

REPORT ON GEOTECHNICAL INVESTIGATION

Work For The Proposed 4 (G+III) Storied Building

At

***Premises No. 31A, Panch Masjid Road,
Ward No. – 125, Borough No. – XVI, P.S. – Thakurpukur,
Dist: 24 Pgs (S), Kolkata – 700 063
under Kolkata Municipal Corporation***

GEOTECHNICAL INVESTIGATION BY

CALCUTTA TEST CENTRE

AN ISO 9001 : 2015 CERTIFIED ORGANIZATION

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NO.	TABLE OF CONTENTS	PAGE NO.
	INTRODUCTION	1
1.0	SCOPE OF WORK	1 - 2
2.0	FIELD WORK	2
2.1	BORING	3
2.2	STANDARD PENETRATION TEST	3
2.3	COLLECTION OF SOIL SAMPLES	3
3.0	LABORATORY TESTS	4 - 6
3.7	STANDING WATER LEVEL	6
4.0	SUB - SOIL STRATIFICATION AND PROPERTIES	7 - 9
5.0	DISCUSSION ON FOUNDATION ASPECTS AND RECOMMENDATION	10 - 19
6.0	RECOMMENDATION	14
APPENDIX		
⇒	LOCATION OF BOREHOLES	20
⇒	BORELOG DATA SHEET	21 - 22
⇒	SUB SOIL PROFILE WITH 'N' VS. DEPTH PLOT	23
⇒	LABORATORY TEST RESULT	24 - 25
⇒	PARTICLE SIZE DISTRIBUTION CURVE	26 - 27
⇒	E VS LOG p CURVES	28 - 32

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SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

INTRODUCTION :

The soil investigation work for the proposed **4 (G+III)** storied building at **Premises No. 31A, Panch Masjid Road, Ward No. – 125, Borough No. – XVI, Mouza – Paschim Barisha, J.L. No. – 19, R.S. No. – 43, Touzi Nos. – 1-6, 8-10, 12-16, R.S. & L.R. Dag No. 3099, R.S. Khatian Nos. 4183 & 4174, L.R. Khatian No. – 10897, P.S. – Thakurpukur, Dist: 24 Pgs (S), Kolkata – 700 063 under Kolkata Municipal Corporation** was entrusted to **M/S CALCUTTA TEST CENTRE** with a view to determining the soil properties.

This report presents the findings of the above soil investigation work and then recommends the probable foundation systems for the structure envisaged.

1.0 SCOPE OF WORK :

Scope of the investigation work includes

- i. Sinking of a total of **2 (two)** nos. bore holes, at maximum depth of **26.05m** below Existing Ground Level, conducting standard penetration tests and collection of soil samples.
- ii. Laboratory testing on selected soil samples for classification purpose and to determine their strength and other physical properties.
- iii. Engineering analysis to determine safe bearing pressure to be applied on soil through suitable type of foundation for the proposed structure.
- iv. Preparation and submission of report in **2 (two)** copies, which will include the results of study, analysis and recommendations of suitable parameters for the purpose of designing foundations.

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Field and Laboratory Test Conducted as per BIS Specification

FIELD WORK		Relevant IS. Codes
1	Collection of soil samples	IS : 1982-2021 IS : 2131-1981 IS : 2132-1986
2	Labelling & Packing	IS : 1982-2021 IS : 2131-1981 IS : 2132-1986
3	Standard Penetration Test (SPT)	IS : 2131-1981
Laboratory Tests		Relevant IS. Codes
1	Water Content	IS : 2720 (Part-2)-1973
2	Liquid Limit (LL) & Plastic Limit (PL)	IS : 2720 (Part-5)-1985
3	Grain-Size Analysis	IS : 2720 (Part-4)-1985
4	Specific Gravity	IS : 2720 (Part-3)-1980
5	Consolidation Test	IS : 2720 (Part-15)-1986
6	Unconfined Compression Strength (UC)	IS : 2720 (Part-10)-1991
7	Tri-axial Test (UU)	IS : 2720 (Part-11)-1993
8	Direct Shear Test (DS)	IS : 2720 (Part-13)-1986

2.0 FIELD WORK:

Necessary field work was carried out during the period between **02.09.2024** to **03.09.2024** and subsequently laboratory tests were taken up on sufficient no. of selected samples collected from site. A brief description of method of boring, field tests, collection of samples etc. and type of equipment used are given below.

TABLE :1

BORE HOLE NO.	TERMINATING DEPTH OF BORE HOLE BELOW E.G.L.	DATE OF COMMENCEMENT	DATE OF COMPLETION	S.W.L BELOW E. G. L. DURING FIELD WORK (m)	NO. OF SAMPLES COLLECTED		
					UNDISTURBED (U)	DISTURBED (D)	PENETROMETER (P)
1	26.05 m	02.09.2024	03.09.2024	0.300	3	2	14
2	10.45 m	03.09.2024	03.09.2024	0.300	2	2	04

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2.1 BORING:

Auger boring was adopted up to a depth of about 3.0 m below the Existing Ground Level (E.G.L.) followed by Rotary Wash boring technique to advance the 150 mm dia. boreholes up to termination depths. Casing was used at top and bentonite slurry was used for stabilization of boreholes.

2.2 STANDARD PENETRATION TEST:

S.P.T. was conducted at the boring points at suitable intervals. The number of blows required for last 30.0 cm penetration of split spoon sampler out of a total penetration of 45.0 cm driven by a 63.5 kg hammer falling freely through a height of 75 cm was recorded as 'N' value. The sample from split spoon sampler was collected after each test and was properly labeled and placed in air-tight polythene bag before sending it to the laboratory. The test procedure conformed to IS- 2131-1981.

2.3 COLLECTION OF SOIL SAMPLES:

Undisturbed soil samples were collected, wherever required and feasible, by means of a two tier 100 mm I.D. open drive sampling assembly. Before sampling, the borehole was thoroughly cleaned. The sampling assembly was driven to the required depth manually with the help of a jarring link. Sample collected in the lower tube was retained, labeled and waxed at both ends before sending to the laboratory.

Representative disturbed soil samples were collected frequently from auger, split spoon sampler of standard penetrometer and cutting shoe of undisturbed sampling assembly to maintain a continuous record of strata encountered.

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3.0 LABORATORY TESTS:

All samples brought to the laboratory were first subjected to through physical examination before judiciously selecting a few of them for carrying out various relevant tests as per IS specifications. The following laboratory tests were conducted on soil samples.

⇒ Determination of Natural Moisture Content and Bulk density.

⇒ Determination of Liquid Limit and Plastic Limit

⇒ Sieve and Hydrometer Analysis.

⇒ Determination of Specific Gravity.

⇒ Triaxial Compression (UU) Test.

⇒ One-dimensional Consolidation Test.

Laboratory test results are summarized in "Test Result Sheet".

3.1 Natural moisture content & Atterberg limits

Natural moisture content of this soil samples have been determined by oven drying liquid limit and plastic limit of clayey samples were determined (a) to classify the soil by the IS classification system and (b) to qualitatively assess their consistency and compressibility.

3.2 Bulk density & Dry density

These were determined by measuring the weights and dimensions of tri-axial shear and unconfined compressive strength test samples before testing and after oven drying. The bulk density and dry density values of the samples have been given in the enclosed laboratory sheet.

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3.3 Grain size analysis

The grain size distributions of some representative samples were determined from hydrometer and /or sieve analysis. The results are plotted and shown in this report.

3.4 Tri-axial shear test (UU)/ Unconfined compressive strength

For triaxial shear and unconfined compressive strength tests, three no. 38 mm diameter 76 mm long specimens were obtained by jacking out the soil core, each into a thin-walled brass tube, having the wall thickness of 1/32". The inside of the tubes was coated with a thin layer of silicon oil. The tests were run on the clayey silt samples to determine their shear strengths. The cell pressures employed, in case of triaxial tests were 0.5, 1.0 and 1.5 kg/sq.cm. Unconfined Compression strength tests were conducted for the samples which had higher clay content. The samples were tested under quick condition at a rate of 1.25 mm/min and were loaded up to maximum 20% axial strain.

3.5 Consolidation test

To obtain specimens for consolidation test, the odometer ring was placed on the trimmed horizontal faces of the soil within the 10 cm diameter sampling tube and the soil around the cutting edge was gradually removed with a spatula as the ring was gently pushed into the soil. The ring with the soil was then removed by cutting across the soil core with the help of a piano wire saw. Consolidation tests were run in floating ring type odometers, mounted in single & four unit consolidation frames under standard load increment ratio starting from 0.25 kg/sq.cm and going up to 8 kg/sq.cm in general. The pressure vs void ratio curves are given in this report.

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3.6 Specific Gravity

The Specific Gravity of the soil samples was determined by adopting standard procedure. The soil sample was dried in oven dried for 24 hours and pulverized. The sample was then poured into a specific gravity bottle and topped up with distilled water. The specific gravity bottle was stirred and heated to eliminate air bubbles. The weight of the specific gravity bottle was recorded along with the temperature of the sample.

3.7 STANDING WATER LEVEL:

*Standing Water levels in the bore holes were observed during field investigation. Final water reading in each bore hole was recorded 24 hours after completion of boring operation in the bore hole and is shown in the respective Borelog Data Sheet. The average level of standing water was found approximately at **0.30m** below E.G.L. at the borehole locations. However, for design purpose, it will be wise to consider water level at ground level for the worst case.*

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4.0 SUB-SOIL STRATIFICATION AND PROPERTIES:

A study of the borehole logs, laboratory test results and field standard penetration test results indicates the following stratification of the sub-soil deposit.

Table-2 : SUB-SOIL STRATIFICATION

STRATUM	DESCRIPTION OF STRATUM	DEPTH OF EXISTENCE BELOW E.G.L.			THICKNESS (m)	IS Classification
		B.H	From (m)	To (m)		
I	Filling: soil mixed with brick pcs and rubbish.	1	0.00	1.30	1.30	
		2	0.00	1.30	1.30	
II	Soft brown silty clay (high silt content) with occasional kankars.	1	1.30	3.90	2.60	CH/CI
		2	1.30	3.70	2.40	
III	Very soft to soft grey silty clay with decomposed vegetation, wood pcs. (Note: Presence of silt pocket in Bh. No. 1&2. from depth 5.00- 7.00m bgl).	1	3.90	19.00	15.10	CH
		2	3.70	10.45*	≥ 6.75	
IV	Stiff bluish grey sandy silty clay with sand in varying percentages.	1	19.00	22.50	3.50	CI
V	Medium dense brown sand with varying percentage of fines.	1	22.50	26.05*	≥ 3.55	SM

*Up to termination Depth.

Brief descriptions of the various soil strata and physical properties are as follows.

