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REPORT
ON
SOIL INVESTIGATION FOR CONSTRUCTION
OF
RESIDENTIAL BUILDING.
AT
RAHUMANIYA PURAM, 10E CROSS, THILLAI NAGAR, TRICHY

Client

Dr. M. Devi Meenakshi,
Ward No. M, Block No. 35,
T.S. No. 66/1, 2, 67, 76,
Door No. 12,
Rahumaniya Puram,
10E Cross,
Thillai Nagar,
Trichy.

By

Time



TIME INSTITUTE FOR MATERIALS TESTING
NO. 25, SANJEEVI NAGAR,
TRICHY - CHENNAI BYEPASS ROAD,
TIRUCHIRAPPALLI,
TAMIL NADU - 620 002.
PH: 0431 2401326

JANUARY 2024

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SUMMARY

Project : Construction of Residential Building Devi Residency Stilt Parking plus three floors containing 15 dwelling units at 12, Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy

Project Reference : Time /27/ Soil Test / January 2024

Owner : Dr. M. Devi Meenakshi, Ward No. M, Block No. 35, T.S. No. 66/1, 2, 67, 76, Door No. 12, Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy.

Type of Structure : R.C.C. Framed construction

Location : Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy

Scope : Geotechnical investigation for the entire area of construction

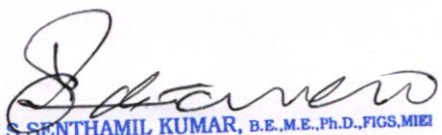
Test conducted : Two explanatory bore hole up to 6m depth was made and conducted standard penetration tests at every 1.5m depth. The undisturbed soil samples were collected at every 1.5m depth for laboratory test.

FINDINGS

Soil at shallow depth : Clay exists up to 1.9m depth

Hard stratum : Soft rock exists from 3m to 5m depth in bore hole no. 1 & 4m to 6m depth in bore hole no. 2

Ground water table : Ground water table exists at 3m depth from ground level during soil investigation


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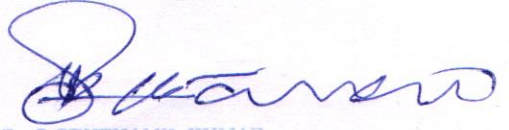
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6. SOIL SAMPLE PHOTOS

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ANNEXURE


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SOIL INVESTIGATION

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1.2 Investigation Programme, Procedure and Data:

Investigation was carried out in two locations at the site through exploratory bore holes. Soil samples were collected from each bore hole at different depths for conducting laboratory test. Standard Penetration test was conducted at regular intervals and 'N' values were recorded. Undisturbed soil samples were collected and were preserved and transported to the laboratory for detailed identification tests. Based on the field and laboratory tests on the samples collected, the results are furnished in this report.

An exploratory bore hole was advanced from the existing ground level using truck mounted rotary drilling techniques supplemented by Betonies mud circulation. This drilling procedure with mud circulation is found most suitable for making exploratory bore hole. The mud circulation was employed through the drill rods and letting it out through the side jets provided in the cutting tool thus preventing any disturbance at the bore hole bottom. Mud circulation was used to stabilize the sides and the bottom of the bore hole, and then to bring the soil cuts to the surface. It is important to note that the mud jet is not used to cut the soils as in the case of wash boring technique. Use of drilling mud will also help in preventing the disturbance to the soil at the bore hole bottom during drilling operations. Diameter of the bore hole is about 150mm.

Bore hole was always kept full with the drilling mud so that a positive head is maintained in the bore hole thus preventing any disturbance to the soil within the test zone.

The field tests included Standard penetration test, Disturbed and undisturbed soil sampling, identification of different soil layers, Ground water table observation, complete logging of the bore hole, etc.

Laboratory investigation consisted of classification tests like grain size distribution analysis, determination of specific gravity etc. Unconfined Compression test and Direct shear was conducted on preserved soil samples. All the field and laboratory tests were conducted according to the procedures stipulated in relevant IS codes.

1.3 Review of Field and Laboratory Results:

Sub soil Profile

The original ground level in the presently investigated area was plain terrain.

Bore Hole 1:

The natural soil below the existing ground level is filled up soil. This layer is extended up to 0.5m depth. Clay exists from 0.5m to 1.9m depth. Clay with gravels mixed exists from 1.9m to 2.4m depth. Gravels mixed exist from 2.4m to 3m depth. Below which soft rock exists from 3m to 6m depth from the existing ground level. The soil stratification and its variation under present investigation are available in bore log details. The 'N' value is progressively increasing towards depth, due to the soil stratification.

Bore Hole 2:

The natural soil below the existing ground level is filled up soil. This layer is extended up to 1m depth. Clay exists from 1m to 1.9m depth. Clay with gravels mixed exists from 1.9m to 2.2m depth. Gravels mixed exist from 2.2m to 4m depth. Below which soft rock exists from 4m to 6m depth from the existing ground level. The soil stratification and its variation under present investigation are available in bore log details. The 'N' value is progressively increasing towards depth, due to the soil stratification.

Ground Water Table

Ground water table exists at 3m depth from ground level during soil investigation

Shear Strength

Standard Penetration test blow counts 'N' is measured at different levels in the bore hole. Mainly these 'N' values are used to assess the shear strength of different soil layers.

Cohesive layers: The classification of 'N' values in moderate to high plasticity medium clay deposits developed by Terzaghi is used for estimating the unconfined compression strength and untrained shear strength of clay and sandy clay layers. The consistency between the N values and the liquidity index values is reviewed while assigning undrained shear strength for soft to medium clay layers.

Non - Cohesive Layers: The sand layers towards depth are of residual type and suitable modifications are made to take care of the presence of plastic fines in the residual soil. Conventional method of estimating the angle of shearing resistance ϕ corresponding to the relative density and the grain size distribution as per the classification suggested by Peck and suitably modified by the R.K. Hough to account for the influence of grain size distribution is adopted here.

Laboratory Tests:

The Collected soil samples were tested as per relevant procedure in IS codes. The following parameters are evaluated.

