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GEOTECHNICAL REPORT FOR

Multistoried Apartment Building
(Sundaram Tirumala Towers) at Salem,
Tamil Nadu.

Client :

M/s K.M Builders,
No.48, Rangasamy Street,
Gugai,
Salem-636 006

Architect :

M/s Habricks Architects,
No.48, Rangasamy Street,
Gugai,
Salem-636 006

Consultant :

Structural Consultant :

(B)12309 08.12.2020

Job No : Date :

Bangalore

Project :

Multistoried Apartment Building (Sundaram Tirumala Towers)
at Salem, Tamil Nadu

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G(B)12309 -GEOTECHNICAL INVESTIGATION REPORT for the Proposed Multistoried Apartment Building (Sundaram Tirumala Towers) at Salem, Tamil Nadu

EXECUTIVE SUMMARY

M/s K.M Builders, Salem, propose to construct a Multistoried Apartment Building (Sundaram Tirumala Towers) at Salem, Tamil Nadu. M/s Habricks Architects, Salem are the Architects for the project. The site is fairly level. The ground level at the site is same as road level.

The proposed Multistoried Residential Building (Sundaram Tirumala Towers) will be an RCC Framed Structure having stilts, ground floor and four upper floors.

For obtaining the required parameters for the design of the foundations of the proposed building, geotechnical investigations have been undertaken at the site which consisted of progressing 3 boreholes down to 8m depth in soil strata. Notably, refusal strata was encountered at depths varying from 3.1 to 4.2m below existing ground level, in the boreholes.

The borehole investigations indicate the presence of top layer of filled up soil extending down to depths varying from 1.3 to 1.4m below existing ground level. The fill contains soil, brickbats, debris, concrete pieces, etc.

The top strata of virgin soil encountered at the site underlying the filled up soil is silty sandy clay to sandy silty clay with traces of gravel, underlain by strata of clayey silty sand to gravelly silty sand with clay. The colour of the virgin soil varies from dark grey to brownish grey at shallow depths to greyish white at larger depths.

The observed N-values (N : 15-24) evaluated from the Standard Penetration Tests indicate that the top strata of virgin soil encountered at the site underlying the filled-up soil is stiff to very stiff clay down to about 3m below existing ground level below which the subsoil is very dense (N : 92-98).

The ground water table was encountered at an depth of 1.2m below existing ground level, at the time of investigation carried out in the fourth week of November, 2020. The water table can be expected to rise up to ground level during rainy season.

Based on subsoil characteristics as determined from the geotechnical investigations, Shallow Foundations are recommended at a minimum depth of 2.5m below existing ground level.

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Net allowable bearing pressures recommended for design of foundations having widths of 1.5m & above, resting at various depths for an allowable settlement of 25mm are given below :

Depth (m) of Foundation below Existing Ground Level	*Net Allowable Bearing Pressure (t/m^2) for Widths of foundation (m)*
	1.5 & above
2.5	*22*
3.0	*24*

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2.2 Scope

2.2.1 The scope of investigations, as specified by the Client, included the following:

a) Progressing 3 boreholes to a minimum depth of 8m or refusal strata, whichever is encountered earlier

b) Conducting relevant laboratory tests, on soil samples collected from the boreholes

c) Preparing a detailed report, giving recommendations regarding allowable bearing pressure on foundations of the proposed building.

2.2.2 The following operations were to be undertaken while progressing the boreholes:

a) Conducting standard penetration tests at regular intervals

b) Recovering undisturbed soil samples from various levels of the subsoil strata

c) Recording ground water table levels, if met with.

3.0 PROJECT DETAILS

3.1 Site Location

The site for the proposed Multistoried Apartment Building (Sundaram Tirumala Towers) is located at Salem, Tamil Nadu.

3.2 Site Layout and Topography

3.2.1 A schematic site plan with location of boreholes is given in (fig.1).

3.2.2 The site is fairly level. The ground level at the site is same as road level.

3.3 Structure

The proposed Multistoried Residential Building (Sundaram Tirumala Towers) will be an RCC Framed Structure having stilts, ground floor and four upper floors.

