PRASAD ARMSTRONG YEN G E C (P) LTD.
821 (Old No. 439/4) Poonamallee High Road, Arumbakkam, Chennai 600 106.
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CIN: U74210TN1992PTC023645

GEOTECHNICAL SITE INVESTIGATION
BORING 1 AND 2
PROPOSED RESIDENTIAL VILLA BUILDINGS SITE
S. NO. 28/11 AND 32/3 PART, THALAMBUR VILLAGE
VANDALUR TALUK, CHENGALPET DISTRICT, TN.

Report to

M/s. Varman Constructions Private Limited
No. 5/20, Blue Beach Road, ECR
Neelangarai, Chennai 600 115, TN.

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Report No. 051/GI/23-24.
June 19, 2023.

M/s. Varman Constructions Private Limited
No. 5/20, Blue Beach Road, ECR
Neelangarai, Chennai 600 115, TN.

Geotechnical Site Investigation
Boring 1 and 2
Proposed Residential Villa Buildings Site
S. No. 28/11 & 32/3 Part, Thalambur Village
Vandalur Taluk, Chengalpet District, TN.

The Prasad Armstrong Yen GEC (P) Ltd., Chennai is pleased to submit this report on our geotechnical site investigation conducted at the above location. This investigation was authorized by your work Order Ref. No. WO / Varman Construction - Soil Test/2023-24/001 dated June 12, 2023.

Estimated capacities of the recommended foundation for the proposed building are presented here in final form together with a summary of laboratory and field data.

We appreciate the opportunity to be of service to you on this project. Please call us if you have any questions or when we can be of further assistance.

Sincerely,

PRASAD ARMSTRONG YEN GEC (P) Ltd.

B. Ram Prasad ME, PhD (Texas A&M)
Managing Director
CMDA Registration No. GTE/19/02/002

(051brpt)
Copies Submitted: (3)

CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
'Thalamuthu Natarajan Building', No.1, Gandhi Irwin Road,
Egmore, Chennai-600 008.

PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that the **Dr.B.RAM PRASAD** has enrolled as **Registered Geo-Technical Engineer (RGTE)** with Chennai Metropolitan Development Authority (CMDA) who has the qualification of **B.E.,(Civil Engg.), M.E.,(Geo-Tech.), Ph.D.,** and experience in the relevant field for **30 years**.

He has been given the Registration No.**GTE/19/02/002** on **19.02.2019.** He shall be required to comply with the duties and responsibilities prescribed by the Government of Tamil Nadu in Part-V, "Registration of Professionals", Tamil Nadu Combined Development and Building Rules, 2019 approved vide G.O.(Ms) No.18 MAWS (MA1) Dept. dated 04.02.2019.

This Registration is valid upto **18.02.2024**.



CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY * CHENNAI-600 008 *

19/02/2019

(R.SHIVAKUMAR)

ASSISTANT PLANNER
CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
CHENNAI - 600 008

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SUMMARY

Prasad Armstrong Yen GEC (P) Ltd. performed a geotechnical site investigation at the Proposed Residential Villa Buildings Site, S. Nos. 28/11 and 32/3 Part, Thalambur Village, Vandalur Taluk, Chengalpet District, TN. The primary purpose of this investigation was to obtain data to develop foundation design recommendations for the proposed G + 2 floors villa buildings. This investigation was performed to identify soil stratification of the site, and select suitable foundation, and estimate load carrying capacities of the considered foundation. Typical maximum column load for the proposed building type will be about 60 tons. These details were used only for estimating the preliminary foundation size and type of foundation.

The field investigation was performed June 14 and 15, 2023. Location and number of borings were provided by the client through a site plan with bore location details. Boring 1 and 2 were drilled to 7.5- and 6-M penetration below the Existing Ground Level (EGL). Hard strata (SPT "N" $\geq$ 75) was encountered continuously from at least 4-M below EGL. Drilling of borings was terminated after encountering at least three successive tests. In Boring 2 NX Diamond drill bit was used for drilling from 5- to 6-M. A small rock core piece was recovered while drilling to 6-M. Tests were conducted to determine the pertinent index and engineering properties of the soils encountered. We then performed engineering analyses to develop the required design data.

Natural topography of the site reflects a flat terrain. Visual observation infers site's EGL was about 0.3-M below the Existing Road Level (ERL) of gravel road in front of the site, and at about 0.5-M below the Existing Road Level (ERL) of Thalambur Link Road near the site. No compound walls were present along site boundaries. Fencing was present along the road facing site and with fencing stones along other boundaries. No significant vegetation was present in the site except for a few neam trees along the boundaries. Proposed construction will be the first major construction activity of this magnitude to cover the site. Soil stratigraphy at the borings is tabulated below:

Boring – 1:

Stratum	Penetration, M From	To	Description
I	0	2.0	Brown Fine to Medium Sand with Silt
II	2.0	7.5+	White Brown Weathered Rock

Boring – 2:

Stratum	Penetration, M From	To	Description
I	0	2.0	Brown Fine to Medium Sand with Silt
II	2.0	6.0+	White Brown Weathered Rock

Data from the borings indicate presence of similar sandy soil and weathered rock profiles with some variations in SPT "N" values in the top 4-M. For the expected column loads, encountered soil profiles it was **recommended** to provide either **Isolated Column Footing Foundation**. Footing was recommended at 2-M below EGL. A minimum footing size of 1.25-M was considered in the analysis. For the considered foundation **estimated ultimate and recommended allowable capacities were 72 and 25 tons/M^2**, respectively. For the expected bearing pressure estimated total settlement was about

6 mm, less than 60 mm, the IS: 1904 - 2006 code limiting settlement for isolated column footing foundations on granular soils for framed structures. In case of columns at close spacing as in the case of staircase area, lift area a common combined footing should be provided.

There was no known groundwater source in the site. In the adjacent plot a 9-M diameter open well of unknown depth was present at about 100-M from Boring 2. In the open well groundwater was at about 4.4-M below EGL. Groundwater sample was collected from the open well for construction suitability tests. Test results indicate that tested groundwater was **suitable** for construction purposes as per IS: 456-2000. Chemical tests were performed on soil sample from 2-, and 3-M depth of Boring 1 and 2, respectively. Soil samples were tested for pH, Chlorides, and Sulphates. A 5% soil solution was initially prepared by mixing with distilled water. This solution was allowed to soak and settle for 24 hours. After that soil solution was filtered pH test was performed on the derived solution. Test results infer no high concentration of adverse chemicals were present in the tested soil samples.