- 1) **Natural Moisture Content:** This test is conducted in all disturbed samples to find the water content in soil samples as per **IS 2720 (Part 2): 1973**
- 2) **Specific Gravity:** This test is conducted in all disturbed soil samples to find specific gravity of soil as per **IS 2720 (Part 3): 1980**
- 3) **Density:** This test is conducted in all disturbed soil samples to find Bulk density and Dry density of soil as per **IS 2720 (Part 8): 1983**
- 4) **Sieve Analysis:** This test is conducted to identify and classify the samples as per **IS 2720 (Part 4) : 1985**
- 5) **Direct Shear Test:** This test conducted in coarse grained soil to find the angle of shearing resistance of the soil as per **IS 2720 (Part 13):1986**
- 6) **Unconfined Compression Test:** This test conducted in Clay soil to find Cohesion of the soil as per **IS 2720 (Part 10):1995**

Report on soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy

1.4 Recommended Safe bearing capacity values at different depths

Bore Hole	Depth (m)	Safe Bearing Capacity (t/m ²) (40mm Settlement)
BH - 1	1.50	9.51
	3.00	53.02
	4.50	63.89
	6.00	65.25

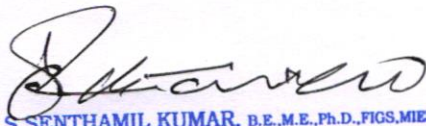
BH - 2	1.50	4.07
	2.50	9.51
	3.00	20.39
	4.50	63.89
	6.00	66.61

1.5 Conclusions:

The scope of foundation is purely the decision of the structural engineer. However, the following suggestion are furnished for your reference.

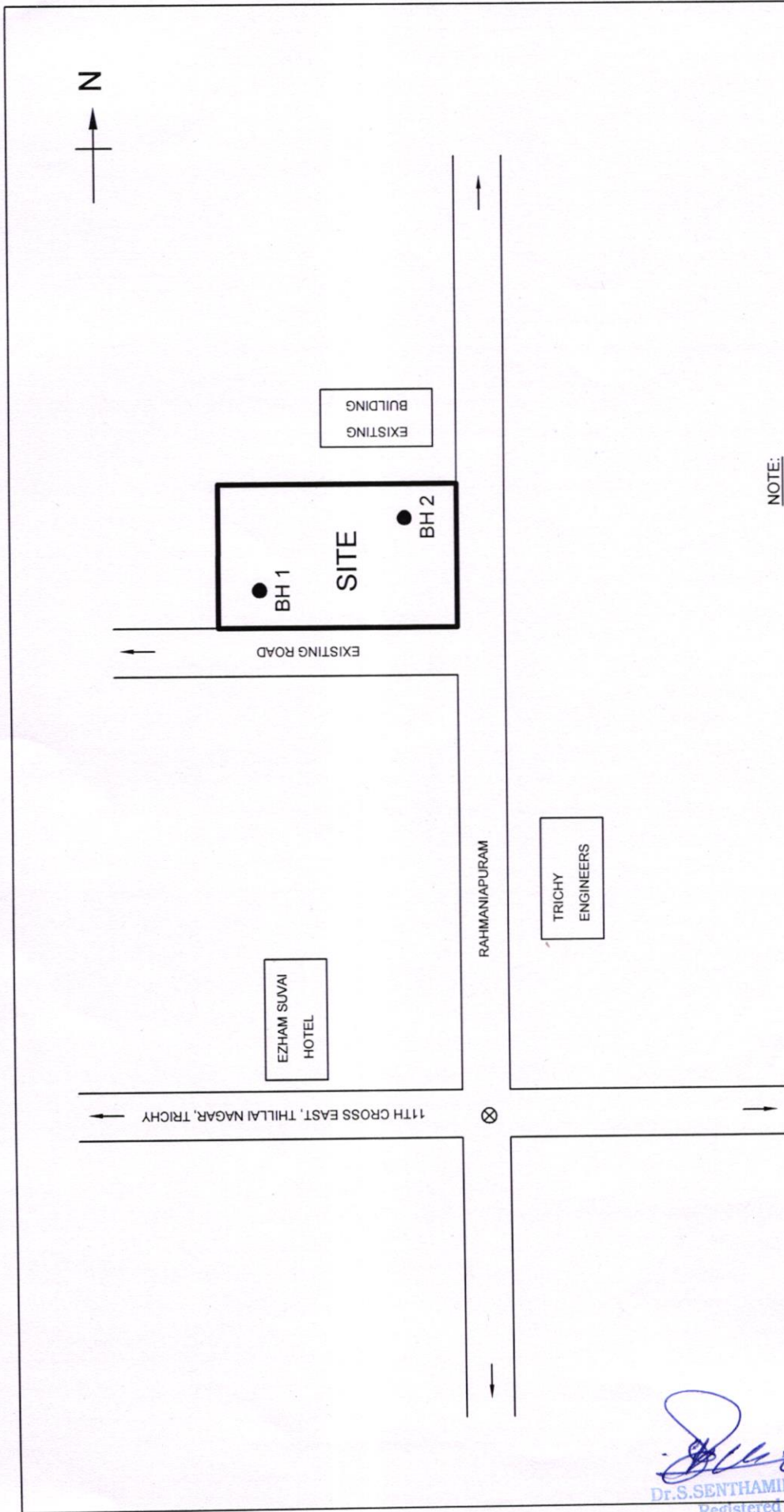
1. There are two types of foundation as Open foundation and Deeper foundation.
2. Under Open foundation, there are four types like Isolated, Combined, Raft and Mat Foundation.
3. Under Deeper foundation, it is only Pile foundation.
4. Under which condition we can prefer Open foundation or Pile foundation?
5. In general, to have Open foundation for any type of loading via Light load /Heavy load, symmetrically spaced columns or unsymmetrically spaced columns, it is preferable to have SBC as 20t/m^2 and above at 3m depth and it should continue to increase as proceed down, further it should not increase and decrease after 3m depth to satisfy the settlement criteria.
6. Based on the existing soil condition in this location the above condition to provide open foundation is fully satisfied.
7. **Hence it is Suggested to provide Open foundation at 3m depth by considering SBC values as 20t/m^2 .**
8. The minimum width of footing should be maintained as 1.2m x 1.2m to avoid Punching Shear failure and the footing should rest on natural undisturbed soil strata.
9. The Excavated material can be reused for Backfilling since the Bulk density and Permeability values are well within the Permissible limits.

