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REPORT

ON

SOIL INVESTIGATION FOR CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT MUTHU NAGAR, SRIRANGAM, TRICHY

Client

M/s. Sri Kesavaa Builders,

Project

M/s. Navaneetha Sahasraroopa,
With 16 Flats, Basement +3 Floor,
In T.S. No. 1292/30, Ward A,
Block. 39, Mellur Vilage,
Srirangam Zone- 1,
Tiruchirappalli City Corporation.

By

Time

Quality is Excellence

TIME INSTITUTE FOR MATERIALS TESTING
NO.25, SANJEEVI NAGAR,
TRICHY – CHENNAI BYEPASS ROAD,
TIRUCHIRAPPALLI – 620 002.
Ph: 0431 2401326

AUGUST 2022

For Navaneetha Property Developers

Managing Partner

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For SRI KESAVAA BUILDERS

PARTNER

SUMMARY

Project	:	Construction of Residential Apartment Building at Muthu Nagar, Srirangam, Trichy
Project Reference	:	Time /03 - A/ Soil Test / August 2022
Client	:	M/s. Sri Kesavaa Builders,
Project	:	M/s. Navaneetha Sahasraroopa, With 16 Flats, Basement +3 Floor, In T.S. No. 1292/30, Ward A, Block. 39, Mellur Vilage, Srirangam Zone- 1, Tiruchirappalli City Corporation.
Type of Structure	:	R.C.C. Framed construction
Location	:	Muthu Nagar, Srirangam, Trichy
Scope	:	Geotechnical investigation for the entire area of construction
Test conducted	:	Two explanatory bore holes up to 6m depth were 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 1.5m depth
Hard stratum	:	No trace of rock exists up to 6m depth
Ground water table	:	Ground water exists at 3m depth from ground level during investigation.
FOUNDATION	:	Based on the existing soil condition, it is recommended to provide Pile foundation.

For Navaneetha Property Developers

Managing Partner

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ANNEXURE

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SOIL INVESTIGATION

AHAO-BAR
REDITED
17025:2017
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Time Institute for Materials Testing
टाइम इन्स्टिट्यूट चीज़े शोध केलिए

Soil & Structural Consultant, Construction Materials Testing Lab

Quality is Excellence

August 03, 2022

To

Client

M/s. Sri Kesavaa Builders,

Project

M/s. Navaneetha Sahasraroopa,
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In T.S. No. 1292/30, Ward A, Block. 39, Mellur Vilage,
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Tiruchirappalli City Corporation.

REPORT ON SOIL INVESTIGATION

(Ref: TIME/03 - A/ SOIL TEST/ AUGUST 2022)

Sub: Soil Investigation for Construction of Residential Apartment Building at Muthu Nagar, Srirangam, Trichy – reg.,

Ref: Based on letter dated: 28.07.2022

1.1 Introduction:

It is proposed to construct a **Residential Apartment Building at Muthu Nagar, Srirangam, Trichy.** A detailed soil investigation was suggested for estimating the safe bearing capacity of the soil, so that suitable type of foundation can be decided for the proposed structure. Time Institute for Materials Testing (TIME) has been requested to undertake the soil investigation at the proposed site. The study was carried out by TIME on **29.07.2022.** This report presents complete investigation data and discusses the results to recommend the bearing capacity values at different depths for the proposed structure.

Section 2 describes the soil profile and bore log details of two explanatory bore holes. Section 3 of this report gives the Grain size distribution curves and its analysis. Section 4 of this report presents the calculated safe Bearing capacity values of soil at various depths. Section 5 of this report reviews the test results and the recommended safe bearing capacity values and pile load capacity values for design of foundation. Section 6 of this report presents the Soil sample photos. Section 7 of this report presents the Site Photos.

For Navaneetha Property Developers

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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 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 though 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.

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1.3 Review of Field and Laboratory Results:

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

Sub soil Profile

Bore Hole 1:

The natural soil below the existing ground level is sand with clay mixed. This layer is extended up to 0.5m depth. Clay exists from 0.5m to 1.5m depth. Sand exists from 1.5m to 4m depth. Below which clay with fine sand mixed 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.

Bore Hole 2:

The natural soil below the existing ground level is sand with clay mixed. This layer is extended up to 0.5m depth. Clay exists from 0.5m to 1.5m depth. Sand exists from 1.5m to 4m depth. Below which clay with fine sand mixed 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 exists at 3m depth from ground level during 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.

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1.4 Conclusions & Recommendation:

Shear strength parameters and compressibility parameters of different soil layers are established from the field and laboratory tests.

Based on the existing soil condition, it is recommended to provide Pile foundation.

Time Institute for Materials Testing Tiruchirappalli-1

For Time Institute for Materials Testing

03rd August 2022

Dr. B.N. Krishnaswami.