3.4 Seismic Zone

The site for the proposed Multistoried Apartment Building (Sundaram Tirumala Towers) at Salem, Tamil Nadu, which comes under Seismic Zone II, as per IS 1893 (Part 1) - 2016.

4.0 FIELD INVESTIGATIONS

4.1 Preliminary Details

4.1.1 Field investigations had been carried out on 25th November, 2020. The weather was cloudy with occasional rains and sunny at the time of investigation.

4.1.2 A schematic site plan showing the test locations, is given in fig.1.

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4.2 Boreholes

4.2.1 3 boreholes were progressed to study the subsoil conditions at the site. The boreholes were progressed using hand operated auger. The boreholes have been designated as BH1 to BH3.

4.2.2 The scope of work comprised of progressing boreholes to 8m depth. Notably, refusal strata was encountered at depths less than 8m in all the boreholes and the boreholes were terminated.

4.2.3 The depth of refusal strata encountered at each borehole location is given below :

Borehole No	Depth (m) of Refusal Strata Below Existing Ground Level
BH1	4.2
BH2	3.1
BH3	3.8

4.2.4 Standard Penetration Tests were conducted at regular intervals in the boreholes to determine N-values.

4.2.5 Undisturbed soil samples were recovered by thin walled shelby tubes.

4.2.6 The samples thus recovered were transported to the laboratory for testing purposes.

4.3 Ground Water Table

The ground water table was encountered at an depth of 1.2m below existing ground level, at the time of investigation carried out in the fourth week of November, 2020. The water table can be expected to rise up to ground level during rainy season.

5.0 LABORATORY INVESTIGATIONS

5.1.1 The soil samples brought to the laboratory were subjected to various tests to determine the following properties :

a) Type of soil and its gradation
b) Consistency limits
c) Natural Bulk Density & Water Content
d) Strength parameters like cohesion, angle of shearing resistance.

5.1.2 In order to determine the above properties, the following tests have been conducted:

a) Sieve analysis on coarse grained soil fraction
b) Atterberg Limits namely Liquid and Plastic Limits
c) Hydrometer analysis on fine grained soil fraction
d) Natural Density and Water Content
e) Triaxial compression tests.

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6.0 *RESULTS & ANALYSIS*

6.1 Presentation of Results

6.1.1 The results of the borehole investigations have been presented in the form of soil profile tables.

6.1.2 The soil profile tables indicate the following:

a) Standard Penetration Test values at various depths

b) Soil description identifying the type of soil

c) Grain size analysis indicating composition of subsoil

d) Consistency limits

e) Natural density and water content

f) Triaxial compression tests.

6.2 Analysis of Soil Profile

6.2.1 A perusal of the data presented in the soil profile tables indicates that the subsoil mainly consists of the following three strata in the boreholes:

a) Stratum - I : Filled-up soil with brickbats, debris, concrete pieces etc.

b) Stratum - II : Silty sandy clay to sandy silty clay with traces of gravel. The colour of the strata varies from dark grey to brownish grey

c) Stratum - III : Clayey silty sand to gravelly silty sand with clay. The colour of thc strata is greyish white

6.2.2 The thickness of the three strata in the boreholes are as follows :

Borehole No.	Strata (depth in m : from : to)		
	Stratum - I	Stratum - II	Stratum - III
BH1	0.0 - 1.3	1.3 - 2.7	2.7 - 4.2
BH2	0.0 - 1.4	1.4 - 2.5	2.5 - 3.1
BH3	0.0 - 1.3	1.3 - 2.9	2.9 - 3.8

6.2.3 The above results show that :

a) Stratum - I : consisting of filled up soil extending down to depths varying from 1.3 to 1.4m below existing ground level. The fill is contains soil, brickbats, debris, concrete pieces, etc.

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b) Stratum - II : consisting of predominantly clayey soil with varying percentages of sand, silt and low percentage of gravel

c) Stratum - III : consisting of predominantly sandy soil with varying percentage of silt, clay and gravel.