23rd January 2024


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SITE LOCATION PLAN

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NOTE:

SITE LEVEL IS EQUAL TO THE ROAD LEVEL

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SOIL CONSULTANT	TIME Institute for Materials Testing No 25, Sanjeevi Nagar, Trichy - Chennai Bypass road , Trichy - 620002. PHONE : 0431 - 2401326(OFF)
DATE OF SURVEY	22.01.2024
SCALE	NTS
TITLE	PLAN OF BORE HOLE AND SITE DETAILS AT RAHUMANIYA PURAM, 10E CROSS, THILLAI NAGAR, TRICHY
DRG NO	DRAWING - 01
REV.	0

SITE PLAN

LEGEND:

- BORE LOG LOCATION
- ⊗ SITE LOCATION

BORE LOG DETAILS

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Report on soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy

2.2 BORE LOG DETAILS FOR BORE HOLE 1

Project	: Report on soil investigation for Construction of Residential Building		
Location	: Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy		
Started on	: 22.01.2024	Ended on	: 22.01.2024
Depth of G.W.T	: 4m		
Type of Boring	: Calyx drilling		
Site Level	: Equal to the road level		

Lithology of Bore Hole			SPT Data					Graphical representation of penetration Resistance ('N' Value)
Depth below G.L. (m)	Profile	Soil Description	Depth of SPT (m)	0-15cm	15-30cm	30-45cm	N Value	
0 - 0.5m		Filled up soil						
0.5m - 1.9m		Clay	1.5	3	4	6	10	
1.9m - 2.4m		Clay with gravels mixed						
2.4m - 3m		Gravels	3.0	15	20	22	42	
3m - 6m		Soft rock	4.5	Rebound			50	
			6.0	Rebound			51	

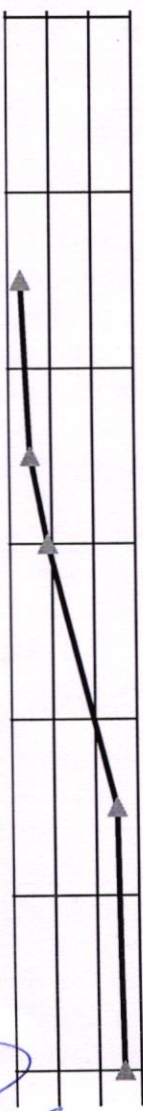
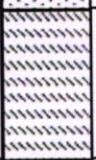
Bore terminated at 6m depth from the existing ground level



Report on soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy

2.3 BORE LOG DETAILS FOR BORE HOLE 2

Project : Report on soil investigation for Construction of Residential Building
Location : Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy
Started on : 22.01.2024 Ended on : 22.01.2024
Depth of G.W.T : 4m
Type of Boring : Calyx drilling
Site Level : Equal to the road level

Lithology of Bore Hole			SPT Data					Graphical representation of penetration Resistance ('N' Value)
Depth below G.L. (m)	Profile	Soil Description	Depth of SPT (m)	0-15cm	15-30cm	30-45cm	N Value	
0 - 1m		Filled up soil						
1m - 1.9m		Clay	1.5	1	1	5	6	
1.9m - 2.2m		Clay with gravels mixed						
2.2m - 4m		Gravels	2.5	8	6	4	10	
			3.0	4	6	12	18	
4m - 6m		Soft rock	4.5	Rebound			50	
			6.0	Rebound			52	

Bore terminated at 6m depth from the existing ground level

2.4 Summary of Engineering Geo Properties

Natural Moisture Content:

The natural water content also called the natural moisture content is the ratio of the weight of water to the weight of the solids in a given mass of soil. This ratio is usually expressed as percentage.

$$W = [(W_2 - W_3) / (W_3 - W_1)] \times 100$$

Where,

W_1 = Weight of container gm

W_2 = Weight of container + wet soil gm

W_3 = Weight of container + dry soil

Bulk Density:

The total, or wet, density of soil, ρ , is the ratio of the total mass of soil to its total volume and can be defined as follows:

$$Y_{\text{bulk}} = M / V$$

Where

M_t = Total Mass of soil

V_t = Total Volume

Dry Density:

The soil dry density, ρ_b , is the ratio of the mass of the solid phase of the soil (i.e., dried soil) to its total volume (solid and pore volumes together) and is defined as follows:

$$Y_{\text{dry}} = M_b / V_b$$

Where

M_b = Total Mass of dried soil

V_b = Total Volume

Specific gravity:

Specific gravity is the ratio of the weight of a given volume of a material at a standard temperature to the weight of an equal volume of distilled water at the same stated temperature.

$$\text{The specific gravity } G \text{ of the soil} = (W_2 - W_1) / [(W_4 - W_1) - (W_3 - W_2)]$$

Where

W_1 = Weight of density bottle

W_2 = Weight of density bottle + dry soil

W_3 = Weight of bottle + dry soil + water at temperature

W_4 = Weight of density bottle + Water

Void Ratio:

Soil void ratio (e) is the ratio of the volume of voids to the volume of solids:

$$e = (V_v) / (V_s)$$

Where

V_v is the volume of the voids (empty or filled with fluid),

V_s is the volume of solids.

Porosity:

Soil porosity (η), which is defined as the ratio of the volume of voids to the total volume of the soil.

The porosity and the void ratio are inter-related as follows:

$$\eta = (1 - (\gamma_d / G_s)) * 100$$

$$e = \eta / (1 - \eta) \text{ \& } \eta = e / (1 + e)$$

Where

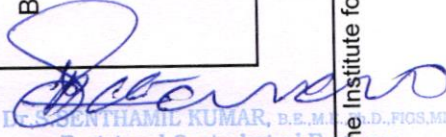
γ_d = Dry Density

G_s = Specific gravity

Summary of Engineering Geo Properties for Bore Holes 1 & 2

Bore hole No.	Depth (m)	Soil Description	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry Density (gm/cc)	Specific gravity	Porosity (%)	Void Ratio
Bore Hole 1	1.5	Clay	20.75	1.83	1.52	2.61	42	0.72
	3.0	Gravels	9.20	1.99	1.82	2.66	31	0.46
	4.5	Soft rock	4.85	2.05	1.96	2.69	27	0.38
	6.0		4.60	2.06	1.97	2.69	27	0.37

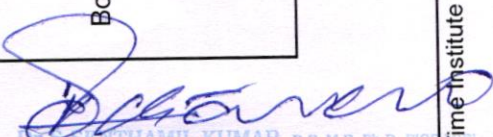
Bore Hole 2	1.5	Clay	20.88	1.82	1.51	2.61	42	0.73
	2.5	Gravels	9.85	1.97	1.79	2.65	32	0.48
	3.0		9.60	1.98	1.81	2.65	32	0.47
	4.5	Soft rock	4.50	2.06	1.97	2.69	27	0.36
	6.0		4.40	2.07	1.98	2.69	26	0.36


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2.5 Summary of Laboratory Test Results for Bore Hole 1 & 2

Bore hole No.	Depth (m)	Soil Description	Atterberg limits			Gravel (%)	Coarse sand (%)	Medium Sand (%)	Fine sand (%)	Silt (%)	Clay (%)
			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)						
Bore Hole 1	1.5	Clay	29.5	22.5	7.0	0.0	0.0	9.8	24.3	4.5	61.4
	3.0	Gravels	-	-	-	57.9	26.1	13.8	2.2	0.0	0.0