For SRI KESAVAA BUILDERS

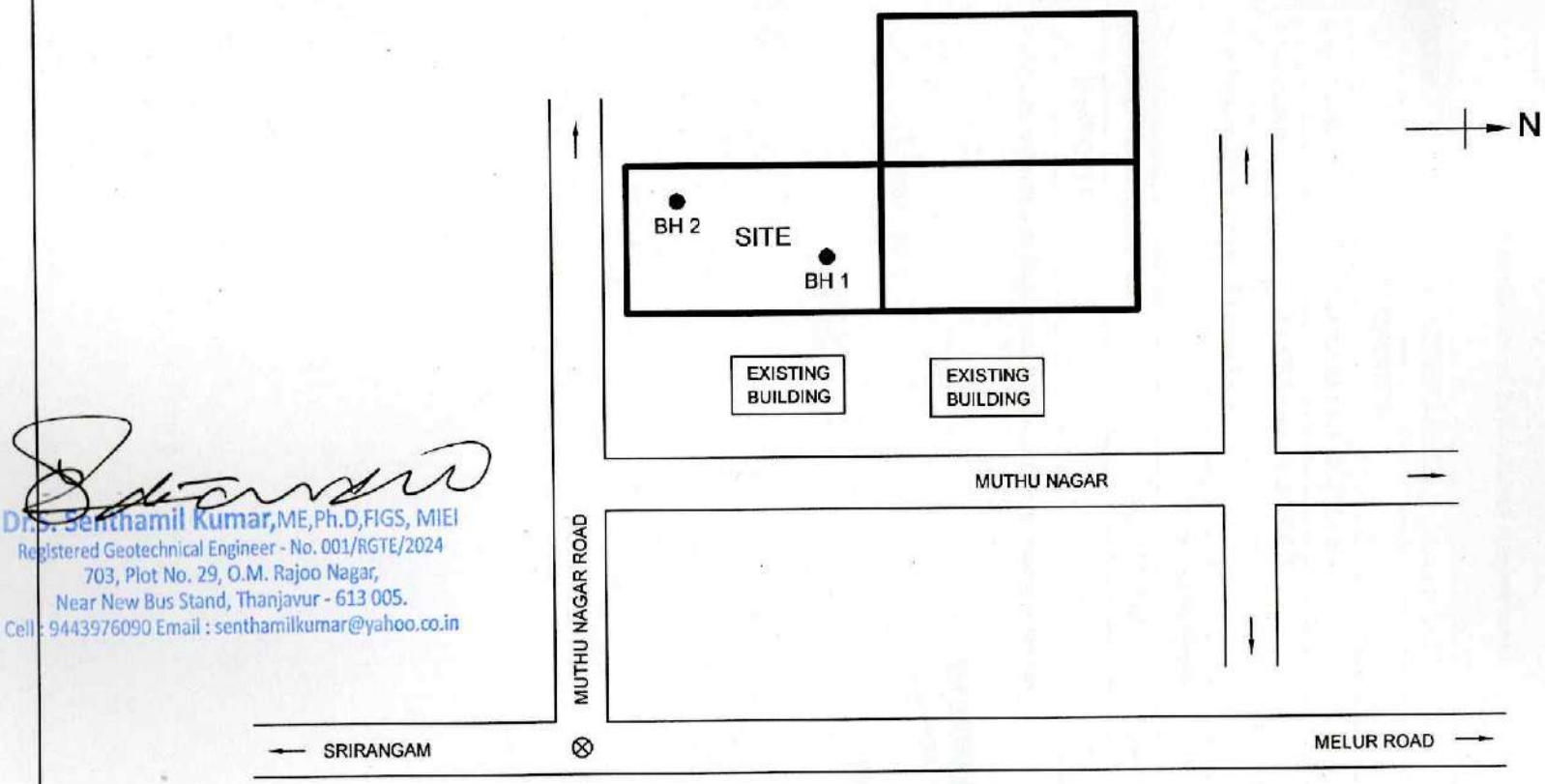
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SITE LOCATION PLAN



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NOTE:

SITE LEVEL IS EQUAL TO THE ROAD LEVEL

LEGEND:

● BORE LOG LOCATION

⊗ SITE LOCATION

For SRI KESAVAA BUILDERS

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SITE PLAN

CLIENT	M/s. Sri Kesavaa Builders	
PROJECT	M/s. Navaneetha Sahasraroopa, With 16 Flats, Basement +3 Floor, In T.S. No. 1292/30, Ward A, Block. 39, Melur Vilage, Srirangam Zone- 1, Tiruchirappalli City Corporation.	
SOIL CONSULTANT	TIME Institute for Materials Testing No 25, Sanjeevi Nagar, Trichy - Chennai Byepass road , Trichy - 620002. PHONE : 0431 - 2401326(OFF)	
DATE OF SURVEY	20.07.2022	TITLE PLAN OF BORE HOLE AND SITE DETAILS AT MUTHU NAGAR, SRIRANGAM, TRICHY
SCALE	NTS	DRG.NO DRAWING - 01 REV. 0

BORE LOG DETAILS

2.2 BORE LOG DETAILS FOR BORE HOLE 1

Project : Report on soil investigation for construction of Residential Apartment Building
Location : Muthu Nagar, Srirangam, Trichy
Started on : 29.07.2022 **Ended on** : 29.07.2022
Depth of G.W.T : 3m
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 20 40 60
0 - 0.5m		Sand with clay mixed						
0.5m - 1.5m		Clay						
1.5m - 4m		Sand	1.5	6	10	10	20	
			3.0	8	8	11	19	
4m - 6m		Clay with fine sand mixed	4.5	2	4	4	8	
			6.0	3	3	4	7	