STRATUM I: Fill: (0.00m-1.30m) This layer consists of heterogeneous filling. Thickness is **1.30m** below GL. No foundation should be seated in this stratum. Bulk unit weight of this layer may be taken as **1.70 t/m³**.

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

STRATUM II: (1.30 – 3.50m)

*It consists of soft brown silty clay (high silt content) with occasional kankars. The soil in this stratum is intermediate to cohesive in nature. Field 'N' values are **3 to 4** blows / 30 Cm. As per IS, the soil may be classified as **CH/CI**. The following values of relevant soil parameters may be considered in design.*

Thickness = 2.40m to 2.60m

Bulk Density : 1.82 t/m³

Cohesion Value, C = 2.7 t / m²

Co - efficient of volume change $m_v = 0.056 \text{ cm}^2/\text{kg}$

STRATUM III: (3.50 -19.0m)

It consist of very soft to soft grey silty clay with decomposed vegetation, wood pcs.

Presence of silt pocket in Bh. No. 1& 2. from depth 5.00- 7.00m bgl).

*The soil in this stratum is highly cohesive in nature. Field 'N' value of this layer is **2 to 3** blows / 30 Cm. As per IS, the soil may be classified as **CH**. It has low shear strength and very high compressibility and susceptibility to higher order of settlement under the action of superimposed load for the building foundation. This should be taken care of. The following values of relevant soil parameters may be considered in design: **Bh.***

No. 2 was terminated in this layer.

Thickness = 15.10m.

Bulk Density : 1.63 t/m³

Cohesion Value, C = 1.8 t / m²

Co - efficient of volume change $m_v = 0.086 \text{ cm}^2/\text{kg}$

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STRATUM IV: (19.0-22.50m)

*Stiff bluish grey sandy silty clay with sand in varying percentages. Field 'N' values are **9 and 11** blows / 30 Cm. As per IS, the soil may be classified as **CI**. The following values of relevant soil parameters may be considered in design:*

Thickness = 3.50m.

Bulk Density : 1.90 t/m³

Cohesion Value, C = 6.0 t / m²

STRATUM V: (22.50 -26.05m)

*It consist medium dense brown sand with varying percentage of fines. The soil in this stratum is non cohesive in nature. Field 'N' values are **30, 36 and 41** blows / 30 Cm. As per IS, the soil may be classified as **SM**. The following values of relevant soil parameters may be considered in design: (Based on standard chart and test books). Actual thickness could not be estimated as boring operation has been terminated in this stratum.*

Thickness = $\geq$ 3.55m.

Bulk Density : 1.91 t/m³

Angle of internal friction, $\phi \approx 33^{\circ}$

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

5.0 DISCUSSION ON FOUNDATION ASPECTS AND RECOMMENDATION:

Considering the sub-soil conditions as obtained from the present investigation and the proposed buildings (**G+III**) to be built at the site, shallow as well as deep foundations are discussed below.

5.1 Type 1 : Shallow Foundation

Ground conditions:

Thickness of stratum I: Fill:	Thickness is 1.30m .
Thickness of stratum II:	2.40m to 2.60m thick with moderate shear strength and moderately high compressibility.
Thickness of stratum III:	15.00m with low shear strength and very high compressibility.
Thickness of stratum IV & V:	with high shear strength and low to very low compressibility.

Remarks: Soil environment is poor upto **19.0m** depth bgl.

Reader may refer the bore logs. Thickness of fill is **1.30m**. It is seen that 'N' Values of **stratum II** was 3 to 4. Considering the depth of shallow foundation **1.50m** below E.G.L the thickness available of **stratum II** is **2.20m - 2.40m** below the foundation level. Shear strength of stratum II is medium with moderately high compressibility and that of **stratum III** is low with very high compressibility.

As such this building (G+III) type may be subjected to considerable settlement when it is placed on shallow foundation at a depth of 1.50m BGL on stratum II.

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

Table-3: Shallow Foundation at 1.5 m below E. G. L.

Size of Footing	Depth of Footing	Net Safe Bearing Capacity (NSBC)	Settlement for pressure = NSBC (mm)	Suggested Net Allowable Bearing Capacity (NABC)
2.0 m wide Strip	1.5	6.30 t/m ²	84.5 for 6.30 t/m ²	5.30 t / m ²
2.5 m wide Strip	Below E.G.L.	6.20 t/m ²	98.3 for 6.20 t/m ²	4.70 t / m ²

Note:

- 1) Settlement will be within the permissible limit of 75mm for NABC values. Typical calculations are presented in appendix. Interference of foundation has not been considered.
- 2) Suggested value is expected to produce lesser settlement than 75mm.
- 3) Stability etc. should be checked as per BIS code of practice.
- 4) Construction of foundation can be taken up in dry season.
- 5) Foundation bed should not be kept exposed to atmosphere.
- 6) After excavation at the foundation level the explored bed should be removed and compacted of suitable brown sand Planning should be done accordingly.

Remarks:

- i) **Sand Fill** : Thickness of fill (as recorded) = **1.30m**.and depth of foundation at **1.50m** below E.G.L with this is depth of excavation should be properly chosen . After dressing the exposed soil bed it should be covered by compacted sand, Thickness of such compacted sand may be **400mm to 500mm**.
- ii) **Timber Pile** : Otherwise installation of timber piles (**C.O.L at 1.50m bgl**) mid girth **dia 150mm, length 5.50m** arranged at a square grid **600mm x 600mm** situation improves considerably and NABC values may be raised at around **6.5 t/m²**. for the two-way strip.

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

Table – 4: Timber Pile :

Mid girth dia	Length Of Pile		Cut off Level	Net Allowable Bearing Capacity (NABC)
$\leq 150\text{mm}$	$\leq 5.50\text{m}$	600mm x 600mm (Arrange in square grid)	1.50m B.G.L.	6.50 t / m ² for 75 mm settlement

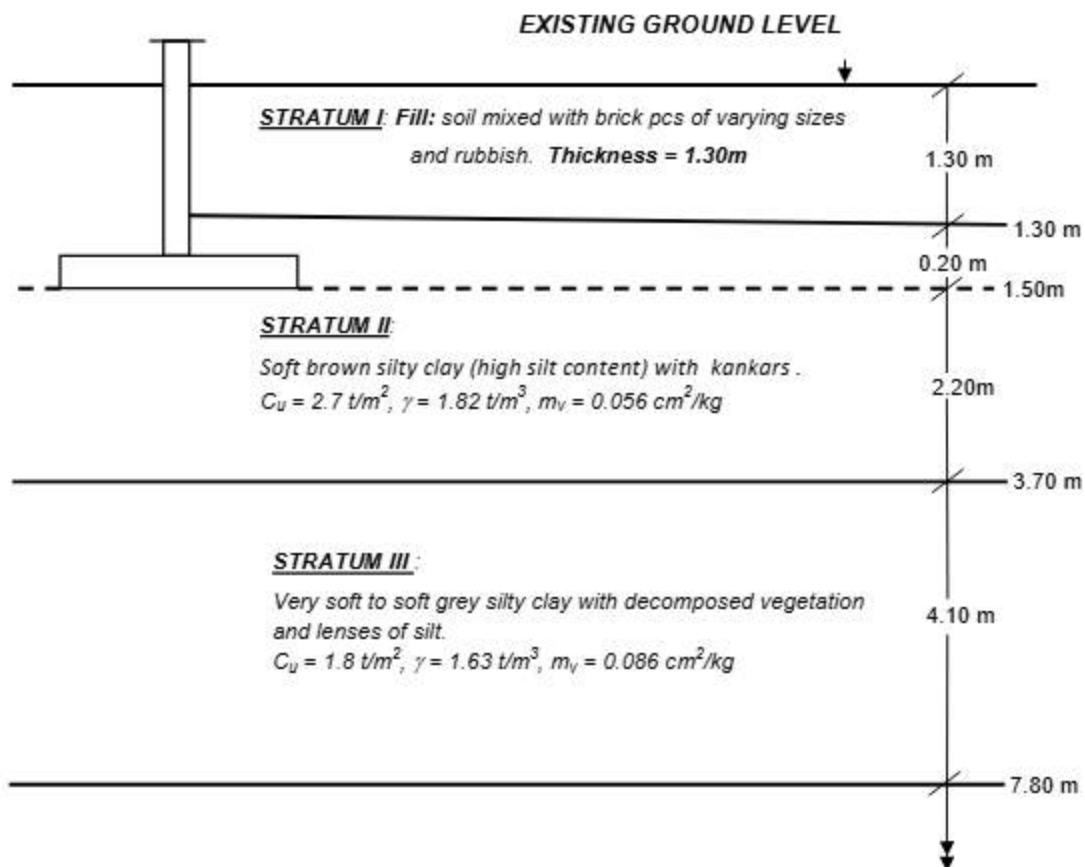


Fig.1: Sub- Soil Profile for Bearing Capacity and Settlement calculations (Based on BH No. 1)

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5.2 Type 2 : Deep Foundation:

Straight shaft R.C.C. Bored Cast-in-situ pile is considered as deep foundation. The recommended values of Safe Vertical and Lateral Capacities of **450 mm** and **500 mm** nominal diameter R.C.C. Bored Cast-in-situ Piles having cut-off level at **1.50 m** and tip level at **23.00 m** below E.G.L. are shown in **Table-5** below. The generalized sub-soil profile, based on which pile capacities are calculated is shown in **Fig. 2**.

The actual pile capacity, however, shall be checked at site by load test as per latest I.S. specifications and design load should be chosen accordingly.

Pile integrity test should also be carried out as per BIS code of practices.

A typical calculation of pile capacities is enclosed for reference.

Table-5 : R.C.C. BORED CAST-IN-SITU PILE FOUNDATION

Pile Dia. (mm)	Cut-off Level below E.G.L.	Pile Tip Level below E.G.L.	Pile Shaft Length	Safe Vertical Capacity of Pile		Grade of Concrete in pile = M25	
				In Compression	In Tension (Uplift)	Safe lateral Capacity for a deflection of 5 mm	Depth of fixity below C.O.L.
450 mm	1.5 m	23.0m	21.5 m	34 ton	21 ton	2.81 ton	4.74 m
500 mm	1.5 m	23.0 m	21.5 m	36 ton	24on	3.15 ton	5.28 m

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

6.0 Recommendation:

- 1) From the subsoil exploration it is observed that the soil below existing G.L. consists of soft brown silty clay down to **4.00m** followed by a thick deposit of very soft / soft grey silty clay down to **19.00m** below G.L. This is underlain by stiff bluish grey sandy silty clay and brown sand till termination depth of **26.05m**. B.G.L.
- 2) Shallow foundation for **(G+III)** type building structure has been proposed. **Two – way strip** foundation has been suggested at **1.50m** bgl. Thickness of sand fill (compacted) = 0.50m. NABC values have been given in **Table – 3**. For shallow foundation dry season is preferred.
- 3) For further, ground improvement Timber pile foundation for **(G+III)** type building has been suggested. Bearing capacity of such piles have been given in **Table –4**.
- 4) Straight shaft **Bored Cast – in – situ pile** foundation is the deep foundation and this has been discussed also for alternate foundation system if shallow foundations is found to be unsuitable and inadequate. Bearing capacity of piles resting at a depth of **23.0m** below G.L. have been given in **Table – 5**.
- 5) Adequate precautions during constructions of piles should be taken in order to prevent localized collapse.
- 6) Pile integrity tests and pile load tests should be conducted as per IS. Code of practices to check the quality of construction and load carrying capacity respectively in case of deep foundation.
- 7) All stability etc. are to be checked for all type of foundations as per BIS code of practices.