Bore Hole 2	1.5	Clay	29.3	22.2	7.1	0.0	0.0	8.7	25.2	3.9	62.2
	2.5	Gravels	-	-	-	38.9	29.5	21.9	9.7	0.0	0.0
	3.0		-	-	-	42.8	30.6	19.0	7.6	0.0	0.0


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2.6 Shear Strength Parameters for Different layers of Bore Holes 1 & 2

Bore Hole No.	Depth below G.L. (m)	Soil Description	N	Cohesion 'c' (t/m ²)	Shear Strength 'Ø' (in degrees)
Bore Hole 1	1.5	Clay	10	6.89	-
	3.0	Gravels	42	-	36.99
	4.5	Soft rock	50	-	37.61
	6.0		51	-	37.82

Bore Hole 2	1.5	Clay	6	3.49	-
	2.5	Gravels	10	-	29.65
	3.0		18	-	31.12
	4.5	Soft rock	50	-	37.82
	6.0		52	-	38.02

GRAIN SIZE ANALYSIS

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CALCULATION OF SAFE BEARING CAPACITY

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4. CALCULATION OF SAFE BEARING CAPACITY

4.1 Safe bearing capacity calculation based on settlement and Shear

Safe Bearing Capacity calculations based on settlement consideration (SPT value):

Safe Bearing Capacity calculations for shallow foundation will vary based on the width of foundation.

For example, in the case of Individual footing such as isolated, combined etc., we are supposed to use the formula as mentioned below. (Using Teng's Modified formula)

$$q_{na} = 51.4 \times (N - 3) \times \left(\frac{B + 0.3}{2B} \right)^2 \times R_w \times C_d$$

Where,

q_{na}	=	Net safe bearing capacity of soil (kN/m ²) (for 40mm settlement as per Skempton and MacDonald)
N	=	Corrected SPT values
B	=	Width of foundation (m) (let us assume 2m)
R_w	=	Correction factor for water table level
C_d	=	Correction factor for depth of embedment

For 40mm Settlement:

For Bore Hole 1 @ 3m depth SPT 'N' Value = 42

$$\Rightarrow q_{na} = (51.4 \times (42 - 3) \times ((2 + 0.3)/(2 \times 2))^2 \times 0.5 \times 1) \times (40/25) = 530.21 \text{ kN/m}^2$$

$$\therefore q_{na} = 53.02 \text{ t/m}^2$$

Safe Bearing Capacity calculations based on Unconfined Compression Test (UCC):

As Per IS 6403:1981

Net safe bearing capacity of the soil,

$$q_{ult} = C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W'$$

Where

C	=	Cohesion in Kgf/cm ²
N _c , N _q , N _γ	=	Bearing Capacity Factors
S _c , S _q , S _γ	=	Shape Factors
d _c , d _q , d _γ	=	Depth Factors
i _c , i _q , i _γ	=	Inclination Factors
q	=	Effective surcharge at the base level of foundation in Kgf/cm ²
	=	γ x d
B	=	Width of footing, diameter of circular footing in cm
γ	=	Bulk unit weight of soil in Kgf/cm ³
W'	=	Correction factor for location of water table

At 1.5m depth (Bore Hole 1), the Soil profile is Clay

If	Φ	=	0 (assumed)
	N _c	=	5.14
	N _q	=	1
	N _γ	=	0 (Zero)
and Cohesion C		=	6.89 (based on laboratory test)

Applying these parameters in the equation No. 1

$$\begin{aligned} q_{ult} &= C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W' \\ &= C N_c S_c d_c i_c + q (1 - 1) S_q d_q i_q + 0.5 B \gamma 0 S_\gamma d_\gamma i_\gamma W' \\ &= C N_c S_c d_c i_c + 0 + 0 \\ q_{ult} &= C N_c S_c d_c i_c \end{aligned}$$

Where S_c = Shape factor which is equal to 1

$$\begin{aligned} d_c &= 1 + 0.2 \frac{df}{B} \sqrt{Nq} \\ &= 1 + 0.2 \frac{2.6}{18} \sqrt{\tan^2(45 + \phi/2)} \\ &= 1.028 \text{ (hence considered the minimum value as 1)} \\ &= 1 \end{aligned}$$

$$i_c = (1 + \alpha/90)^2$$

Where α = inclination of the load to the vertical in degree which is equal to zero

$$i_c = 1$$

$$\begin{aligned} \text{Therefore } q_{ult} &= C N_c S_c d_c i_c \\ &= 6.89 \times 5.14 \times 1 \times 1 \times 1 \\ &= 35.414 \text{ t/m}^2 \end{aligned}$$

Applying factor of safety as 3

Then allowable bearing capacity

$$\begin{aligned} q_{allowable} &= 35.414 / 3 \\ &= 11.80 \text{ t/m}^2 \end{aligned}$$

Safe Bearing Capacity calculations based on shear consideration (Direct Shear):

As Per IS 6403:1981

At 3m depth (Bore Hole 1)

Proving Ring capacity 200kg = 966.2 division

Area of the shear box = 6cm x 6cm = 36cm²

Normal Stress (kg/cm ²)	No. of Division	Stress
0.5	23	0.132
1.0	88	0.506
1.5	154	0.885

$$\begin{aligned} \text{Stress} &= \text{Load} / \text{Area} \\ &= (200/966.2) \times 23 \times (1/36) = 0.132 \end{aligned}$$

$$\phi = \tan^{-1} (0.885 - 0.132) = 36.99^\circ$$

Net safe bearing capacity of the soil (for general shear failure as per IS 6403:1981)

$$q_{ult} = C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W'$$

Where

C	=	Cohesion in t/m ²
N _c , N _q , N _γ	=	Bearing Capacity Factors (From Table 1 of IS 6403 – 1981)
S _c , S _q , S _γ	=	Shape Factors (From Table 2 of IS 6403 – 1981)
d _c , d _q , d _γ	=	Depth Factors
i _c , i _q , i _γ	=	Inclination Factors
q	=	Effective surcharge at the base level of foundation in t/m ²
B	=	Width of footing, diameter of circular footing in m
γ	=	Bulk unit weight of soil in t/m ³
W'	=	Correction factor for location of water table

At 3m depth (Bore hole 1), the Soil profile is Gravels

If	C	=	0 (Since no Cohesion)
	Φ	=	36.99° (based on laboratory test)
Therefore	N _c	=	57.728;
	N _q	=	45.588;
	N _γ	=	72.440

Applying these parameters in the above equation

$$q_{ult} = C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W'$$

Where C = 0 (Since no Cohesion)

$$\text{Therefore, } q_{ult} = q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W'$$

Bearing Capacity calculation through shear density of soil 'γ'

There are two relationships of weight of soil to Volume of soil as

- Total density or Bulk density
- Dry density

$$\text{Therefore, Total Bulk density, } Y_t = \frac{\text{Total Weight of soil}}{\text{Total Volume of soil}} = \frac{W}{V}$$

$$\text{Dry Density } Y_d = W_s/V; \quad \text{Whereas } W_s = \text{Total weight of solids}$$

In a particular case the **total density** will be known as **saturated density**, when the soil is saturated.

