

**Report
On
Sub-Soil Investigation
For
Proposed Buildings
At
Pre. No. - 214 F, Raja Rammohan
Roy Road, Ward No. - 122,
Borough - XII, P.S. - Haridevpur,
Kolkata - 700008.**

Name of Client
**SHREE BALASARIA
CONSTRUCTION PVT. LTD.**
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Kolkata - 700 007.

Name of Structural Engineer
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Name of Architect
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8B, Royd Street, Kolkata - 700 016.

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REPORT NO. : GT / SD / 37 / 2019 - 2020



REPORT

ON

SUB-SOIL INVESTIGATION

FOR

PROPOSED BUILDINGS

AT

**PRE. NO. - 214 F, RAJA RAMMOHANROY ROAD, WARD NO. - 122,
BOROUGH - XII, P.S. - HARIDÉVPUR, KOLKATA – 700 008.**

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1. INTRODUCTION

The work of sub-soil exploration for the Proposed Building at Pre. No.- 214 F, Raja Rammohan Roy Road, Ward No. - 122, Borough- XII, P.S - Haridevpur, Kolkata – 700 080 was awarded to M/S. GEOTEST ENGINEERS PVT. LTD. of 6A, Milan Park, Kolkata - 700 084 by the Client SHREE BALASARIA CONSTRUCTION PVT. LTD. of 20, Mullick Street. Opposite- Mahabir Khatra, Kolkata – 700 007. The sub-soil investigation purpose for the proposed building at the aforesaid site was to determine the sub-soil condition and to ascertain the foundation types that would be suitable for the proposed building. The Fieldwork was done in the month of June, 2019. 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 building at this site, 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 3 (three) numbers, 150 mm. dia., exploratory boreholes, all with termination depth of about 25.00 m. below E.G.L. each at prefixed location at the site. The borehole numbers, depths & location were finalized & fixed by the **Structural Engineer**. 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 of proposed building.

- (c) Carrying out standard penetration tests as per the provisions laid down in IS: 2131 (1981) 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 building 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 Shell & Auger boring technique upto their termination depths below E.G.L. in all the boreholes by Mechanically Power Driven Winch, by providing casing throughout the explored depths.

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 (1981) (Reaffirmed 1987). 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 both 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 level was at an average depth of about 1.75 m. below Road Level, during the period of fieldwork from 17.06.2019 to 21.06.2019.



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4. LABORATORY INVESTIGATION

For proper identification and classification of the sub-surface deposits and for deriving adequate informations 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 boreholes.

- (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) Unconfined compression tests on undisturbed cohesive soil samples.
- (g) 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} .
- (h) Consolidation tests on cohesive soil samples for determination of settlement potentials.
- (i) 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 profile as revealed by all the boreholes is shown in 'Sub-Soil Profile' and in 'TABLE 1'. On the basis of extensive field and laboratory tests on disturbed and undisturbed soil specimens and on visual inspection, the classification of different strata and engineering properties of soil are discussed below:

Stratum I *Top fill of very soft / soft grey silty clay / clayey silt with grass roots, stone chips, snail shells, brick pieces, brick bats & kankars.*

This layer extends from *E.G.L. to 3.20 m. below E.G.L. in B.H.1, from *E.G.L. to 3.00 m. below E.G.L. in B.H.2 and from *E.G.L. m. to 2.80 m. below E.G.L. in B.H.3. This layer contains top fill of very soft / soft grey silty clay / clayey silt with grass roots, stone chips, snail shells, brick pieces, brick bats & kankars. Field 'N' value of this layer is 02. This layer is very much unreliable in behavior under sustained concentrated loads from super structure and foundation should not be placed on it under normal circumstances. The relevant engineering properties are mentioned herewith, although, these parameters never represent the properties of entire stratum as the soil sample, which has been subjected to the following test, was collected only from the middle reaches of the filled-up layer.

Field 'N' value	= 02
Bulk Unit weight	= 18.04 kN/m ³ to 19.41 kN/m ³
Dry Unit weight	= 14.09 kN/m ³ to 15.24 kN/m ³
Natural Moisture Content	= 27.30 % to 28.02 %
Liquid Limit	= 58 %
Plastic Limit	= 20 % to 22 %
Undrained cohesion 'C'	= 20.66 kN/m ² to 25.10 kN/m ²

(From U.C.S. Test)

*During the period of fieldwork, E.G.L. was almost same as Road Level in B.H.1 & B.H.2 & 0.20 m. below Road Level in B.H.3.

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Specific gravity = 2.70
Initial void ratio 'e₀' = 0.737 to 0.756

Grain Size Analysis (Hydrometer Analysis):

Gravels = 02 % to 12 %
Sand = 14 % to 18 %
Silt = 24 % to 48 %
Clay = 36 %

The following are the average coefficient of volume compressibility (m_v) values of this stratum:

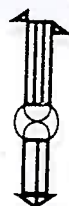
Pressure Range in kg/cm ²	m_v (m ² /kN)
0.00 – 0.25	0.000456
0.25 – 0.50	0.000384
0.50 – 1.00	0.000297
1.00 – 2.00	0.000197
2.00 – 4.00	0.000133
4.00 – 8.00	0.000083

Stratum II Soft grey silty clay with some traces of kankars and rusty brown silty spots.
(absent B.H.2)

This layer extends from 3.20 m. to 5.80 m. below E.G.L. in B.H.1 & 2.80 m. to 8.80 m. below E.G.L. in B.H.3. This layer contains soft grey silty clay with some traces of kankars and rusty brown silty spots. Field 'N' value of this layer ranges from 02 to 03, indicating its soft state of consistency. The relevant engineering properties are mentioned herewith:

Field 'N' value = 02 to 03
Bulk Unit weight = 17.71 kN/m³ to 18.06kN/m³
Dry Unit weight = 13.12 kN/m³ to 13.48 kN/m³
Natural Moisture Content = 33.93 % to 34.89 %
Liquid Limit = 64 % to 67 %
Plastic Limit = 22 % to 24 %

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Undrained cohesion 'C'	= 22.00 kN/m ² (From U.C.S. Test)
Undrained Cohesion 'C _u '	= 24.16 kN/m ² to 28.07 kN/m ² (From Triaxial U.U. Test)
Undrained angle of shear resistance 'φ _u '	= 0° (From Triaxial U.U. Test)
Specific gravity	= 2.60 to 2.65
Initial void ratio 'e ₀ '	= 0.899 to 0.905
Grain Size Analysis (Hydrometer Analysis):	
Gravels	= 02 %
Sand	= 04 %
Silt	= 52 % to 56 %
Clay	= 38 % to 44%
I.S. Classification	= CH

The following are the average coefficient of volume compressibility (m_v) values of this stratum:

Pressure Range in kg/cm ²	m_v (m ² /kN)
0.00 – 0.25	0.000504
0.25 – 0.50	0.000462
0.50 – 1.00	0.000341
1.00 – 2.00	0.000223
2.00 – 4.00	0.000152
4.00 – 8.00	0.000101

Stratum III Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium to high percent) of decomposed wood & organic matter.

This layer extends from 5.80 m. to 14.80 m. below E.G.L. in B.H.1, from 3.00 m. to 14.95 m. below E.G.L in B.H.2 & from 8.80 m. to 14.00 m. below E.G.L. in B.H.3. This layer contains very soft / soft grey / dark grey silty clay with varying percentage (traces to medium to high

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percent) of decomposed wood & organic matter. Traces to medium to high percentage of decomposed wood was observed in B.H.1 and traces to medium percentage of decomposed wood was observed in B.H.1 & B.H.3 only. Field 'N' value of this layer ranges from 01 to 03, indicating its very soft / soft state of consistency. The relevant engineering properties are mentioned herewith:

Field 'N' value	= 01 to 03
Bulk Density	= 14.29 kN/m ³ to 18.08 kN/m ³
Dry Density	= 8.60 kN/m ³ to 13.53 kN/m ³
Natural Moisture Content	= 33.61 % to 56.32 % / **66.14 %
Liquid Limit	= 68 % to 86 % / **93.00%
Plastic Limit	= 24 % to 29 % / **38.00%
Undrained cohesion 'C'	= 15.65 kN/m ² to 27.73 kN/m ² (From U.C.S. Test)
Undrained Cohesion 'C _u '	= 18.31 kN/m ² to 27.41 kN/m ² (From Triaxial U.U. Test)
Undrained angle of shear resistance 'φ _u '	= 0° (From Triaxial U.U. Test)
Specific Gravity	= 2.48 to 2.60
Initial void ratio 'e ₀ '	= 0.873 to 1.396
Grain Size Analysis (Hydrometer Analysis):	
Sand	= 01 % to 03 %
Silt	= 51 % to 55 %
Clay	= 42 % to 48 %
I.S. Classification	= CH - OH

****High values due to presence of high percentage of decomposed wood and organic matter in soil sample.**

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The following average are the coefficient of volume compressibility (m_v) values of this stratum:

Pressure Range in kg/cm^2	m_v (m^2/kN)
0.00 – 0.25	0.000685
0.25 – 0.50	0.000611
0.50 – 1.00	0.000441
1.00 – 2.00	0.000302
2.00 – 4.00	0.000207
4.00 – 8.00	0.000105

Stratum IV *Stiff / very stiff bluish grey / brown silty clay / clayey silt with rusty spots and kanakrs.*

This layer extends from 14.80 m. to 23.50 m. below E.G.L. in B.H.1, from 14.95 m. to 22.50 m. below E.G.L. in B.H.2 & from 14.00 m. to 23.50 m. below E.G.L. in B.H.3. This layer contains stiff / very stiff bluish grey / brown silty clay / clayey silt with rusty spots and kanakrs. Field 'N' value of this layer ranges from 08 to 23, indicating its stiff / very stiff state of consistency. The relevant engineering properties are mentioned herewith:

Field 'N' value	= 08 to 23
Bulk Density	= 18.57 kN/m^3 to 19.70 kN/m^3
Dry Density	= 14.11 kN/m^3 to 15.74 kN/m^3
Natural Moisture Content	= 23.00 % to 31.69 %
Liquid Limit	= 46 % to 65 %
Plastic Limit	= 21 % to 24%
Undrained Cohesion ' C_u '	= 39.06 kN/m^2 to 87.44 kN/m^2 (From Triaxial U.U. Test)
Undrained angle of shear resistance ' ϕ_u '	= 0° to 6° (From Triaxial U.U. Test)
Specific Gravity	= 2.70 to 2.72
Initial void ratio ' e_0 '	= 0.682 to 0.761

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Grain Size Analysis (Hydrometer Analysis)

Sand	= 07 %
Silt	= 53 % to 67 %
Clay	= 26 % to 40 %
I.S. Classification	= CH - MH

The following are the average coefficient of volume compressibility (m_v) values of this stratum:

Pressure Range in kg/cm^2	m_v (m^2/kN)
0.00 – 0.25	0.000410
0.25 – 0.50	0.000352
0.50 – 1.00	0.000264
1.00 – 2.00	0.000173
2.00 – 4.00	0.000119
4.00 – 8.00	0.000077

Stratum V Medium / dense brownish grey silty fine sand with traces of mica & clay & silt as binder.

This layer extends from 23.50 m. to the borehole termination depth of about 25.45 m. below E.G.L. in B.H.1 & from 22.50 m. to that of about 25.45 m. below E.G.L. in B.H.2 & from 23.50 m. to that of about 25.00 m. below E.G.L. in B.H.3. This layer consists of medium / dense brownish grey silty fine sand with traces of mica & clay & silt as binder. Field 'N' value of this layer ranges from 21 to 36, indicating its medium / dense degree of compactness.