Bore terminated at 6m depth from the existing ground level

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2.3 BORE LOG DETAILS FOR BORE HOLE 2

Project : Report on soil investigation for construction of Residential Apartment Building
Location : Muthu Nagar, Srirangam, Trichy
Started on : 29.07.2022 **Ended on** : 29.07.2022
Depth of G.W.T : 3m
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 20 40 60
0 - 0.5m		Sand with clay mixed						
0.5m - 1.5m		Clay						
1.5m - 4m		Sand	1.5	3	7	7	14	
			3.0	4	5	5	10	
4m - 6m		Clay with fine sand mixed	4.5	3	3	3	6	
			6.0	3	3	4	7	

Bore terminated at 6m depth from the existing ground level

For SRI KESAVAA BUILDERS

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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.

$$W = [(W2-W3)/(W3-W1)] \times 100$$

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, $_t$, is the ratio of the total mass of soil to its total volume and can be defined as follows:

$$\gamma_{bulk} = M / V$$

Where

M_t = Total Mass of soil

V_t = Total Volume

Dry Density:

The soil dry density, $_b$, 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:

$$\gamma_{dry} = M_b / V_b$$

Where

M_b = Total Mass of dried soil

V_b = Total Volume

For SRI KESAVAA BUILDERS

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Specific gravity:

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

The specific gravity G 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:

$$e = (Vv) / (Vs)$$

Where
Vv is the volume of the voids (empty or filled with fluid),
Vs 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:

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

$$e = \eta/(1-\eta) \;\&\; \eta = e / (1+e)$$

Where
γ_d = Dry Density
G_s = Specific gravity

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For Navaneetha Property Developers
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For SRI KESAVAA BUILDERS
PARTNER

Summary of Engineering Geo Properties for Bore Hole 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	Sand	17.28	1.93	1.65	2.63	37	0.60
	3.0		17.11	1.94	1.66	2.63	37	0.59
	4.5	Clay with fine sand mixed	18.67	1.87	1.58	2.62	40	0.66
	6.0		18.52	1.88	1.59	2.62	39	0.65
Bore Hole 2	1.5	Sand	17.46	1.94	1.65	2.63	37	0.59
	3.0		17.29	1.95	1.66	2.63	37	0.58
	4.5	Clay with fine sand mixed	18.54	1.86	1.57	2.62	40	0.67
	6.0		18.33	1.88	1.59	2.62	39	0.65

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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	Sand	---	---	---	0.0	14.5	39.6	37.3	5.2	3.4
	3.0		---	---	---	0.0	15.7	41.9	34.8	3.6	4.0
	4.5	Clay with fine sand mixed	28.4	22.9	5.5	0.0	7.6	16.3	33.8	5.2	37.1
	6.0		28.9	23.0	5.9	0.0	7.8	15.4	35.5	4.9	36.4
Bore Hole 2	1.5	Sand	---	---	---	0.0	13.0	41.8	35.6	6.5	3.1
	3.0		---	---	---	0.0	13.7	43.4	34.7	5.2	3.0
	4.5	Clay with fine sand mixed	28.7	23.0	5.7	0.0	9.6	19.4	31.7	5.6	33.7
	6.0		30.2	24.0	6.2	0.0	11.0	21.3	29.5	4.8	33.4

For SRI KESAVAA BUILDERS

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2.6 Shear Strength Parameters for Different layers of Bore Hole 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	Sand	20	-	31.12
	3.0		19	-	30.88
	4.5	Clay with fine sand mixed	8	3.49	27.10
	6.0		7	2.10	26.58

Bore Hole 2	1.5	Sand	14	-	28.14
	3.0		10	-	27.36
	4.5	Clay with fine sand mixed	6	2.10	26.05
	6.0		7	2.80	26.31