6.3 Soil Composition

6.3.1 The grain size distributions of the soil samples in the boreholes have been presented in the form of grain size analysis curves in fig.3 .

6.3.2 The variations in the grain size distributions in each of the strata in the boreholes are as follows:

a) Stratum - II : Silty sandy clay to sandy silty clay with traces of gravel

BH. No.	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
BH1	0	23	33	44
BH2	4	36	21	39
BH3	0	42	13	45

b) Stratum - III : Clayey silty sand to gravelly silty sand with clay

BH. No.	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
BH1	10	50	24	16
BH2	22	40	28	10
BH3	15	50	27	8

6.3.3 The above results indicate that :

a) Stratum - II : consists of about 23 - 42% of sand, 13 - 33% of silt, 39 - 45% of clay and 0-4% of gravel

b) Stratum - III : consists of about 40 - 50% of sand, 24 - 28% of silt, 8 - 16% of clay and 10 - 22% of gravel.

6.4 Natural Density and Water Content (Refer Table Nos. 1 to 3)

6.4.1 The natural bulk densities, water contents and dry densities in the boreholes vary as follows:

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BH. No.	Bulk Density (g/cm^3)	Water Content (%)	Dry Density (g/cm^3)
BH1	1.89 -1.94	11.5-17.8	1.61-1.74
BH2	1.87	15.2	1.63
BH3	1.88	16.6	1.62

6.4.2 The Natural Bulk Density of the subsoil ranges between 1.87g/cm^3 and 1.94g/cm^3 and the Natural Water Content varies between 11.5% and 17.8%.

6.5 Consistency Limits (Refer Table Nos. 1 to 3)

The liquid limit of the subsoil ranges between 29% to 51% and the plastic limit varies from 15% to 33%.

6.6 Triaxial Test Results (Refer Table Nos. 1 to 3)

Tri-axial shear tests were conducted on the soil samples, collected from the boreholes. The angle of shearing resistance (Ø), determined from tri-axial shear tests, ranges between 17^0 and 34^0. The Cohesion (c) values of the subsoil vary between 0.05kg/cm^2 and 0.40kg/cm^2.

6.7 Standard Penetration Test Values (N-values)

6.7.1 Standard Penetration Tests were conducted at various depths of each borehole, to determine N-values. The N-values are also presented in tables. 1 to 3, and in compiled soil profile fig.2.

6.7.2 The observed N-values (N : 15-24) evaluated from the Standard Penetration Tests indicate that the top strata of virgin soil encountered at the site underlying the filled-up soil is stiff to very stiff clay down to about 3m below existing ground level below which the subsoil is very dense (N : 92-98).

6.7.3 The N-values (observed) have been plotted with respect to depth in fig.4

6.8 Compiled Soil Profile

6.8.1 An overview of the results and their analysis has been presented in the form of a compiled soil profile in fig.2.

6.8.2 The above figure shows the various strata encountered and their thicknesses in each of the boreholes and also gives the soil composition and the observed N-values at various depths.

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7.0 DESIGN CRITERIA

7.1 Design Parameters

7.1.1 The parameters required for the design of the foundation system for the proposed building are:

a) Type of foundation to be adopted

b) Depth at which the foundations have to be laid

c) Allowable bearing pressure on the soil at the foundation level.

7.1.2 On the basis of the analysis of the results of the investigations, the required design parameters have been arrived at, as given in the following sections.

7.2 Type of Foundation

7.2.1 The type of foundations for any structure, depends upon the subsoil conditions, type of structure as well as, the loading intensity on the foundations.

7.2.2 The top strata of virgin soil encountered at the site underlying the filled up soil is stiff to very stiff clay strata and are further underlain by very dense strata. Additionally, the borehole investigations indicate that, refusal strata was encountered at depths varying from 3.1 to 4.2m below existing ground level. Hence, Shallow Foundations can be adopted for the proposed building. The Shallow Foundations may be *Isolated /Combined footings*, depending upon the column loads, their spacing and configuration.