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SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

SAMPLE CALCULATIONS FOR R.C.C. BORED CAST-IN-SITU PILE

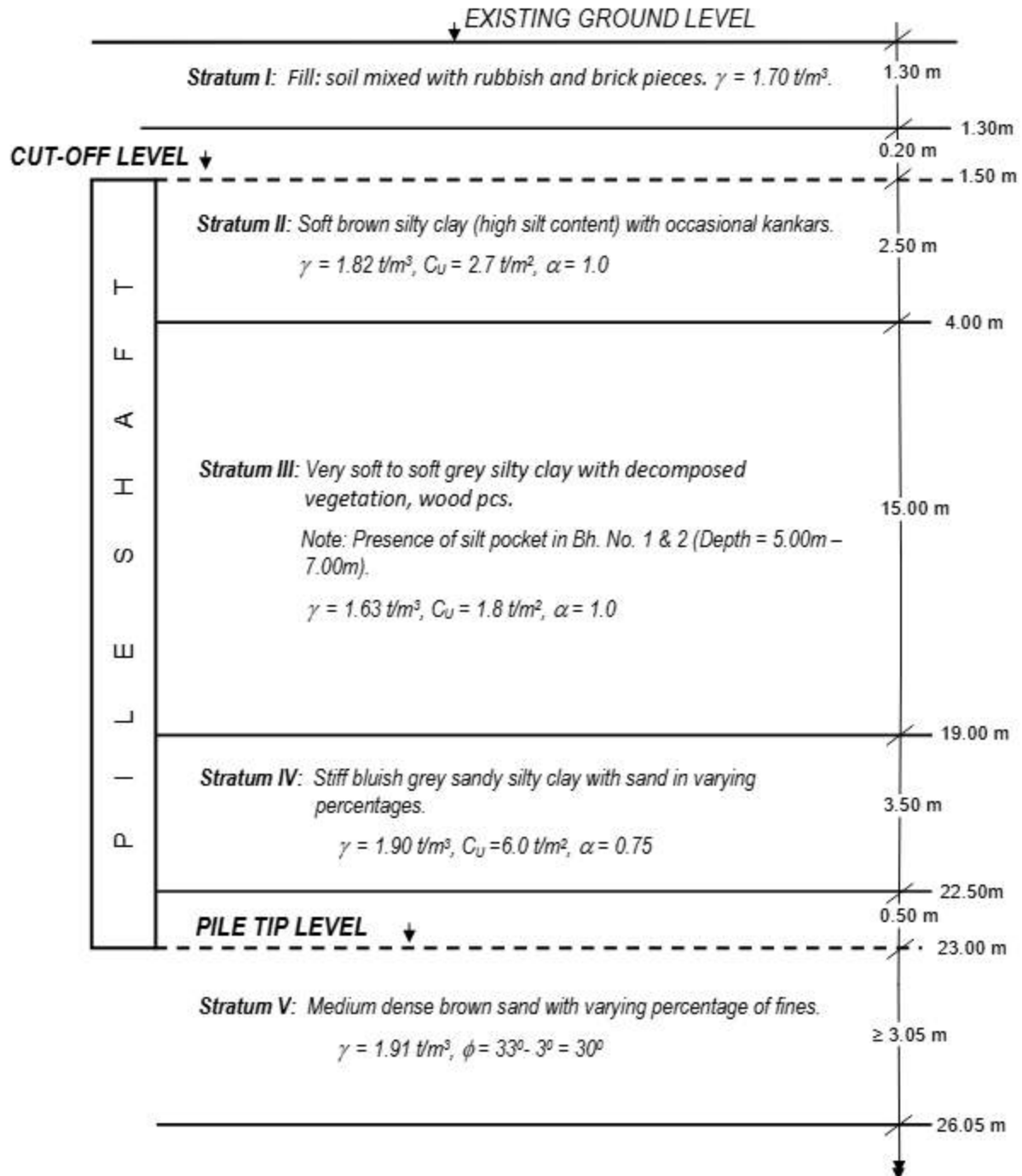


Fig 2 : Generalized Sub-soil Profile for calculation of pile capacity

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

SAMPLE CALCULATIONS FOR SHALLOW FOUNDATION

Considerations:

1. Depth of foundation = 1.00 m. below E.G.L
2. Water level at E.G.L for the worst case.
3. Calculations are based on IS 6403 - 1981
4. Size of foundation: 2.0m.wide strip.
5. Consider design cohesion, $C_u = 2.7 \text{ t/m}^2$, $\gamma = 1.82 \text{ t/m}^3$

Ultimate Bearing Capacity, $q_{ult} = C_u N_c S_c d_c i_c$

Bearing Capacity Factor:-

$$N_c = 5.14, S_c \approx 1.0, \text{ say, } i_c = 1.0$$

$$d_c = 1 + 0.2 (D_f / B) = 1 + 0.2 \times (1.0 / 2.0) = 1.10$$

$$q_{ult} = 2.7 \times 5.14 \times 1.15 \times 1.10 = 15.96 \text{ t/m}^2$$

$$q_{all} = 15.96 / 2.5 = 6.38 \text{ t/m}^2, \text{ say } 6.30 \text{ t/m}^2$$

Settlement :

$$q = 6.30 \text{ t/m}^2$$

$$\begin{aligned} \text{Consolidation Settlement } P_c &= m_{v1} \times \Delta p_1 \times \Delta H_1 + m_{v2} \times \Delta p_2 \times \Delta H_2 \\ &= 0.056 \times 220 \times 0.581 \times 0.630 + 0.086 \times 410 \times 0.2246 \times 0.63 = 9.42 \text{ cm} \end{aligned}$$

$$\Delta p_1 \approx 2.0 \times 10.0 / (2.0 + 1.10) \times (10.0 + 1.10) q = 0.581 q$$

$$\Delta p_2 \approx 2.0 \times 10.0 / (2.0 + 2.2 + 2.05) \times (10.0 + 2.2 + 2.05) q = 0.2246 q$$

Depth correction factor ≈ 0.89 .

Assume 25% extra for elastic settlement.

Pore pressure factor = 1.00

Rigidity factor = 0.80

$$\text{Corrected Settlement } P_{corr} = 9.50 \times 0.89 \times 1.25 \times 0.80 = 8.45 \text{ cm.}$$

$$\text{Allowable, } q = 75 / 84.5 \times 6.3 = 5.34 \text{ t/m}^2$$

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

SAMPLE CALCULATIONS FOR SHALLOW FOUNDATION (Timber Pile)

Considerations:

1. Depth of foundation = 1.50 m. below E.G.L
2. Water level at E.G.L for the worst case.
3. Diameter of pile = 0.15m
4. Length of Pile = 5.50m

Ultimate friction in layer I

$$2.7 \times 1.0 \times 2.20 \times 3.14 \times 0.15 = 2.797 \text{ ton}$$

Ultimate friction in layer II

$$1.8 \times 1.0 \times 3.30 \times 3.14 \times 0.15 = 2.797 \text{ ton}$$

Therefore, total Ultimate friction = $(2.797 + 2.797) \text{ ton} = 5.594 \text{ ton}$

Factor of safety = 2.0 say

$$Q_{\text{safe}} = 5.594 / 2.0 = 2.797 \text{ ton.}$$

Influence area of pile in square grid $(4d \times 4d) = 0.36 \text{ m}^2$

Intensity of load = $2.797 \text{ ton} / 0.36 \text{ m}^2 = 7.769 \text{ t/m}^2$, say 7.0 t/m^2 .

Frictions Footing = 1.83m above pile tip.

Influence depth $\approx 2.5 \times 2.5$ i.e. 2.5 times B

$$= 6.25 \text{ m i.e., } (1.83 + 4.42 \text{ m})$$

Intensity of loading $(2:1) q = (2.5 \times 10 \times q) / (2.5 + 2.21) \times (10 + 2.21) = 0.432q$

Depth factor = 0.73

$$\text{Settlement} = 0.73 \times (0.086 \times 4.42 \times 0.432 \times 0.70) / q \times 1.3 \times 0.80 = 8.05 \text{ cm} > 75 \text{ mm}$$

Reduced, $q = (75 / 80.5) \times 0.7 = 6.52 \text{ t/m}^2$, say 6.50 t/m^2

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

Calculation is done by Static Capacity formula as given in

IS : 2911(Part-I / Sec.-2) -2010.

Refer to Fig. 2 in the page no.15

Consider, diameter of pile $D = 500$ mm. Average bulk density $= 1.85 \text{ t/m}^3$, say.

Skin friction in stratum II

$$(Q_{su})_{II} = \alpha.C.A_s = 1.0 \times 2.7 \times \pi \times D \times 2.50 = 21.19 D \text{ ton}$$

Skin friction in stratum III

$$(Q_{su})_{III} = \alpha.C.A_s = 1.0 \times 1.8 \times \pi \times D \times 15.00 = 84.78 D \text{ ton}$$

Skin friction in stratum IV

$$(Q_{su})_{III} = \alpha.C.A_s = 0.75 \times 6.0 \times \pi \times D \times 3.50 = 49.45 D \text{ ton}$$

Skin friction in stratum V

$$1.00 \times (17D \times D \times 0.80) \times \tan 30^\circ \times \pi \times D \times 0.50 = 12.32 D^2$$

Therefore, total ultimate skin friction,

$$Q_{su} = D(21.19 + 84.78 + 49.45 + 12.32D) = D(155.42 + 12.32D + 42.39D)$$

End bearing

$$9 \times 6.0 \times \pi \times D^2 / 4 = 42.39D^2$$

Therefore, total ultimate capacity, $Q_u = D(155.42 + 12.32D + 42.39D)$

Consider, factor of safety $= 2.5$

$$\text{Safe capacity} = (1 / 2.5) \times D(155.42 + 12.32d + 42.39D)$$

$$= D(62.16 + 4.93 + 16.95)$$

$$= 0.5 (62.16 + 88D)$$

Therefore, safe capacity = Say **36.0 ton.**

SITE: 31A, PANCH MASJID ROAD, WARD NO. – 125, BOROUGH NO. - XVI, KOLKATA – 700 063.