We do not expect construction problems at this site due to site soil and groundwater conditions in non-rainy seasons. Foundation work should be completed when groundwater was below the required foundation level to avoid expensive dewatering activity. Site's EGL was about 0.3-M below ERL of gravel road in front of the site. In order to minimize future building flooding from road runoff it was recommended to raise FGL of the site by **at least 0.6-M above ERL** of road in front of the site. FFL of **stilt floor** should be 0.45-M above FGL of the site. This will minimize rainwater runoff flooding into site and building. All footings should be rigidly interconnected with surrounding footings.

Backfilling of the foundation excavations should be done with granular soil, and fill should be compacted properly to achieve proper densification to avoid settlements in flooring. Exposed bottom surface of the foundation excavation must be properly cleaned of loose material and exposed surface should be compacted with heavy duty rammer to compact the exposed surface that gets loosened by mechanical excavation activities. This was to minimize the settlements that can arise if the loosened soil in foundation excavation was not removed or compacted. New foundations should be located on virgin formation and not on old foundations. If any loose pockets of soils are encountered at foundation level then the looser material should be replaced till denser material with well compacted PCC. Excavated sandy soil can be used for foundation and site filling purposes.

All structures at this site have to be designed for higher seismic forces (**Zone III**) due to increased seismic activity in peninsular India in the last two decades. Seismic events of 5.1 magnitude on August 24, 2021, 5.1 magnitude on February 12, 2019, 7.9 magnitude on April 25, 2015, 6.0 magnitude on May 21, 2014, 8.4 magnitude on April 11, 2012, 7.2 magnitude on June 13, 2010, and 7.6 magnitude on August 11, 2009 with epicenters in Himalayas, Bay of Bengal, and near Andaman Islands were felt at Chennai. It was recommended to provide rigid plinth beams in ground level, columns designed for shear forces or shear walls in the structure, and continuous lintels in each floor. Lintels must be integrated into columns of the structure. Plinth beams must be designed to be rigid to allow redistribution of loads in case of differential settlements. For soil profile of Boring 1 with GWL at 1-M infers **"No"** seismic susceptibility. **At EGL** under a seismic event of **6.0 Richter scale**, and peak horizontal ground acceleration of **0.16g** as per IS Code for **Zone III** the total estimated vertical settlement was 0.0 cms and total horizontal displacement was about 0.0 cms. Iwasaki liquefaction potential was 0.0 inferring "**No Liquefaction**."

INTRODUCTION

Purpose and Scope

Prasad Armstrong Yen GEC (P) Ltd. performed a geotechnical site investigation at the Proposed Residential Villa Buildings Site, S. Nos. 28/11 and 32/3 Part, Thalambur Village, Vandalur Taluk, Chengalpet District, TN. The primary purpose of this investigation was to obtain data to develop foundation design recommendations for the proposed G + 2 floors villa buildings. This investigation was performed to identify soil stratification of the site, and select suitable foundation, and estimate load carrying capacities of the considered foundation. Typical maximum column load for the proposed building type will be about 60 tons. These details were used only for estimating the preliminary foundation size and type of foundation. To accomplish these purposes, the following tasks were performed:

(1) Boring 1, and 2 were drilled to 7.5- and 6-M below EGL to explore the subsurface stratigraphy and obtain soil and weathered rock samples for laboratory testing;

(2) Field and laboratory tests were conducted to evaluate the pertinent index and engineering properties of the foundation materials; and

(3) Engineering analyses were performed to develop foundation design information for the proposed building.

Report Format

The initial sections of this report contain brief descriptions of the field and laboratory phases of our study. A general soils description is then presented, followed by discussions of foundation design recommendations followed by a brief on construction considerations for this project.

FIELD AND LABORATORY INVESTIGATIONS

Exploratory Borings

Soil conditions at the site were explored by Boring 1 and 2. Bore location details were presented on Plate 1. Location and number of borings were provided by the client through a site plan with bore location details. Boring 1 and 2 were drilled to 7.5- and 6-M penetration below EGL. Hard strata (SPT "N" $\geq$ 75) was encountered continuously from at least 4-M below EGL. Drilling of borings was terminated after encountering at least three successive tests. In Boring 2 NX Diamond drill bit was used for drilling from 5- to 6-M. A small rock core piece was recovered while drilling to 6-M. Tests were conducted to determine the pertinent index and engineering properties of the soils encountered. We then performed engineering analyses to develop the required design data. Groundwater was at about 4.4-M below EGL in the nearby open well. Log of Boring are presented on Plate 2 and 3.

Field and Laboratory Tests

Boring was drilled using Calyx drilling unit. In the boring SPT was performed at 1-M interval. Soil samples for laboratory tests were collected from SPT split spoon sampler. SPT consists of driving a standard split spoon sampler, 50.8-mm outside diameter and 35-mm inside diameter into soil under the blows of a drop hammer of 63.5 kg falling weight freely through 75-cm. The number of blows

required for 30-cm of penetration of sampler in soil is designated as N value and it is termed as the SPT blow count. Detailed information regarding SPT can be found in the IS: 2131 code of practice.

The soil-testing program was designed to evaluate pertinent index and engineering properties of the foundation soils. During the field operations soil and weathered rock samples were collected at 1-M interval either disturbed or undisturbed as the case may be. All samples were shipped to our Chennai laboratory where pertinent index properties - grain size analyses, natural water content Atterberg limit tests were performed on collected soil samples. All the test results were tabulated on the Summary of Test Results on Plate 4. Grain size distribution curves of tested soil are presented on Plate 5. Summary of Water and Soil Chemical Test Results are presented on Plate 6.

GENERAL SOIL CONDITIONS

Topography

Natural topography of the site reflects a flat terrain. Visual observation infers site's EGL was about 0.3-M below ERL of gravel road in front of the site, and at about 0.5-M below ERL of Thalambur Link Road near the site. No compound walls were present along site boundaries. Fencing was present along the road facing site and with fencing stones along other boundaries. No significant vegetation was present in the site except for a few neam trees along the boundaries. Proposed construction will be the first major construction activity of this magnitude to cover the site.

Soil Stratigraphy

The soil stratigraphy disclosed by our field and laboratory investigations of the boring was presented on the log of boring on Plate 2 and 3. The soil stratigraphy is based on classification of soil samples recovered from the boring, and our observations during drilling operations. A generalized summary of the major soil strata is tabulated below:

Boring – 1:

Stratum	Penetration, M From	To	Description
I	0	2.0	Brown Fine to Medium Sand with Silt
II	2.0	7.5+	White Brown Weathered Rock

Boring – 2:

Stratum	Penetration, M From	To	Description
I	0	2.0	Brown Fine to Medium Sand with Silt
II	2.0	6.0+	White Brown Weathered Rock

Detailed soil descriptions that include textural variations and inclusions are noted on the log of boring presented on Plate 2 and 3.

