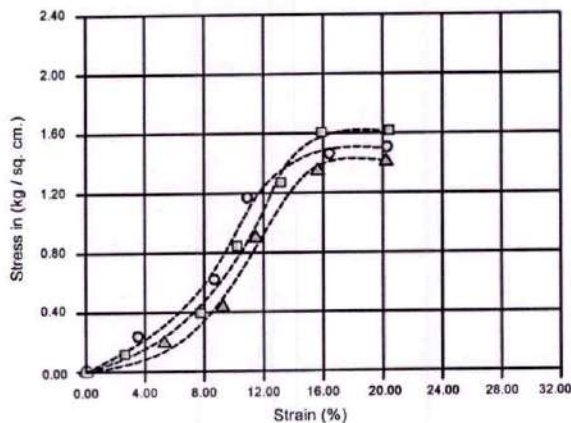
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 5

Sample Depth: 15.00 m. - 15.45 m.



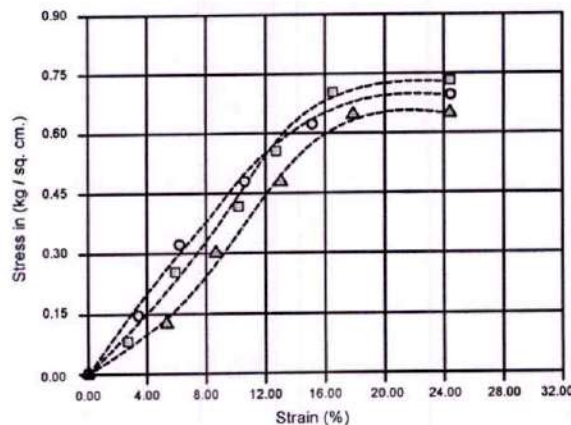
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 5

Sample Depth: 21.00 m. - 21.45 m.



SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 6

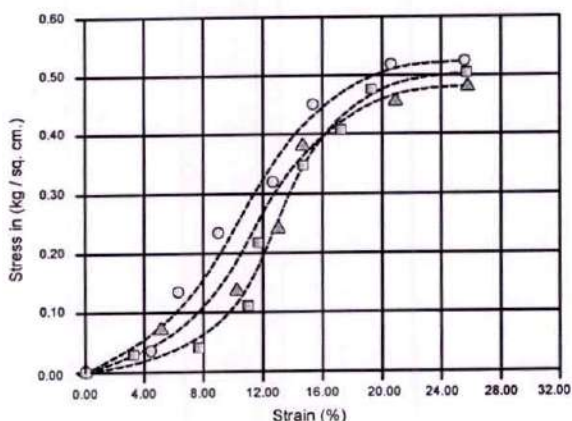
Sample Depth: 5.00 m. - 5.45 m.



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STRESS VS STRAIN CURVES OF U.C.S. TEST

Location : Jheel Road, Kolkata.



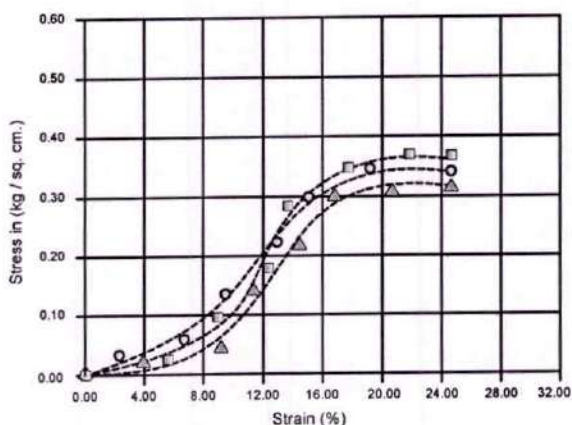
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 6

Sample Depth: 8.00 m. - 8.45 m.



