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REPORT
ON
SOIL INVESTIGATION FOR CONSTRUCTION
OF
RESIDENTIAL APARTMENT BUILDING
AT
K.K. NAGAR, TRICHY

Client

M/s. MKB Housing Promoters,
T.S. No. 20, 21, 24, 26, 29 & 30,
Block No: 0023, Ward: A.H, Sathanur South (P),
Tiruchirappalli East Taluk,
Trichy District.

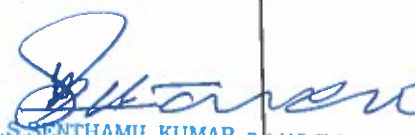
By

Time



TIME INSTITUTE FOR MATERIALS TESTING
NO. 25, SANJEEVI NAGAR,
TRICHY - CHENNAI BYEPASS ROAD,
TIRUCHIRAPPALLI,
TAMIL NADU - 620 002.
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JULY 2023


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SUMMARY

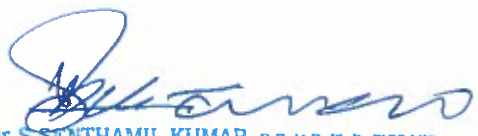
Project	:	Construction of Residential Apartment Building at K.K. Nagar, Trichy
Project Reference	:	Time /14/ Soil Test / July 2023
Owner	:	M/s. MKB Housing Promoters, T.S. No. 20, 21, 24, 26, 29 & 30, Block No: 0023, Ward: A.H, Sathanur South (P), Tiruchirappalli East Taluk, Trichy District.
Type of Structure	:	R.C.C. Framed construction
Location	:	K.K. Nagar, Trichy
Scope	:	Geotechnical investigation for the entire area of construction
Test conducted	:	Two explanatory bore hole up to 3m 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	:	Red soil with gravels mixed exist up to 1m depth
Hard stratum	:	Soft rock exists between 1.3m to 3m depth in bore hole 1 & 1m to 3m depth in Bore Hole 2
Ground water table	:	Ground water table was not encountered during investigation up to 3m depth

FOUNDATION

Based on existing soil condition, it is recommended to provide foundation at 3m depth


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SOIL INVESTIGATION

July 07, 2023

To

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T.S. No. 20, 21, 24, 26, 29 & 30,
Block No: 0023, Ward: A.H, Sathanur South (P),
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REPORT ON SOIL INVESTIGATION

(Ref: TIME/14/ SOIL TEST/ JULY 2023)

Sub: Soil Investigation for construction of Residential Apartment Building at K.K. Nagar,
Trichy – reg.,

Ref: Based on letter dated: 05.07.2023

1.1 Introduction:

It is proposed to construct a **Residential Apartment Building at K.K. Nagar, 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 **06.07.2023**. 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 exploratory bore holes. Section 3 of this report presents the calculated safe Bearing capacity values of soil at various depths. Section 4 of this report reviews the test results and the recommended safe bearing capacity values for design of foundation. Section 5 of this report presents the Soil & Rock sample photos. Section 6 of this report presents site photo.


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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.



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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 soil below the existing ground level is red soil with gravels mixed. This layer is extended up to 1.3m depth. Below which soft rock exist from 1.3m to 3m 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 soil below the existing ground level is red soil with gravels mixed. This layer is extended up to 1m depth. Below which soft rock exist from 1m to 3m 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.

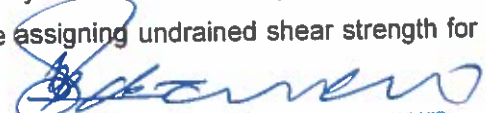
Ground Water Table

Ground water table was not encountered during the soil investigation up to 3m depth from ground level.

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.


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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.