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For SRI KESAVAA BUILDERS

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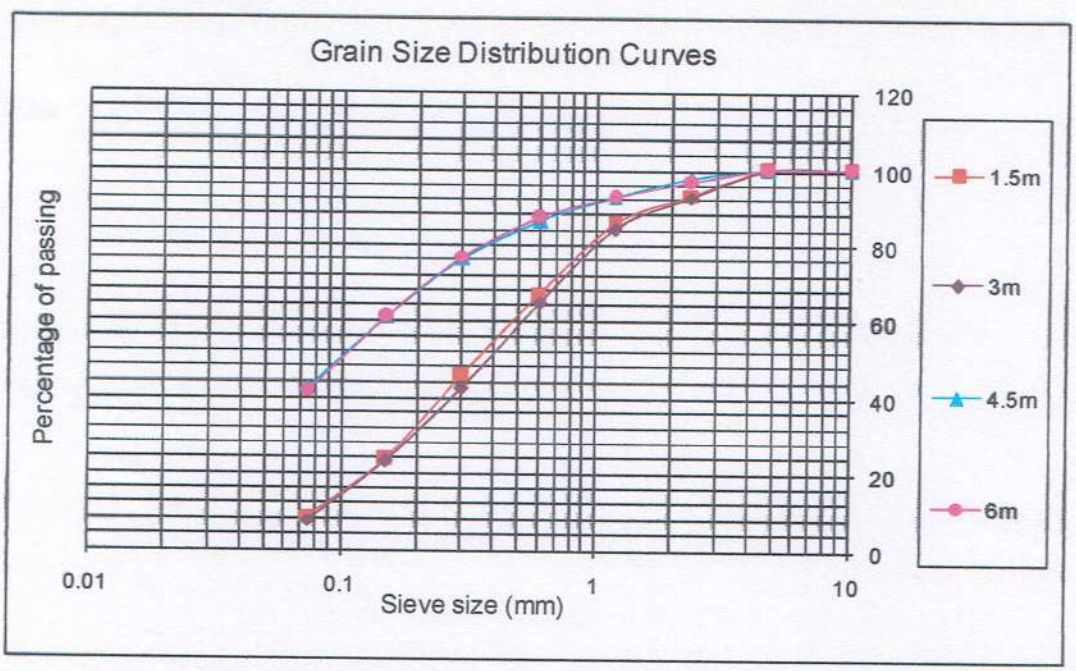
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GRAIN SIZE ANALYSIS

3.1 TEST REPORT ON SIEVE ANALYSIS OF SAMPLE

Bore Hole – 1 @ 1.5m to 6m

SIEVE SIZE	PERCENTAGE OF PASSING			
	1.5m Depth	3m Depth	4.5m Depth	6m Depth
10 mm	100	100	100	100
4.75 mm	100.0	100.0	100.0	100
2.36 mm	93.1	92.5	97.7	96.8
1.18 mm	85.5	84.3	92.4	92.2
600 micron	67.2	64.7	86.2	87.1
300 micron	45.9	42.4	76.1	76.8
150 micron	23.8	23.2	60.5	60.8
75 micron	8.6	7.6	42.3	41.3



Description	1.5m Depth	3m Depth	4.5m Depth	6m Depth
Fineness modulus	2.759	2.853	1.448	1.450

Observation:

The inference from the graph shows that the sand exists up to 3m depth, clay with sand mixed exist up to 6m depth.

For Navaneetha Property Developers

Managing Partner

For SRI KESAVAA BUILDERS

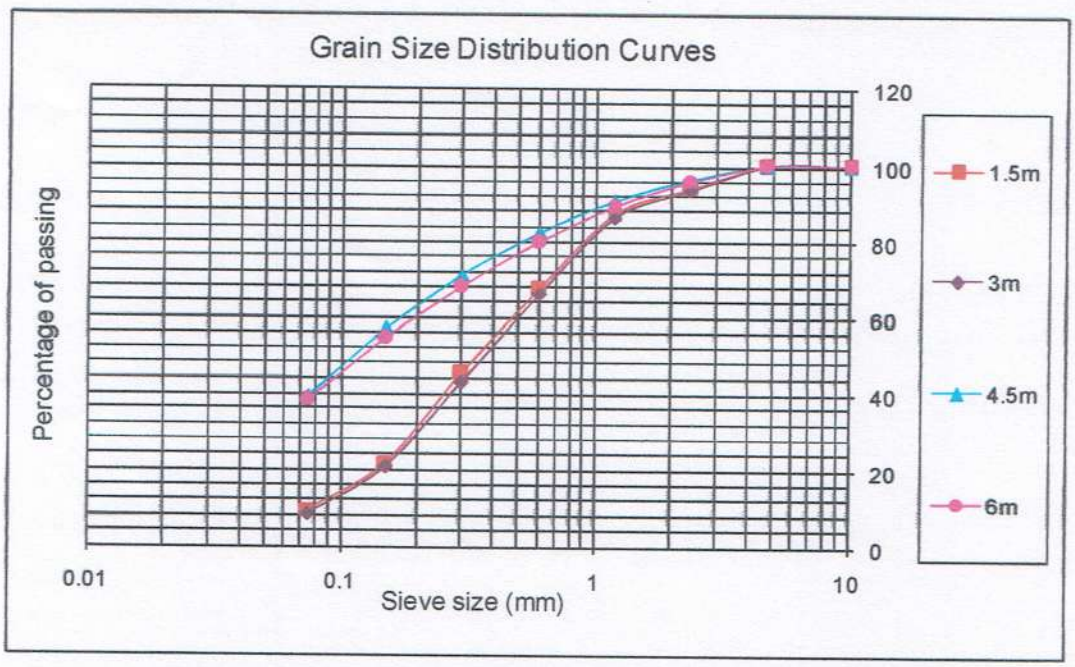
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3.2 TEST REPORT ON SIEVE ANALYSIS OF SAMPLE

Bore Hole – 2 @ 1.5m to 6m

SIEVE SIZE	PERCENTAGE OF PASSING			
	1.5m Depth	3m Depth	4.5m Depth	6m Depth
10 mm	100	100	100	100
4.75 mm	100.0	100.0	100.0	100
2.36 mm	93.9	93.5	96.4	95.7
1.18 mm	87	86.3	90.4	89
600 micron	67.5	66.1	82.1	79.8
300 micron	45.2	42.9	71	67.7
150 micron	22	20.7	56.7	54.5
75 micron	9.6	8.2	39.3	38.2



Description	1.5m Depth	3m Depth	4.5m Depth	6m Depth
Fineness modulus	2.748	2.823	1.641	1.751

Observation:

The inference from the graph shows that the sand exists up to 3m depth, clay with sand mixed exist up to 6m depth.