I.S. Classification = SM

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TABLE - 1

AVERAGE SUB-SOIL PROFILE

<i>Stratum</i>	<i>Description</i>	<i>Average Thickness</i>	<i>Range of Field 'N' value</i>	<i>IS Classification</i>
I	Top fill of very soft / soft grey silty clay / clayey silt with grass roots, stone chips, snail shells, brick pieces, brick bats & kankars.	3.00 m.	02	-
II	Soft grey silty clay with some traces of kankars and rusty brown silty spots. (absent B.H.2)	2.87 m.	02 to 03	CH
III	Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium to high percent) of decomposed wood & organic matter.	8.72 m.	01 to 03	CH - OH
IV	Stiff / very stiff bluish grey / brown silty clay / clayey silt with rusty spots and kanakrs.	8.58 m.	08 to 23	CH - MH
V	Medium / dense brownish grey silty fine sand with traces of mica & clay & silt as binder.	More than 1.95 m., 2.95 m. & 1.50 m. in B.H.1, B.H.2 & B.H.3 respectively.	21 to 36	SM



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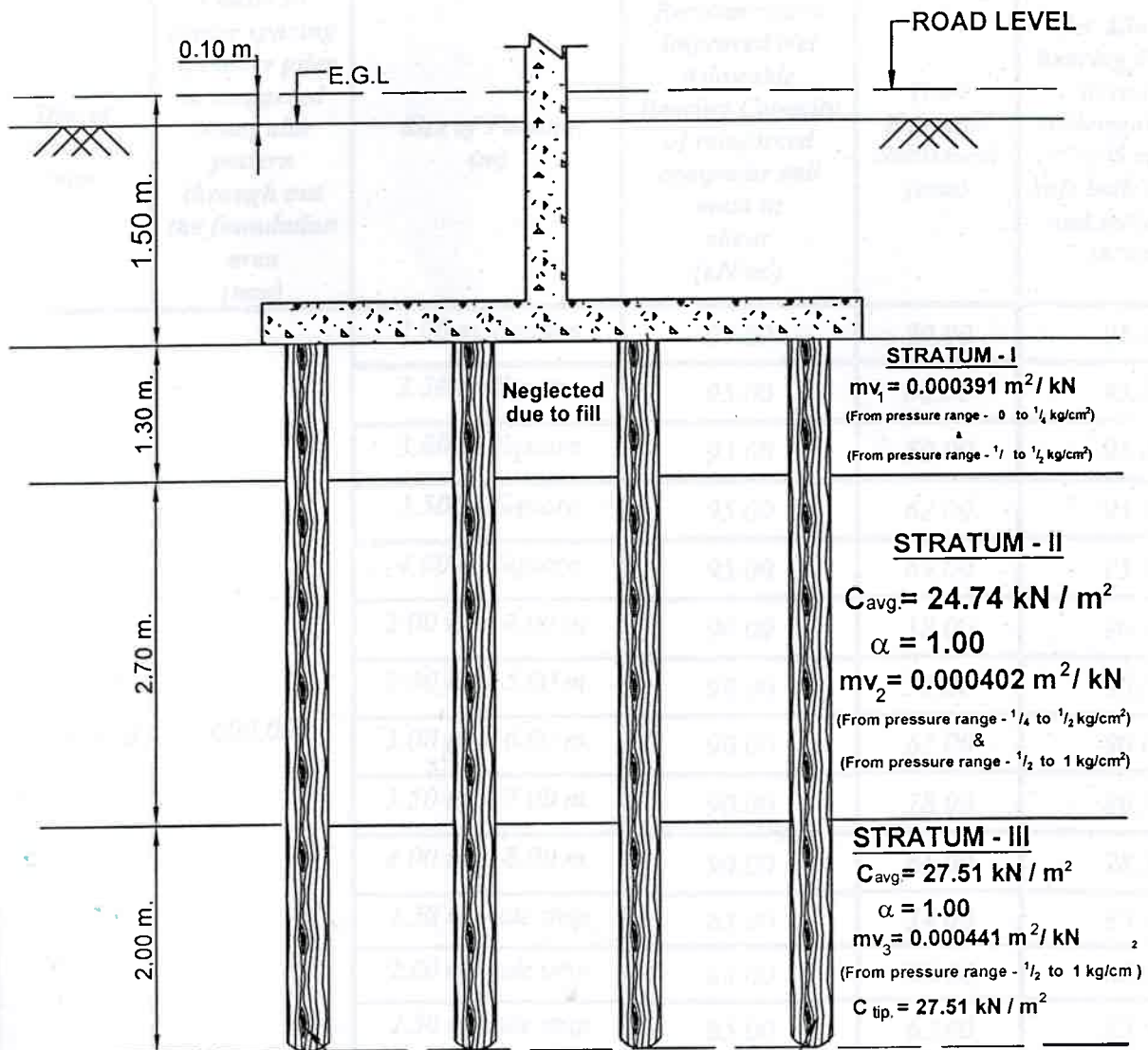
6. BEARING CAPACITY OF TIMBER PILE & DEEP FOUNDATIONS

FOUNDATION DESIGN MODEL

FOR SHALLOW FOUNDATION RESTING ON REINFORCED SOIL MASS (BY TIMBER PILING)

DEPTH OF FOUNDATION = 1.50 m BELOW ROAD LEVEL.

(DRAWING NOT TO SCALE)



TIMBER PILE (6" dia at top and 4" dia at toe, 6m long @ 600 mm C/C)

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6.1 Improved bearing capacity of composite soil mass reinforced with vertical timber piles (sal balla, not eucalyptus balla) above which footings are to be placed at 1.50 m. below Road Level.

Termination depth of timber piles = 7.50 m. below Road Level.

Assumed cut-off level = 1.50 m. below Road Level.

Length of timber pile = 6.00 m.

TABLE 2(A)

Dia. of timber pile (mm)	Center to center spacing of timber piles in staggered triangular pattern through out the foundation area (mm)	Size of Footing (m)	Recommended Improved Net Allowable Bearing Capacity of reinforced composite soil mass 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)
(6" ϕ at top & 4" ϕ at bottom)	600.00	2.00 m. Square	95.00	29.00	95.00
		2.50 m. Square	95.00	40.00	95.00
		3.00 m. Square	95.00	50.00	95.00
		3.50 m. Square	95.00	62.00	95.00
		4.00 m. Square	95.00	69.00	95.00
		2.00 m. x 4.00 m.	90.00	38.00	90.00
		2.50 m. x 5.00 m.	90.00	51.00	90.00
		3.00 m. x 6.00 m.	90.00	63.00	90.00
		3.50 m. x 7.00 m.	90.00	78.00	86.50
		4.00 m. x 8.00 m.	90.00	86.00	78.50
		1.50 m. wide strip	85.00	34.00	85.00
		2.00 m. wide strip	85.00	48.00	85.00
		2.50 m. wide strip	85.00	62.00	85.00
		3.00 m. wide strip	85.00	77.00	82.80
		3.50 m. wide strip	85.00	96.00	66.40

*As per Table – 1 of I.S.1904 (1986) for isolated foundation for Multistoried Building in plastic clay, like in present case.



6.2. Deep Foundations: R.C. Bored Pile

The load carrying capacities of R.C. Bored Piles, for various dia., are calculated on the basis of I.S. Code of Practice of design and construction of pile foundations, IS: 2911 (Part I / Sec 2) – 2010.

Using the static formula,

For piles in granular soils

$$Q_u = A_p (1/2 D \gamma N_\gamma + P_d N_q) + \sum K P_d \tan \phi A_s \text{ [I.S. 2911 (Part I / sec-2)-2010, Annex -B: clause 6.3.1.1 and 6.3.2],}$$

- Where, A_p = Cross-sectional area of pile toe.
 D = Stem diameter.
 γ = Effective unit weight of soil at pile toe.
 P_d = Effective overburden pressure at pile toe.
 A_s = Surface area of pile shaft.
 N_γ, N_q = Bearing capacity factors depending on ϕ .

For piles in cohesive soils

$$Q_u = A_p N_c C_p + \sum \alpha C A_s \text{ [I.S. 2911 (Part I / sec-2)-2010, Annex -B: clause 6.3.1.1 and 6.3.2],}$$

- Where, A_p = Cross-sectional area of pile toe.
 N_c = Bearing capacity factor = 9.0.
 C_p = Average cohesion at pile toe.
 α = Reduction factor.
 C = Average cohesion throughout the length of pile.
 A_s = Surface area of pile shaft.

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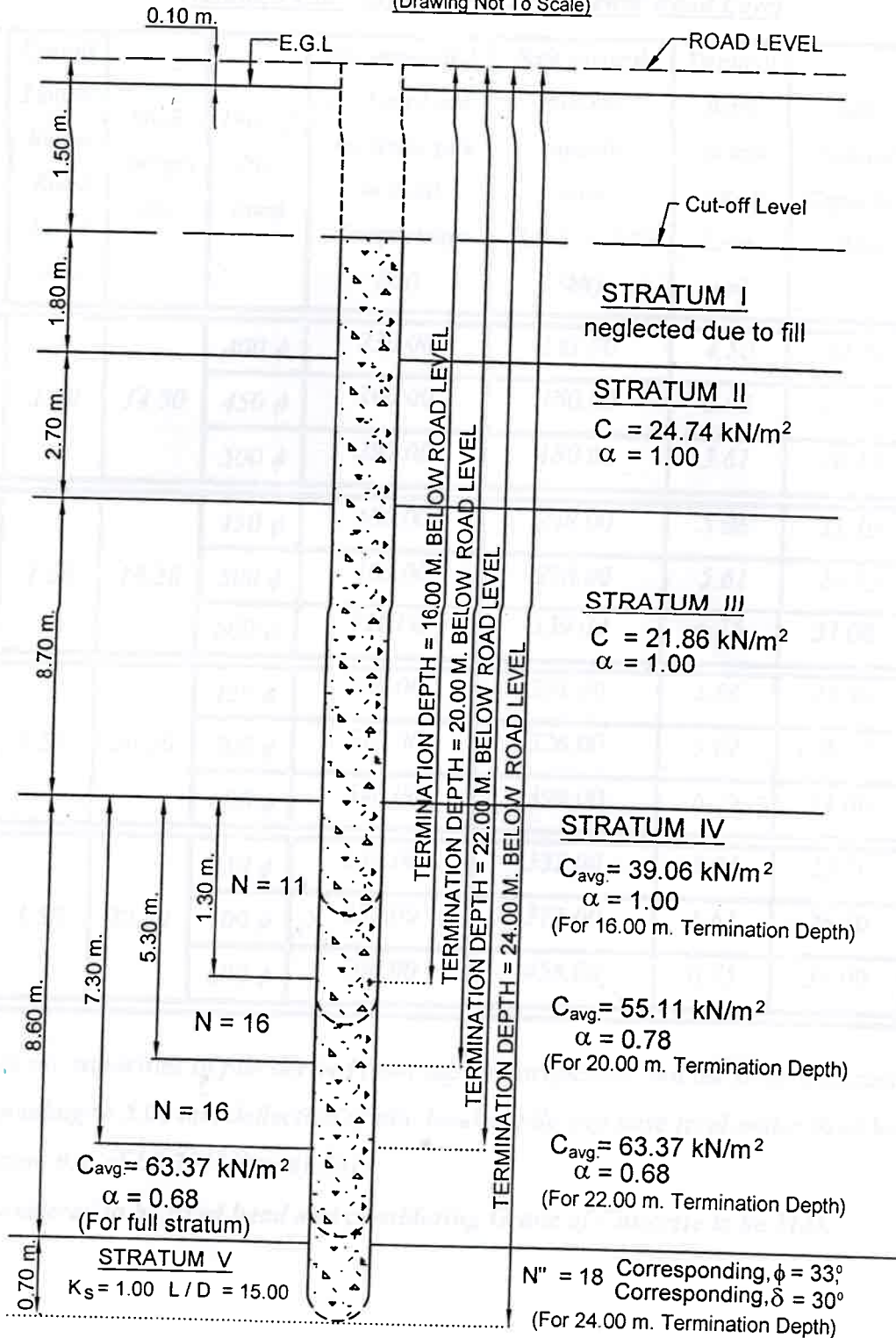
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FOUNDATION DESIGN MODEL FOR R.C. BORED CAST IN-SITU PILE

Termination Depth = 16.00 m, 20.00 m, 22.00 m, & 24.00 m below Road Level.