Interpretation of Soil Properties

Shear strength parameters for cohesionless soils were selected based on the SPT, and grain size distribution analyses. Shear strength parameters for cohesive soils were selected based on the SPT

results. The unit weight (soil density) profiles of the soils in the borings were developed from estimated values based on correlations of unit weight with particle size gradation and field test results (Bowles, 1982.)

Recommendations presented herein are based on the soil properties encountered in the Boring 1. There may be a need to drill additional borings to investigate soil variability if encountered during the foundation work. Based on the field and laboratory test results the following are the properties for soils encountered in the boring.

Boring – 1:

Stratum	Penetration, M From	To	Properties
Ia	0	1.0	$\phi = 28^o$; $\gamma_{sat} = 1.6$ tons/M^3
Ib	1.0	2.0	$\phi = 31^o$; $\gamma_{sat} = 1.65$ tons/M^3
IIa	2.0	3.0	$\phi = 34^o$; $\gamma_{sat} = 1.85$ tons/M^3
IIb	3.0	4.0	$\phi = 35^o$; $\gamma_{sat} = 1.95$ tons/M^3
IIc	4.0	6.0	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
IId	6.0	7.0	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3
IIe	7.0	7.5+	$\phi = 39^o$; $\gamma_{sat} = 2.25$ tons/M^3

Boring – 2:

Stratum	Penetration, M From	To	Properties
Ia	0	1.0	$\phi = 31^o$; $\gamma_{sat} = 1.65$ tons/M^3
Ib	1.0	2.0	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
IIa	2.0	2.75	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
IIb	2.75	4.0	$\phi = 36^o$; $\gamma_{sat} = 2.0$ tons/M^3
IIc	4.0	5.0	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3
IId	5.0	6.0	$\phi = 40^o$; $\gamma_{sat} = 2.3$ tons/M^3

DESIGN INFORMATION

Data from the borings indicate presence of similar sandy soil and weathered rock profiles with some variations in SPT "N" values in the top 4-M. For the expected column loads, encountered soil profiles it was **recommended** to provide either **Isolated Column Footing Foundation**. Footing was recommended at 2-M below EGL. A minimum footing size of 1.25-M was considered in the analysis. The ultimate bearing capacity of the soil was estimated as per IS: 6403 Code of Practice Method using the following equation and soil parameters presented above sections:

$$q_{ult} = CN_c s_c d_c i_c + q(N_q - 1)s_q d_q i_q + 0.5B\gamma' N_\gamma s_\gamma d_\gamma i_{\gamma\delta}$$

Where

B = Width of Footing;
q_{ult} = Ultimate Bearing Capacity of the Soil;
C = Avg. Soil Undrained Shear Strength;
N_c , N_q & N_γ = Bearing Capacity Factors;
q = Eff. Vertical Pressure at Footing Level
γ' = Eff. Unit Weight of Soil;
s_c, s_q, s_γ = Shape Factors;
d_c, d_q, d_γ = Depth Factors;
i_c, i_q, i_γ = Inclination Factors; and

For the considered foundation **estimated ultimate and recommended allowable capacities were 72 and 25 tons/M^2**, respectively. For the expected bearing pressure estimated total settlement was about 6 mm, less than 60 mm, the IS: 1904 - 2006 code limiting settlement for isolated column footing foundations on granular soils for framed structures. In case of columns at close spacing as in the case of staircase area, lift area a common combined footing should be provided. Sample calculations were presented on Plate 7.

GROUNDWATER AND SOIL CHEMICAL ANALYSIS

There was no known groundwater source in the site. In the adjacent plot a 9-M diameter open well of unknown depth was present at about 100-M from Boring 2. In the open well groundwater was at about 4.4-M below EGL. Groundwater sample was collected from the open well for construction suitability tests. Test results indicate that tested groundwater was **suitable** for construction purposes as per IS: 456-2000. Chemical tests were performed on soil sample from 2-, and 3-M depth of Boring 1 and 2, respectively. Soil samples were tested for pH, Chlorides, and Sulphates. A 5% soil solution was initially prepared by mixing with distilled water. This solution was allowed to soak and settle for 24 hours. After that soil solution was filtered pH test was performed on the derived solution. Test results infer no high concentration of adverse chemicals were present in the tested soil samples. Summary of groundwater and soil chemical test results are presented on Plate 6.

CONSTRUCTION CONSIDERATIONS

We do not expect construction problems at this site due to site soil and groundwater conditions in non-rainy seasons. Foundation work should be completed when groundwater was below the required foundation level to avoid expensive dewatering activity. Site's EGL was about 0.3-M below ERL of gravel road in front of the site. In order to minimize future building flooding from road runoff it was recommended to raise FGL of the site by **at least 0.6-M above ERL** of road in front of the site. FFL of **stilt floor** should be 0.45-M above FGL of the site. This will minimize rainwater runoff flooding into site and building. All footings should be rigidly interconnected with surrounding footings.

Backfilling of the foundation excavations should be done with granular soil, and fill should be compacted properly to achieve proper densification to avoid settlements in flooring. Exposed bottom surface of the foundation excavation must be properly cleaned of loose material and exposed surface should be compacted with heavy duty rammer to compact the exposed surface that gets loosened by mechanical excavation activities. This was to minimize the settlements that can arise if the loosened soil in foundation excavation was not removed or compacted. New foundations should be located on virgin formation and not on old foundations. If any loose pockets of soils are encountered at foundation level then the looser material should be replaced till denser material with well compacted PCC. Excavated sandy soil can be used for foundation and site filling purposes.

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shear forces or shear walls in the structure, and continuous lintels in each floor. Lintels must be integrated into columns of the structure. Plinth beams must be designed to be rigid to allow redistribution of loads in case of differential settlements. For soil profile of Boring 1 with GWL at 1-M infers **"No"** seismic susceptibility. **At EGL** under a seismic event of **6.0 Richter scale**, and peak horizontal ground acceleration of **0.16g** as per IS Code for **Zone III** the total estimated vertical settlement was 0.0 cms and total horizontal displacement was about 0.0 cms. Iwasaki liquefaction potential was 0.0 inferring "**No Liquefaction**." Liquefaction Analysis results are presented on Plate 8.