7.3 Depth of Foundations

7.3.1 The minimum depth of foundations depends upon the following factors :

a) Top loose zone/filled up soil, if any

b) Adequate depth of soil above founding level, to ensure mobilization of full safe bearing capacity

c) Adequate depth of soil strata below founding level of requisite strength to mobilize the safe bearing capacity.

7.3.2 Filled-up soil is encountered at the site extending down to depths varying from 1.3 to 1.4m below existing ground level. Therefore, the foundations of the proposed building must be taken below the top filled-up soil and rest for a minimum depth of 1.2m in underlying dense to very dense subsoil.

7.3.3 *Hence, based on the discussion and criteria given above, the minimum depth of foundations recommended is 2.5m below existing ground level.*

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8.0 *RECOMMENDATIONS*

8.1 Type of Foundations : *Shallow Foundations - Isolated/Combined footings*

8.2 Minimum Depth of Foundations : *2.5m below existing ground level*

8.3 Net Allowable Bearing pressure : *for Isolated/Combined footings with an allowable settlement of 25mm*

Depth (m) of Foundation below Existing Ground Level	*Net Allowable Bearing Pressure (t/m^2) for Widths of foundation (m)*
	1.5 & above
2.5	*22*
3	*24*

8.3.1 ***Note:*** The recommendations given in this report have been arrived at on the basis of design parameters which have been judiciously adopted by giving due consideration to the results of field and laboratory investigations as well as NAGADI's experience of over four decades in working in various types of soil and rock conditions all over India.

9.0 *CONSTRUCTION ADVISORIES*

9.1.1 Loose pockets of soil, wherever encountered, should be completely removed and backfilled with well compacted earth. A 15cm thick layer of 40-60mm size gravel should be laid and rammed into the backfilled earth. A layer of sand should be placed and compacted in order to fill the voids. A leveling course of lean concrete can then be laid over the gravel, and construction of foundations can be taken up subsequently.

9.1.2 All foundations pits must be carefully inspected to ensure that footings are taken below the top filled up soil and rest for the specified minimum depth of 1.2m below existing ground level. However, overall depth of foundations should not be less than 2.5m below existing ground level.

9.2 Deep Excavation

The top strata of subsoil encountered at the site is filled-up. The top strata of virgin soil encountered at the site underlying the filled-up soil is stiff clay strata. Also, high ground water table was encountered at the site. Hence, adequate precautions must be taken against collapse of the sides of the excavation and foundation pits. This can be done by providing adequate shoring and supports, or proper slope.

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9.3 Appendices

9.3.1 An appendix sheet showing the typical analysis of the allowable bearing pressure has been given in Appendix - A of this report .

9.3.2 A list of IS Codes referred for providing the recommendations and that which might be required to implement the same is also enclosed in this report in Appendix- B.

10.0 LIMITATIONS

The recommendations given in the report are based on the results of borehole investigations at 3 locations as per scope of work. In case there is any substantial variation in the substrata conditions, from those encountered at the borehole locations, additional investigations may be carried out, if necessary.

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ANALYSIS FOR ALLOWABLE BEARING PRESSURE

Data

(i) Soil Properties :

c (kg/cm^2) = 0.1 $\quad \phi = 32^0$ $\quad \gamma$ (g/cm^3) = 1.9

(ii) Depth of Foundation, D (m) = 2.5 below existing ground level

(iii) Allowable Settlement, s (mm) = 25

Shear Failure Criterion (Ref. IS : 6403)

$N_c' = 26.54$ $\quad N_q' = 15.75$ $\quad N_\gamma' = 18.99$ $\quad R_w = 0.5$ $\quad R_w' = 0.5$

$$q_s = \frac{1}{3} \cdot \left(c \cdot N'_c + 0.5 \gamma \cdot B \cdot N_\gamma' \, Rw + \gamma \cdot D \cdot N_q' \cdot R_w' \right) - \gamma \cdot D$$

B (m)	1.5	3
q_s (t/m^2)	23.5	28.0

Settlement Criterion (Ref. IS : 8009)

(i) From N Values

B (m)	1.5	3
H (m)	1.5	3
N_{av}	40	45
q_a (t/m^2)	23.1	22.0

(ii) From Triaxial Compression Tests : $\quad q_a = \dfrac{s \cdot E}{0.7 \cdot H}$

B (m)	1.5	3
H (m)	1.5	3
E (t/m^2)	950	1850
q_a (t/m^2)	22.6	22.0

ADOPT	B (m)	1.5 & above
	q (t/m^2)	22

Note : q_s and q_a are NET VALUES, Weight of backfill etc. need not be added to the loading except in case of filling above original G.L.