Cut - off Level = 1.50 m. below Road Level.

(Drawing Not To Scale)



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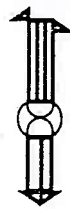
TABLE 2(B)
Load Carrying Capacities of R.C. Bored Piles of Straight Shaft
Assumed Cut – off level = 1.50 m. below Road Level

Termination Depth of pile Below Road Level (m)	Cut-off Length Below Road Level (m)	Shaft Length (m)	Dia. of Pile (mm)	Recommended working Load on single pile in Axial Compression (kN)	Safe vertical Pull-out capacity with F.O.S. = 3.00 (kN)	Depth of fixity Below cut off Level (m)	Safe Lateral Capacity* (kN)	Safe Vertical Compressive Load capacity of single pile during seismic condition (kN)
16.00	1.50	14.50	400 ϕ	230.00	141.00	4.50	20.70	322.00
			450 ϕ	260.00	160.00	5.06	23.30	363.00
			500 ϕ	290.00	180.00	5.61	26.10	403.00
20.00	1.50	18.50	450 ϕ	400.00	248.00	5.06	23.30	571.00
			500 ϕ	460.00	278.00	5.61	26.10	635.00
			600 ϕ	520.00	339.00	6.75	31.00	762.00
22.00	1.50	20.50	450 ϕ	460.00	291.00	5.06	23.30	673.00
			500 ϕ	510.00	326.00	5.61	26.10	748.00
			600 ϕ	640.00	399.00	6.75	31.00	898.00
24.00	1.50	22.50	450 ϕ	530.00	332.00	5.06	23.30	772.00
			500 ϕ	580.00	373.00	5.61	26.10	861.00
			600 ϕ	700.00	458.00	6.75	31.00	1040.00

N.B. : These are the capacities of pile derived from sub-soil properties, not the structural capacities.

*Corresponding to 5.00 mm deflection of pile head at pile cap base level under fixed head condition, as per clause 8.4. of I.S.2911(Part4):2013.

Pile is considered to be fixed head and considering Grade of Concrete to be M25.



7. RECOMMENDATIONS

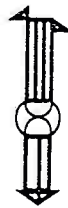
From the information as supplied by the client, it is known that there is a proposal for the construction of some (G+4) storied buildings at the site. However, whatever be the type, height and nature of the buildings, their foundation design should satisfy two basic criteria. They are as follows:

- (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 (1986).*

Considering the above mentioned criteria and sub-soil condition in situ, it is observed that, the site has Poor subsoil condition at upper reaches. Top 'fill' of very soft / soft grey silty clay / clayey silt with grass roots, stone chips, brick pieces, kankars and conch shells was observed upto 3.20 m. (to exist below E.G.L.) in B.H.1, 3.00 m. (to exist below E.G.L.) in B.H.2 & 2.80 m. (to exist below E.G.L.) in B.H.3. This layer is very much unreliable in behavior under sustained concentrated loads from super structure and foundation should not be placed on it, under normal circumstances. Hence, conventional shallow foundations are not suggested to be provided. So, it is suggested to try to use shallow foundations after ground improvement, which can be done by Timber Piles. The improved bearing capacity of shallow foundations resting on ground reinforced with vertical timber piling, is provided in TABLE 2(A) of previous chapter.

For Ground Improvement by timber piling to be done, it is suggested to excavate the entire foundation area (may be in phases) upto 1.50 m. below Road Level, drive the timber piles of 6.00 m. long, 6" dia. at top and 4" dia. at tip, to be driven at 600 mm c/c staggered triangular spacing & then to design & place the shallow footings with net allowable bearing pressure as given in TABLE 2(A) of previous chapter. Timber piles are to be driven irrespective of column and foundation position, for the entire foundation area & its horizontal extent should go at least 0.50 m. extra beyond the outer periphery of the proposed foundations on outer sides of the proposed buildings. Timber piles should be coated with creosote coating before driving.

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Complete submergence of timber piles below ground water table can be envisaged & hence its long-term performance can also be expected.

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

It is very important to note that quality of timber piling is very important to get a successful timber piling job. Undersized timber piles (be it in dia & or be it in length) should never be used. In many cases, casual approach is taken in timber pile spacing which is driven @ 700 mm to 800 mm c/c spacing. In those cases, long term foundation settlement problem persists even after timber pile driving. Another important point to note is that, sal balla should be used, not eucalyptus balla.

In present case, if undersized timber piles are used & if spacing is increased from 600 mm c/c to more, then it cannot be confidently said that timber piling will be successful.

The last option is to go for deep foundation in the form of R.C. Bored Piles, the load capacities of which are provided in TABLE 2(B) of previous chapter.

For pile having termination depth of 16.00 m. below Road Level. if used, the entire piling job can be done by Hand Auger piling method, although DMC piles would produce better quality pile.

But for pile having termination depth of 20.00 m. or 22.00 m. or 24.00 m. below Road Level, if used, D.M.C. method of piling is strongly suggested.

It is strongly recommended that the design load carrying capacities should be verified as per routine Load Test on working pile to be done as per IS: 2911 (Part 4):2013, if R.C. Bored Piles are used.

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For R.C. bored piles, if used, while considering the seismic effect, the skin friction component the pile load capacities, as given in TABLE 2(B), may be increased by 25 % as per Table 1 (clause 6.4.2.1) of IS: 1893 (Part I): 2016 & the increased load capacity are provided in extreme R.H.S column of TABLE 2(B) of previous chapter. However, no percentage increase in SBC is allowed under seismic condition for Timber Pile foundation as given in TABLE 2(A), respectively, in present type of sub soil condition, as per (clause 6.4.2.1) of IS: 1893 (Part I): 2016.

Now-a-days, to ensure and assess quality control in R.C. piling job, load test as per IS: 2911 (Part 4) is not solitarily enough. It is suggested that load tests should be supplemented by low-strain non-destructive integrity tests on piles, in early, intermediate and last stage of piling job, if R. C. Bored Piles are used.

Ground water level during the period of fieldwork was observed at a depth of about 1.75 m. below Road Level Since the fieldwork was done in the month of June, before the advent of monsoon, it can be considered as low water table location, which can be normally expected to come up in Monsoon. So it is envisaged that, constant pumping will not be necessary to keep the excavation water free, due to the position of water table below the founding depth in case of shallow foundation & below the cut off level in case of concrete piles. However, situation may be worsened if foundation excavation is done in heavy and continuous monsoon, when water table may rise above 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 Timber Pile and load carrying capacities of R.C. Bored Piles 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.

Back filling of foundation pits should be done by good quality earth and by proper compaction.

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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, is to be adopted to avoid excessive ground settlement and damage to adjoining structures.

For and on behalf of GEOTEST ENGINEERS PVT. LTD.


[ALOK ROY]

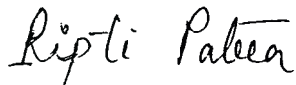
B.E. (CIVIL), MCE (SOIL MECH. and FOUNDN. ENGG.)

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

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

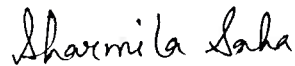
Director.

Report Prepared By



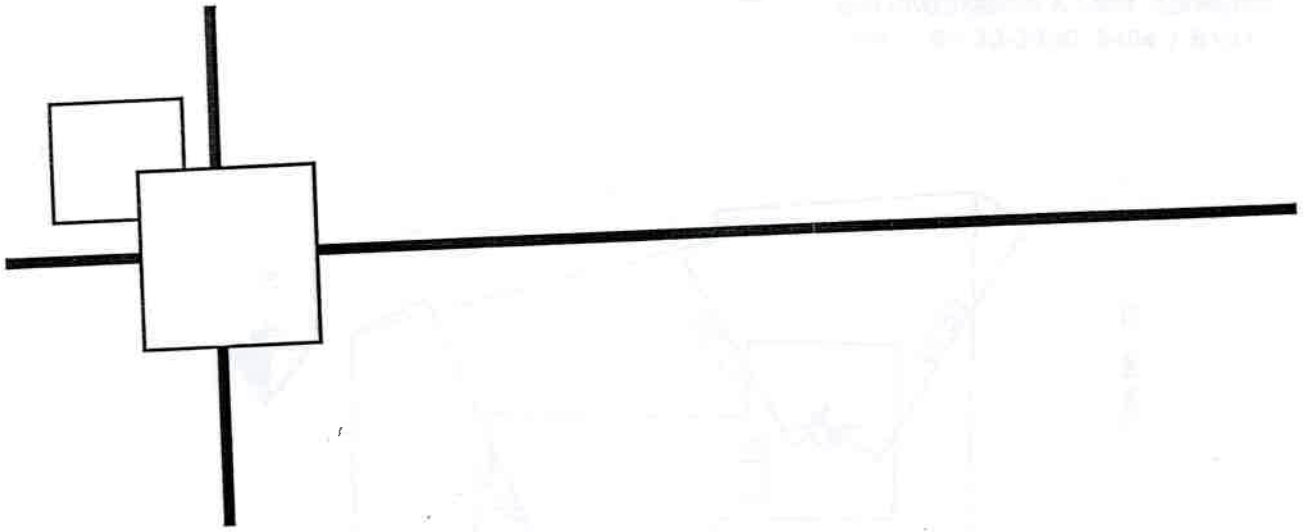
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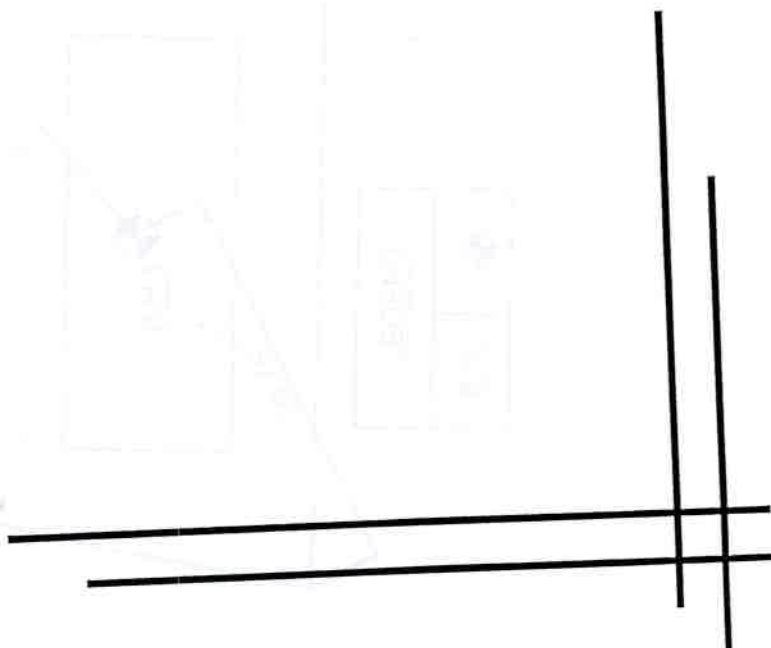
[SHARMILA SAHA]