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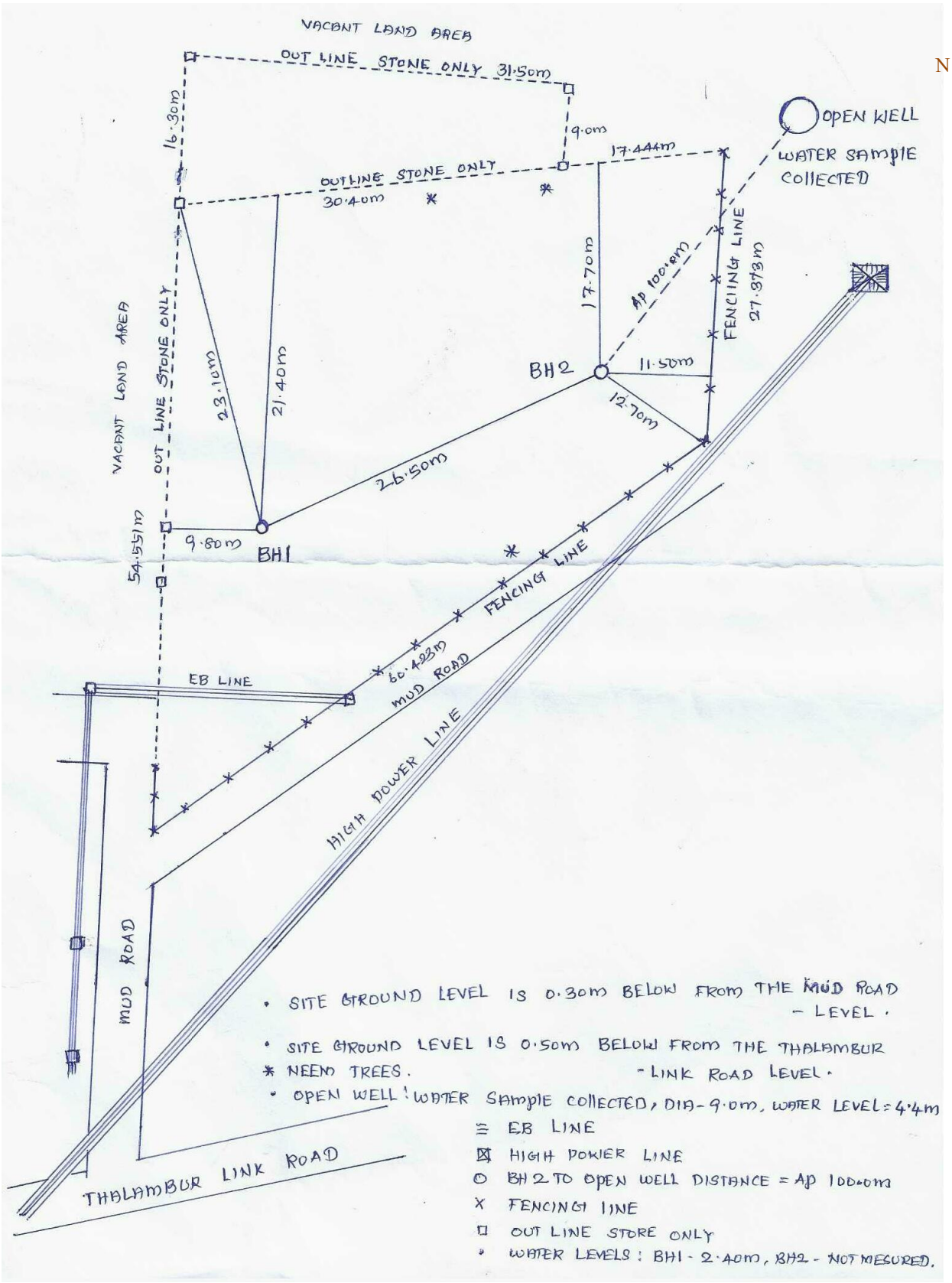
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(Not To Scale)

Site EGL = 0.5-M Below ERL of Road In-Front of the Site.

SITE PLAN WITH BORE LOCATION DETAILS.

PLATE 1

LOG OF BORING

Project: Proposed Residential Villa Buildings Site, S. No. 28/11 & 32/3 Part, Thalambur Village, Vandalur Taluk, Chengalpet District, TN.

Bore Hole No.: 1 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 14-06-'23 **Ended on:** 14-06-'23 **Field Work In Charge:** R Murugesan
Final Depth: 7.5-M **Depth to G W S:** 4.4-M **Remarks:** GWL From Opp. Site's open Well.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	BROWN FINE TO MEDIUM SAND with silt (To 2.0-M)	SPT @ 0.25 M 3/3/4 = 7 Blows		
1.0	0.0- to 1.0-m – $\phi = 28^o$; $\gamma_t = 1.6$ tons/M^3 ($N_{avg} = 7$)	SPT @ 1 M 4/5/7 = 12 Blows		
	1.0- to 2.0-m – $\phi = 31^o$; $\gamma_t = 1.65$ tons/M^3 ($N_{avg} = 12$)			
2.0	-white brown color, 2- to 4-m	SPT @ 2 M 8/14/16 = 30 Blows		
	WHITE BROWN WEATHRED ROCK (Below 2.0-M)			
3.0	2.0- to 3.0-m – $\phi = 34^o$; $\gamma_t = 1.85$ tons/M^3 ($N_{avg} = 30$)	SPT @ 3 M 14/17/21 = 38 Blows		
	3.0- to 4.0-m – $\phi = 35^o$; $\gamma_t = 1.95$ tons/M^3 ($N_{avg} = 38$)			
4.0		SPT @ 4 M 30/ 8 cms for 20 Blows		
GWL				
5.0	4.0- to 6.0-m – $\phi = 37^o$; $\gamma_t = 2.1$ tons/M^3 ($N_{avg} > 75$)	SPT @ 5 M 29/ 4 cms for 10 Blows		
		3.5 cms for 10 Blows (Hammer Rebound)		
6.0		SPT @ 6 M 3 cms for 10 Blows		
	6.0- to 7.0-m – $\phi = 38^o$; $\gamma_t = 2.2$ tons/M^3 ($N_{avg} > 100$)	2 cms for 10 Blows (Hammer Rebound)		
7.0		SPT @ 7 M (SNR) 1 cm for 10 Blows		
	7.0- to 7.5-m – $\phi = 39^o$; $\gamma_t = 2.25$ tons/M^3 ($N_{avg} >> 100$)	0.5 cms for 10 Blows (Hammer Rebound)		
8.0		SPT @ 7.5 M (SNR) 0 cms for 10 Blows (Hammer Rebound)		
9.0				
10.0				
11.0				

BORE HOLE TERMINATED AT 7.5-M.