Another density of soil will be known as submerged or buoyant density, γ_b , when the soil is submerged in water.

$$\gamma_b = \gamma_t - \gamma_w$$

Where $\gamma_w =$ Density of water = 1 g/cc or 1 t/m³

Mostly soils submerged in water are saturated.

Hence $\gamma_{\text{buoyant}} = \gamma_{\text{sat}} - \gamma_w$

Based on the above equations,

$$\gamma = \gamma_{\text{sat}} = 1.8 \text{ t/m}^3$$

$$d = 3\text{m}$$

Here, $\gamma_b = \gamma_{\text{sat}} - 1 = 1.8 - 1 = 0.8 \text{ t/m}^3$

Therefore, $q = \gamma_b \times d = 0.8 \times 3 = 2.4 \text{ t/m}^2$

$$S_q = S_v = \text{Shape factor which is equal to 1}$$

$$d_q = d_v = 1 + 0.1 \frac{df}{B} \sqrt{N\phi}$$

$$= 1 \quad (\text{Minimum value of 1 can be taken})$$

$$i_q = \text{inclination factor } (1 - \alpha/90)^2$$

Where $\alpha =$ inclination of the load to the vertical in degree which is equal to zero

$$i_q = 1$$

$$B = \text{Width of footing (2m)}$$

$$W' = 0.5$$

Applying in the above equation

$$\begin{aligned} Q_{\text{ult}} &= q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_v S_v d_v i_v W' \\ &= 2.4 \times (45.588 - 1) \times 1 \times 1 \times 1 + 0.5 \times 2 \times 1.8 \times 72.440 \times 1 \times 1 \times 1 \times 0.5 \\ &= 172.207 \text{ t/m}^2 \end{aligned}$$

Applying factor of safety as 3

Then allowable bearing capacity

$$\begin{aligned} Q_{\text{na}} &= 172.207 / 3 \\ &= 57.40 \text{ t/m}^2 \end{aligned}$$

Settlement Calculations as per IS – 8009 (Part – 1) 1976

- | | | |
|--|---|---|
| 1. Recommended depth of foundation | = | 3m from EGL |
| 2. Soil Strata at 3m depth from EGL | = | Gravels |
| 3. The allowable bearing capacity value based on shear calculation =
(as Per IS 6403 – 1981) at 3m depth from EGL | = | 574.0 kN/m ² ≈ 575 kN/m ² |
| 4. Young's Modulus, Es for Gravels
(As per "Foundation analysis and Design" by Bowles, Pg. No. 125) | = | 150 Mpa = 150 x 10 ³ kN/m ² |
| 5. Poisson's ratio μ
(As per "Foundation analysis and Design" by Bowles, Pg. No. 123) | = | 0.3 |
| 6. Width of Foundation | = | 2m |

$$\text{Settlement } S_i = I * Q_s * B (1 - \mu^2) / E_s$$

Q_s = Pressure, S_i = Immediate Settlement, I = Influence Factor,
 B = Width of Foundation, μ = Poisson's ratio, E_s = Elastic Modulus

$$\begin{aligned} S_i &= (0.95 \times 575 \times 2 (1 - 0.3^2) / (150 \times 10^3)) \\ &= 0.00663\text{m} \\ &= 6.63 \text{ mm} \end{aligned}$$

$$\text{Settlement} = 6.63 \text{ mm} < 50\text{mm. Hence safe}$$

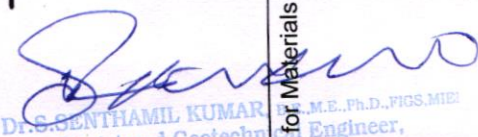
The maximum settlement for sand and gravel as per IS 1904 -1986 will be 50mm.
(Details Enclosed)

**TABLE 1 PERMISSIBLE DIFFERENTIAL SETTLEMENTS AND TILT (ANGULAR DISTORTION)
FOR SHALLOW FOUNDATION IN SOILS
(Clause 16.3.4)**

Sl No.	Type of Structure	ISOLATED FOUNDATIONS						RAFT FOUNDATIONS					
		Sand and Hard Clay			Plastic Clay			Sand and Hard Clay			Plastic Clay		
		Maximum settlement	Differential settlement	Angular distortion	Maximum settlement	Differential settlement	Angular distortion	Maximum settlement	Differential settlement	Angular distortion	Maximum settlement	Differential settlement	Angular distortion
(1)	(2)	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
i) For steel structure		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
ii) For reinforced concrete structures		50	0.03 3L	1/300	50	0.03 3L	1/300	75	0.03 3L	1/300	100	0.03 3L	1/300
iii) For multistoreyed buildings		50	0.01 5L	1/666	75	0.01 5L	1/666	75	0.02 1L	1/500	100	0.02 1L	1/500
a) RC or steel framed buildings with panel walls		60	0.02 L	1/500	75	0.02 L	1/500	75	0.002 5L	1/400	125	0.003 3L	1/300
b) For load bearing walls		60	0.00 2L	1/5 000	60	0.00 2L	1/5 000	Not likely to be encountered					
1) L/H = 2+		60	0.00 4L	1/2 500	60	0.00 4L	1/2 500	100	0.002 5L	1/400	125	0.002 5L	1/400
2) L/H = 7+		50	0.01 5L	1/666	75	0.01 5L	1/666						
iv) For water towers and silos													

NOTE — The values given in the table may be taken only as a guide and the permissible total settlement/different settlement and tilt (angular distortion) in each case should be decided as per requirements of the designer.
L denotes the length of deflected part of wall/raft or centre-to-centre distance between columns.
H denotes the height of wall from foundation footing.
+ For intermediate ratios of L/H, the values can be interpolated.