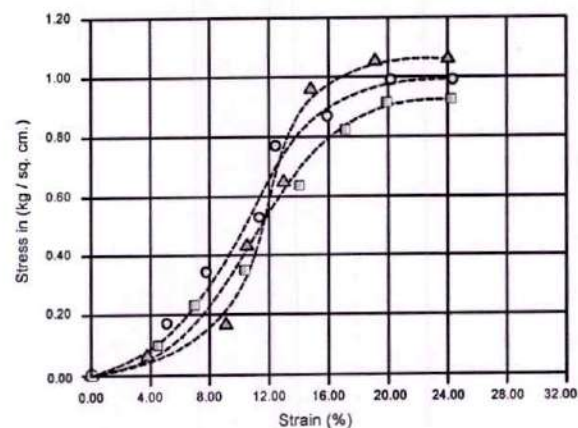
SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 6

Sample Depth: 11.00 m. - 11.45 m.



SAMPLE - 1 ○

SAMPLE - 2 △

SAMPLE - 3 □

B.H. No: 6

Sample Depth: 17.00 m. - 17.45 m.



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9. CALCULATIONS OF BEARING CAPACITY & PROBABLE SETTLEMENT VALUES OF CONVENTIONAL SHALLOW OPEN FOUNDATIONS & RIGID RAFT FOUNDATION

9.1 Design Consideration for Shallow Open Footings resting on cohesive stratum at $D_f = 4.50$ m. below avg. E.G.L. (During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level)

In this case, the bearing capacity failure surface lies in stratum II. Hence the avg. value of C_u of stratum II = 31.00 kN/m^2 , have been used in bearing capacity equation.

$C_u = 31.00 \text{ kN/m}^2$ (Considering the avg. value of C_u of stratum II)

$\phi_u = 0^\circ$

$E = 600 C_u = 600 \times 31.00 = 18600 \text{ kN/m}^2$ (From Table 5 – 5 of Foundation Analysis & Design, by J.E. Bowles, 5th Edition) (Considering the avg. value of C_u of stratum II)

$\mu = 0.50$ (for clay)

$m_{v1} = 0.000246 \text{ m}^2/\text{kN}$ (for relevant pressure range – $\frac{1}{2}$ to 1 kg/cm^2)

$m_{v2} = 0.000469 \text{ m}^2/\text{kN}$ (for relevant pressure range – $\frac{1}{2}$ to 1 kg/cm^2 & 1 to 2 kg/cm^2)

Pore Pressure Correction Factor = 0.80 considered for N.C. Clay. [Table 1 of I.S. 8009 (Part 1) 1976, Reaffirmed 2003]

Depth correction factor as per fig.12 of I.S.8009 (Part 1) 1976 (Reaffirmed 2003).

The bearing capacity and probable settlement values of shallow footings are tabulated in TABLE 2(A) of TEXT.

9.1.1 Sample Calculations of bearing capacity and probable settlement of shallow footings for $D_f = 4.50$ m. below avg. E.G.L. (During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level)

Considering the avg. value of $C_u = 31.00 \text{ kN/m}^2$, where the bearing capacity failure surface lies in stratum II.

Example for $2.00 \text{ m} \times 2.00 \text{ m}$ square footing at $D_f = 4.50$ m. below avg. E.G.L. (During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level)

SBC Calculations

Properties of founding stratum:

$C = 31.00 \text{ kN/m}^2$ (considering the avg. value of stratum II)

$N_c = 5.14$ (for $\phi = 0^\circ$) [Table 1 of IS 6403: 1981, Reaffirmed 2002]

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$$S_c = 1.30 \text{ (for square footing) [Clause 5.1.2.1 of IS 6403 : 1981, Reaffirmed 2002]}$$

$$d_c = 1.00 \text{ (not considered in design, to be on safe side)}$$

$$i_c = 1.00 \text{ (for vertical load) [Clause 5.1.2.3 of IS 6403: 1981, Reaffirmed 2002]}$$