SPT=Standard Penetration Test; DS=Disturbed Sample; UDS = UnDisturbed Sample; WS=Water Sample; SNR=Sample Not Recovered; LS = Liner Sample; +----+ = Plastic and Liquid Limits; ♦ = N M C; ■ = % -75μ Size

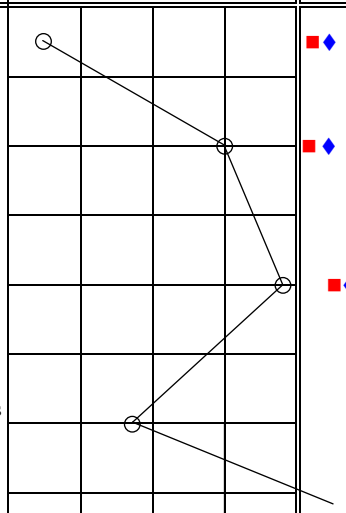
PLATE 2

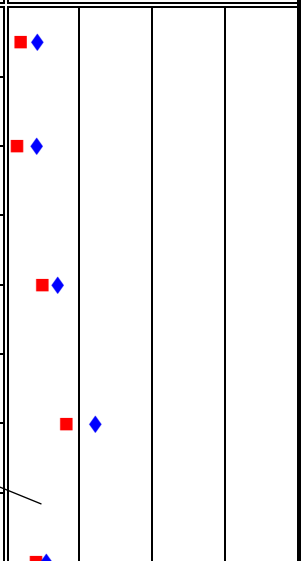
LOG OF BORING

Project: Proposed Residential Villa Buildings Site, S. No. 28/11 & 32/3 Part, Thalambur Village, Vandalur Taluk, Chengalpet District, TN.

Bore Hole No.: 2 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 14-06-'23 **Ended on:** 15-06-'23 **Field Work In Charge:** R Murugesan
Final Depth: 6.0-M **Depth to G W S:** 4.4-M **Remarks:** GWL From Opp. Site's open Well.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE
	BROWN FINE TO MEDIUM SAND with silt (To 2.0-M)	SPT @ 0.25 M 5/5/8 = 13 Blows
	0.0- to 1.0-m – $\phi = 31^{o}$; $\gamma_t = 1.65$ tons/M^3	SPT @ 1 M 27/
1.0	($N_{avg} = 13$)	8 cms for 20 Blows
	1.0- to 2.0-m – $\phi = 37^{o}$; $\gamma_t = 2.1$ tons/M^3	
	($N_{avg} = 75$)	SPT @ 2 M 24/
2.0		4 cms for 10 Blows
	WHITE BROWN WEATHRED ROCK (Below 2.0-M) ($N_{avg} > 75$)	3 cms for 10 Blows
	2.0- to 2.75-m – $\phi = 37^{o}$; $\gamma_t = 2.1$ tons/M^3	SPT @ 3 M
3.0		11/19/25 = 44 Blows
	2.75- to 4.0-m – $\phi = 36^{o}$; $\gamma_t = 2.0$ tons/M^3	
	($N_{avg} = 44$)	SPT @ 4 M
4.0		3 cms for 10 Blows
GWL		2 cms for 10 Blows
	4.0- to 5.0-m – $\phi = 38^{o}$; $\gamma_t = 2.2$ tons/M^3	(Hammer Rebound)
	($N_{avg} > 100$)	SPT @ 5 M (SNR)
5.0		1 cm for 10 Blows
	-NX Diamond bit drilling from 5-m	0.5 cms for 10 Blows
	5.0- to 6.0-m – $\phi = 40^{o}$; $\gamma_t = 2.3$ tons/M^3	(Hammer Rebound)
	($N_{avg} >> 100$)	SPT @ 6 M (SNR)
6.0	-drilled from 5- to 6-m in 60 minutes	0 cms for 10 Blows
	-7 cms core & 8 stone pieces recovered drilling to 6-m	(Hammer Rebound)
7.0		
8.0		
9.0		
10.0		
11.0		





BORE HOLE TERMINATED AT 6.0-M.

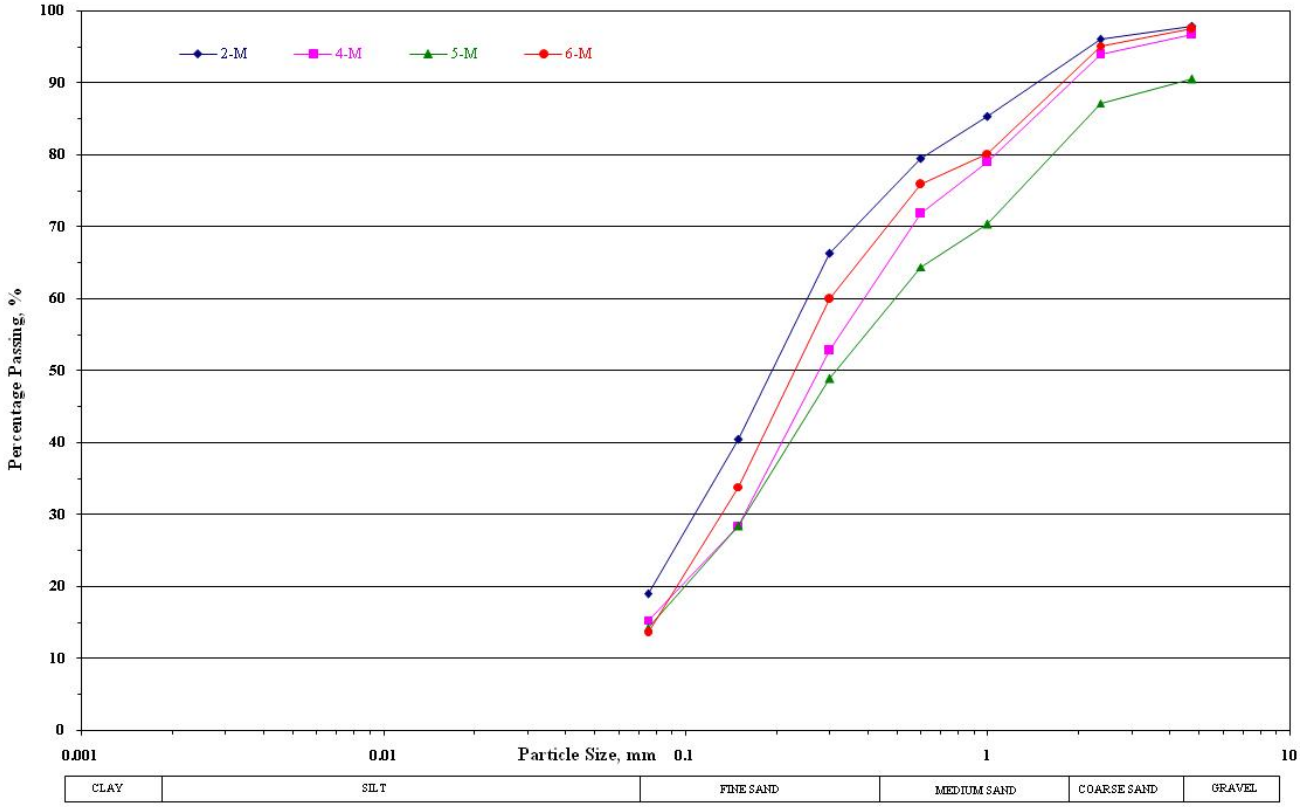
SPT=Standard Penetration Test; DS=Disturbed Sample; UDS = UnDisturbed Sample; WS=Water Sample; SNR=Sample Not Recovered; LS = Liner Sample; +----+ = Plastic and Liquid Limits; ♦ = N M C; ■ = % -75μ Size