Vertical Capacity in Tension (Uplift) :

From above, total ultimate skin friction in compression, $Q_{suc} = D(155.42 + 12.32D)$

Total ultimate skin friction in tension (uplift), $Q_{sut} = 0.50$ of Q_{suc}

$$= 0.50 \times D(155.42 + 12.32D)$$

$$\text{Safe load} = D(77.7 + 6.31) \times (1 / 2.50) = D (31.08 + 2.5D)$$

Buoyant weight of pile has been ignored.

Therefore, safe capacity in tension (uplift) = **16 ton**

Lateral Capacity:

Consider, grade of pile concrete = M25

$$E \text{ of pile concrete} = 5000 \sqrt{f_{ck}} = 5000 \times \sqrt{25} = 25000 \text{ N/mm}^2 = 25000 \text{ MN/m}^2$$

$$I \text{ of pile cross section (only concrete)} = (\pi/64) \times (0.50)^4 \approx 3.10 \times 10^{-3} \text{ m}^4$$

$$C = 2.5 \text{ ton}$$

$$U_{cs} = 5.00 \text{ t/m}^2. \text{ Say } 4.4 \text{ t/m}^2$$

$$\text{Considering } q_u = 44 \text{ kN/m}^2, k_1 \text{ (vide Table 4)} = 7.92 \text{ MN/m}^3$$

$$KB = 0.3k_1/1.5 = 0.3 \times 7.92 / 1.5 = 1.584 \text{ MN/m}^2$$

$$\text{Stiffness factor, } R = (EI / KB)^{1/4} = (25000 \times 3.10 \times 10^{-3} / 1.584)^{1/4} = 2.64 \text{ m}$$

$$\therefore 3.5R = 3.5 \times 2.64 = 9.24 \text{ m} < 21.5 \text{ m (shaft length)}$$

Therefore, the pile will act as Long (Elastic) Pile.

$$e = L_1 = 0 \therefore L_1/R = 0. \text{ Correspondingly, } L/R = 2.0$$

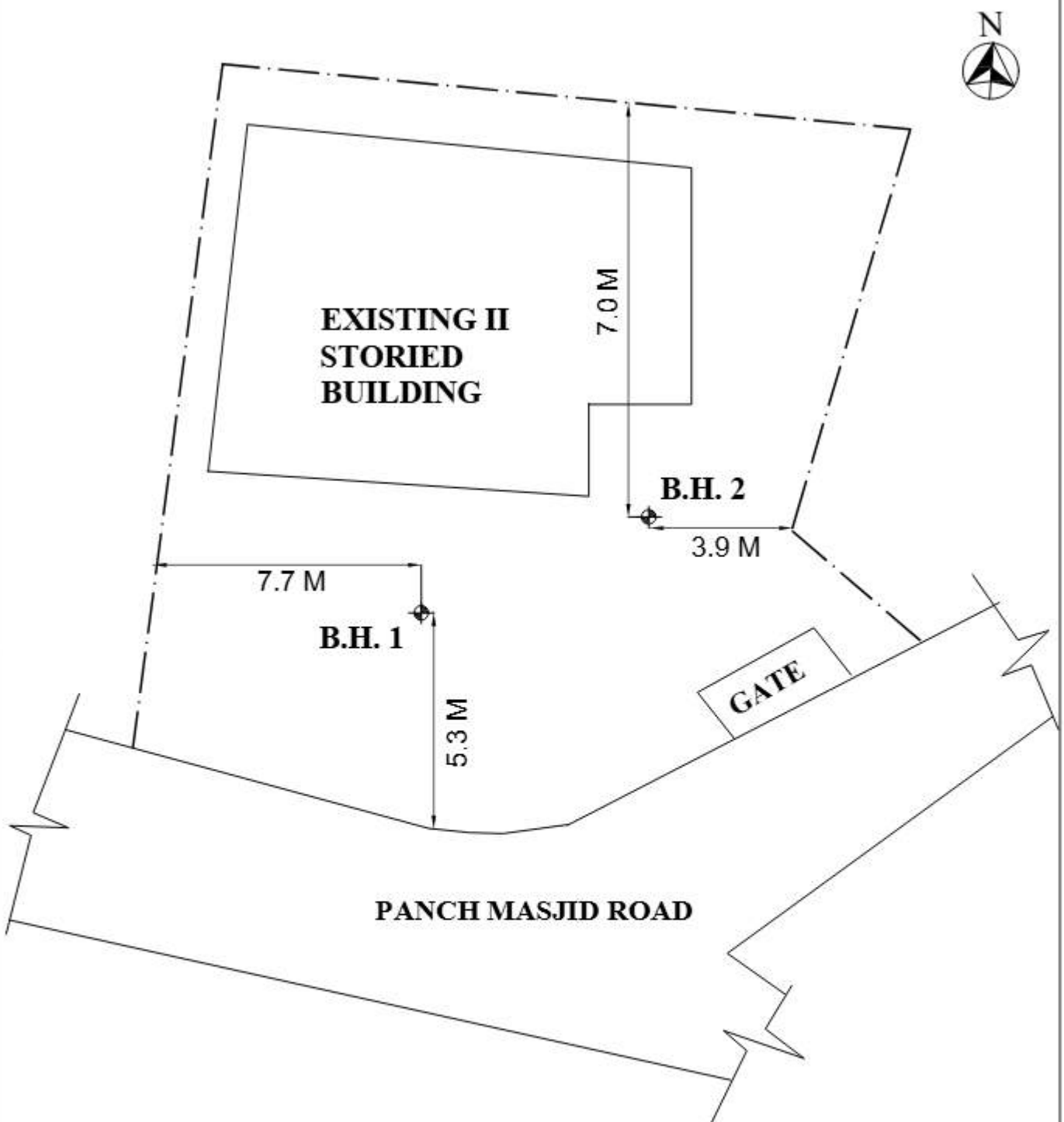
$$\therefore L_f = Z_f = 2.0 \times 2.64 = 5.28 \text{ m}$$

Now, applying formula given in the code,

Horizontal load causing a deflection of 5 mm is found out as

$$Q = 5 \times (12 \times 25000 \times 10^3 \times 3.10 \times 10^{-3}) / \{(0 + 5.28)^3 \times 10^3\} = 31.59 \text{ kN} \approx \mathbf{3.15 \text{ ton}}$$

LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125, BOROUGH NO. - XVI, KOL - 063.



NOTE :

1. THIS DRAWING IS NOT TO SCALE
2. DIMENSIONS ARE APPROXIMATE
3. BORE HOLE LOCATIONS ARE SHOWN THUS 

LOCATIONS OF BORE-HOLES

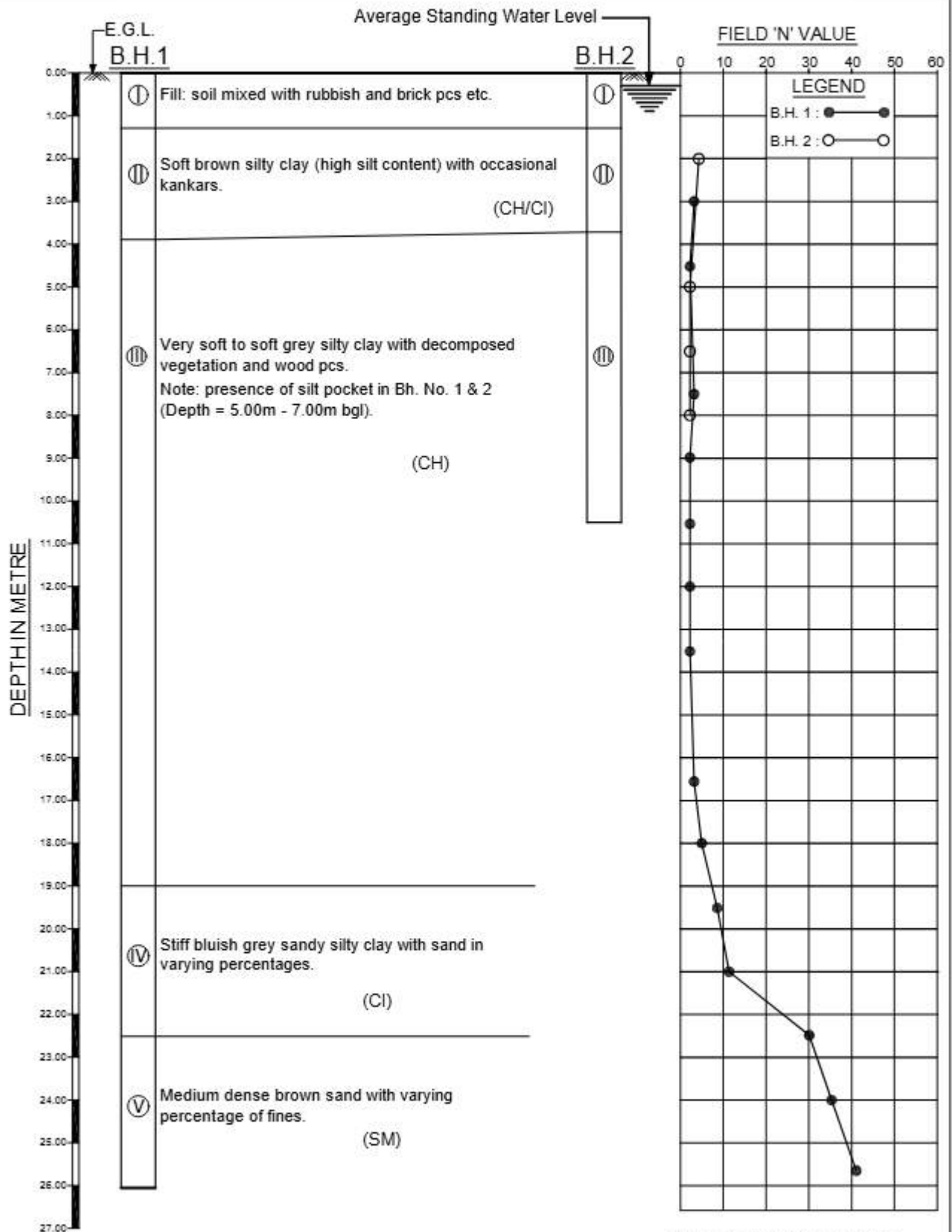
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Page No. 22