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LIST OF IS CODES

Field Investigation

1. IS : 1892 - 1979 : Code of practice for sub surface investigations for foundations (First revision)
2. IS : 2131 - 1981 : Method of Standard Penetration Tests for soils (First revision)
3. IS : 2132 - 1986 : Code of practice for thin walled tube sampling of soils (Second revision)

Laboratory Tests

1. IS : 2720 - 1983 (Part 1) : Methods of test for soils: Preparation of dry soil samples for various tests (Second revision)
2. IS : 2720 - 1980 (Part 2) : Method of test for soils: Determination of water content (Second revision) Amendment 1
3. IS : 2720 - 1980 (Part 3/sec 1) : Method of Test for Soils : Determination of Specific Gravity : Fine Grained Soils. (First Revision)
4. IS : 2720 - 1980 (Part 3/Sec 2) : Method of test for soils : Determination of Specifi Gravity : Fine, Medium & Coarse grained soils. (First revision).
5. IS : 2720 - 1985 (Part 4) : Method of test for soils : Grain size analysis (Second revision)
6. IS : 2720 (Part 8) -1983 :Determination of water content - dry density relation using heavy compaction. (First revision)
7. IS : 2720 - 1985 (Part 5) : Method of test for soils : Determination of liquid and plastic limit (Second revision)
8. IS 2720-1981 Part 12: Method of tests for soils : Determination of shear strength parameters using triaxial apparatus.

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Foundation Construction

1.	IS : 1080 - 1986 :	Code of practice for design and construction of shallow foundations on soils (other than raft, ring and shell) (Second revision)
2.	IS : 1904 - 1986 :	Code of practice for design and construction of foundation in soils: General requirements (Third revision).
3.	IS : 6403 - 1981 :	Code of practice for determination of bearing capacity of shallow foundations : First revision (Amendment 1).
4.	IS : 8009 - 1976 (Part 1) :	Code of practice for calculation of settlements of foundations: Shallow foundations subject to symmetrical static vertical loads (Amendment 2).

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TABLES



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Job No.G(B)12309

Sheet No. : 1

SOIL PROFILE	Project : Multistoried Apartment Building (Sundaram Tirumala Towers) at Salem, Tamil Nadu.													
	B.H. Location :				Water Table : 1.2m				Term. Depth : 4.2m				B.H. No.: 1	
				Grain Size Analysis				Atterberg Limits		In-situ properties		Triaxial Test		
■ N - Value	Depth (m)	Soil Description	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density γ_b(g/cm^3)	Water Cont (%)	Type	c (kg/cm^2)	ϕ (°)	
	0.0	Existing ground level												
	0.5	Filled up soil from 0.0m to 1.3m depth with brickbats and debries etc												
	1.5	Dark grey sandy silty clay	0	23	33	44	51	33	1.89	17.8	CD	0.40	17	
15	2.5	Dark grey sandy silty clay												
	3.5	Grey with white clayey silty sand with gravel	10	50	24	16	29	15	1.94	11.5	CD	0.05	34	
30/ 5cm	4.0	Grey with white clayey silty sand with gravel												
	4.2	Refusal strata (32 blows for 3cm penetration)												

Note : 1) ■N-Value (Observed)
2) γ_b : Bulk Density

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SOIL PROFILE

Project : Multistoried Apartment Building (Sundaram Tirumala Towers) at Salem, Tamil Nadu.