PLATE 3

SUMMARY OF TEST RESULTS

Boring	Depth,	w %	PL	LL	-75μ%	SAND			GRAVEL	IS
No.	M					Fine%	Medium%	Coarse%	%	CLASS.
1	0.25	9			3					
	1.0	10			4					
	2.0	16			19	55	20	4	2	SM
	3.0	12			5					
	4.0	11			15	49	27	6	3	SM
	5.0	10			14	43	26	7	10	SM
	6.0	11			14	55	23	5	3	SM
	7.0	SNR								
	7.5	SNR								
2	0.25	10			4					
	1.0	11			3					
	2.0	19			15	68	16	1	0	SM
	3.0	30			22	66	8	0	4	SM
	4.0	14			11	51	20	4	14	SP-SM
	5.0	SNR								
	6.0	SNR	rock	core	piece					

Grain Size Distribution Curves
Boring 1



Grain Size Distribution Curves
Boring 2

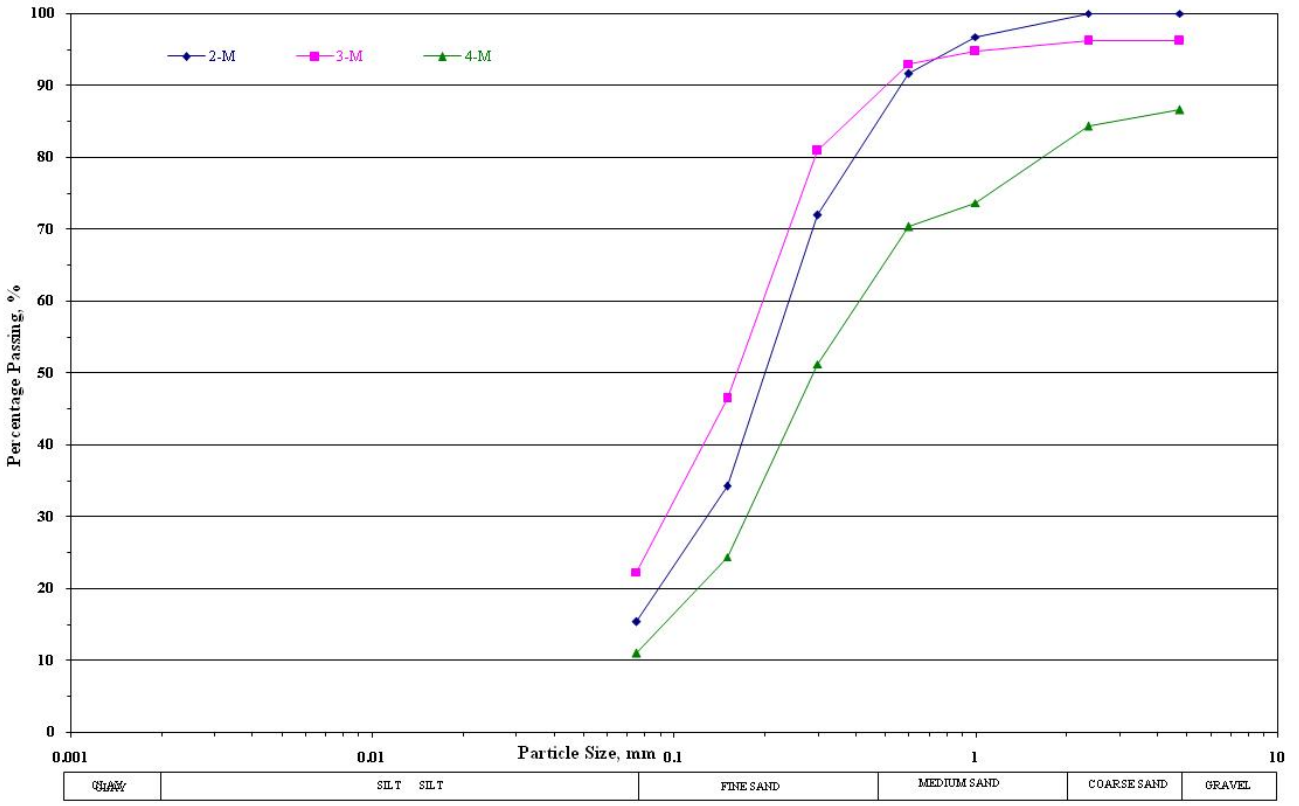


PLATE 5

SUMMARY OF WATER TEST RESULTS

NEARBY PLOT'S OPEN WELL; DEPTH = UNKNOWN

DISTANCE FROM BORING 2 ~ 100-M; WATER LEVEL = 4.4-M

S. No.		Description	Results Obtained	As per IS:456 – 2000
1		To neutralize 100 cc of water using phenolphthalein as indicator	0.50 ml	Not more than 5 ml of 0.02N NaOH
2		To neutralize 100 cc of water using methyl orange as indicator	24.20 ml	Not more than 25 ml of 0.02N H_2SO_4
3	a	Organic Solids, mg/liter	28	200 Max.
	b	Inorganic Solids, mg/liter	718	3,000 Max.
	c	Sulphates as SO_3, mg/liter	73	400 Max.
	d	Chlorides as Cl, mg/liter	124	2,000 Max. - Plain Concrete 500 Max. RCC
	e	Suspended Solids, mg/liter	0	2,000 Max.
	f	pH	7.05	6 Min.

Remarks: The sample meets the requirements of above clauses.
Hence water can be used for construction purposes as per IS 456 - 2000.

SUMMARY OF SOIL CHEMICAL TEST RESULTS

Boring No.	Depth, M	pH	Chlorides	Sulphates, ppm	
			ppm	SO_4	SO_3
1	2.0	8.25	80	48	40
2	3.0	8.31	71	41	34

Remarks:

pH tests on soil samples were performed on soil solution prepared with 5% soil. Soil solution was soaked in water for 24 hours, and the solution was filtered. Tests were performed on the filtered water.

Sulphates and chlorides content were for total soil weight.

Test results infer tested site soils had low adverse chemical ions.