1.4 Conclusions & Recommendations:

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

Based on existing soil condition, it is recommended to provide foundation at 3m depth

07th July 2023

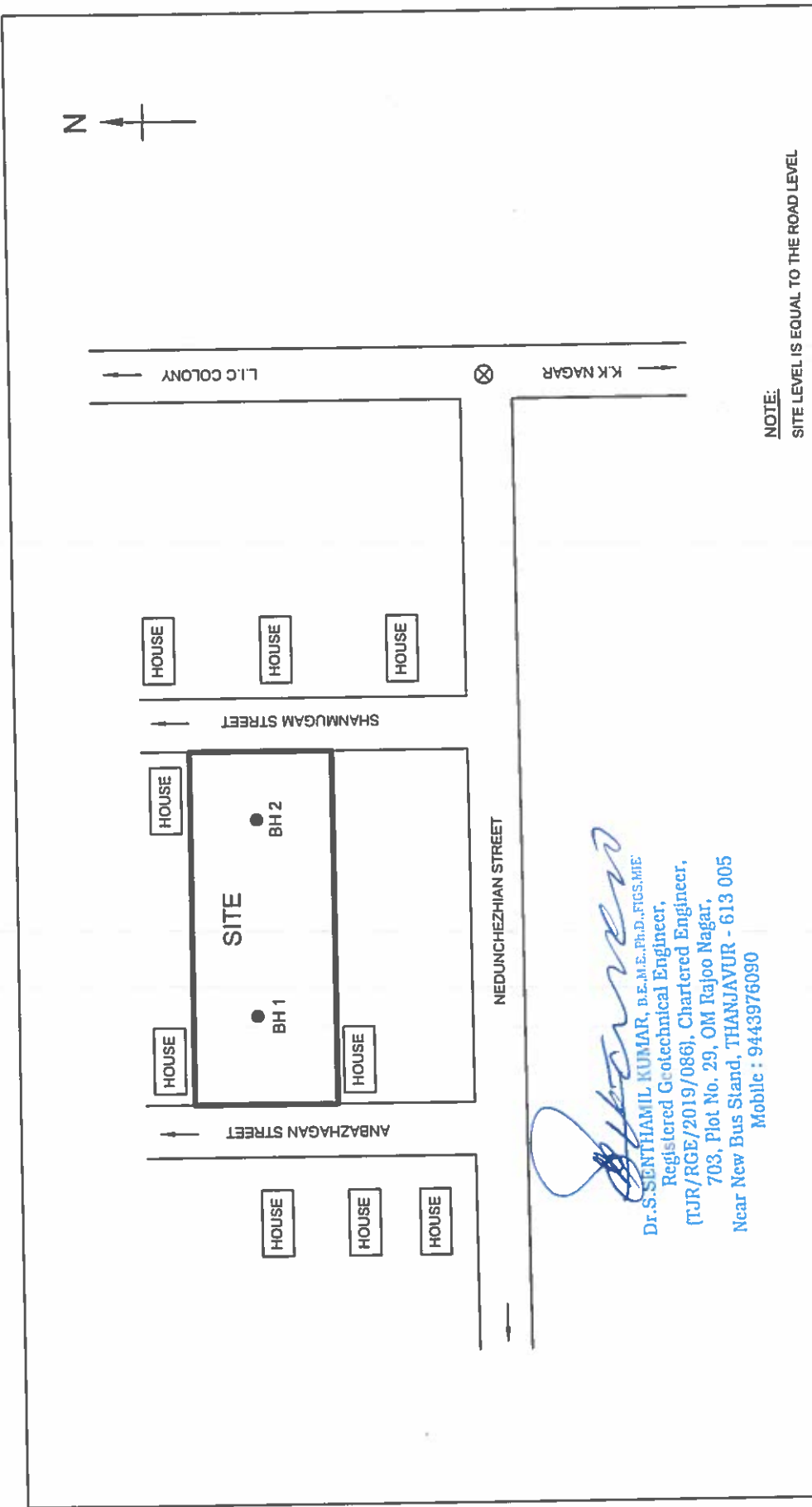


For Time Institute for Materials Testing

Dr. B.N. Krishnaswami.