B.H. Location :

Water Table : 1.0m

Term. Depth : 3.1m

B.H. No.: 2

■ N - Value	Depth (m)	Soil Description	Grain Size Analysis				Atterberg Limits		In-situ properties		Triaxial Test		
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density γ_b(g/cm^3)	Water Cont (%)	Type	c (kg/cm^2)	Φ (°)
	0.0	Existing ground level											
	0.5	Filled up soil from 0.0m to 1.4m depth with brickbats and debries etc											
20	1.5	Brownish grey silty sandy clay with traces of gravel	4	36	21	39	41	25	1.87	15.2	CD	0.35	21
	2.5	Brownish grey silty sandy clay with traces of gravel											
92	2.8	Greyish white gravelly silty sand with clay	22	40	28	10							
	3.1	Refusal strata (32 blows for 3cm penetration)											

Note : 1) ■N-Value (Observed)
2) γ_b : Bulk Density

Job No:G(B)12309

Sheet No. : 2

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SOIL PROFILE		Project : Multistoried Apartment Building (Sundaram Tirumala Towers) at Salem, Tamil Nadu.												B.H. No.: 3	
		B.H. Location :		Water Table : 1.3m				Term. Depth : 3.8m						Triaxial Test	
				Grain Size Analysis				Atterberg Limits		In-situ properties					
■ N - Value	Depth (m)	Soil Description		Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density γ_b(g/cm^3)	Water Cont (%)	Type	c (kg/cm^2)	ϕ (°)	
	0.0	Existing ground level													
	0.5	Filled up soil from 0.0m to 1.3m depth with brickbats and debries etc													
	1.5	Brownish grey silty sandy clay		0	42	13	45	43	24	1.88	16.6	CD	0.35	18	
24	2.5	Brownish grey silty sandy clay		15	50	27	8	-							
98	3.5	Greyish white gravelly silty sand with clay													
	3.8	Refusal strata (20 blows for 3cm penetration)													
		Note : 1) ■N-Value (Observed) 2) γ_b : Bulk Density													

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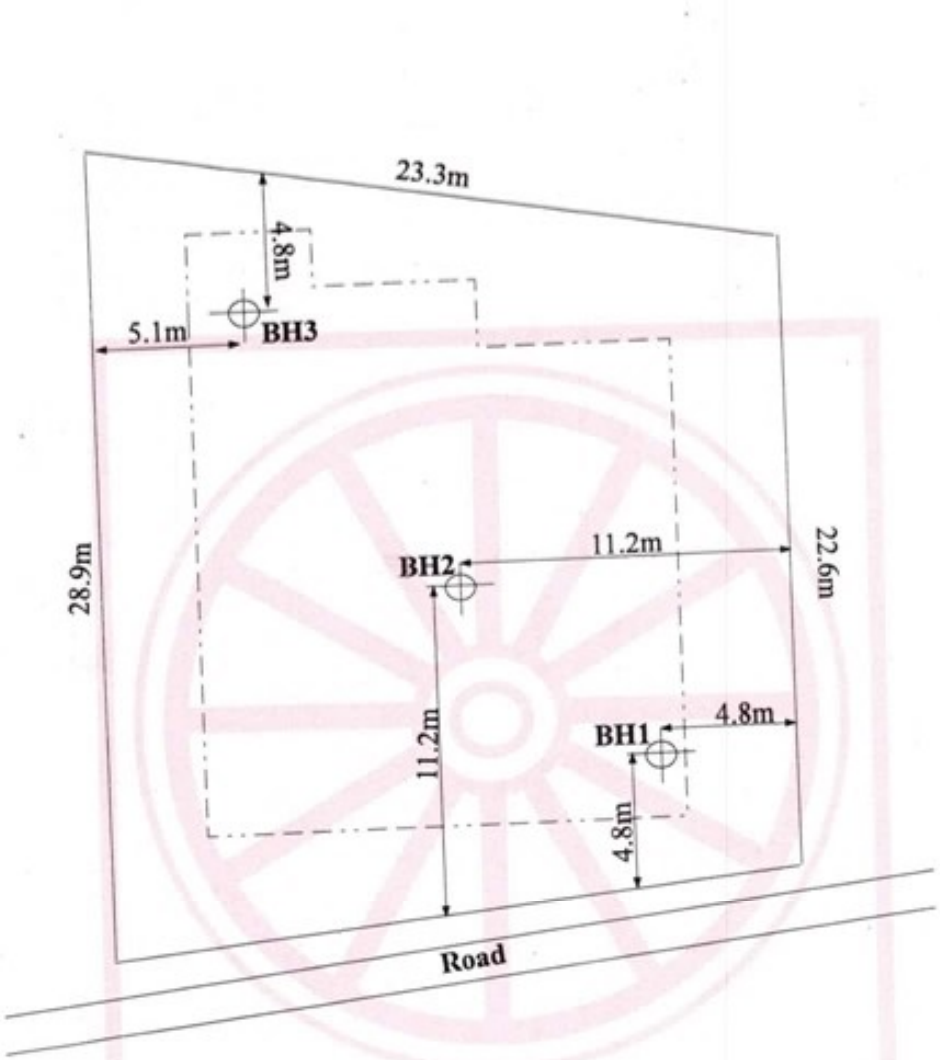
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FIGURES