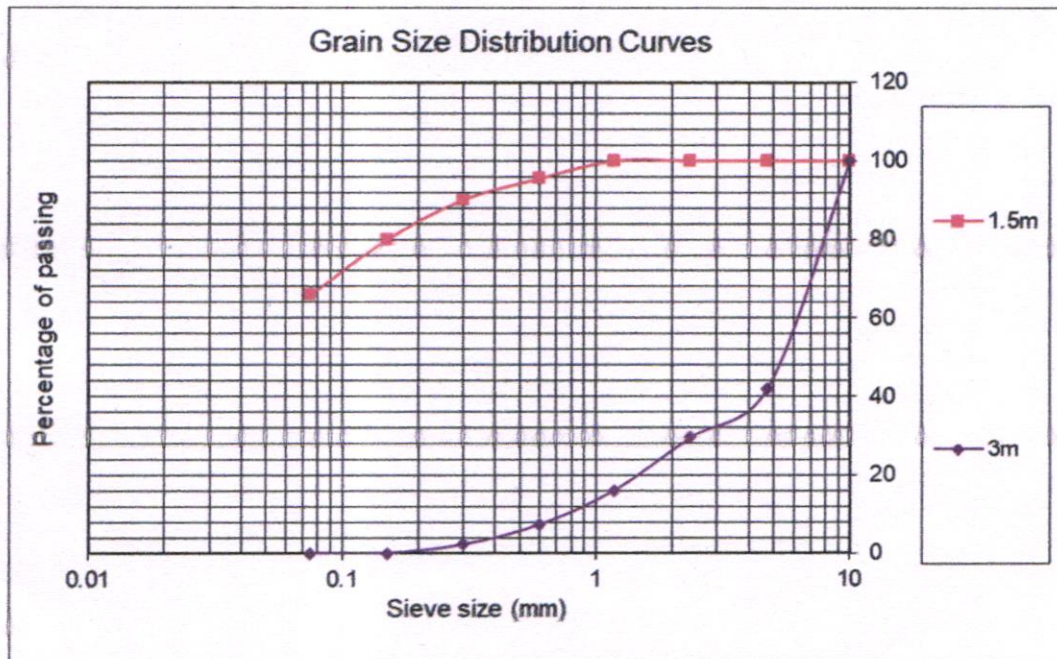
IS : 1904 - 1986


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3.1 TEST REPORT ON SIEVE ANALYSIS OF SAMPLE

Bore Hole – 1 @ 1.5m & 3m

SIEVE SIZE	PERCENTAGE OF PASSING	
	1.5m Depth	3m Depth
10 mm	100	100
4.75 mm	100.0	42.1
2.36 mm	100	29.6
1.18 mm	100	16
600 micron	95.6	7.3
300 micron	90.2	2.2
150 micron	80.1	0
75 micron	65.9	0



Description	1.5m Depth	3m Depth
Fineness modulus	0.682	5.028

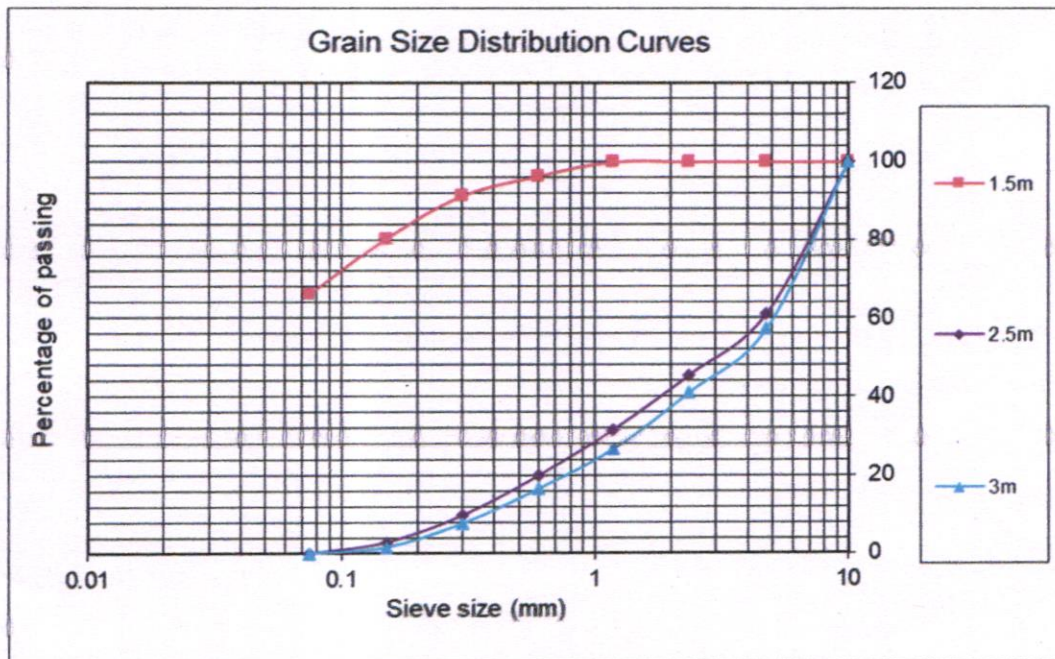
Observation:

The inference from the graph shows that the clay exists at 1.5m depth and gravels exists at 3m depth.

3.1 TEST REPORT ON SIEVE ANALYSIS OF SAMPLE

Bore Hole – 1 @ 1.5m to 3m

SIEVE SIZE	PERCENTAGE OF PASSING		
	1.5m Depth	2.5m Depth	3m Depth
10 mm	100	100	100
4.75 mm	100.0	61.1	57.2
2.36 mm	100	45.5	41.1
1.18 mm	100	31.6	26.6
600 micron	96.4	19.9	16.5
300 micron	91.3	9.7	7.6
150 micron	80.4	2.8	1.5
75 micron	66.1	0	0



Description	1.5m Depth	2.5m Depth	3m Depth
Fineness modulus	0.658	4.294	4.495

Observation:

The inference from the graph shows that the clay exists at 1.5m depth and gravels exists upto 3m depth.

SAFE BEARING CAPACITY RESULTS

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4. Calculation of Safe bearing capacity of the soil:

4.2 Safe Bearing capacity of soil based on SPT values for Bore Holes 1 & 2

Bore Hole No.	Depth (m)	SPT value	Safe Bearing capacity of soil (40mm Settlement)	
			KN/m ²	t/m ²
BH - 1	1.50	10	95.16	9.51
	3.00	42	530.21	53.02
	4.50	50	638.97	63.89
	6.00	51	652.57	65.25

BH - 2	1.50	6	40.78	4.07
	2.50	10	95.16	9.51
	3.00	18	203.92	20.39
	4.50	50	638.97	63.89
	6.00	52	666.16	66.61

4.3 Safe Bearing capacity of soil based on Shear Failure Criteria:

Through Unconfined Compression Test (UCC)

Bore Hole No.	Depth (m)	Max. Load (Div)	Max. Deformation (Div)	Cohesion (t/m ²)	Safe Bearing capacity of soil (t/m ²)
BH - 1	1.50	50	170	6.89	11.80