CALCUTTA TEST CENTRE						
BORELOG DATA SHEET						
SITE:	31A, PANCH MASJID ROAD, WARD NO. - 125, BOROUGH NO. - XVI, KOLKATA - 700 063.					
COMMENCED ON	02.09.2024	BORE HOLE NO.	1 (one)	SAMPLES	NOS.	
COMPLETED ON	08.09.2024	TERMINATION DEPTH	26.05 m below E.G.L.	UNDISTURBED (U)	3	
BOREHOLE DIA	150 mm			PENETROMETER (P)	14	
R.L GROUND	Not known			DISTURBED (D)	2	
WATER STRUCK				WATER SAMPLES (W)	Nil	
STANDING WATER LEVEL		0.30m below E.G.L.		CO - ORDINATES	Not known	
TYPE OF BORING	Augar & Rotary Wash method.					
ALL DEPTHS ARE MEASURED FROM THE EXISTING GROUND LEVEL (E.G.L.)						
DESCRIPTION	DEPTH (m)		THICKNESS (m)	SAMPLES		'N' VALUE
	From	To		Type	Depth (m)	
Fill: soil mixed with brick pcs and rubbish etc.	0.00	1.30	1.30	D D	0.50 1.00	
Soft brown silty clay (high silt content) with occasional kankars.	1.30	3.90	2.60	U P	1.50-1.95 3.00-3.45	3
Very soft to soft grey silty clay with decomposed vegetation and wood pcs.	3.90	19.00	15.10	P U	4.50-4.95 6.00-6.45	2
Note: presence of silt pocket at 5.00m - 7.00m bgl.				P	7.50-7.95	3
				P	9.00-9.45	2
				P	10.50-10.95	2
				P	12.00-12.45	2
				P	13.50-13.95	2
				U	15.00-15.45	
				P	16.50-16.95	3
				P	18.00-18.45	5
Stiff bluish grey sandy silty clay with sand in varying percenatges.	19.00	22.50	3.50	P P	19.50-19.95 21.00-21.45	9 11
Medium dense brown sand with varying percentage of fines.	22.50	26.05	3.55	P P P	22.50-22.95 24.00-24.45 25.60-26.05	30 36 41
BOREHOLE TERMINATED AT 26.05 M DEPTH						

CALCUTTA TEST CENTRE						
BORELOG DATA SHEET						
SITE:		31A, PANCH MASJID ROAD, WARD NO. - 125, BOROUGH NO. - XVI, KOLKATA - 700 063.				
COMMENCED ON	14.08.2024	BORE HOLE NO.	2 (two)		SAMPLES	NOS.
COMPLETED ON	14.08.2024	TERMINATION DEPTH	10.45 m below E.G.L.	UNDISTURBED (U)	2	
BOREHOLE DIA	150 mm			PENETROMETER (P)	4	
R.L.GROUND	Not known			DISTURBED (D)	2	
WATER STRUCK				WATER SAMPLES (W)	Nil	
STANDING WATER LEVEL	0.60m below E.G.L.			CO - ORDINATES	Not known	
TYPE OF BORING	Augar & Rotary Wash method.					
ALL DEPTHS ARE MEASURED FROM THE EXISTING GROUND LEVEL (E.G.L.)						
DESCRIPTION	DEPTH (m)		THICKNESS (m)	SAMPLES		'N' VALUE
	From	To		Type	Depth (m)	
Fill: soil mixed with brick pcs and rubbish etc.	0.00	1.30	1.30	D	0.50	
				D	1.00	
Soft brown silty clay (high silt content) with occasional kankars.	1.30	3.70	2.40	P	2.00-2.45	4
				U	3.50-3.95	
Very soft to soft grey silty clay with decomposed vegetation and wood pcs. Note: presence of silt pocket at 5.00m - 7.00m bgl.	3.70	10.45	6.75	P	5.00-5.45	2
				P	6.50-6.95	2
				P	8.00-8.45	2
				U	10.00-10.45	
BOREHOLE TERMINATED AT 10.45 M DEPTH						

LOCATION : 31A, PANCH MASJID ROAD, WARD NO. 125, BOROUGH NO. - XVI, KOLKAT - 700 063.



SUB-SOIL PROFILE WITH FIELD 'N' VALUE Vs. DEPTH PLOT

CALCUTTA TEST CENTRE

**LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125,
BOROUGH NO. - XVI, KOLKATA - 700 063.**

LABORATORY TEST RESULT SHEET

SHEET NO. 24

UNCONFINED/ TRIAXIAL COMPRESSION

CONSOLIDATION

GRADING

B.H No. & Sample No.	Type of Sample	Depth (meter)	Description	Liquid limit	Plastic limit	Plasticity Index	Specific Gravity	Classification	Type of Test	Bulk density gm/cc	Water Content %	Lateral Pressure Kg/Cm ²	Compressive Strength Kg/cm ²	Cohesion Kg/cm ²	Angle of friction degrees	Consolidation Pressure Kg/cm ²	Coefficient of Volume decrease Cm ³ /kg	Gravel %	Sand %	Silt %	Clay%	% Passing 75 micron IS Sieve
1	U	1.50-1.95	Soft brown silty clay with high silt content and kankars.	49	18	31	2.66	CH/CI	UU	1.81	34.9			0.25	0	0.25 - 0.5 0.5 - 1.0 1.0 - 2.0 2.0 - 4.0 4.0 - 8.0	0.0629 0.0386 0.0235 0.0150 0.0103	2	1	72	25	97 (hyd)
1	U	6.00-6.45	Soft grey silty clay with lenses of silt.	46	18	28	2.64	CI	UU	1.82	34.7			0.20	0	0.25 - 0.5 0.5 - 1.0 1.0 - 2.0 2.0 - 4.0 4.0 - 8.0	0.0499 0.0394 0.0278 0.0206 0.0127	0	1	75	24	99 (hyd)
1	P	7.50-7.95	Grey silty clay with lenses of silt.	49	27	22		CI										0	1	75	24	99 (hyd)
1	P	9.00-9.45	Grey silty clay with decomposed vegetation and wood pcs.	-	-			CH			43.9							0	1	64	35	99 (hyd)
1	U	15.00-15.45	Soft grey silty clay with decomposed vegetation and wood pcs.	68	28	40	2.58	CH	UU	1.65	54.0			0.19	0	0.25 - 0.5 0.5 - 1.0 1.0 - 2.0 2.0 - 4.0 4.0 - 8.0	0.0827 0.0577 0.0441 0.0308 0.0195	0	4	62	34	96 (hyd)
1	P	18.00-18.45	Grey silty clay with decomposed vegetation and wood pcs.	-	-			CH			44.7							0	5	62	33	95 (hyd)

NOTE : N.P.=Non-Plastic, Hyd= Hydrometer, UU= Triaxial Undrained, UD= Triaxial Drained, UC= Unconfined, UCR= Unconfined Remoulded, CU/CD= Consolidated Undrained/Drained, DS= Direct Shear.