Net ultimate bearing capacity, $q_d = 31.00 \times 5.14 \times 1.30 \times 1.00 \times 1.00 = 207.14 \text{ kN/m}^2$

Taking a factor of safety = 2.50,

Net safe bearing capacity, $q_{ns} = 207.14 / 2.50 = 82.86 \text{ kN/m}^2 \approx 83.00 \text{ kN/m}^2$

Settlement Calculations

$$\text{Immediate settlement } (S_i) = q_{ns} B (1 - \mu^2) I_f / E$$

[Clause 9.2.3.2 of IS 8009 (Part 1) 1976, Reaffirmed 2003]

$$q_{ns} = 83.00 \text{ kN/m}^2$$

$$B = 2.00 \text{ m}$$

$$\mu = 0.50 \text{ (for clay)}$$

$$I_f = 1.12 \text{ (for square footing) [Table 2 of I.S.8009 (Part 1) 1976 (Reaffirmed 2003)]}$$

$$E = 18600 \text{ kN/m}^2$$

$$\text{So, } S_i = \{83.00 \times 2.00 \times (1 - 0.50^2) \times 1.12 \times 10^3\} / 18600 = 7.49 \text{ mm.}$$

After applying Depth correction factor of 0.730 [fig.12 of I.S.8009 (Part 1) 1976 (Reaffirmed 2003)] and Rigidity correction factor being not applied for flexible footings,

$$S_i \text{ corrected} = 7.49 \times 0.730 = 5.46 \text{ mm.}$$

Consolidation Settlement (S_c):

$$\text{Consolidation settlement, } S_c = \Sigma m_v \Delta P H$$

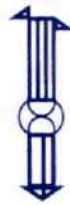
Where,

$$m_{v1} = 0.000246 \text{ m}^2/\text{kN} \text{ (for relevant pressure range - } \frac{1}{2} \text{ to } 1 \text{ kg/cm}^2)$$

$$\Delta P_1 = 26.34 \text{ kN/m}^2 \text{ (assuming 2: 1 dispersion)}$$

$$H_1 = 3.10 \text{ m.}$$

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$mv_2 = 0.000469 \text{ m}^2/\text{kN}$ (for relevant pressure range – $\frac{1}{2}$ to 1 kg/cm^2 to 1 to 2 kg/cm^2)

$\Delta P_2 = 10.77 \text{ kN/m}^2$ (assuming 2: 1 dispersion)

$H_2 = 0.90 \text{ m}$.

$$S_c = \{(0.000246 \times 26.34 \times 3.10) + (0.000469 \times 10.77 \times 0.90)\} \times 10^3 \text{ mm} \\ = 24.63 \text{ mm}.$$

Applying a Depth correction factor [fig. 12 of I.S. 8009 (Part 1) 1976, Reaffirmed 2003] of 0.730 and pore pressure correction factor of 0.80 [Table 1 of I.S. 8009 (Part 1) 1976, Reaffirmed 2003],

$$S_{c \text{ corrected}} = 24.63 \times 0.730 \times 0.80 = 14.38 \text{ mm}.$$

$\therefore$ Total corrected settlement, $S = (5.46 + 14.38) = 19.84 \text{ mm}$, say 20.00 mm.

Similarly, the bearing capacity-probable settlement values of other sizes & types of shallow foundations at 4.50 m. below avg. E.G.L. (During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level) are also calculated & presented in **TABLE 2(A) of TEXT**.



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9.2. Example for 15.00 m. x 20.00 m. size of shallow rigid raft at 4.50 m depth below avg. E.G.L. (During the period of field work, Avg. E.G.L. was about 0.60 m. below H.T. Tower Raft Top Level)

Given Data:

Size of foundation: 15.00 m x 20.00 m.

Depth of foundation = 4.50 m depth below avg. E.G.L.