[SRESTHA CHAKRABORTY]



WIDEHILL LOCATION PLAN

ANNEXURE



REPORT SHEET



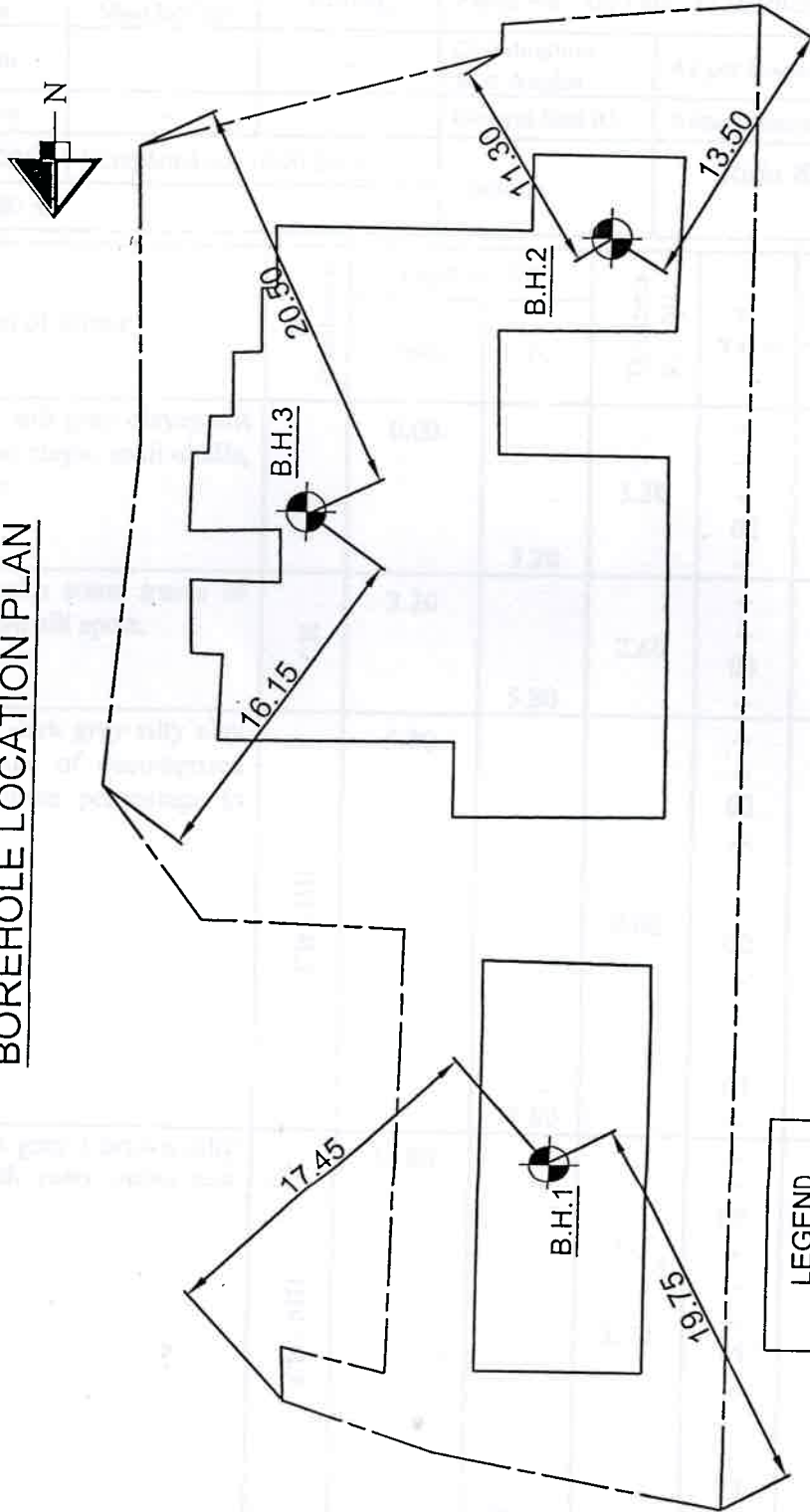
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BOREHOLE LOCATION PLAN



NOTE

- i) Drawing not to scale.
- ii) All dimensions are in m.
- iii) All dimensions are approximate.

LEGEND

B.H.



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BORE LOG DATA SHEET

Type of boring	Shell and Auger	Bentonite Mud Boring	Drilling	Report No.: GT / SD / 37 / 2019-2020	B.H.1
Dia of Hole	150 mm.	--	--	Coordination Sext Angles	As per Borehole Location Plan.
Depth	25.45 m	--	--	Ground Bed RL	Almost Same as Road Level.
Commenced on: 17.06.2019	Completed on: 18.06.2019		Location:	Raja Rammohan Roy Road, Kolkata.	
Standing Water Level: 1.80 m					

Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES Type	Depth in 'M'
		From	To				
Top fill of very soft / soft grey clayey silt with grass roots, stone chips, snail shells, brick pieces & kankars.		0.00		3.20	--	D	0.00
					--	D	0.50
					--	D	1.00
					02	P	1.50 - 1.95
					--	D	2.50
Soft grey silty clay with some traces of kankars and rusty brown silt spots.	CH	3.20		2.60	--	*U	3.00 - 3.45
					--	D	4.00
					03	P	4.50 - 4.95
					--	D	5.50
Very soft / soft grey / dark grey silty clay with varying percentage of decomposed wood. (Traces to medium percentage to high percentage)	CH - OH	5.80		9.00	--	U	6.00 - 6.45
					--	D	7.00
					02	P	7.50 - 7.95
					--	D	8.50
					--	U	9.00 - 9.45
					--	D	10.00
					02	P	10.50 - 10.95
					--	D	11.50
					--	U	12.00 - 12.45
					--	D	13.00
Stiff / very stiff bluish grey / brown silty clay / clayey silt with rusty spots and kankars.	CH - MH	14.80		8.70	--	U	15.00 - 15.45
					--	D	16.00
					09	P	16.50 - 16.95
					--	D	17.50
					--	U	18.00 - 18.45
					--	D	19.00
					16	P	19.50 - 19.95
					--	D	20.50
					--	U	21.00 - 21.45
					--	D	22.00
Dense brownish grey silty fine sand with traces of mica & clay & silt as binder.	SM	23.50			31	P	24.00 - 24.45
					36	P	25.00 - 25.45

Borehole Terminated.

S. S.: Sujoy Ray

D - Disturbed Sample

U - Undisturbed Sample

P - Standard Penetration Test

UDS lies in interface zone between 2 different layers.

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BORE LOG DATA SHEET

Type of boring	Shell and Auger	Bentonite Mud Boring	Drilling	Report No.: GT / SD / 37 / 2019-2020	B.H.2
Dia of Hole	150 mm.	--	--	Coordination Sext Angles	As per Borehole Location Plan.
Depth	25.45 m	--	--	Ground Bed RL	Almost Same as Road Level.
Commenced on: 20.06.2019	Completed on: 21.06.2019		Location:	Raja Rammohan Roy Road, Kolkata.	
Standing Water Level: 1.65 m					

Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES Type	Depth in 'M'
		From	To				
Top fill of very soft / soft grey silty clay with grass roots, brick pieces sand & kankars.		0.00		3.00	--	D	0.00
					--	D	0.50
					02	P	1.00 - 1.45
					--	D	2.00
Very soft / soft grey / dark grey silty clay with varying percentage of decomposed wood and organic matter. (Traces to medium percentage)	CH - OH	3.00		11.95	--	D	3.50
					03	P	4.00 - 4.45
					--	D	5.00
					--	U	5.50 - 5.95
					--	D	6.50
					02	P	7.00 - 7.45
					--	D	8.00
					--	U	8.50 - 8.95
					--	D	9.50
					03	P	10.00 - 10.45
					--	D	11.00
					--	U	11.50 - 11.95
					--	D	12.50
Stiff / very stiff bluish grey / mottled brown silty clay with kankars and rusty brown silt spots.	CH - MH	14.95		7.55	--	D	15.50
					11	P	16.00 - 16.45
					--	D	17.00
					--	U	17.50 - 17.95
					--	D	18.50
					18	P	19.00 - 19.45
					--	D	20.00
Medium / dense brownish grey silty fine sand with traces of mica.	SM	22.50	25.45		--	U	20.50 - 20.95
					--	D	21.50
					17	P	22.00 - 22.45
					27	P	23.50 - 23.95
					32	P	25.00 - 25.45

Borehole Terminated.

S. S.: Sujoy Ray

D - Disturbed Sample

U - Undisturbed Sample

P - Standard Penetration Test

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BORE LOG DATA SHEET

Type of boring	Shell and Auger	Bentonite Mud Boring	Drilling	Report No.: GT / SD / 37 / 2019-2020	B.H.3
Dia of Hole	150 mm.	--	--	Coordination Sext Angles	As per Borehole Location Plan.
Depth	25.45 m	--	--	Ground Bed RL	About 0.20 m. below Road Level.
Commenced on: 18.06.2019	Completed on: 19.06.2019		Location:	Raja Rammohan Roy Road, Kolkata.	
Standing Water Level: 1.60 m					

Description of strata	I.S. Classification	Depth in 'M'		Thickness in 'M'	'N' Value	SAMPLES	Depth in 'M'
		From	To			Type	
Top fill of very soft / soft grey clayey silt mixed with rubbish, stone chips, brick pieces, sand, brick bats & grass roots.		0.00	2.80	2.80	--	D	0.00
						D	0.50
						D	1.00
						U	1.50 - 1.95
						D	2.50
Soft grey silty clay with rusty brown silt spots and kankars.	CH	2.80	8.80	6.00	02	P	3.00 - 3.45
						D	4.00
						U	4.50 - 4.95
						D	5.50
						03	6.00 - 6.45
						D	7.00
						U	7.50 - 7.95
D	8.50						
Very soft / soft grey silty clay with varying percentage of decomposed wood. (Traces to medium percentage)	CH - OH	8.80	14.00	5.20	01	P	9.00 - 9.45
						D	10.00
						U	10.50 - 10.95
						D	11.50
						02	12.00 - 12.45
						D	13.00
Firm / stiff bluish grey / mottled brown silty clay / clayey silt with rusty brown silt spots & kankars.	CH - MH	14.00	23.50	9.50	--	D	14.50
						08	15.00 - 15.45
						D	16.00
						U	16.50 - 16.95
						D	17.50
						12	18.00 - 18.45
						D	19.00
						U	19.50 - 19.95
						D	20.50
						14	21.00 - 21.45
D	22.00						
Medium / dense brownish grey silty fine sand with traces of mica.	SM	23.50	25.45		09	Uslip	22.50 - 22.95
						P	23.00 - 23.45
						P	24.00 - 24.45
						P	25.00 - 25.45

Borehole Terminated.