Schematic Site Plan

Legend

: Borehole

: Proposed Bldg

NOTE : Sketch Not To Scale

Project : Multistoried Apartment Building (Sundaram Tirumala Towers) at Salem, Tamil Nadu.

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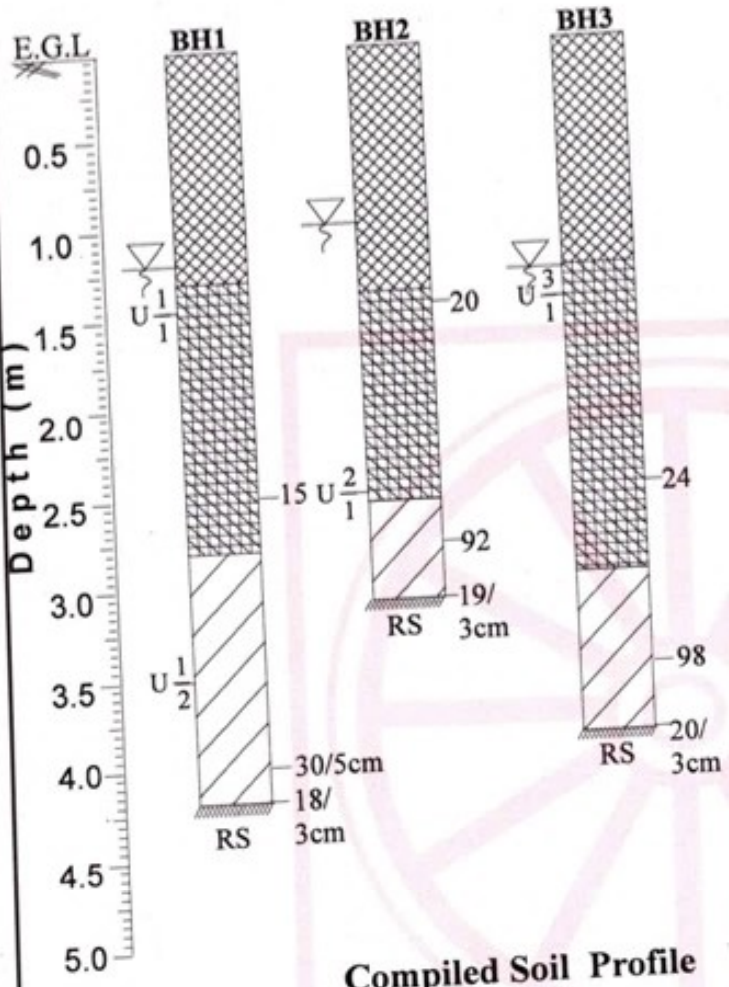
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Compiled Soil Profile

Legend

Stratum I

Filled up soil with brickbats, debris etc

Stratum II

Dark grey to brownish grey Silty sandy clay to sandy silty clay with traces of gravel[Gravel (4%) Sand (23-42%) Silt (13-33%) Clay (39-45%)]