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SITE LOCATION PLAN



[Signature]
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NOTE:
SITE LEVEL IS EQUAL TO THE ROAD LEVEL

SITE PLAN

LEGEND:

- BORE LOG LOCATION
- ⊗ SITE LOCATION

CLIENT	M/s. MKB Housing Promoters, Tiruchirappalli East Taluk, Tiruchy District.		
SOIL CONSULTANT	TIME Institute for Materials Testing No 25, Sanjeev Nagar, Tiruchy - Chennai Bypass road . Tiruchy - 620002. PHONE 0431 - 2401326(OFF)		
DATE OF SURVEY	06.07.2023	TITLE	PLAN OF BORE HOLE AND SITE DETAILS AT K.K NAGAR, TIRUCHY
SCALE	NTS	DRG.NO	DRAWING - 01
		REV.	

BORE LOG DETAILS



2.2 BORE LOG DETAILS FOR BORE HOLE 1

Project : Report on soil investigation for construction of Residential Apartment Building
Location : K.K. Nagar, Trichy
Started on : 06.07.2023 Ended on : 06.07.2023
Depth of G.W.T : Nil
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 - 1.3m		Red soil with gravels mixed						
1.3m - 3m		Soft rock	1.5	Rebound			55	
			3.0	Rebound			57	

Bore terminated at 3m depth from the existing ground level



2.3 BORE LOG DETAILS FOR BORE HOLE 2

Project : Report on soil investigation for construction of Residential Apartment Building
 Location : K.K. Nagar, Trichy
 Started on : 06.07.2023 Ended on : 06.07.2023
 Depth of G.W.T : Nil
 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		Red soil with gravels mixed						
1m - 3m		Soft rock	1.5	Rebound			56	
			3.0	Rebound			59	

Bore terminated at 3m depth from the existing ground level

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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.

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

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_t 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_d 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


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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:

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

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

Where

v_d = Dry Density

G_s = Specific gravity


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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	Soft rock	5.11	2.08	1.98	2.70	27	0.36
	3.0		4.76	2.10	2.00	2.70	26	0.35

Bore Hole 2	1.5	Soft rock	4.91	2.10	2.00	2.70	26	0.35
	3.0		4.33	2.11	2.02	2.70	25	0.34



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2.5 Shear Strength Parameters for Different layers of Bore Hole 1 & 2

Bore Hole No.	Depth below G.L. (m)	Soil Description	N	Shear Strength 'Ø' (in degrees)
Bore Hole 1	1.5	Soft rock	55	38.02
	3.0		57	38.43

Bore Hole 2	1.5	Soft rock	56	38.23
	3.0		59	38.83


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CALCULATION OF SAFE BEARING CAPACITY

3. CALCULATION OF SAFE BEARING CAPACITY

3.1 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 = 57

$$\Rightarrow q_{na} = 51.4 \times (57 - 3) \times \left(\frac{2 + 0.3}{2 \times 2} \right)^2 \times 0.5 \times 1 = 458.84 \text{ kN/m}^2$$

$$\therefore q_{na} = 45.88 \text{ t/m}^2$$


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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	24	0.138
1.0	93	0.535
1.5	162	0.931

$$\begin{aligned}\text{Stress} &= \text{Load} / \text{Area} \\ &= (200/966.2) * 24 * (1/36) = 0.138\end{aligned}$$

$$\phi = \tan^{-1} (0.931 - 0.138) = 38.43^\circ$$

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 Soft rock

If	C	=	0 (Since no Cohesion)
	φ	=	38.43° (based on laboratory test)
Therefore	N _c	=	66.153;
	N _q	=	54.507;
	N _γ	=	90.155


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Applying these parameters in the above equation

$$q_{ult} = C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_s S_d i_d W'$$

Where $C = 0$ (Since no Cohesion)

$$\text{Therefore, } q_{ult} = q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_s S_d i_d W'$$

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

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

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

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.