S. S.: Sujoy Ray

D - Disturbed Sample

U - Undisturbed Sample

P - Standard Penetration Test

REPORT SHEET



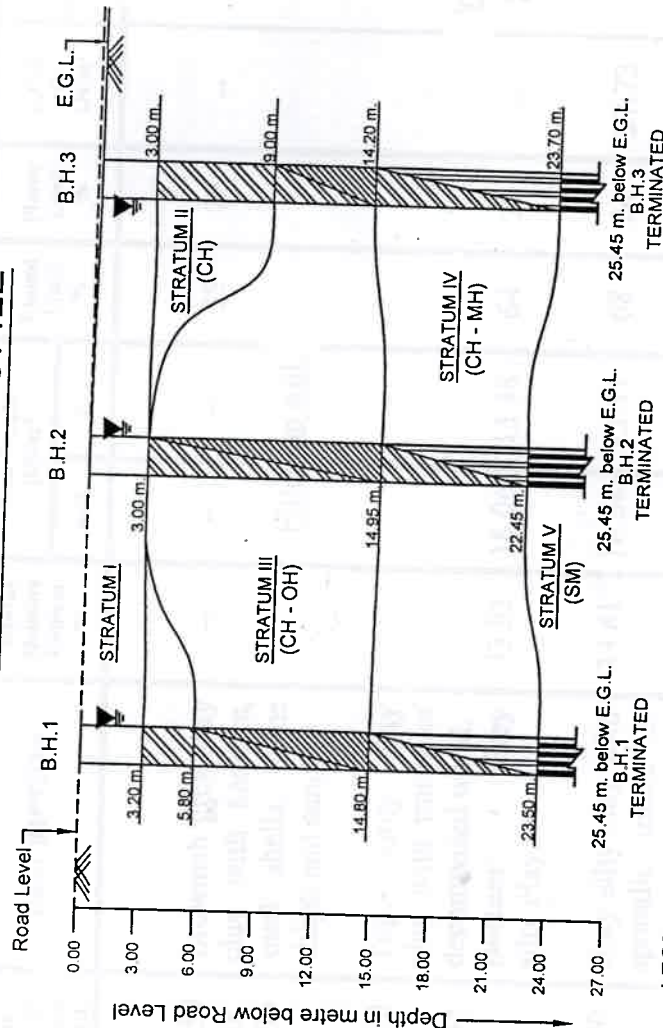
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SUB SOIL PROFILE



LEGEND :-

STRATUM I

Top fill of very soft / soft grey silty clay / clayey silt with grass roots, stone chips, snail shells, brick pieces, brick bats & kankars.

STRATUM II

Soft grey silty clay with some traces of kankars and rusty brown silty spots. (absent B.H.2)

STRATUM III

Very soft / soft grey / dark grey silty clay with varying percentage (traces to medium to high percent) of decomposed wood & organic matter.

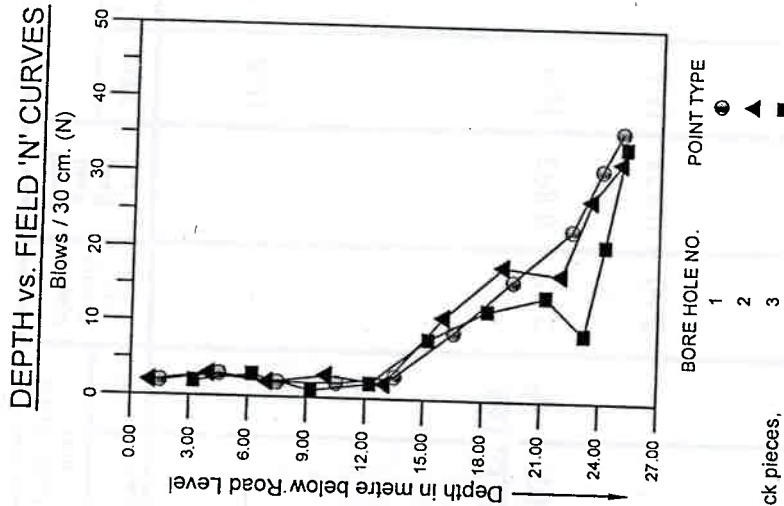
STRATUM IV

Stiff / very stiff bluish grey / brown silty clay / clayey silt with rusty spots and kankars.

STRATUM V

Medium / dense brownish grey silty fine sand with traces of mica & clay & silt as binder.

During the period of fieldwork, E.G.L. was almost same as Road Level in B.H.1 & B.H.2 & 0.20 m. below Road Level in B.H.3.



Laboratory Test Results

Location: Raja Rammohan Roy Road, Kolkata.

B.H. No.	Stratum	TYP E	Depth in Metre below EGL	DESCRIPTION	Natural Moisture Content %	Unit Weight (kN/m ³)		Liquid Limit %	Plastic Limit %	U.C.S. 'C' kN/m ²	Triaxial / Direct Shear		Specific Gravity 'G'	Initial Void Ratio 'e ₀ '	GRAIN SIZE				
						Bulk	Dry				'C' kN/m ²	'ψ'			TYPE	Gravel %	Sand %	Silt %	Clay %
1. I	P		1.50 to 1.95	Brownish grey silty clay with kankars, snail shells, stone chips, and sand.	--	--	--	59	20	--	--	--	--	--	H.A.	02	09	53	36
1. I & II	U		3.00 to 3.45	Top:- Grey silty clay with traces of decomposed wood. Bottom: - Grey silty clay.	33.93	18.06	13.48	64	23	--	Tr. U. U. Test 28.07	0°	2.65	0.899	H.A.	--	04	52	44
1. III	U		6.00 to 6.45	Grey silty clay with sporadic traces of decomposed wood.	33.61	18.08	13.53	68	24	27.73	--	--	2.60	0.873	H.A.	--	03	51	46
1. III	U		9.00 to 9.45	Grey silty clay with high percentage of decomposed wood.	66.14	14.29	8.60	* 93	* 38	15.65	--	--	--	--	--	--	--	--	--

*High values due to presence of high percentage of decomposed wood in soil sample.

Note: 1) Atterberg's limit tests have been conducted on air dried samples.
2) Triaxial tests have been conducted with minimum cell pressure equal to or slightly greater than the geostatic stress at 'in-situ' condition from where the Sample had been procured.

Abbreviation: U = Undisturbed Sample, P = SPT Sample, H.A. = Hydrometer Analysis, S.A. = Sieve Analysis.

Laboratory Test Results

Location: Raja Rammohan Roy Road, Kolkata.

BH. No.	Stratum	TYPE	Depth in Metre below EGL	DESCRIPTION	Natural Moisture Content %	Unit Weight (kN/m ³)		Liquid Limit %	Plastic Limit %	U.C.S. 'C' kN/m ²	Triaxial/Direct Shear		Specific Gravity 'G'	Initial Void Ratio 'e ₀ '	GRAIN SIZE				
						Bulk	Dry				'C' kN/m ²	'φ'			TYPE	Gravel %	Sand %	Silt %	Clay %
	III	U	12.00 to 12.45	Grey silty clay with medium percentage of decomposed wood.	41.24	16.62	11.76	73	26	19.64	--	--	--	--	--	--	--	--	--
	IV	U	15.00 to 15.45	Bluish grey silty clay with rusty brown silt spots.	28.20	18.63	14.53	63	21	--	Tr. U. U. Test		2.70	0.761	H.A.	--	07	53	40
	IV	U	18.00 to 18.45	Bluish grey silty clay with rusty brown silt spots.	23.00	19.37	15.74	65	21	--	65.24	0°	--	--	--	--	--	--	--
	IV	U	21.00 to 21.45	Mottled brown clayey silt with traces of mica.	26.25	18.57	14.70	46	22	--	80.58	4°	2.71	0.711	H.A.	--	07	67	26
	IV	P	22.50 to 22.95	Mottled brown silty clay with rusty brown silt spots.	--	--	--	60	20	--	--	--	--	--	H.A.	--	07	55	38

Laboratory Test Results

Location: Raja Rammohan Roy Road, Kolkata.

B.F. No.	Stratum	TYP	Depth in Metre below EGL	DESCRIPTION	Natural Moisture Content %	Unit Weight (kN/m ³)		Liquid Limit %	Plastic Limit %	U.C.S. 'C' kN/m ²	Triaxial / Direct Shear		Specific Gravity 'G'	Initial Void Ratio 'e ₀ '	GRAIN SIZE				
						Bulk	Dry				'C' kN/m ²	'φ'			TYPE				
1.	V	P	24.00 to 24.45	Brownish grey silty fine sand with traces of mica.	--	--	--	NP	NP	--	--	--	--	--	H.A.	--	87	←13→	
2.	I	U	2.50 to 2.95	Brownish grey silty clay with kankars, brick pieces & sand.	27.30	19.41	15.24	58	20	20.66	--	--	2.70	0.737	H.A.	12	28	24	36
2.	III	U	5.50 to 5.95	Grey silty clay with sporadic traces of decomposed wood.	34.13	18.08	13.47	70	24	--	Tr. U. U. Test		--	--	--	--	--	--	--
2.	III	U	8.50 to 8.95	Grey silty clay with medium percentage of decomposed wood.	56.32	16.32	10.44	86	29	16.24	--	--	2.48	1.396	H.A.	--	01	51	48
2.	III	U	11.50 to 11.95	Grey silty clay with traces of decomposed wood.	37.63	17.22	12.51	73	24	--	24.11	0°	--	--	--	--	--	--	--

Laboratory Test Results

LAB- 14
Issue -01

Location: Raja Rammohan Roy Road, Kolkata.

Strat	TYPE	Depth in Metre below EGL	DESCRIPTION	Natural Moisture Content %	Unit Weight (kN/m ³)		Liquid Limit %	Plastic Limit %	U.C.S. 'C' kN/m ²	Triaxial / Direct Shear		Specific Gravity 'G'	Initial Void Ratio 'e ₀ '	GRAIN SIZE			
					Bulk	Dry				'C' kN/m ²	'φ'			Gravel %	Sand %	Silt %	Clay %
III	U	14.50 to 14.95	Grey silty clay with traces of decomposed wood	35.46	17.76	13.11	74	25	23.20	--	--	2.55	0.904	--	03	55	42
IV	U	17.50 to 17.95	Bluish grey silty clay.	31.69	18.59	14.11	61	21	--	Tr. U. U. Test 61.03	0°	--	--	--	--	--	--
IV	U	20.50 to 20.95	Mottled brown silty clay with rusty brown silt spots.	26.86	19.70	15.52	61	21	--	87.44	0°	2.71	0.727	--	07	55	38
IV	P	22.00 to 22.45	Mottled brown silty clay with rusty brown silt spots.	--	--	--	60	20	--	--	--	--	--	--	07	57	36
V	P	23.50 to 23.95	Brownish grey silty fine sand with traces of mica.	--	--	--	NP	NP	--	--	--	--	--	--	87	←13→	--

Laboratory Test Results

Location: Raja Rammohan Roy Road, Kolkata.