Stratum III

Greyish white, Clayey silty sand to Gravelly silty sand with clay [Gravel (10-22%) Sand (40-50%) Silt (24-28%) Clay (8-16%)]

E.G.L. : Existing Ground Level

15: N – value (Observed)

18/3cm : 18blows for 3cm penetration

$U\frac{1}{2}$: Second Undisturbed Sample in Borehole No. 1

RS : Refusal Strata

: Water table

Project : Multistoried Apartment Building (Sundaram Tirumala Towers) at Salem, Tamil Nadu.

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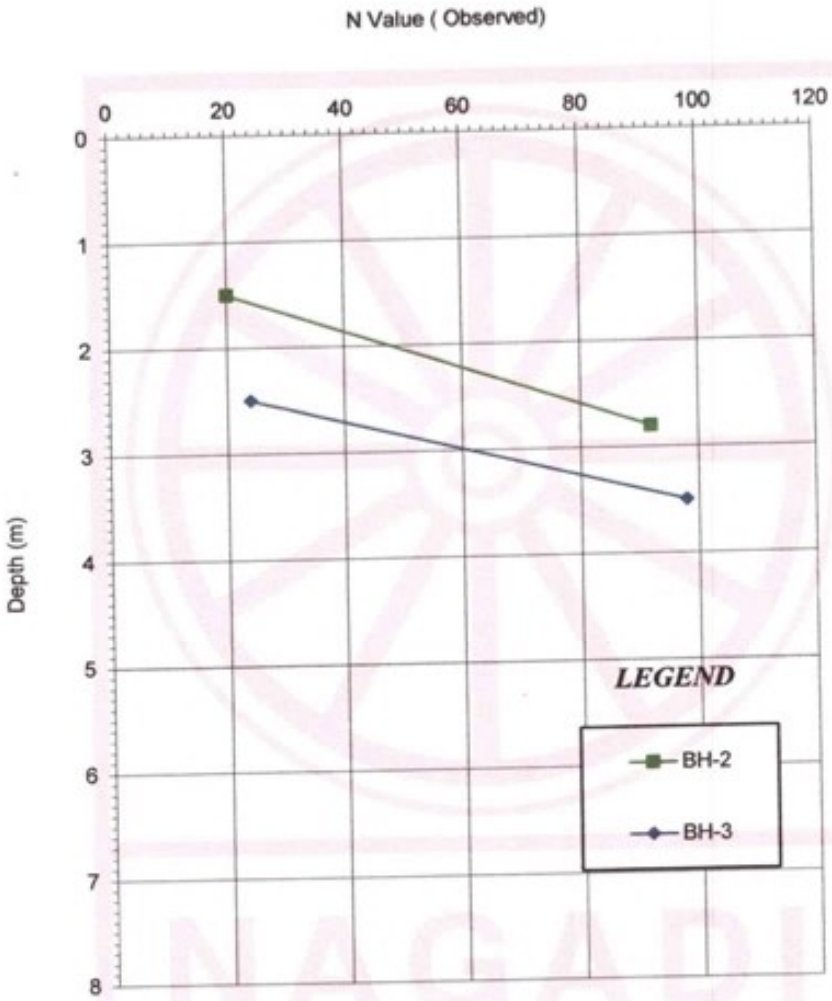
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N Values vs Depth Plot

N. Siddhardha

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WORK IN PROGRESS 2

N. Sudhindra

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Encumbrance Certificate (EC) Search, Find Your SRO, Temple Property Check, WAQF Property Check, View Patta/Chitta, View FMB, Patta Analyzer, EC Analyzer

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Land Use Zone Finder, CRZ Zone Check, Aquifer Zone Check, CBA Check, EWS Check, Road Width Check, Proposed Road Widening Check, FSI Calculator

Property Documentation & Workflow Tools

Forms & Templates, Document Generator, Document Translation, Dictionary

Vastu & Property Management Tools

Home Vastu Shastra, Plot Vastu Shastra, Property Management

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