For SRI KESAVAA BUILDERS

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CALCULATION
OF
SAFE BEARING CAPACITY

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 2.5cm permissible settlement)
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 Bore Hole 1 @ 3m depth SPT 'N' Value = 19

⇒ **q_{na} = 51.4 x (19 - 3) x ((2 + 0.3)/(2 x 2))^2 x 0.5 x 1 = 135.95 kN/m^2**

∴ **q_{na} = 13.59 t/m^2**

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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 4.5m depth (Bore Hole 1), the Soil profile is Clay with fine sand mixed

If	Φ	=	0 (assumed)
	N_c	=	5.14
	N_q	=	1
	N_γ	=	0 (Zero)
and Cohesion C		=	3.49 (based on laboratory test)

Applying these parameter in the equation No. 1

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

$$= C N_c S_c d_c i_c + q (1 - 1) S_q d_q i_q + 0.5 B \gamma 0 S_\gamma d_\gamma i_\gamma W'$$

$$= C N_c S_c d_c i_c + 0 + 0$$

$$q_{ult} = C N_c S_c d_c i_c$$

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Where S_c = Shape factor which is equal to 1

d_c = $1 + 0.2 \frac{df}{B} \sqrt{Nq}$

= $1 + 0.2 \frac{2.6}{18} \sqrt{tan2(45+\emptyset/2)}$

= 1.028 (hence considered the minimum value as 1)

= 1

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

Therefore q_{ult} = $C N_c S_c d_c i_c$

= 3.49 x 5.14 x 1 x 1 x 1

= 17.938 t/m^2

Applying factor of safety as 3

Then allowable bearing capacity

$q_{allowable}$ = 17.938 / 3

= 5.99 t/m^2

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 = 36cm^2

Normal Stress (kg/cm^2)	No. of Division	Stress
0.5	23	0.132
1.0	74	0.425
1.5	127	0.730

Stress = Load / Area

= (200/966.2) * 23* (1/36) = 0.132

Ø = $\tan^{-1}$ (0.730-0.132) = 30.88°

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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, Nq, 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 Sand

If	C	=	0 (Since no Cohesion)
	Φ	=	30.88 (based on laboratory test)
Therefore	N_c	=	32.949;
	N_q	=	21.019;
	N_γ	=	26.906

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)

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

i) Total density or Bulk density

ii) Dry density

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

Dry Density $\gamma_d = W_s/V$; Whereas W_s = Total weight of solids

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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 γ_w = Density of water = 1 g/cc or 1 t/m^3

Mostly soils submerged in water are saturated.

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

Based on the above equations,

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

d = 3m

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

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

$S_q = S_\gamma$ = Shape factor which is equal to 1

$d_q = d_\gamma = 1 + 0.1 \frac{df}{B} \sqrt{N\emptyset}$

= 1 (Minimum value of 1 can be taken)

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

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

i_q = 1

B = Width of footing (2m)

W' = 0.5

Applying in the above equation

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

$= 2.4 \times (21.019 - 1) \times 1 \times 1 \times 1 + 0.5 \times 2 \times 1.8 \times 26.906 \times 1 \times 1 \times 1 \times 0.5$

$= 72.261$ t/m^2

Applying factor of safety as 3

Then allowable bearing capacity

$q_{na} = 72.261 / 3$

$= 24.09$ t/m^2

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SAFE BEARING CAPACITY RESULTS

4. Calculation of Safe bearing capacity of the soil:

4.2 Safe Bearing capacity of soil based on SPT values for Bore Hole 1 to 2

Bore Hole No.	Depth (m)	SPT value	Safe Bearing capacity of soil	
			KN/m^2	t/m^2
BH – 1	1.50	20	144.45	14.44
	3.00	19	135.95	13.59
	4.50	8	42.48	4.24
	6.00	7	33.98	3.39
BH – 2	1.50	14	93.46	9.34
	3.00	10	59.47	5.94
	4.50	6	25.49	2.54
	6.00	7	33.98	3.39

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	4.50	25	75	3.49	5.99
	6.00	15	60	2.10	3.60
BH – 2	4.50	15	60	2.10	3.60
	6.00	20	70	2.80	4.79

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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	1.50	0.5 1.0 1.5	23 75 128	31.12°	16.74
	3.00	0.5 1.0 1.5	23 74 127	30.88°	24.09
	4.50	0.5 1.0 1.5	23 67 112	27.10°	20.21
	6.00	0.5 1.0 1.5	23 66 110	26.58°	23.71
BH - 2	1.50	0.5 1.0 1.5	23 69 116	28.14°	11.24
	3.00	0.5 1.0 1.5	23 68 113	27.36°	15.55
	4.50	0.5 1.0 1.5	23 65 108	26.05°	17.52
	6.00	0.5 1.0 1.5	23 66 109	26.31°	22.88