BH No.	Stratum	TYP E	Depth in Metre below EGL	DESCRIPTION	Natural Moisture Content %	Unit Weight (kN/m ³)		Liquid Limit %	Plastic Limit %	U.C.S. 'C' kN/m ²	Triaxial / Direct Shear		Specific Gravity 'G'	Initial Void Ratio 'e ₀ '	GRAIN SIZE				
						Bulk	Dry				'C' kN/m ²	'φ'			TYPE	Gravel %	Sand %	Silt %	Clay %
1.	I	U	1.50 to 1.95	Brownish grey silty clay with kankars, brick pieces & sand.	28.02	18.04	14.09	58	22	25.10	--	--	2.70	0.756	H.A.	02	14	48	36
						Filled up soil.													
2.	II	U	4.50 to 4.95	Brownish grey silty clay with rusty brown silt spots.	34.83	17.77	13.17	64	24	--	Tr. U. U. Test	24.16	0 ⁰	0.905	H.A.	02	04	56	38
3.	II	U	7.50 to 7.95	Grey silty clay.	34.89	17.71	13.12	67	22	22.00	--	--	--	--	--	--	--	--	--
4.	III	U	10.50 to 10.95	Grey silty clay with medium percentage of decomposed wood.	54.46	16.06	10.39	81	25	--	18.31	0 ⁰	--	--	--	--	--	--	--
5.	III	U	13.50 to 13.95	Grey silty clay with medium percentage of decomposed wood.	43.18	16.20	11.31	84	28	18.22	--	--	2.49	1.075	H.A.	--	01	55	44

Laboratory Test Results

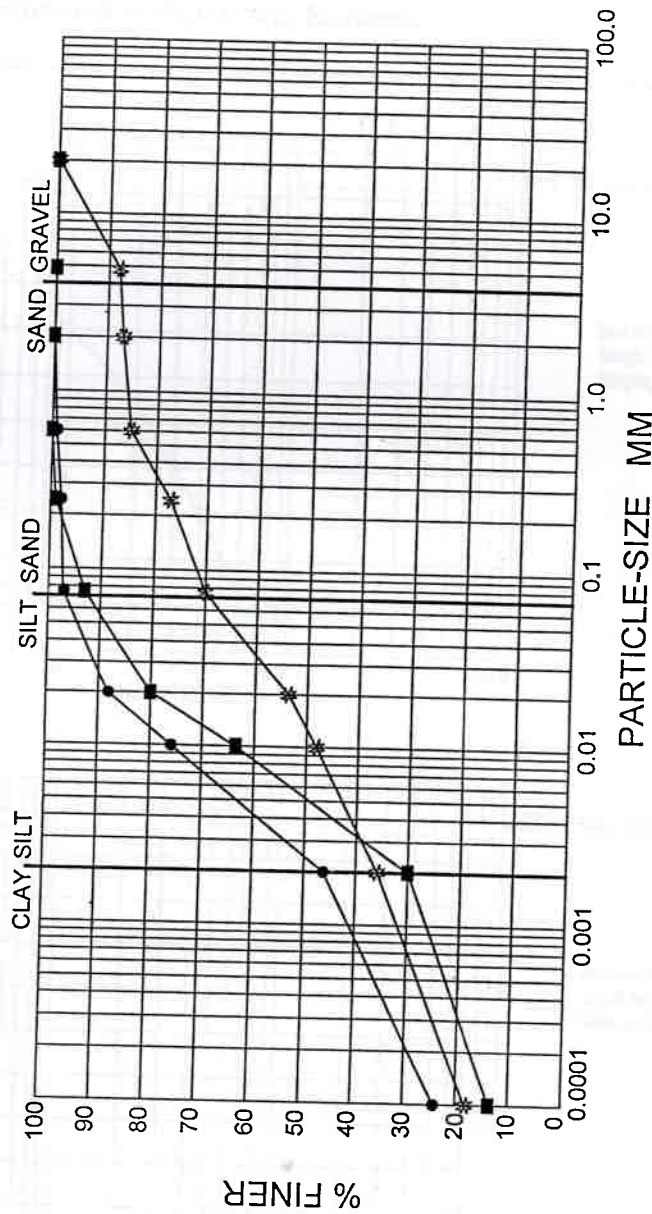
Location: Raja Rammoohan Roy Road, Kolkata.

Stratum	Type	Depth in Metre below EGL	DESCRIPTION	Natural Moisture Content %	Unit Weight (kN/m ³)		Liquid Limit %	Plastic Limit %	U.C.S. 'C' kN/m ²	Triaxial / Direct Shear		Specific Gravity 'G'	Initial Void Ratio 'e ₀ '	GRAIN SIZE				
					Bulk	Dry				'C' kN/m ²	'φ'			TYPE	Gravel %	Sand %	Silt %	Clay %
IV	U	16.50 to 16.95	Bluish grey silty clay with calcareous nodules.	28.91	18.64	14.45	63	24	--	Tr. U. U. Test 43.16 0°		--	--	--	--	--	--	--
IV	U	19.50 to 19.95	Mottled brown silty clay / clayey silt with rusty brown silt spots.	25.08	18.83	15.05	49	21	--	67.08	6°	2.72	0.682	H.A.	07	63	30	
IV	P	23.00 to 23.45	Mottled brown silty clay with rusty brown silt spots.	--	--	--	59	20	--	--	--	--	--	H.A.	07	57	36	
V	P	24.00 to 24.45	Brownish grey silty fine sand with traces of mica.	--	--	--	NP	NP	--	--	--	--	--	S.A.	90	←10→		



PARTICLE-SIZE DISTRIBUTION CURVES

Location : Raja Rammohan Roy Road, Kolkata.



CLAY %	FINE SAND %		MEDIUM SAND %		COARSE SAND %		GRAVEL %
	FINE	MEDIUM	COARSE	FINE	COARSE	GRAVEL	
46	51	03	28	07	12	--	--

B.H. NO.	DEPTH	CLAY %	FINE SAND %	MEDIUM SAND %	COARSE SAND %	GRAVEL %
B.H.1	6.00 m.	46	51	03	28	07
B.H.2	2.50 m.	36	24	28	12	--
B.H.3	19.50 m.	30	63	07	--	--

LEGEND

- B.H.1
- B.H.2
- * B.H.3

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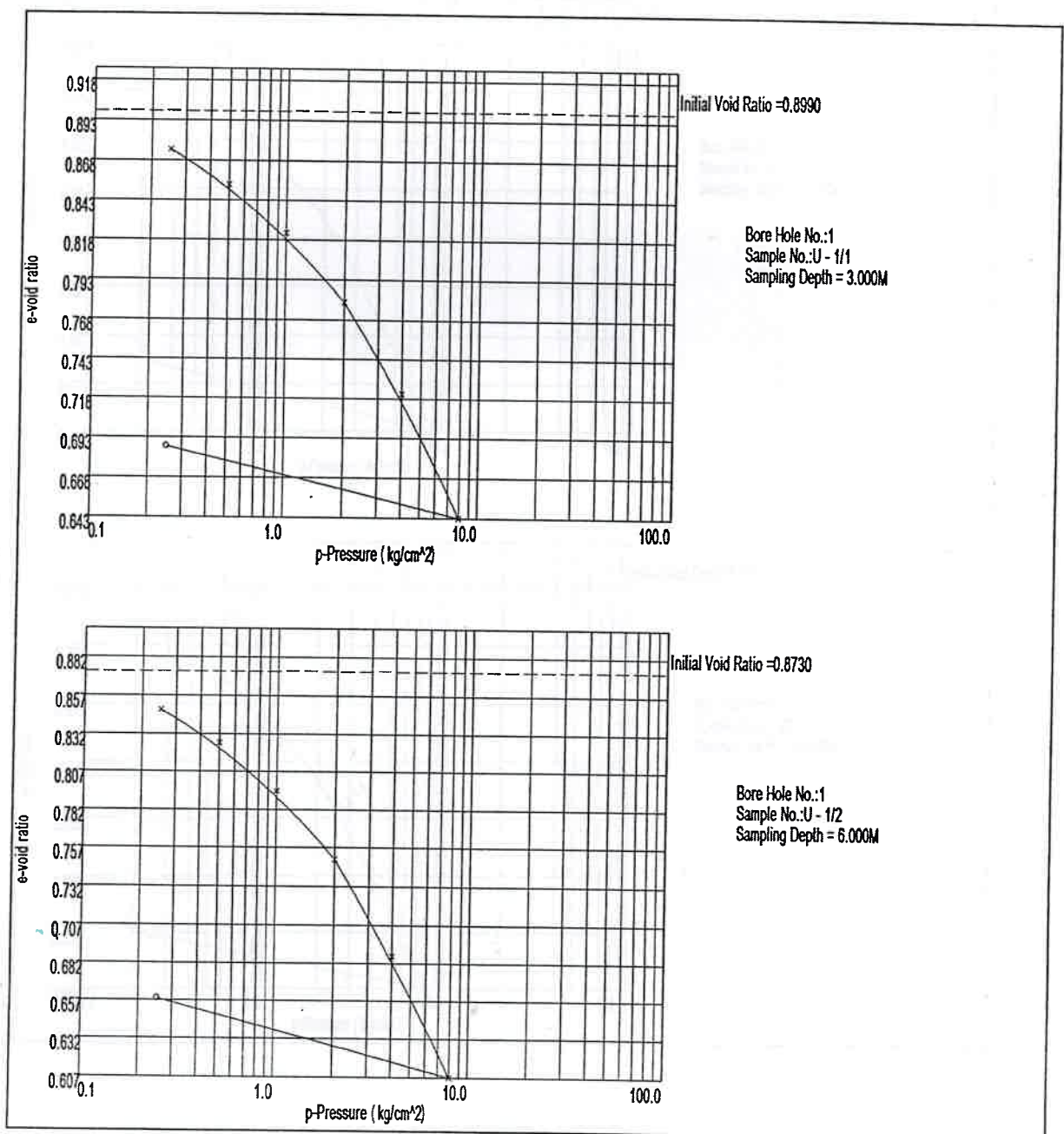
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6.a. $e - \log_{10} P$ Curves

Project: Raja Rammohan Roy Road, Kolkata.