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CALCUTTA TEST CENTRE

**LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125,
BOROUGH NO. - XVI, KOLKATA - 700 063.**

LABORATORY TEST RESULT SHEET

SHEET NO. 25

UNCONFINED/ TRIAXIAL COMPRESSION

CONSOLIDATION

GRADING

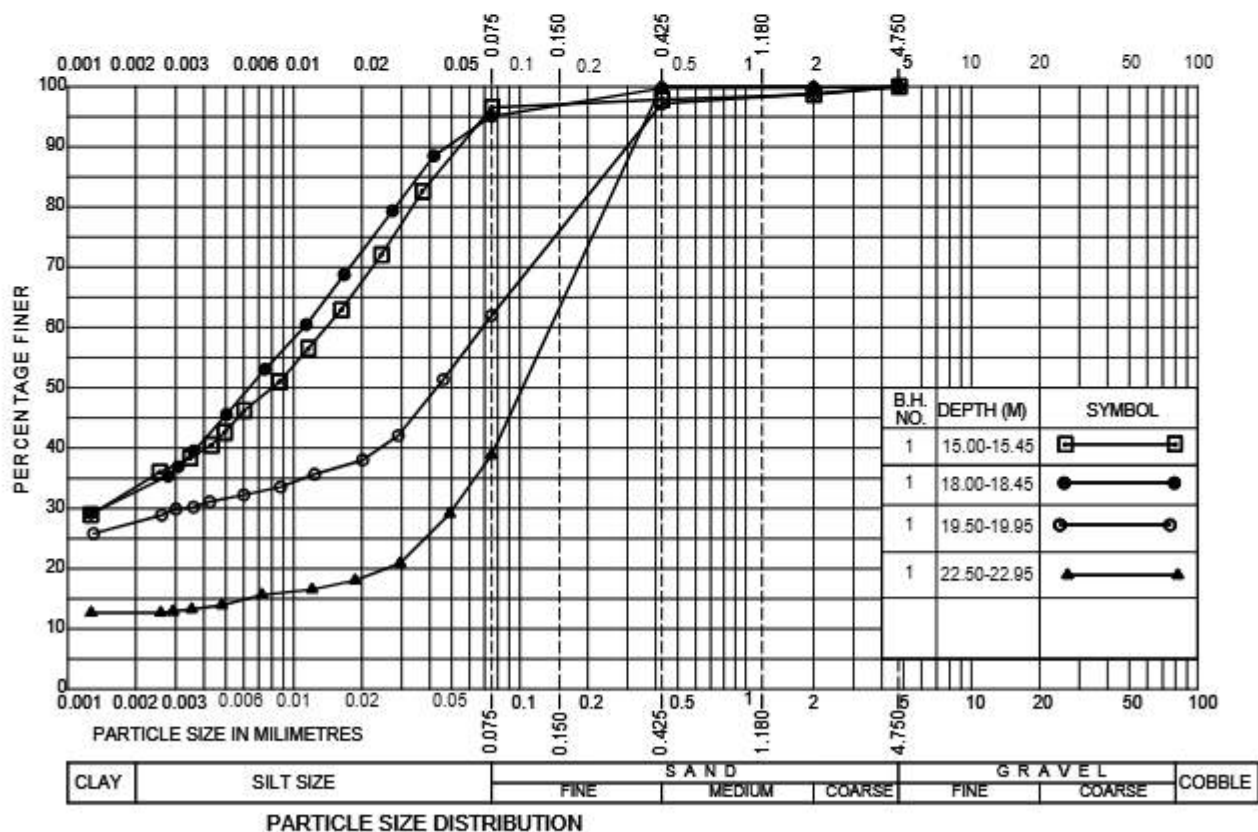
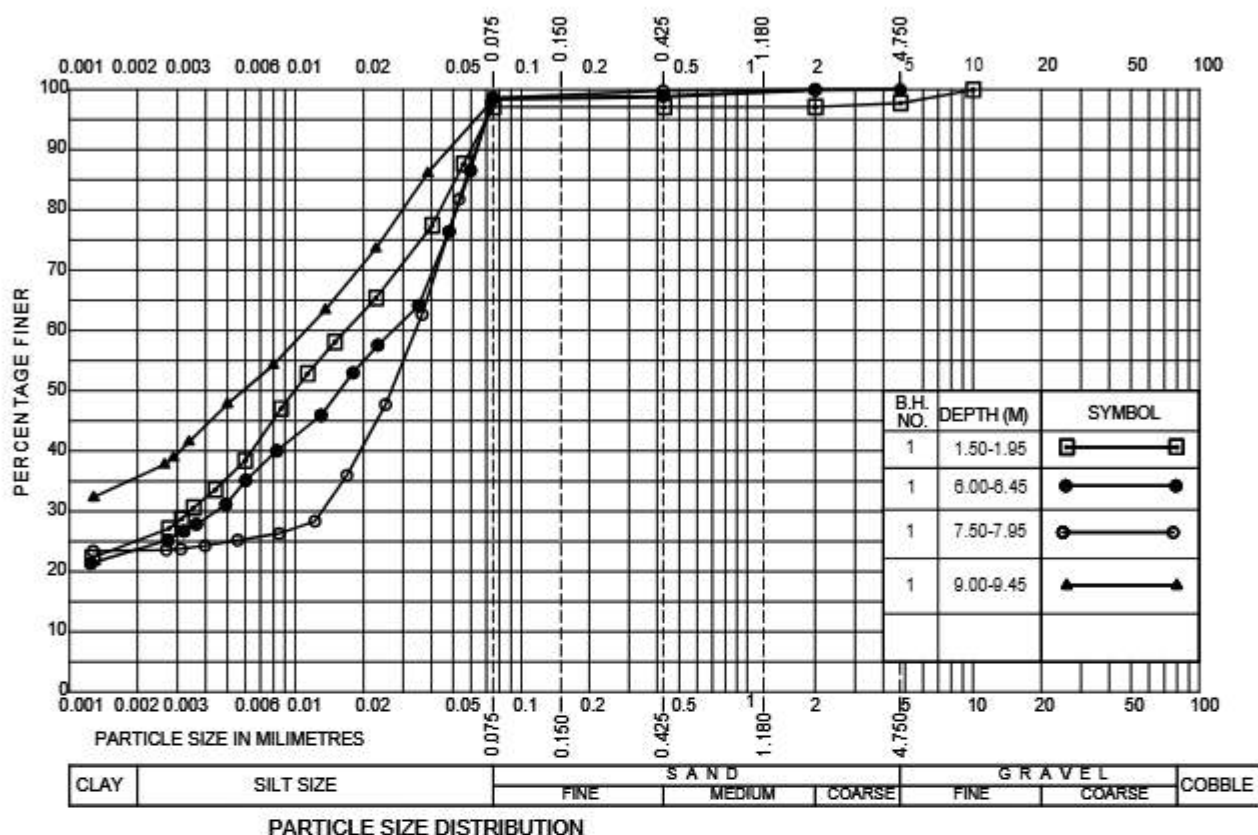
B.H. No. & Sample No.	Type of Sample	Depth (meter)	Description	Liquid Limit	Plastic Limit	Plasticity Index	Specific Gravity	IS specification	Type of Test	Bulk density gm/cc	Water Content %	Lateral Pressure Kg/cm ²	Compressive Strength Kg/cm ²	Cohesion Kg/cm ²	Angle of friction degrees	Consolidation Pressure Kg/cm ²	Coefficient of Volume decrease cm ³ /kg	Gravel %	Sand %	Silt %	Clay %	% Passing 75 micron IS Sieve
1	P	19.50-19.95	Bluish grey sandy silty clay / silty sandy clay.	-	-			CI			21.3							0	38	34	28	62 (hyd)
1	P	22.50-22.95	Medium brown silty fine sand with little clay fractions.	N	P			SM	DS	1.91	29.0			0.1	33			0	61	26	13	24 (hyd)
1	P	24.00-24.45	Dense brown silty fine sand.	N	P			SM			22.2							0	83	17	0	17
1	P	25.60-26.05	Dense brown silty fine sand with little clay fractions.	N	P			SM			24.5							0	75	14	11	25 (hyd)
2	U	3.50-3.95	Soft brown silty clay.	50	19	31	2.65	CH/CI	UU	1.83	32.9			0.30	0	0.25 - 0.5 0.5 - 1.0 1.0 - 2.0 2.0 - 4.0 4.0 - 8.0	0.0508 0.0378 0.0276 0.0189 0.0121	0	1	61	38	99 (hyd)
2	P	5.00-5.45	Grey silty clay with lenses of silt.	51	26	25		CI										0	0	77	23	100 (hyd)
2	P	6.50-6.95	Grey silty clay with lenses of silt.	54	26	28		CI										0	1	73	26	99 (hyd)
2	U	10.00-10.45	Soft grey silty clay with decomposed vegetation and wood pcs.	63	27	36	2.60	CH	UU	1.62	57.0			0.17	0	0.25 - 0.5 0.5 - 1.0 1.0 - 2.0 2.0 - 4.0 4.0 - 8.0	0.0915 0.0705 0.0520 0.0350 0.0252	0	1	63	36	99 (hyd)

NOTE : N.P.=Non-Plastic, Hyd= Hydrometer, UU= Triaxial Undrained, UD= Triaxial Drained, UC= Unconfined, UCR= Unconfined Remoulded, CU/CD= Consolidated Undrained/Drained, DS= Direct Shear.

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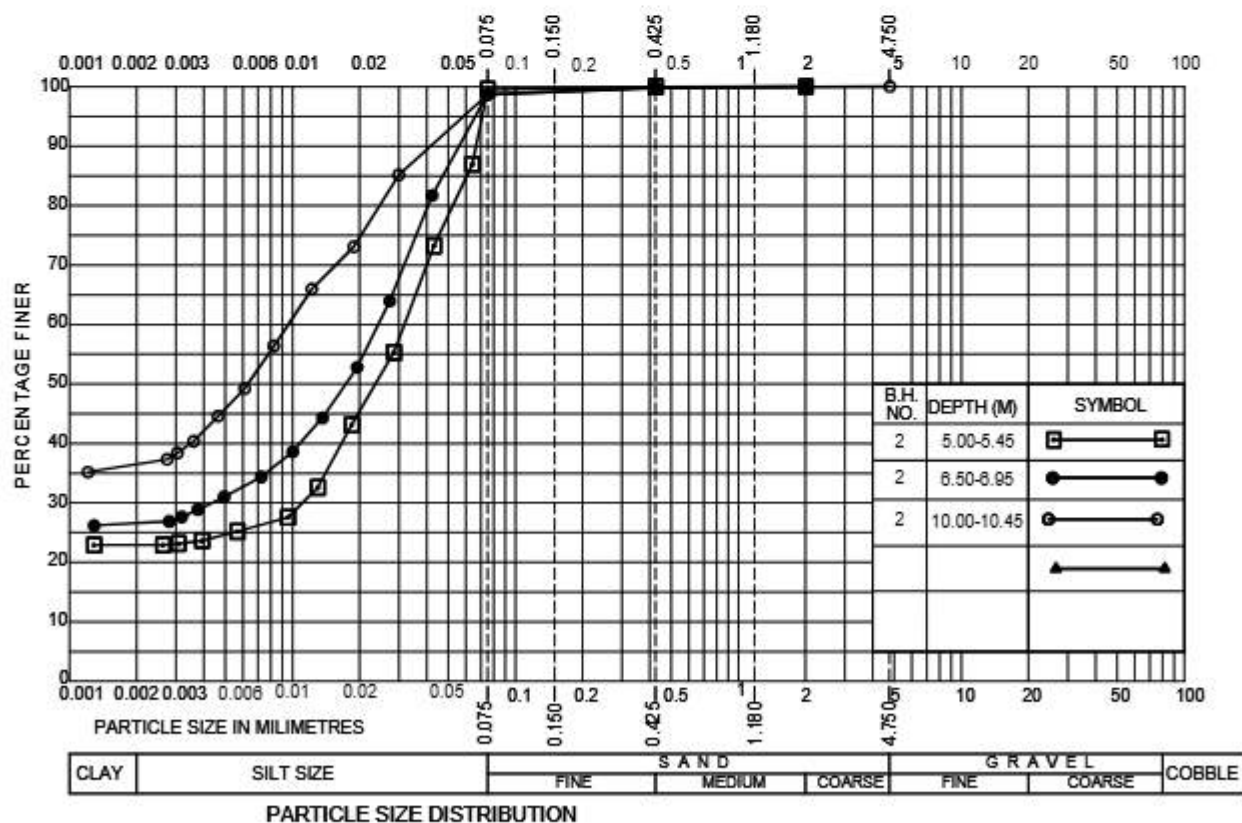
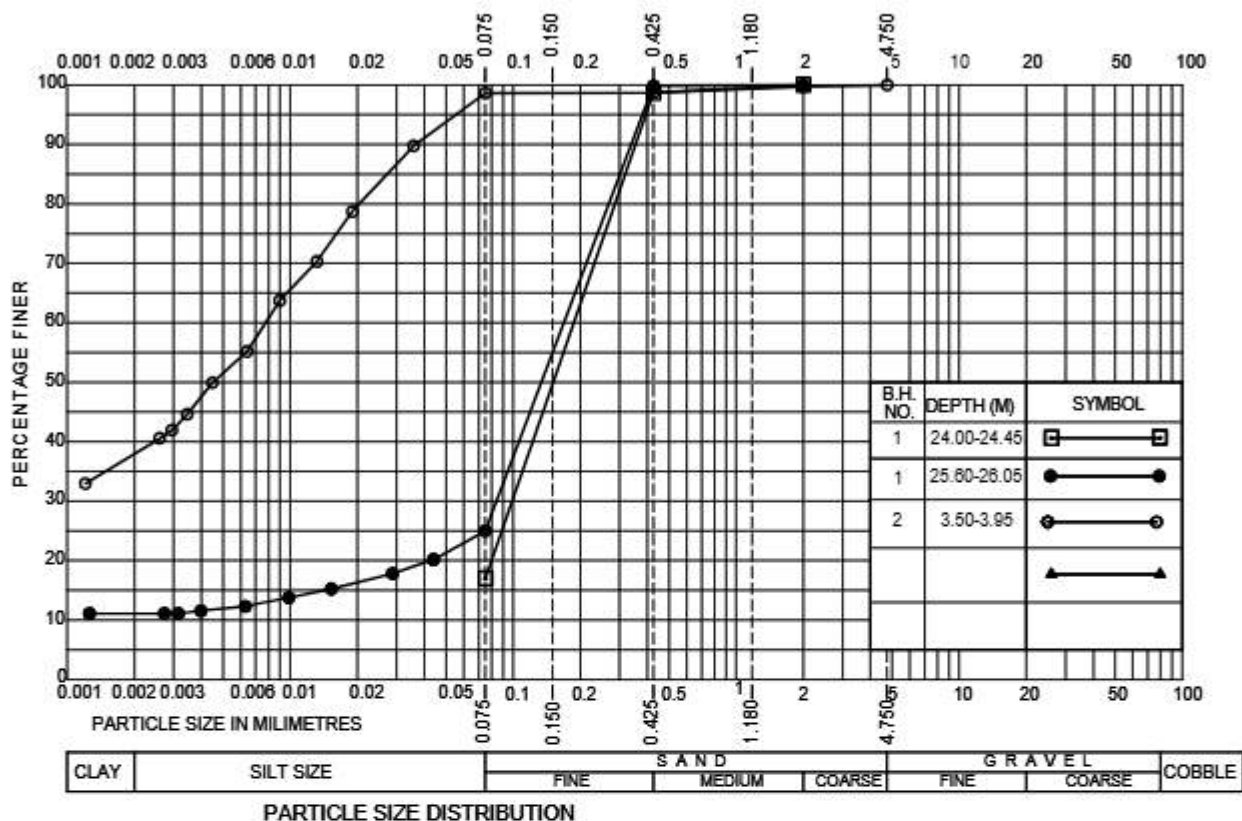
CALCUTTA TEST CENTRE

LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125, BR. NO.-XVI, KOL - 063.