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

$$\text{Where } \gamma_w = \text{Density of water} = 1 \text{ g/cc or } 1 \text{ t/m}^3$$

Mostly soils submerged in water are saturated.

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

Based on the above equations,

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

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

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

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


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Report on soil investigation for construction of Residential Apartment Building
at K.K. Nagar, Trichy

Where

$$\begin{aligned} S_q = S_r &= \text{Shape factor which is equal to 1} \\ d_q = d_r &= 1 + 0.1 \frac{d_f}{B} \sqrt{N\phi} \\ &= 1 \quad (\text{Minimum value of 1 can be taken}) \\ i_q &= \text{inclination factor } (1 - \alpha/90)^2 \\ \alpha &= \text{inclination of the load to the vertical in degree which is equal to zero} \\ i_q &= 1 \\ B &= \text{Width of footing (2m)} \\ W' &= 0.5 \end{aligned}$$

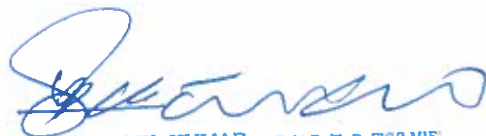
Applying in the above equation

$$\begin{aligned} q_{ult} &= q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_r S_r d_r i_r W' \\ &= 2.4 \times (54.507 - 1) \times 1 \times 1 \times 1 + 0.5 \times 2 \times 1.8 \times 90.155 \times 1 \times 1 \times 1 \times 0.5 \\ &= 209.55 \text{ t/m}^2 \end{aligned}$$

Applying factor of safety as 3

Then allowable bearing capacity

$$\begin{aligned} q_{na} &= 209.55 / 3 \\ &= 69.85 \text{ t/m}^2 \end{aligned}$$


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SAFE BEARING CAPACITY RESULTS

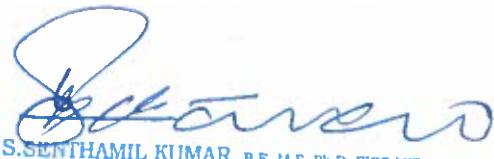
Report on soil investigation for construction of Residential Apartment Building
at K.K. Nagar, Trichy

3. Calculation of Safe bearing capacity of the soil:

3.2 Safe Bearing capacity of soil based on SPT values for Bore Hole 1 & 2

Bore Hole No.	Depth (m)	SPT value	Safe Bearing capacity of soil	
			KN/m ²	t/m ²
BH – 1	1.50	55	441.84	44.18
	3.00	57	458.84	45.88

BH – 2	1.50	56	450.34	45.03
	3.00	59	475.83	47.58


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Report on soil investigation for construction of Residential Apartment Building
at K.K. Nagar, Trichy

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

Through Direct Shear test

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	24	38.02°	45.95
		1.0	92		
		1.5	160		
	3.00	0.5	24	38.43°	69.85
		1.0	93		
		1.5	162		

BH - 2	1.50	0.5	24	38.23°	47.20
		1.0	93		
		1.5	161		
	3.00	0.5	24	38.83°	73.32
		1.0	95		
		1.5	164		


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3.4 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 (Direct Shear)	Settlement consideration
BH - 1	1.50	45.95	44.18
	3.00	69.85	45.88

BH - 2	1.50	47.20	45.03
	3.00	73.32	47.58


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4. Result:

4.1 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)
BH – 1	1.50	44.18
	3.00	45.88

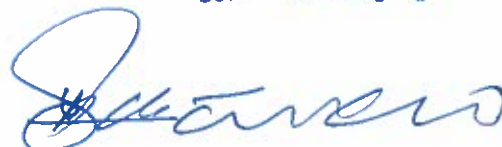
BH – 2	1.50	45.03
	3.00	47.58

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.S.T.
Geo. Technical Engineer


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SOIL & ROCK SAMPLE PHOTOS



Bore Hole No: 1

Depth : 0 to 3m


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Bore Hole No: 2

Depth : 0 to 3m


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SITE PHOTO



K.K. NAGAR, TRICHY


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