BH - 2	1.50	25	75	3.49	5.99
--------	------	----	----	------	------

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Report on soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy

Direct Shear test for Bore Hole 1 & 2

Bore Hole No.	Depth (m)	Normal Stress (kg/cm ²)	Division	Ø (in degrees)	Safe Bearing Capacity of Soil (t/m ²)
BH - 1	3.00	0.5	23	36.99°	57.40
		1.0	88		
		1.5	154		
	4.50	0.5	24	37.61°	82.18
		1.0	91		
		1.5	158		
	6.00	0.5	24	37.82°	104.36
		1.0	92		
		1.5	159		

BH - 2	2.50	0.5	23	29.65°	17.72
		1.0	72		
		1.5	122		
	3.00	0.5	23	31.12°	25.04
		1.0	75		
		1.5	128		
	4.50	0.5	24	37.82°	84.47
		1.0	92		
		1.5	159		
	6.00	0.5	24	38.02°	107.14
		1.0	93		
		1.5	160		

4.4 Comparison of Safe bearing capacity of soil through Shear and Settlement consideration:

Bore Hole no.	Depth (m)	Safe Bearing Capacity (t/m ²)		
		Shear consideration		Settlement consideration (40mm Settlement)
		(UCC)	(Direct Shear)	
BH – 1	1.50	11.80	---	9.51
	3.00	---	57.40	53.02
	4.50	---	82.18	63.89
	6.00	---	104.36	65.25

BH – 2	1.50	5.99	---	4.07
	2.50	---	17.72	9.51
	3.00	---	25.04	20.39
	4.50	---	84.47	63.89
	6.00	---	107.14	66.61

5. Result:

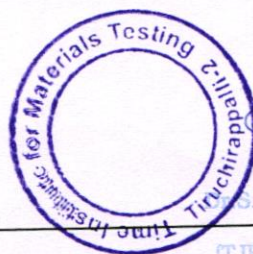
5.1 Recommended Safe bearing capacity values at different depths

Considering the lesser value of the above, the Safe Bearing Capacity, values at different depths are recommended below:

Bore Hole	Depth (m)	Safe Bearing Capacity (t/m ²) (40mm Settlement)
BH - 1	1.50	9.51
	3.00	53.02
	4.50	63.89
	6.00	65.25

BH - 2	1.50	4.07
	2.50	9.51
	3.00	20.39
	4.50	63.89
	6.00	66.61

The above test data and findings are relevant and applicable only for the soil conditions existing at the test site. Any change in the soil strata observed during excavation may be reported to the laboratory, which will redefine the safe bearing capacity of the soil.



For Time Institute for Materials Testing

S. H.
Geo. Technical Engineer

SOIL & ROCK SAMPLE PHOTOS

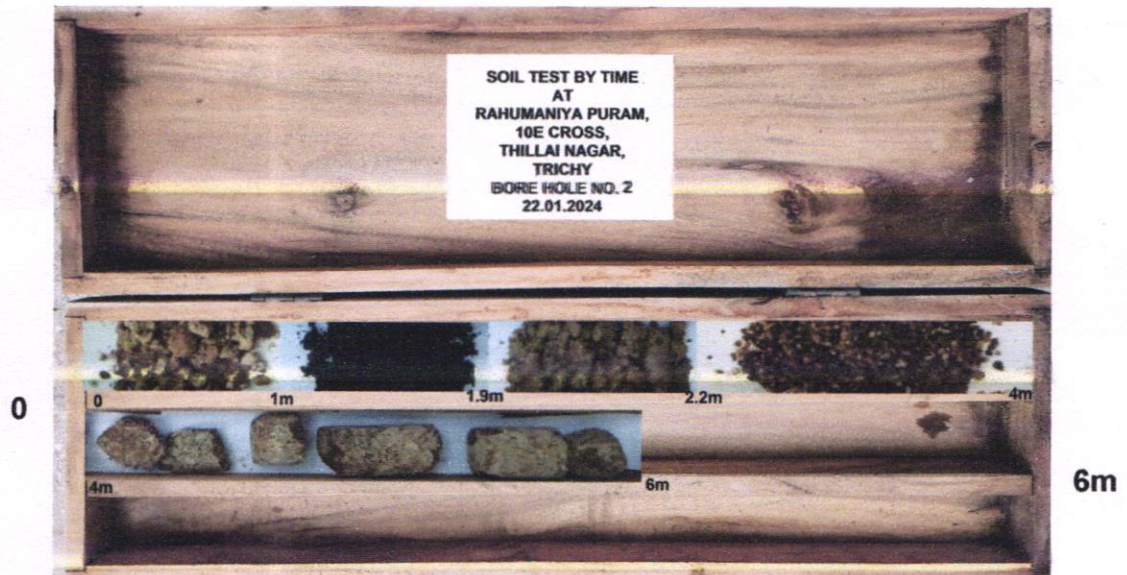
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Bore Hole No: 1

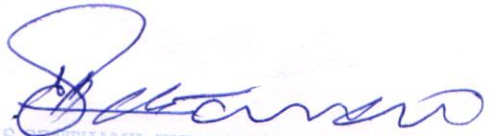
Depth : 0 to 6m


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Bore Hole No: 2

Depth : 0 to 6m

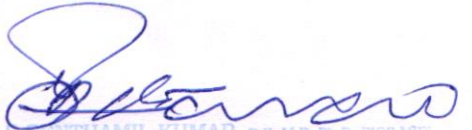

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SITE PHOTO

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ANNEXURE

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Annexure - A

NATURAL MOISTURE CONTENT **(As per IS 2720 (Part - 2) - 1973)**

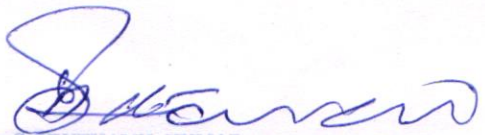
Project Name : Soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy

Bore Hole No. : 1

Depth : 3m

Trial	Wt of container (W) gm	Wt of container + wet soil (W ₁) gm	Wt of container + Dry soil (W ₂) gm	Wt of Water (W ₃ = W ₁ -W ₂) gm	Wt of Dry Soil (W ₄ = W ₂ -W) gm	Water Content (%) = (W ₃ -W ₄)*100
1	23.70	47.50	45.50	2.0	21.8	9.17
2	22.90	51.20	48.80	2.4	25.9	9.27
3	19.80	50.80	48.20	2.6	28.4	9.15