Depth of water table = 0.00 m (assuming the worst condition of G. W. Table during Monsoons).

SBC Calculations

$$C_{(weighted)} = \frac{[(C_1 \times d_1) + (C_2 \times d_2) + (C_3 \times d_3)]}{(d_1 + d_2 + d_3)} = \frac{[(31.00 \times 3.10) + (20.00 \times 5.70) + (70.00 \times 1.805)]}{(3.10 + 5.70 + 1.805)}$$

$$= 31.72 \text{ kN/m}^2 \approx 32.00 \text{ kN/m}^2.$$

[Considering the weighted value of C_u of stratum II ($C_1 = 31.00 \text{ kN/m}^2$), C_u of stratum III ($C_2 = 20.00 \text{ kN/m}^2$) & stratum IV ($C_3 = 70.00 \text{ kN/m}^2$), $d_1 = 3.10 \text{ m.}$, $d_2 = 5.70 \text{ m.}$ & $d_3 = 1.805 \text{ m.}$]

$$N_c = 5.14 \text{ (for } \phi = 0^\circ \text{) [Table 1 of IS 6403 : 1981, Reaffirmed 2002]}$$

$$S_c = 1 + 0.2 (B / L) = 1.15 \text{ (for 15 m wide and 20 m long rectangular footing)}$$

$$d_c = 1 + 0.2 (d_f / B) = 1.15 \text{ (for 15 m. wide raft at 4.50 m. founding depth)}$$

[Clause 5.1.2.2 of IS 6403 : 1981, Reaffirmed 2002]

$$i_c = 1.00 \text{ (for vertical load) [Clause 5.1.2.3 of IS 6403 : 1981, Reaffirmed 2002]}$$

$$\text{Net ultimate bearing capacity, } q_d = 32.00 \times 5.14 \times 1.15 \times 1.00 \times 1.00 = 189.15 \text{ kN/m}^2$$

Considering a factor of safety = 2.50,

$$\text{Net safe bearing capacity, } q_{ns} = 189.15 / 2.50 = 75.66 \text{ kN/m}^2 \approx 76.00 \text{ kN/m}^2$$

Settlement Calculations:

$$\text{Immediate settlement (} S_i \text{)} = q_{ns} B (1 - \mu^2) I_f / E$$

[Clause 9.2.3.2 of IS 8009 (Part 1) 1976, Reaffirmed 2003]

$$q_{ns} = 76.00 \text{ kN/m}^2$$

$$B = 15.00 \text{ m (width of rigid raft)}$$

$$\mu = 0.50 \text{ (for clay)}$$

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$$I_f = 1.53 \text{ (for rectangular footing) [Table 2 of I.S.8009 (Part 1) 1976 (Reaffirmed 2003)]}$$

$$E_{\text{(weighted)}} = [(d_1 \times E_1) + (d_2 \times E_2) + (d_3 \times E_3)] / (d_1 + d_2 + d_3) \approx 29344 \text{ kN/m}^2$$

[Where, $d_1 = 3.10 \text{ m}$, $d_2 = 5.70 \text{ m}$. & $d_3 = 6.20 \text{ m}$.

$E_1 = 600 C_u \text{ (for clay)} = 600 \times 31.00 \text{ kN/m}^2 = 18600 \text{ kN/m}^2$ (From Table 5 – 5 of Foundation Analysis & Design, by J.E. Bowles, 5th Edition) (using avg. C_u of stratum II = 30.00 kN/m^2).

$E_2 = 500 C_u \text{ (for clay)} = 500 \times 20.00 \text{ kN/m}^2 = 10000 \text{ kN/m}^2$ (From Table 5 – 5 of Foundation Analysis & Design, by J.E. Bowles, 5th Edition) (using avg. C_u of stratum III = 20.00 kN/m^2).