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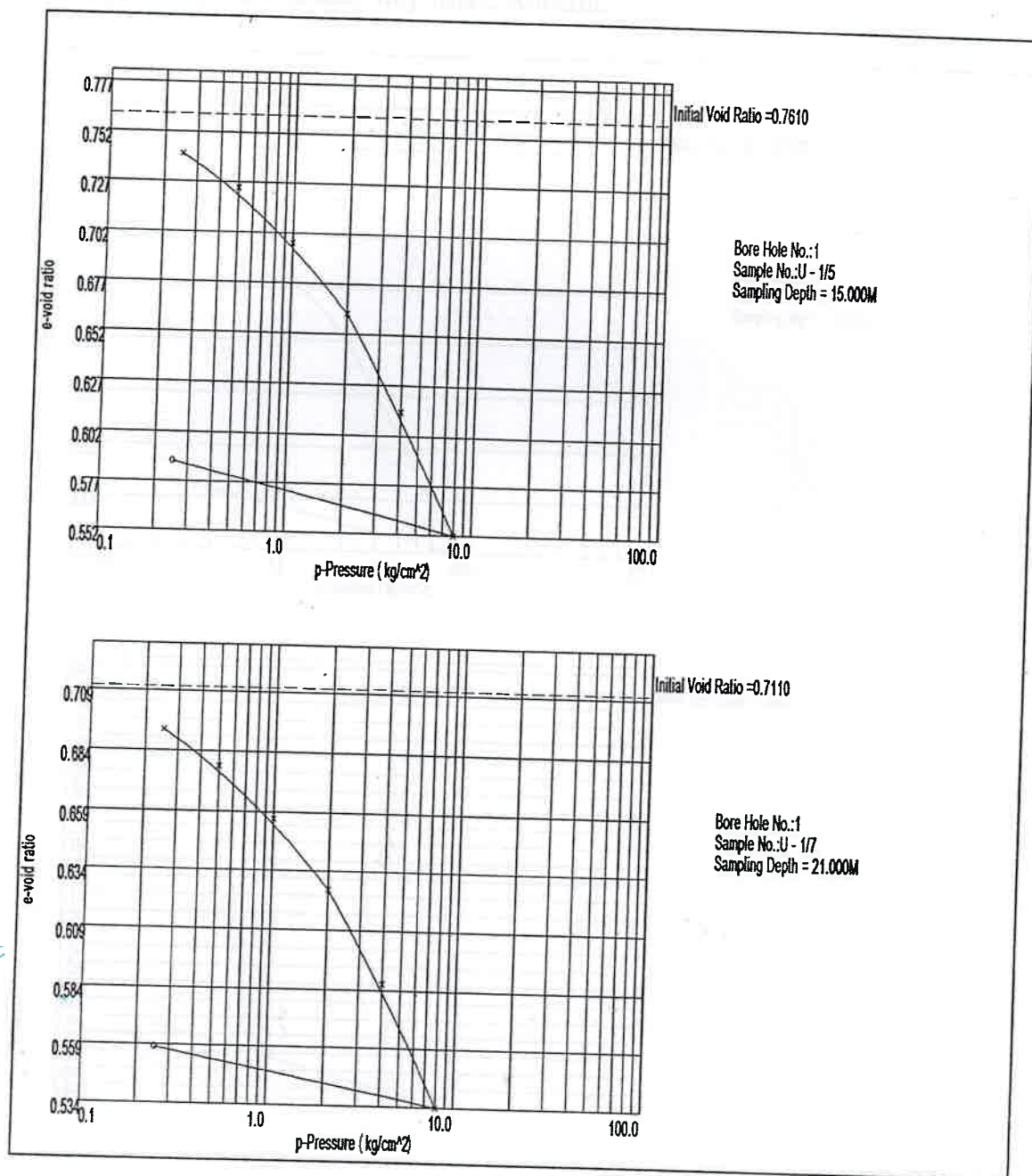
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Project: Raja Rammohan Roy Road, Kolkata.



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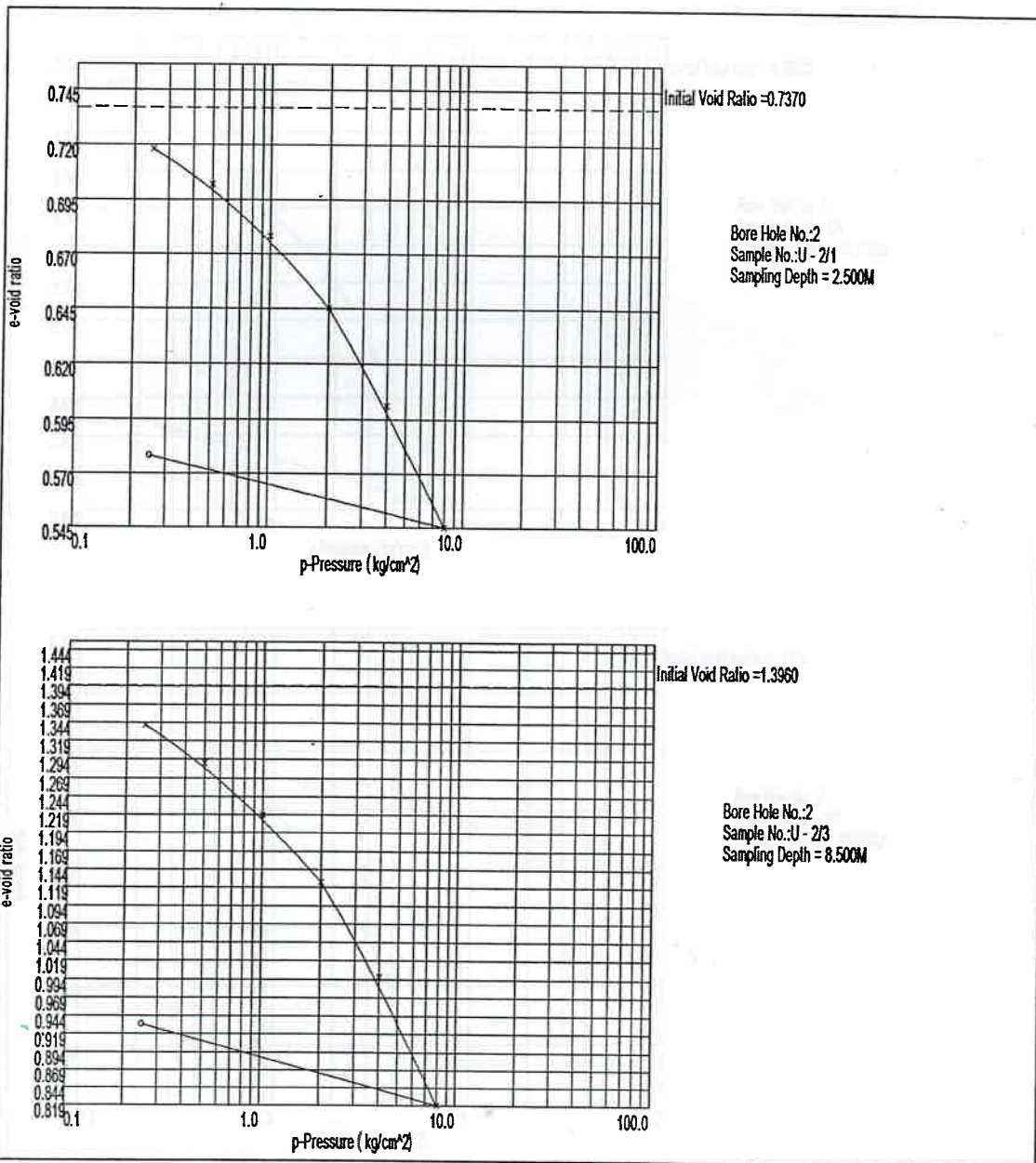


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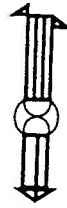
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Project: Raja Rammohan Roy Road, Kolkata.



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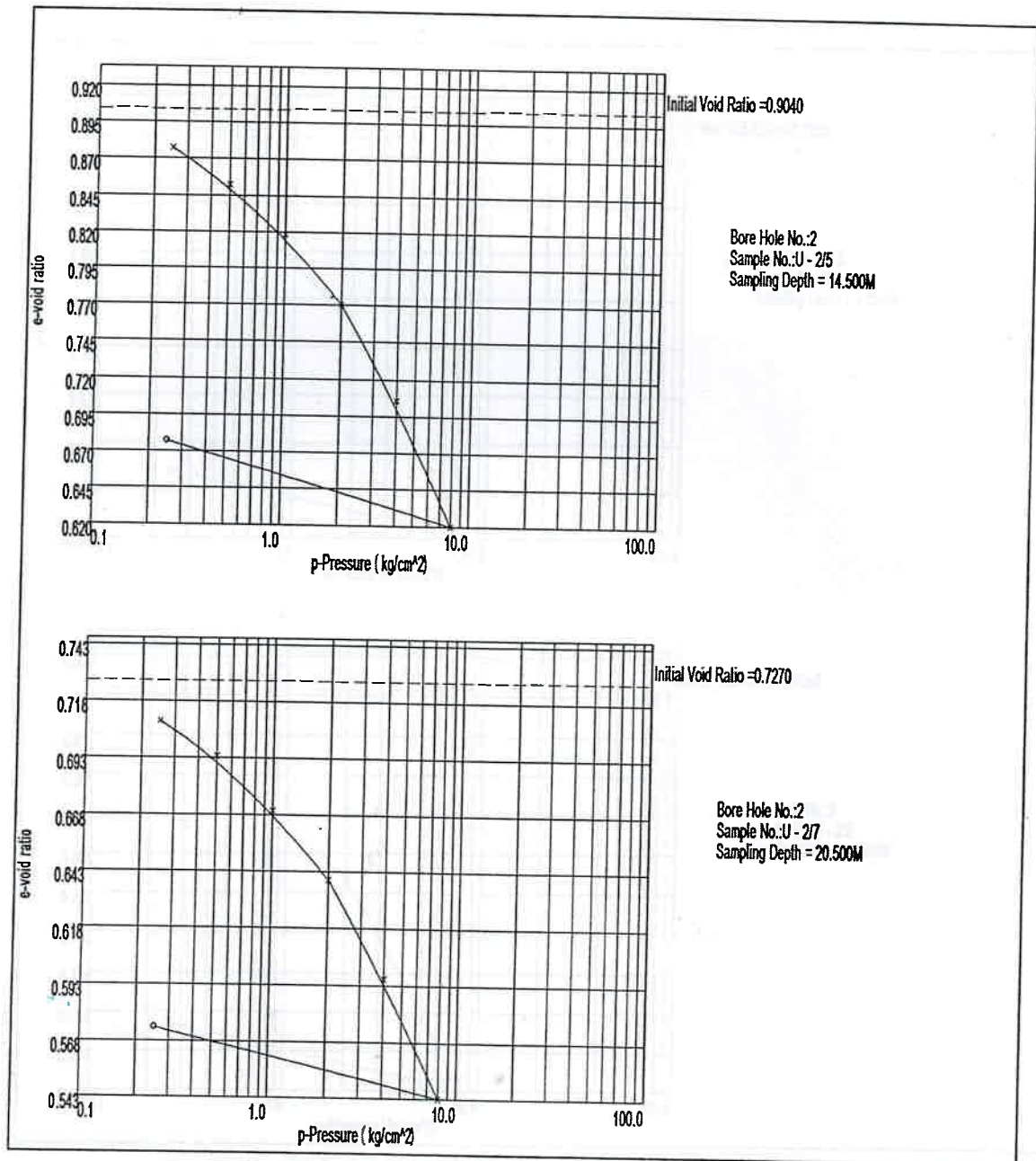
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Project: Raja Rammohan Roy Road, Kolkata.