SAMPLE CALCULATIONS FOR RECOMMENDED FOUNDATION

Bearing capacity was estimated using soil properties from Boring 1. Following is a list of design assumptions:

Type of Foundation	=	Isolated Column Footing
Footing Excavation Depth below EGL	=	2-M below EGL;
Worst Case Ground Water Level	=	At EGL;
Minimum Footing Size	=	1.25- by 1.25-M;
Expected Max. Column Load	=	60 tons.

Bearing Capacity Calculations:

Ultimate Bearing Pressure $q_{ult} = C_u*N_c*S_c*D_c + q'(N_q - 1)*S_q*d_q + 0.5*B*\gamma'*N_\gamma* S_\gamma*d_\gamma$

ϕ	=	34^o
C_u (Undrained Shear Strength)	=	0 tons/M^2
N_c (Bearing Capacity Factor)	=	N/A
N_q (Bearing Capacity Factor)	=	30.32
N_γ (Bearing Capacity Factor)	=	42.90
S_c (Shape Factor)	=	1 + 0.2*(B/L) = 1.0 + 0.2*(1.25/1.25) = 1.20;
D_c (Depth Factor)	=	1 + 0.2*D_f/B*tan (45 + ϕ/2) = 1.50
S_q (Shape Factor)	=	1 + 0.2*(B/L) = 1.0 + 0.2*(1.25/1.25) = 1.20;
d_q (Depth Factor)	=	1 + 0.1*D_f/B*tan (45 + ϕ/2) = 1.25
S_γ (Shape Factor)	=	1 - 0.4*(B/L) = 1.0 - 0.4*(1.25/1.25) = 0.60;
d_γ (Depth Factor)	=	1 + 0.1*D_f/B*tan (45 + ϕ/2) = 1.25
q'(O B @ Footing)	=	1.0*(1.6-1) + 1.0*(1.65-1) = 1.25 tons/M^2.

Note: Ground water is assumed to rise to EGL of the site.

q_{ult} = 0 + 1.25*(30.32-1)*1.20*1.25 + 0.5*0.85*1.25*42.90*0.60*1.25 = 72.07 ~ 72 tons/M^2

$q_{all} = q_{ult} / 2.5$ = 72 / 2.5 = 28.8 tons/M^2 **Use and Limit q_{all} = 25 tons/M^2**

Footing Width Required for 60 tons Load = 60/25.0 = 2.4-M^2 or L = B = 1.55- Say 1.6-M.

Settlement Calculations:

In case of isolated column footing foundation the "Zone of Influence" will extend to "2B" depth below footing, i.e., 2*1.6 = 3.2-M below footing or up to hard stratum level, whichever is earlier. There will be only elastic (immediate) settlement and no consolidation (long term) settlements as profile had only granular soil and weathered rock in the zone of influence.

Elastic or Immediate Settlement:-

1. 2.0- to 3.0-M = H_1 = 1.0-M; SPT "N" = 30; (Weathered Rock); E_s = 3,500 tons/M^2
2. 3.0- to 4.0-M = H_2 = 1.0-M; SPT "N" = 38; (Weathered Rock); E_s = 4,000 tons/M^2
3. 4.0- to 5.2-M = H_3 = 1.2-M; SPT "N" > 75; (Weathered Rock); E_s = 7,500 tons/M^2

E_{savg} = (1.0*3500+1.0*4000+1.2*7500)/3.2 = 5,156.25 ~ 5,150 tons/M^2

q_0 = 25 tons/M^2; H/B' = 3.20/0.8 = 4.0; L/B = 1.6/1.6 = 1.0; μ = 0.2; E_s = 5,150 tons/M^2
I_f = 0.90; I_1 = 0.408; I_2 = 0.037; I_s = 0.436
ΔH_E = 4*25.0*0.8*(1-0.2^2)/5150*0.90*0.436*1000 = **5.85 mm**

Total Elastic Settlement ΔH_E = 5.85 mm.

Consolidation Settlement: None.

Total Consolidation Settlement ΔH_C = 0.00 mm.

Total Combined Settlement **ΔH** = $\Delta H_E + \Delta H_C$ = 5.85 + 0.00 = **5.85 ~ 6 mm**.

Estimated total settlement for a 1.6- by 1.6-M isolated column footing 2-M below EGL was about 6 mm. The estimated total settlement was less than 60 mm – allowable limits for the total settlements for isolated column footing foundations on granular soils as per IS: 1904 - 2006 code. Therefore, isolated column footing foundations can be used for the proposed building.