Natural Moisture Content = 9.20


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Annexure - B

SPECIFIC GRAVITY TEST **(As per IS 2720 (Part - 3) - 1980)**

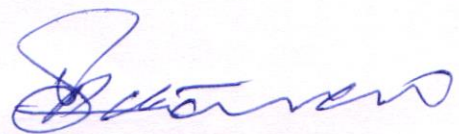
**Project Name : Soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy**

Bore Hole No. : 1

Depth : 3m

Trial	Bottle Wt (W1) gm	Bottle + Sample (W2) gm	Bottle + Sample + Water (W3) gm	Bottle + Water (W4) gm	Specific Gravity
1	32.6	92.2	118.0	80.8	2.661
2	32.6	91.8	117.8	80.8	2.667
3	32.6	90.5	116.9	80.8	2.656

Specific gravity of Fine Aggregate = 2.66


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Annexure - C

DENSITY CALCULATION

Project Name : Soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy

Bore Hole No. : 1

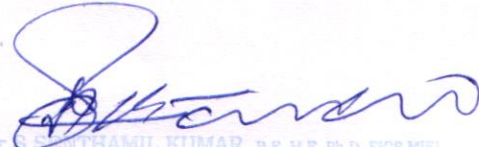
Depth : 3m

Sl. No.	Description	Reading
1	Weight of Empty Box (gm)	630.00
2	Weight of Box + Soil (gm)	809.00
3	Weight of Soil (gm)	179.00
4	Volume of Box (cm ³)	90.00
5	Bulk Density (gm/cm³)	1.99
6	Weight of Container (gm)	23.70
7	Weight of Container + Wet Soil (gm)	47.50
8	Weight of Container + Dry Soil (gm)	45.50
9	Moisture Content (%)	9.17
10	Dry Density (gm/cm³)	1.82

Result

Bulk Density of Soil = 1.99

Dry Density of Soil = 1.82


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Annexure - D

POROSITY & VOID RATIO

Project Name : Soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy
Bore Hole No. : 1
Depth : 3m

Sl. No.	Description	Reading
1	Dry Density γ_d (gm/cm ³)	1.82
2	Specific gravity (G_s)	2.66
	Porosity (%)	$(1 - (\gamma_d/G_s)) \times 100$
		$(1 - (1.82/2.66)) \times 100 = 31.57$
3	Porosity (%)	31
	Void Ratio, (e)	$\eta/(1-\eta)$
		$0.3157/(1-0.3157)$
4	Void Ratio	0.46


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Mobile : 9443976090



Time Institute for Materials Testing

Soil Division,
#25, Sanjeevi Nagar,
Trichy- Chennai Bypass road, Trichy - 620 002.
Phone: 0431 2401326
Fax: 0431 2401596
Email: tmaterialtesting@yahoo.co.in

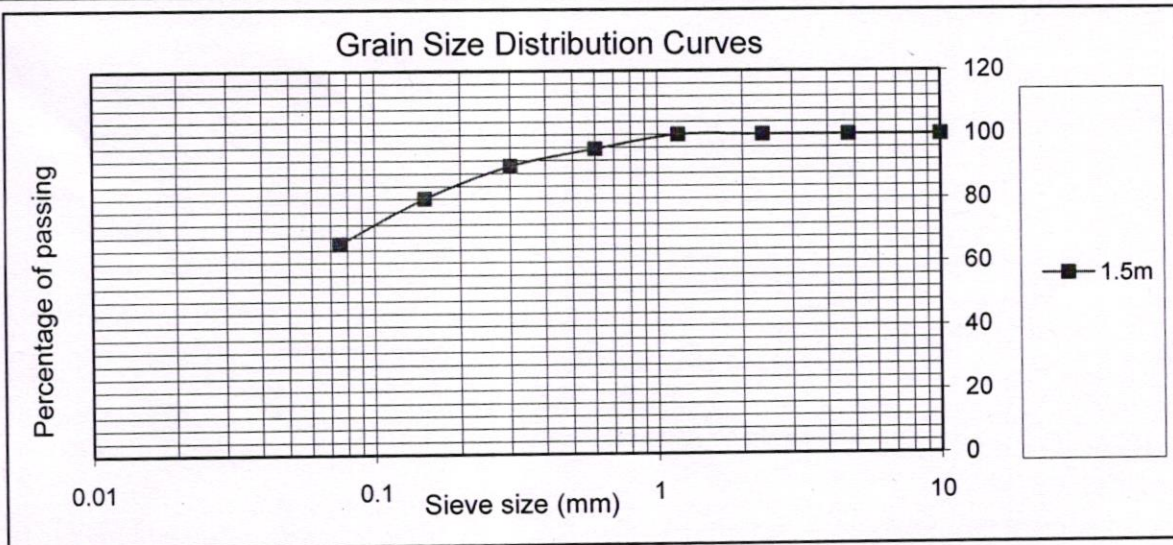
Annexure - E

FINENESS MODULUS TEST

(As per IS 2720 (Part - 4) - 1985)

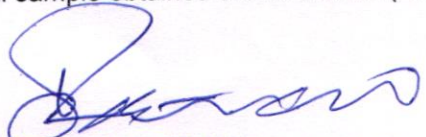
Project Name : Soil investigation for Construction of Residential Building
at Rahumaniya Puram, 10E Cross, Thillai Nagar, Trichy
Bore Hole No. : 1
Depth : 1.5m

Sieve size (mm)	Weight retained (gm)	Cumulative Weight retained (gm)	Percentage cumulative weight retained (gm)	Percentage of passing
10	0	0.0	0.0	100.0
4.75	0	0.0	0.0	100.0
2.36	0	0.0	0.0	100.0
1.18	0	0.0	0.0	100.0
0.6	4.4	4.4	4.4	95.6
0.3	5.4	9.8	9.8	90.2
0.15	10.1	19.9	19.9	80.1
0.075	14.2	34.1	34.1	65.9
Pan	65.9	100.0	100.0	0.0

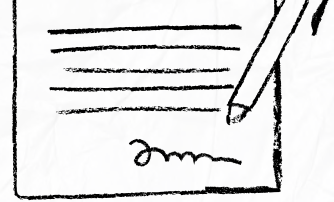


Based on Gradation Curve, the percentge component of each materials in the soil sample obtained are as follows (As per IS 1498 - 1970).

Gravel (%)	0
Coarse Sand (%)	0.0
Medium Sand (%)	9.8
Fine sand (%)	24.3
Silt & Clay (%)	65.9


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 Mobile : 9443976090

Geo. Technical Engineer



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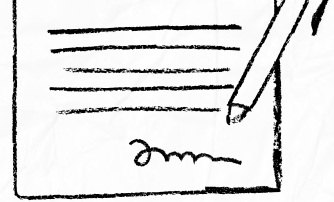
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