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

Comparison of Bearing Capacity of soil for Bore Hole 1 & 2

Bore Hole no.	Depth (m)	Safe Bearing Capacity (t/m²)		
		Shear consideration		Settlement consideration
		(UCC)	(Direct Shear)	
BH – 1	1.50	---	16.74	14.44
	3.00	---	24.09	13.59
	4.50	5.99	20.21	4.24
	6.00	3.60	23.71	3.39
BH – 2	1.50	---	11.24	9.34
	3.00	---	15.55	5.94
	4.50	3.60	17.52	2.54
	6.00	4.79	22.88	3.39

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/m²)
BH – 1	1.50	14.44
	3.00	13.59
	4.50	4.24
	6.00	3.39
BH - 2	1.50	9.34
	3.00	5.94
	4.50	2.54
	6.00	3.39

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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.

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5.2 Recommended pile load capacity Values

Based on the variation of the existing soil profile and usage of M25 grade of concrete, the pile load capacity has been calculated and presented as below.

S. No.	Bore Hole no.	Pile Dia. (mm)	Depth (m)	Bearing Resistance (tonne)	Uplift Resistance (tonne)	Lateral thrust (tonne)
1	BH – 1 & BH – 2	400	6	8.0	4.1	1.1
		450		9.5	4.6	1.4
		500		11.1	5.2	1.6
		600		14.7	6.4	2.2

Time Institute for Materials Testing Tiruchirappalli

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SOIL SAMPLE PHOTOS



Bore Hole No: 1

Depth : 0 to 6m

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0 6m

Bore Hole No: 2

Depth : 0 to 6m

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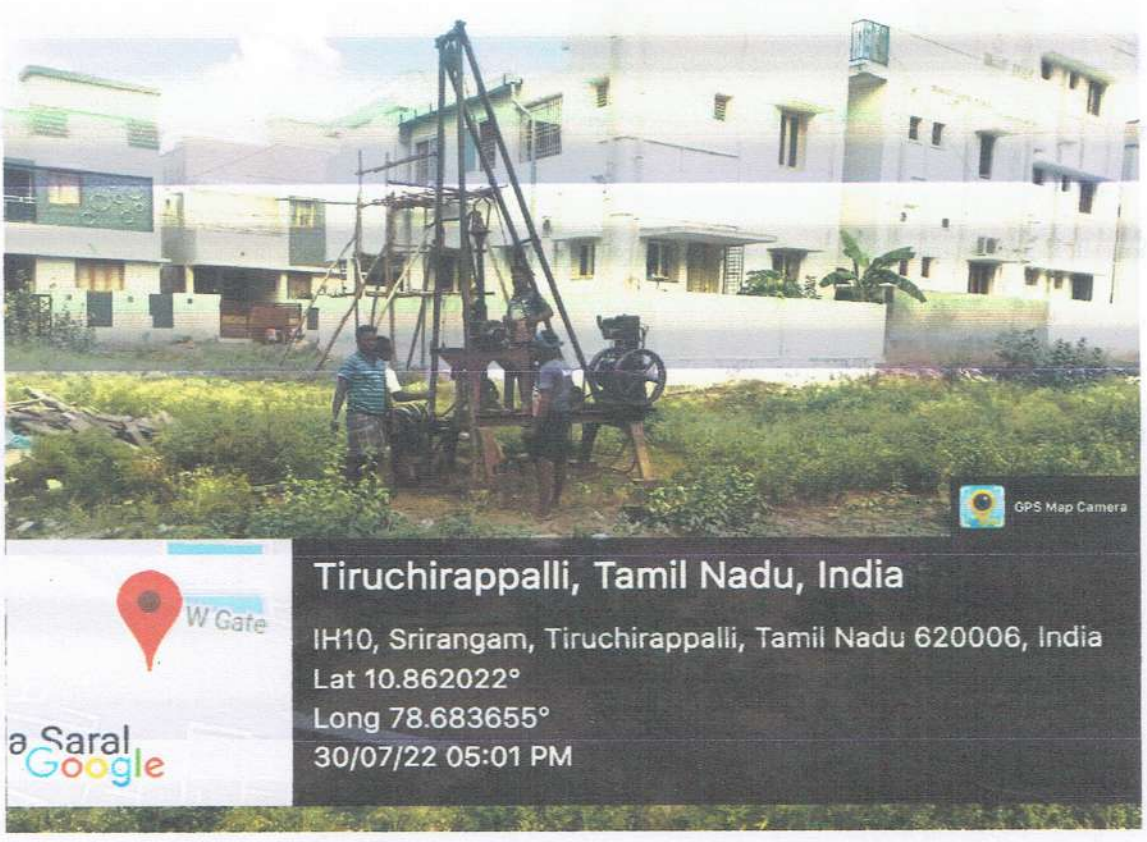
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SITE PHOTO