CALCUTTA TEST CENTRE

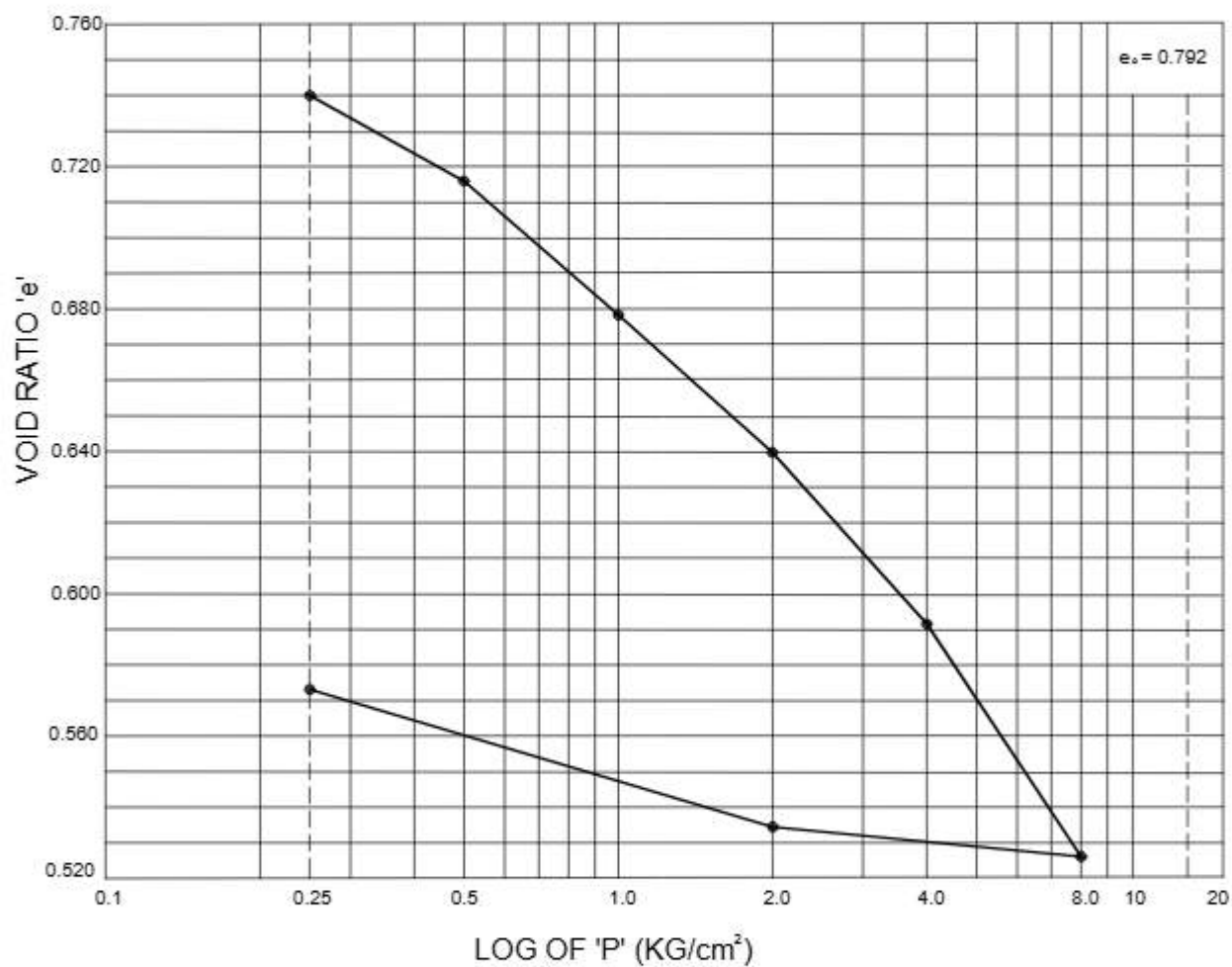
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LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125, BOROUGH NO. - XVI, KOL - 700 063.

e Vs LOG 'P' CURVE



VOID RATIO(e) Vs. LOG 'P' CURVES

BH NO: 1 (ONE)

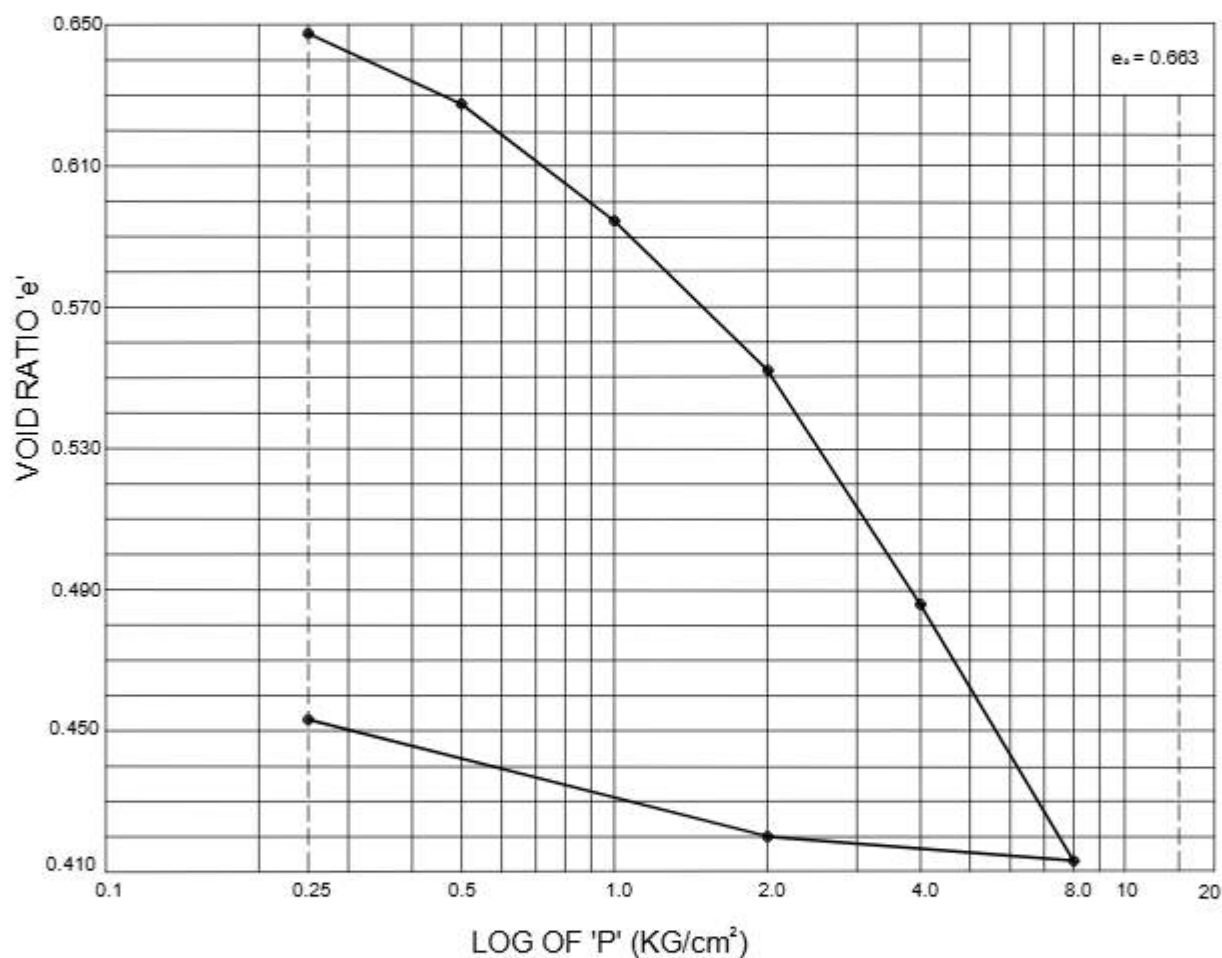
DEPTH: 1.50 - 1.95 M.

CALCUTTA TEST CENTRE

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LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125, BOROUGH NO. - XVI, KOL - 700 063.

e Vs LOG 'P' CURVE



VOID RATIO(e) Vs. LOG 'P' CURVES

BH NO: 1 (ONE)