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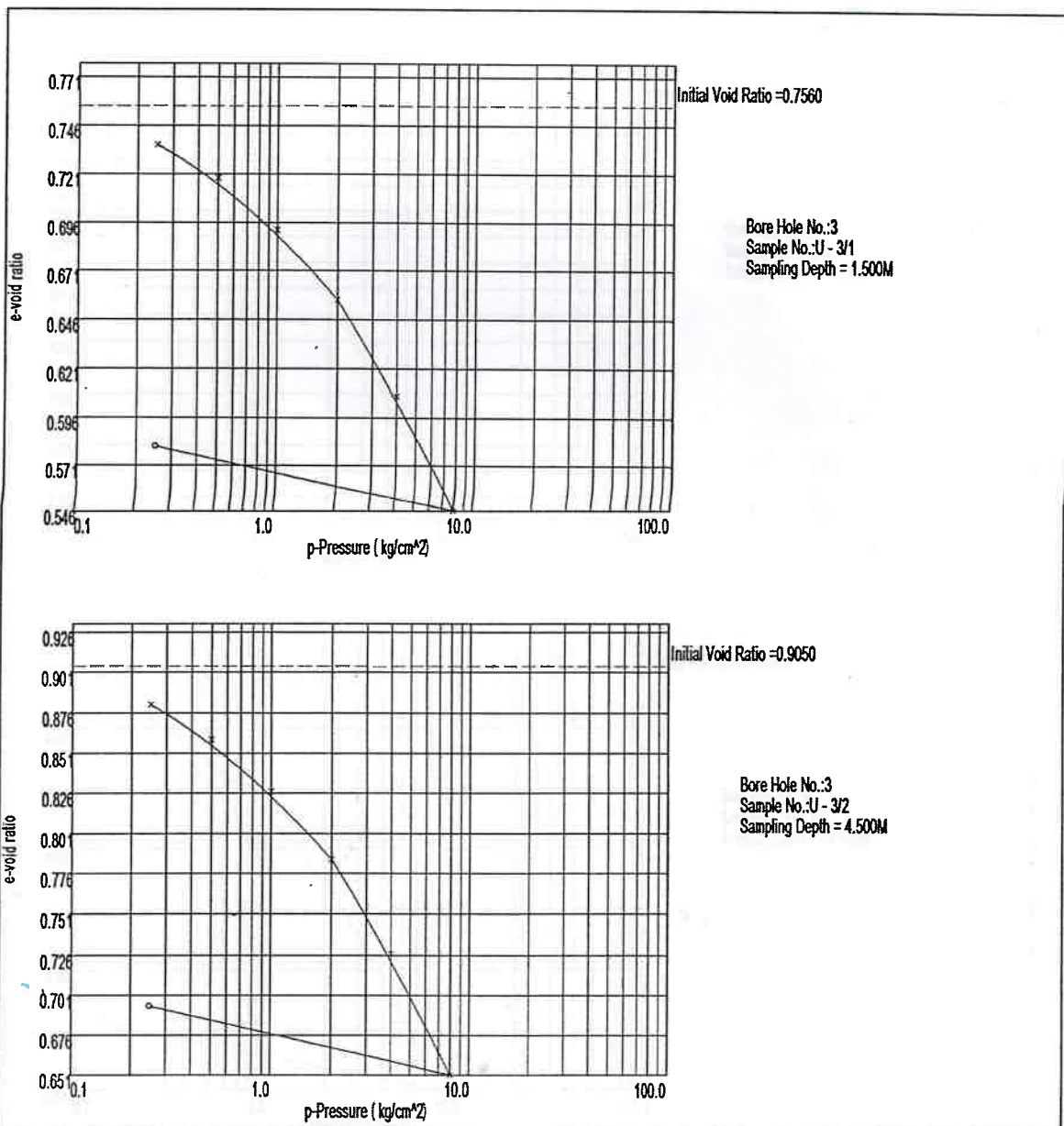


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Project: Raja Rammohan Roy Road, Kolkata.



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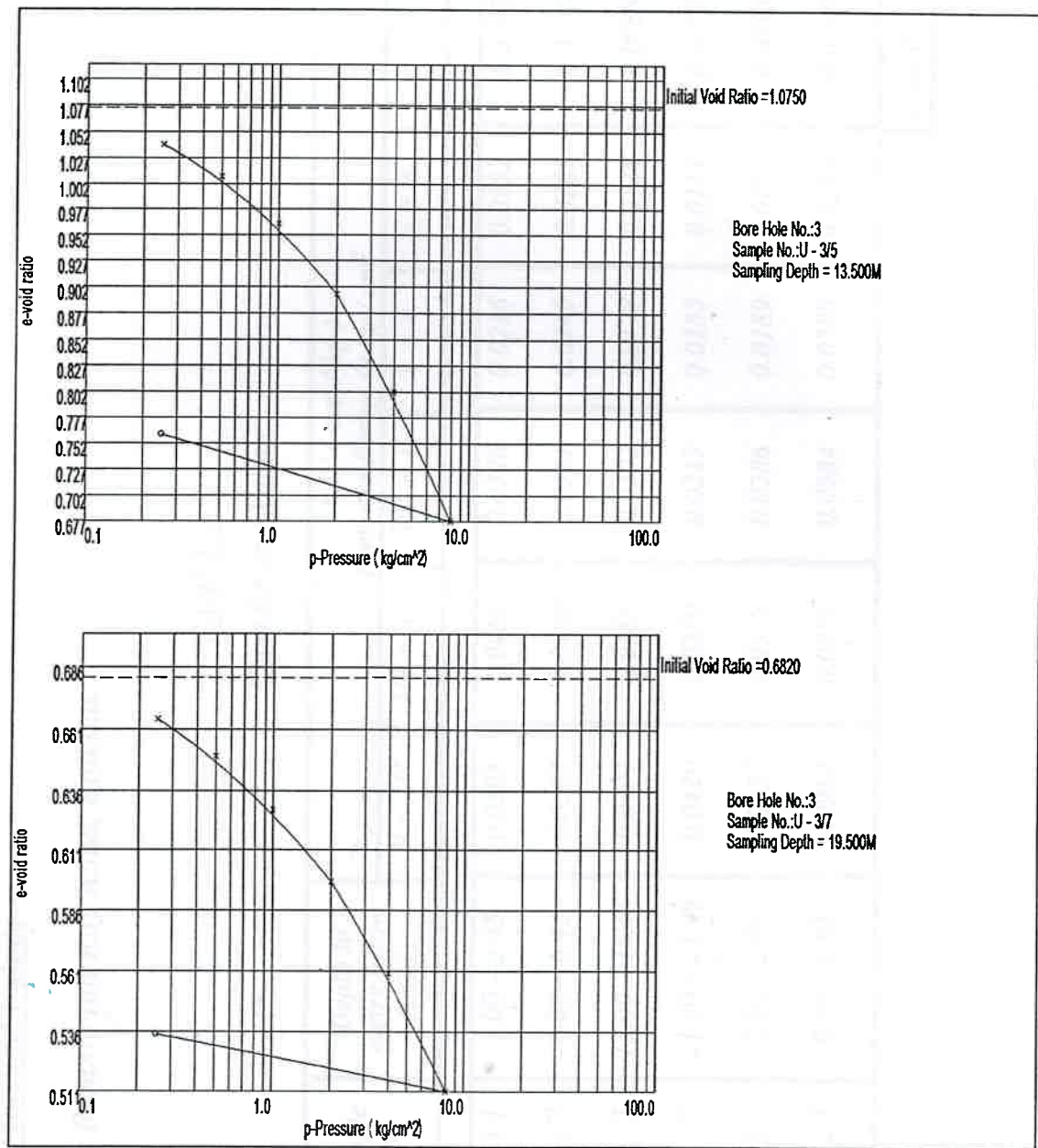


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6.b. Chart for 'm_v' Values

Site: Raja Rammohan Roy Road, Kolkata.

TABLE - 3

Chart for 'm_v' Values

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 - 1/1	3.00 - 3.45	0.0505	0.0463	0.0326	0.0226	0.0152	0.0102
III	U - 1/2	6.00 - 6.45	0.0563	0.0469	0.0361	0.0240	0.0165	0.0106
IV	U - 1/5	15.00 - 15.45	0.0402	0.0366	0.0302	0.0178	0.0126	0.0088
IV	U - 1/7	21.00 - 21.45	0.0420	0.0350	0.0247	0.0165	0.0113	0.0073
I	U - 2/1	2.50 - 2.95	0.0457	0.0378	0.0286	0.0189	0.0126	0.0080
III	U - 2/3	8.50 - 8.95	0.0934	0.0851	0.0584	0.0388	0.0269	0.0185
							Page No : 41	

Continued...

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Site: Raja Ramnohan Roy Road, Kolkata.

TABLE - 3

Chart for 'm_v' Values

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		
III	U-2/5	14.50 - 14.95	0.0567	0.0525	0.0357	0.0252	0.0168	0.0112		
IV	U-2/7	20.50 - 20.95	0.0406	0.0327	0.0257	0.0179	0.0124	0.0076		
I	U-3/1	1.50 - 1.95	0.0455	0.0389	0.0307	0.0205	0.0139	0.0086		
II	U-3/2	4.50 - 4.95	0.0503	0.0461	0.0356	0.0220	0.0152	0.0099		
III	U-3/5	13.50 - 13.95	0.0674	0.0597	0.0463	0.0327	0.0224	0.00150		
IV	U-3/7	19.50 - 19.95	0.0444	0.0356	0.0251	0.0168	0.0112	0.0072		

Page No : 42

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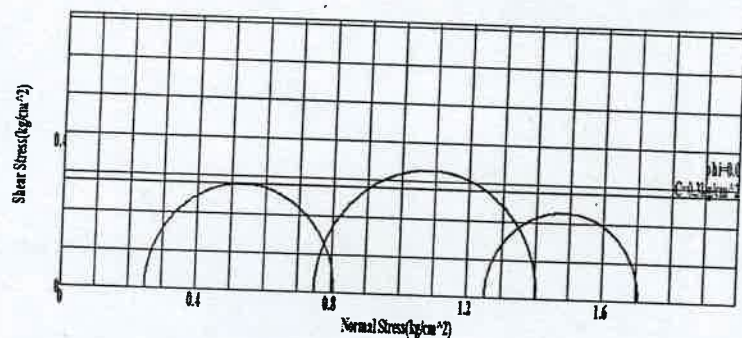
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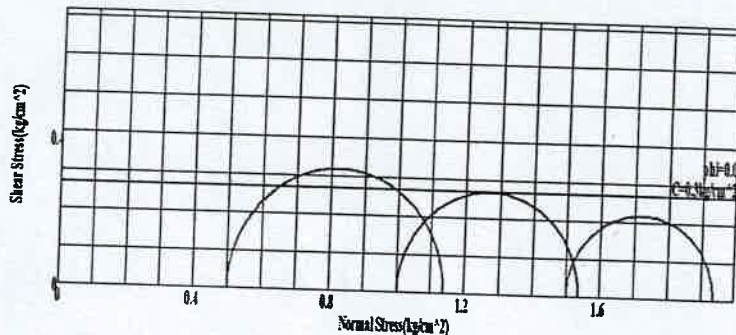
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7. Some Typical Mohr's Circles

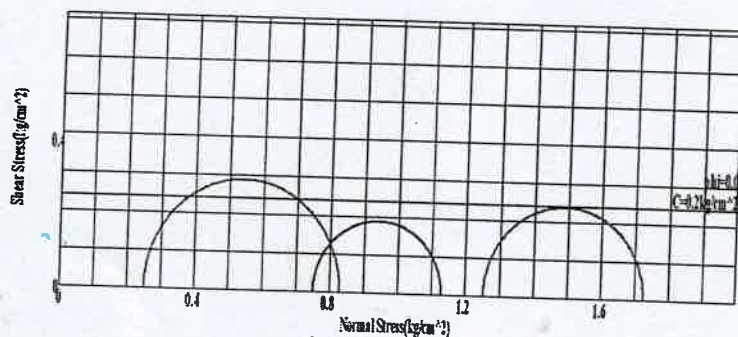
Project: Raja Rammohan Roy Road, Kolkata.



Bore Hole No. = 1
Sample No. = U-1/1
Depth = 3.0M
Type of Test = U.U.



Bore Hole No. = 2
Sample No. = U-2/2
Depth = 5.5M
Type of Test = U.U.



Bore Hole No. = 3
Sample No. = U-3/2
Depth = 4.5M
Type of Test = U.U.