SRIRANGAM, TRICHY

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ANNEXURE

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Quality is Excellence

Annexure - A

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

Project Name : **Soil investigation for construction of Residential Apartment Building at Muthu Nagar, Srirangam, Trichy**

Bore Hole No. : **1**

Depth : **1.5m**

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	24.80	56.70	52.00	4.7	27.2	17.28
2	25.30	50.40	46.70	3.7	21.4	17.29
3	22.90	48.70	44.90	3.8	22.0	17.27

Natural Moisture Content = 17.28

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Annexure - B

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

Project Name : **Soil investigation for construction of Residential Apartment Building at Muthu Nagar, Srirangam, Trichy**

Bore Hole No. : **1**

Depth : **1.5m**

Trial	Bottle Wt (W1) gm	Bottle + Sample (W2) gm	Bottle + Sample + Water (W3) gm	Bottle + Water (W4) gm	Specific Gravity
1	32.6	92.4	117.9	80.8	2.634
2	32.6	93.3	118.4	80.8	2.628
3	32.6	93.7	118.7	80.8	2.634

Specific gravity of Fine Aggregate = 2.63

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Annexure - C

DENSITY CALCULATION

Project Name : **Soil investigation for construction of Residential Apartment Building at Muthu Nagar, Srirangam, Trichy**

Bore Hole No. : **1**

Depth : **1.5m**

Sl. No.	Description	Reading
1	Weight of Empty Box (gm)	630.00
2	Weight of Box + Soil (gm)	804.00
3	Weight of Soil (gm)	174.00
4	Volume of Box (cm^3)	90.00
5	**Bulk Density (gm/cm^3)**	**1.93**
6	Weight of Container (gm)	24.80
7	Weight of Container + Wet Soil (gm)	56.70
8	Weight of Container + Dry Soil (gm)	52.00
9	Moisture Content (%)	17.28
10	**Dry Density (gm/cm^3)**	**1.65**

Result

Bulk Density of Soil = 1.93

Dry Density of Soil = 1.65

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Annexure - D

POROSITY & VOID RATIO

Project Name : **Soil investigation for construction of Residential Apartment Building at Muthu Nagar, Srirangam, Trichy**

Bore Hole No. : **1**

Depth : **1.5m**

Sl. No.	Description	Reading
1	Dry Density γ_d (gm/cm^3)	1.65
2	Specific gravity (G_s)	2.63
	Porosity (%)	$(1 - (\gamma d/Gs))*100$
		(1-(1.65/2.63)) x 100 = 37.26
3	**Porosity (%)**	**37**
	Void Ratio, (e)	$\eta/(1-\eta)$
		0.3726/(1-0.3726)
4	**Void Ratio**	**0.60**

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Annexure - E

FINENESS MODULUS TEST

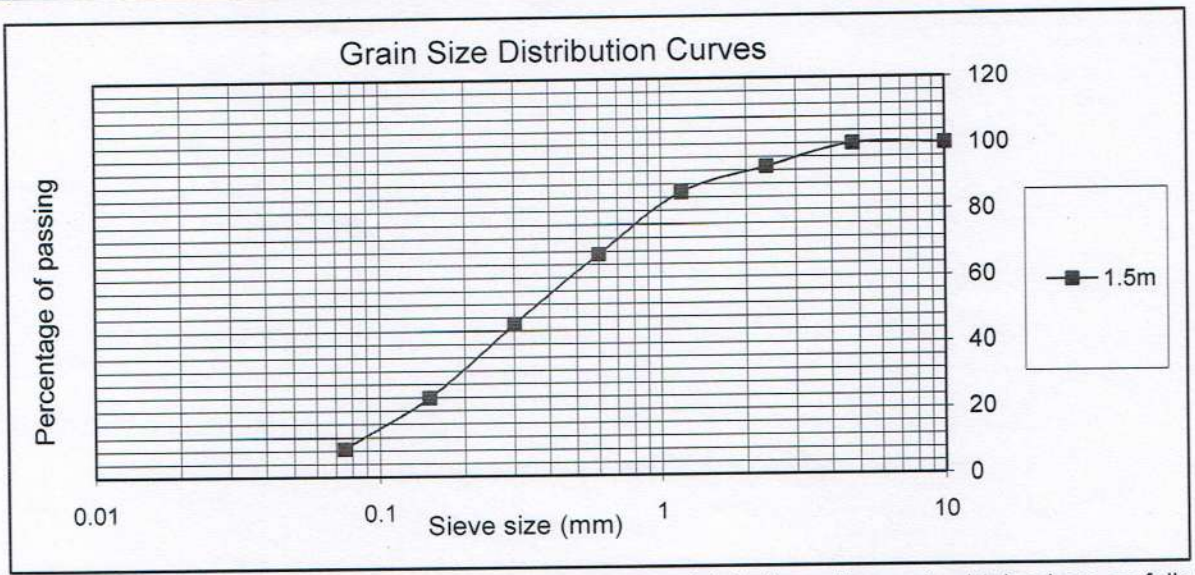
(As per IS 2720 (Part - 4) - 1985)