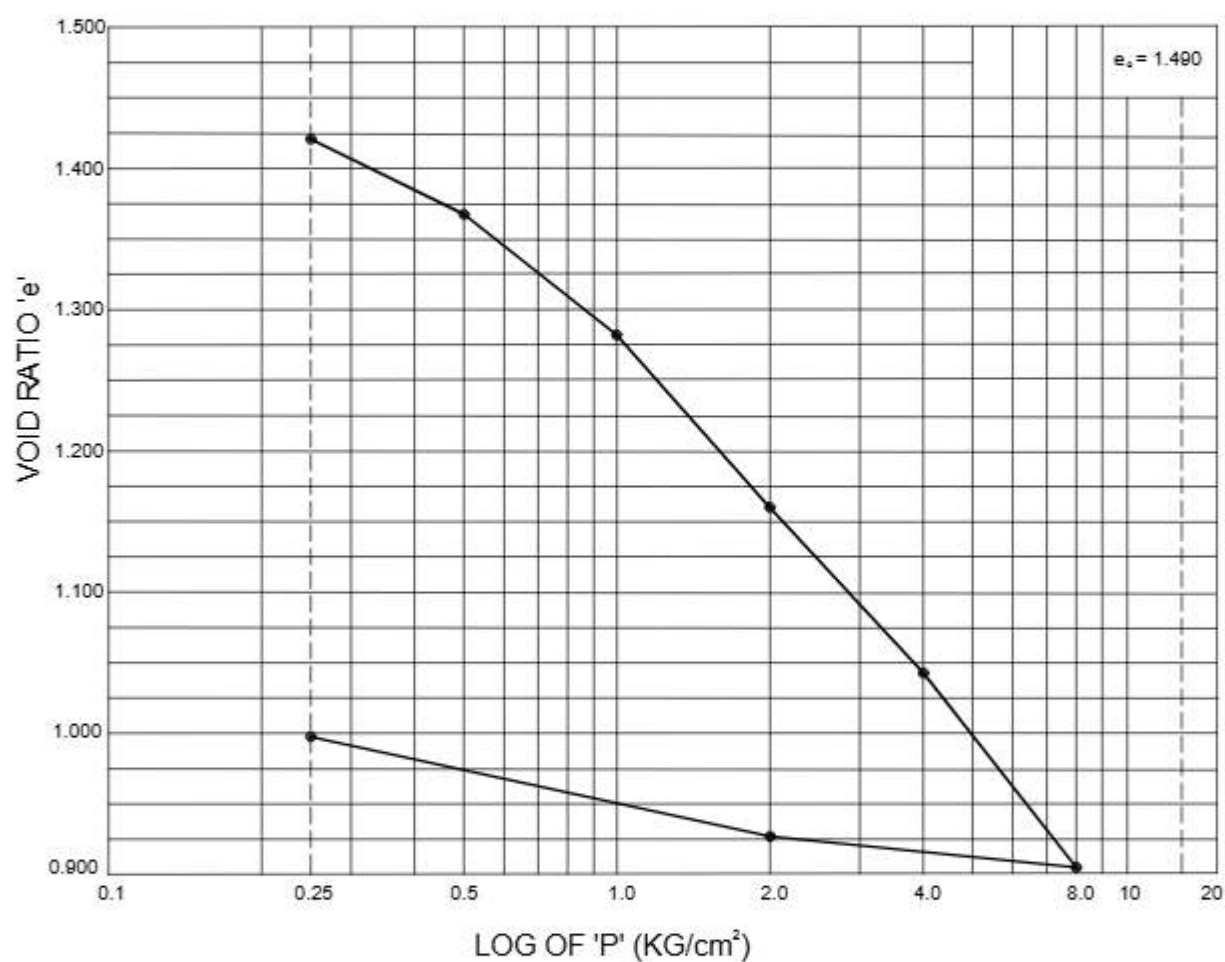
DEPTH: 6.00 - 6.45 M.

CALCUTTA TEST CENTRE

VOID RATIO(e) Vs. LOG 'P' CURVES

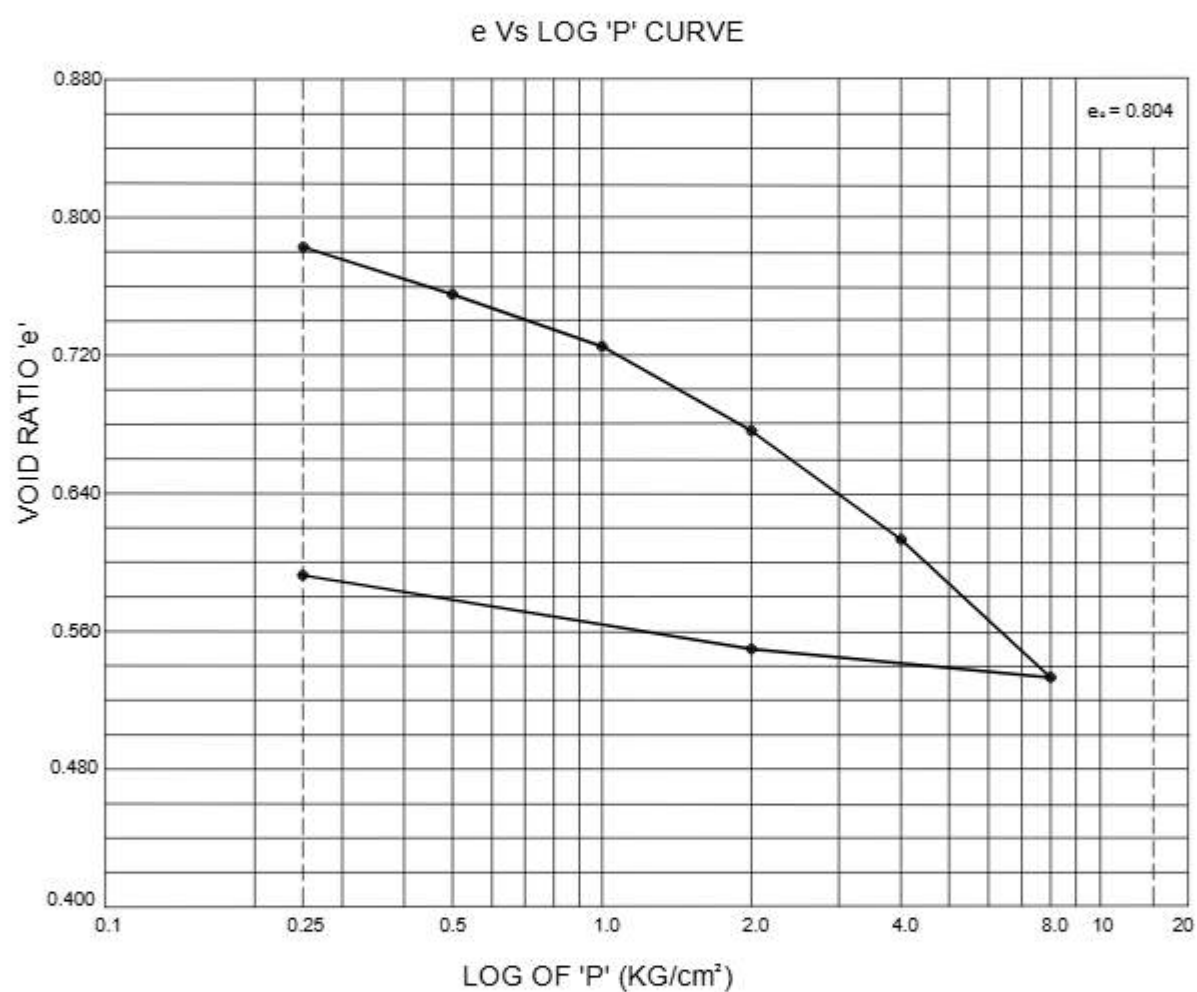
LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125, BOROUGH NO. - XVI, KOL - 700 063.

e Vs LOG 'P' CURVE



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LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125, BOROUGH NO. - XVI, KOL - 700 063.



VOID RATIO(e) Vs. LOG 'P' CURVES

BH NO: 2 (TWO)

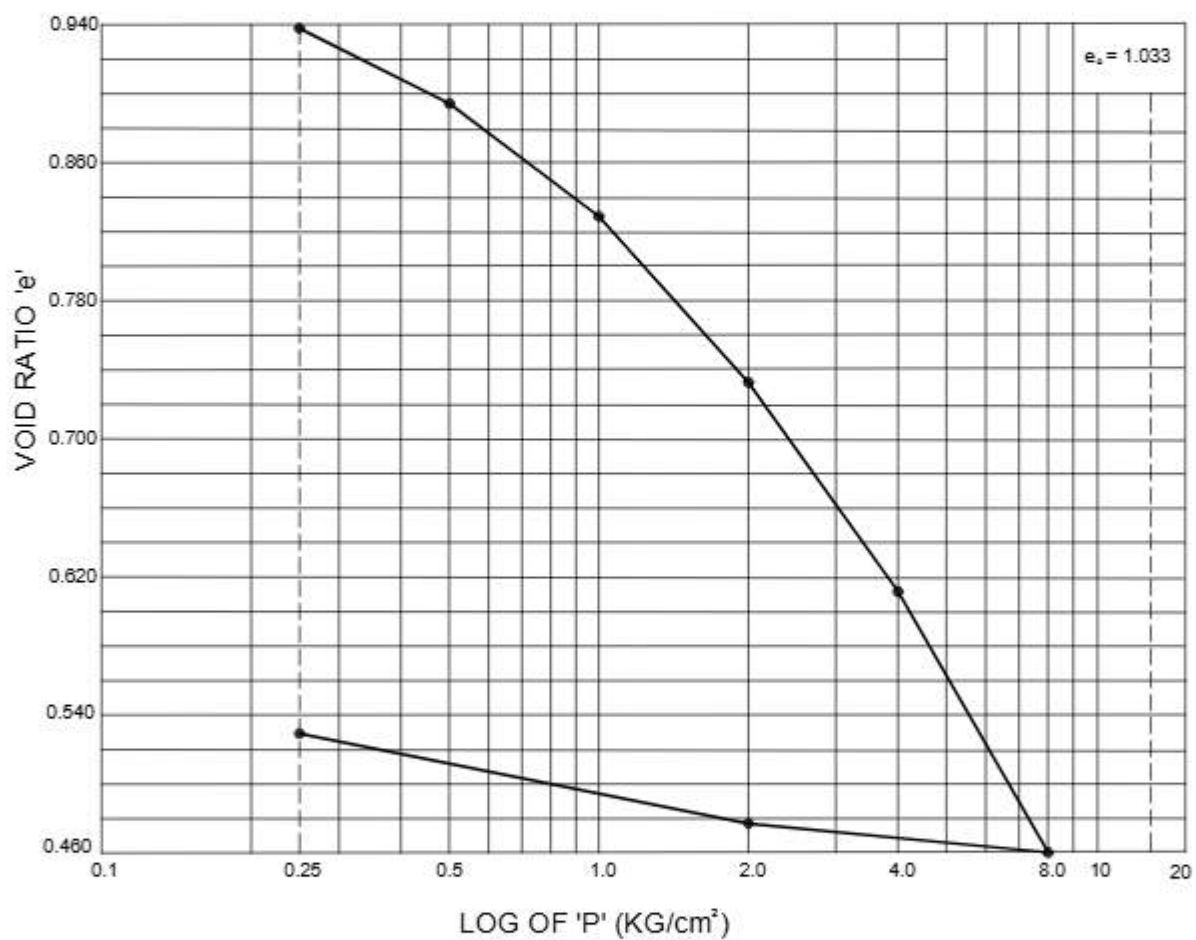
DEPTH: 3.50 - 3.95 M.

CALCUTTA TEST CENTRE

AN ISO 9001 : 2015 CERTIFIED ORGANIZATION

LOCATION : 31A, PANCH MASJID ROAD, WARD NO. - 125, BOROUGH NO. - XVI, KOL - 700 063.

e Vs LOG 'P' CURVE



VOID RATIO(e) Vs. LOG 'P' CURVES

BH NO: 2 (TWO)

DEPTH: 10.00 - 10.45 M.

CALCUTTA TEST CENTRE