$E_3 = 750 C_u \text{ (for clay)} = 750 \times 70.00 \text{ kN/m}^2 = 52500 \text{ kN/m}^2$ (From Table 5 – 5 of Foundation Analysis & Design, by J.E. Bowles, 5th Edition) (using avg. C_u of stratum IV = 70.00 kN/m^2).

$$\text{So, } S_i = \{76.00 \times 15.00 \times (1 - 0.50^2) \times 1.53 \times 10^3\} / 29344 = 44.57 \text{ mm.}$$

After applying Rigidity correction factor of 0.80 [clause 9.5.2 of I.S. 8009 (Part 1) 1976, Reaffirmed 2003] & Depth correction factor of 0.920 as per fig.12 of I.S.8009 (Part 1) 1976 (Reaffirmed 2003).

$$S_i \text{ corrected} = 44.57 \times 0.80 \times 0.920 = 32.80 \text{ mm.}$$

Consolidation Settlement (S_c):

$$\text{Consolidation settlement, } S_c = \Sigma m_v \Delta P H$$

Where,

$$m_{v1} = 0.000246 \text{ m}^2/\text{kN} \text{ (for relevant pressure range - } 1/2 \text{ to } 1 \text{ kg/cm}^2 \text{ kg/cm}^2)$$

$$\Delta P_1 = 63.92 \text{ kN/m}^2 \text{ (assuming 2: 1 dispersion)}$$

$$H_1 = 3.10 \text{ m.}$$

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$mv_2 = 0.000469 \text{ m}^2/\text{kN}$ (for relevant pressure range – $\frac{1}{2}$ to 1 kg/cm^2 & 1 to 2 kg/cm^2)

$\Delta P_2 = 41.93 \text{ kN/m}^2$ (assuming 2: 1 dispersion)

$H_2 = 5.70 \text{ m}$.

$mv_3 = 0.000137 \text{ m}^2/\text{kN}$ (for relevant pressure range – 1 to 2 kg/cm^2 & 2 to 4 kg/cm^2)

$\Delta P_3 = 21.35 \text{ kN/m}^2$ (assuming 2: 1 dispersion)

$H_3 = 12.95 \text{ m}$.

$$S_c = \{(0.000246 \times 63.92 \times 3.10) + (0.000469 \times 41.93 \times 5.70) + (0.000137 \times 21.35 \times 12.95)\} \times 10^3 \\ = 198.71 \text{ mm}.$$

Applying a Rigidity correction factor of 0.80 [clause 9.5.2 of I.S. 8009 (Part 1) 1976, Reaffirmed 2003], depth correction factor of 0.920 as per fig.12 of I.S.8009 (Part 1) 1976 (Reaffirmed 2003) and pore pressure correction factor of 0.80 [Table 1 of I.S. 8009 (Part 1) 1976, Reaffirmed 2003],

$$S_c \text{ corrected} = 198.71 \times 0.80 \times 0.920 \times 0.80 = 117.00 \text{ mm}.$$

$\therefore$ Total corrected settlement, $S = (32.80 + 117.00) \text{ mm} = 149.80 \text{ mm} \approx 150.00 \text{ mm}$, which is greater than the allowable settlement of 125.00 mm . [I.S. 1904 - (2021): clause 16.3, sub-clause 16.3.4, Table - 1]

$\therefore$ Allowable bearing capacity for 125 mm allowable settlement $= 63.33 \text{ kN/m}^2 \approx 63.00 \text{ kN/m}^2$

$\therefore$ Design net allowable bearing pressure $= 63.00 \text{ kN/m}^2$ (least among that from shear & settlement criteria)

TABLE 2(B) of TEXT gives the net allowable bearing pressure (with a factor of safety of 2.50) of the Rigid Raft Foundations of size $15.00 \text{ m} \times 20.00 \text{ m}$ at 4.50 m depth below Avg. E.G.L. (During the period of field work, Avg. E.G.L. was about 0.60 m below H.T. Tower Raft Top Level), for foundation design purposes.