Project Name : **Soil investigation for construction of Residential Apartment Building at Muthu Nagar, Srirangam, Trichy**

Bore Hole No. : **1**

Depth : **1.5m**

Sieve size (mm)	Weight retained	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	6.9	6.9	6.9	93.1
1.18	7.6	14.5	14.5	85.5
0.6	18.3	32.8	32.8	67.2
0.3	21.3	54.1	54.1	45.9
0.15	22.1	76.2	76.2	23.8
0.075	15.2	91.4	91.4	8.6
Pan	8.6	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 (%)	14.5
Medium Sand (%)	39.6
Fine sand (%)	37.3
Silt & Clay (%)	8.6

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Annexure - F

Direct Shear Test (IS 2720 - Part 13 -1986)

Bore Hole	2
Depth (m)	3m
Date of Test	14.07.2022

L.C. Of Dial Gauge	0.002
Proving ring Constant	0.206996
Area of the specimen (cm^2)	36

Trial 1

Normal Stress: 0.5 kg/cm^2

Horizontal Gauge Reading	Proving Ring Reading	Shear Deformation	Shear Stress (kg/cm^2)
0	0	0.00	0.000
50	9	0.50	0.052
100	11	1.00	0.063
150	13	1.50	0.075
200	15	2.00	0.086
250	17	2.50	0.098
300	19	3.00	0.109
350	21	3.50	0.121
400	23	4.00	0.132

Trial 2

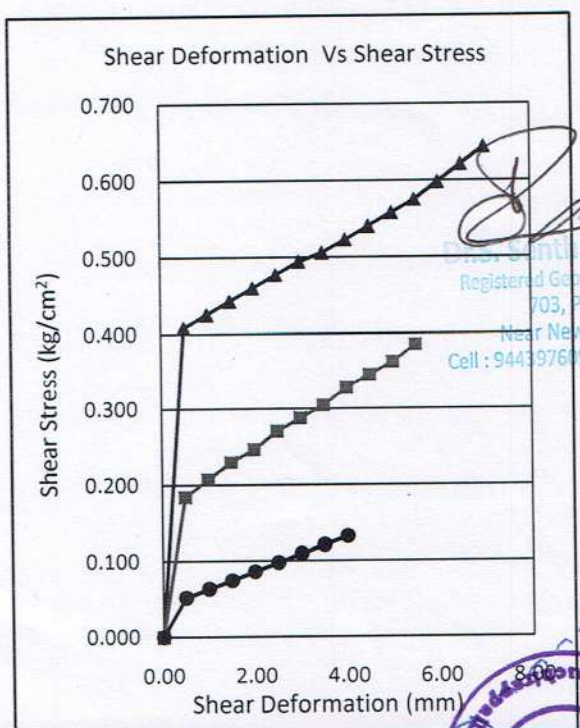
Normal Stress: 1 kg/cm^2

Horizontal Gauge Reading	Proving Ring Reading	Shear Deformation	Shear Stress (kg/cm^2)
0	0	0.00	0.000
50	32	0.50	0.184
100	36	1.00	0.207
150	40	1.50	0.230
200	43	2.00	0.247
250	47	2.50	0.270
300	50	3.00	0.287
350	53	3.50	0.305
400	57	4.00	0.328
450	60	4.50	0.345
500	63	5.00	0.362
550	67	5.50	0.385

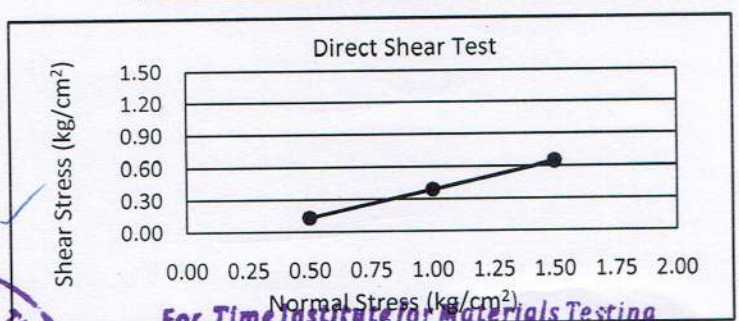
Trial 3

Normal Stress: 1.5 kg/cm^2

Horizontal Gauge Reading	Proving Ring Reading	Shear Deformation	Shear Stress (kg/cm^2)
0	0	0.00	0.000
50	71	0.50	0.408
100	74	1.00	0.425
150	77	1.50	0.443
200	80	2.00	0.460
250	83	2.50	0.477
300	86	3.00	0.494
350	88	3.50	0.506
400	91	4.00	0.523
450	94	4.50	0.540
500	97	5.00	0.558
550	100	5.50	0.575
600	104	6.00	0.598
650	108	6.50	0.621
700	112	7.00	0.644



Normal Stress (Kg/cm^2)	Proving Ring Reading at failure	Shear Stress (kg/cm^2)
0.50	23	0.132
1.00	67	0.385
1.50	112	0.644



Ø = $\tan^{-1}$ (0.644 - 0.132)

Angle of Shearing Resistance (Ø) = 27.10 °

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