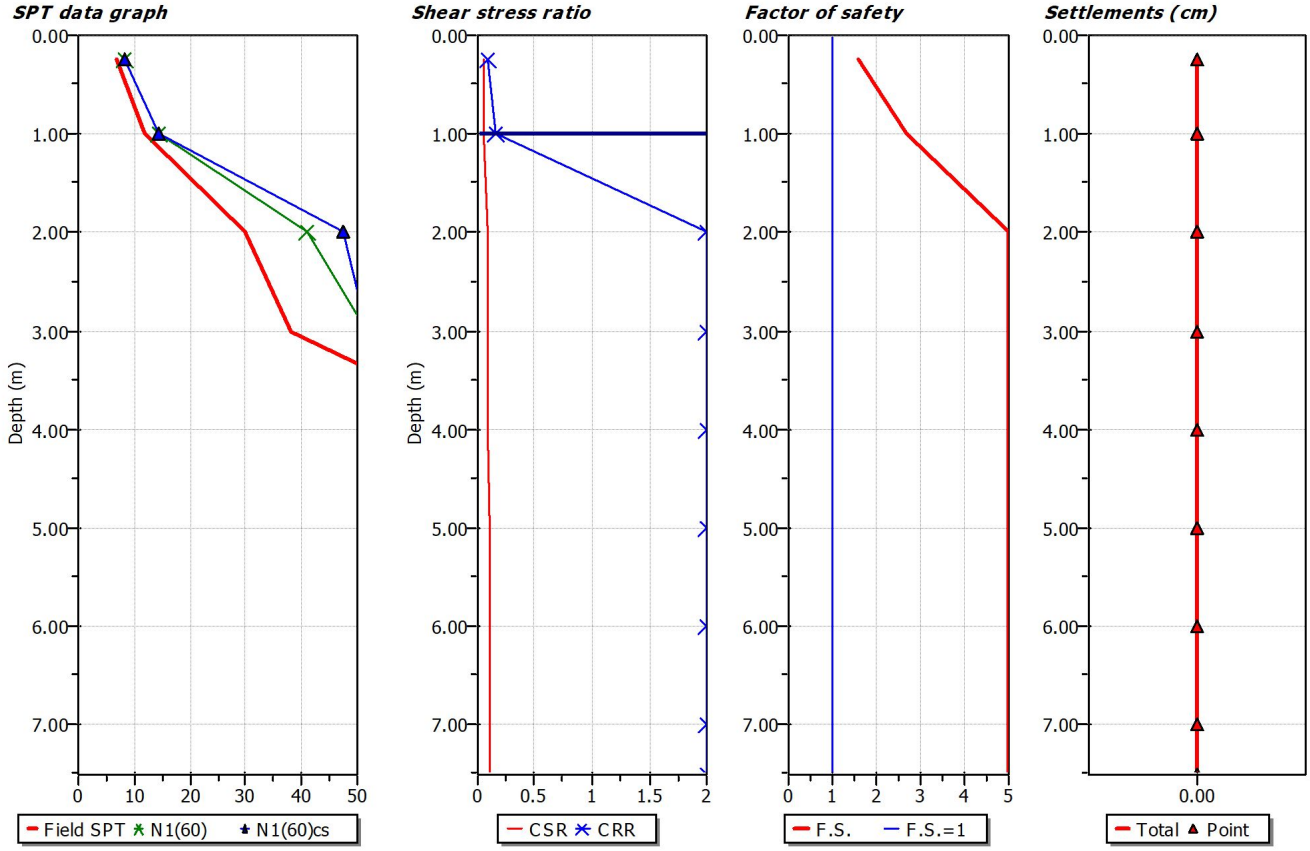
LIQUEFACTION ANALYSIS REPORT

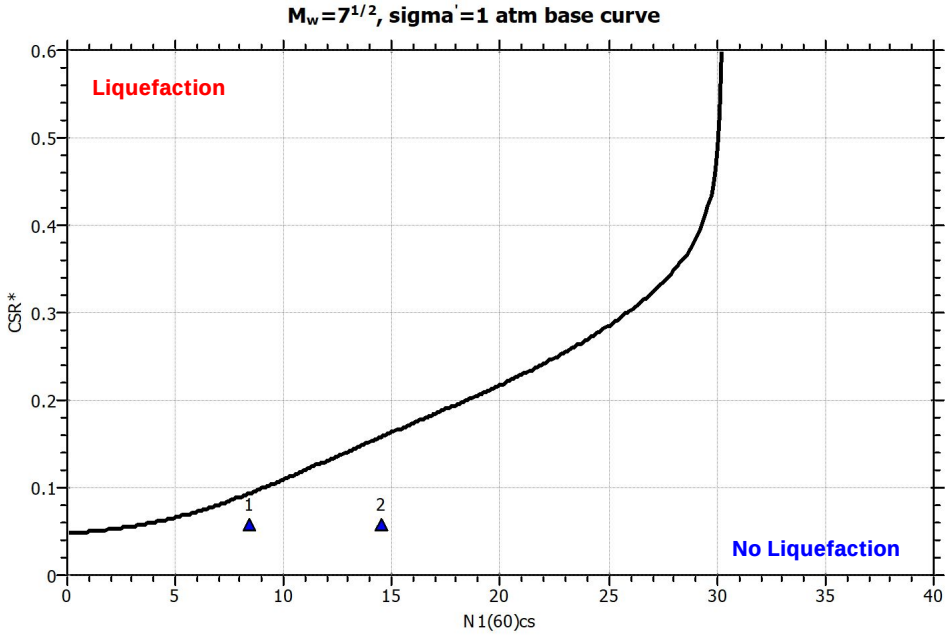
Project title : S. No. 28/11 & 32/3 Part, Thalambur Village, Vandalur Taluk, Chengalpet District, TN.

Project subtitle : Boring 1 Soil Profile

Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	1.00 m
Analysis type:	Deterministic	Earthquake magnitude M_w:	6.00
Analysis method:	NCEER 1998	Peak ground accelaration:	0.16 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00





Horizontal Acceleration, A_h = 0.16g

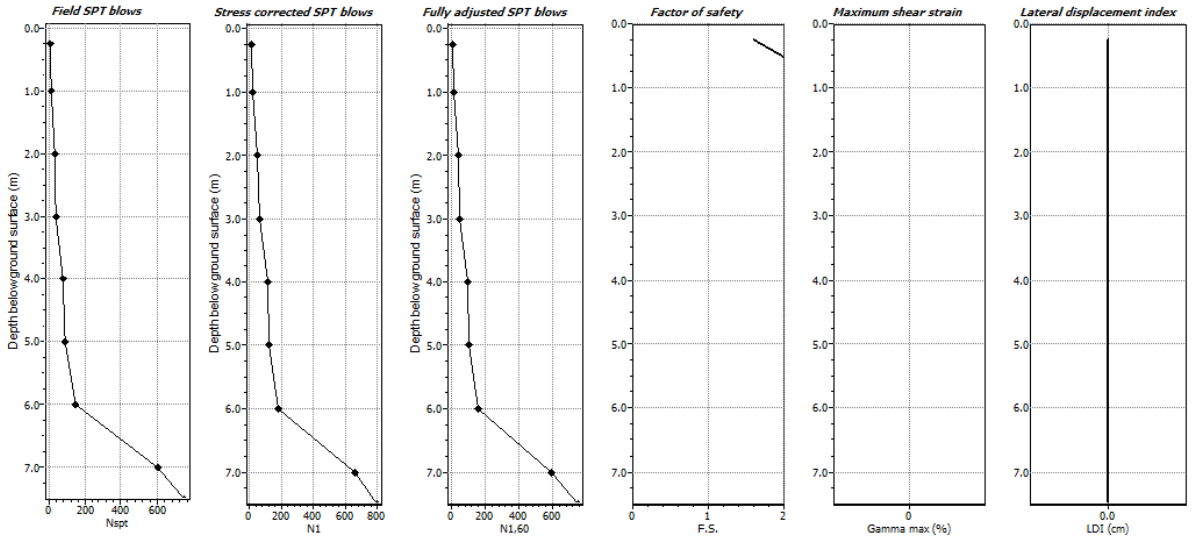
This software is licensed to : TRIAL VERSION

GeoLogismiki - Merarhias 56, 621 25 Serres, Greece
Url : http://www.geologismiki.gr - Email : info@geologismiki.gr

LiqIT software v.4.6
Assessment of soil liquefaction potential from SPT, CPT or Vs data

LATERAL DISPLACEMENTS ESTIMATION DUE TO SOIL LIQUEFACTION[1]

Geometric parameters: Gently sloping ground without free face
Total lateral displacement estimation: 0.00 cm



N_{spt}: Measured SPT blows
N_1: Stress adjusted SPT blows
$N_{1,60}$: Fully adjusted SPT blows

F.S.: Factor of safety
Gamma max: Maximum cyclic shear strain
LDI: Lateral displacement index

[1] This method was developed using the NCEER methods (SPT and CPT) and other methods will produce slightly different results

LiqIT v.4.6 - Soil Liquefaction Assesment Software

PLATE 8b

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