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PRASAD ARMSTRONG YEN G E C (P) LTD.
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Phone: 044 - 2363 7146; e-mail: paygec@yahoo.com
CIN: U74210TN1992PTC023645

GEOTECHNICAL SITE INVESTIGATION

BORING 1 THROUGH 7

PROPOSED CONSTRUCTION OF GROUP DEVELOPMENT RESIDENTIAL CUM CLUBHOUSE BUILDINGS CONSISTS OF 2 BLOCKS WITH COMBINED SINGLE BASEMENT

BLOCK-1: G + 5 FLOORS, TOTAL 95 DWELLING UNITS

BLOCK-2: G +5 FLOORS, TOTAL 107 DWELLING UNITS WITH CLUBHOUSE: G + 2 FLOORS + 3RD FLOOR (PART) WITH SWIMMING POOL ON THE GROUND FLOOR LEVEL

TOTAL 202 DWELLING UNITS

O. S. NO. 40/1 & 40/2, NEW TSLR NO: 129 IN BLOCK 13, WARD A, ISSA PALLAVARAM VILLAGE AND O. S. NO. 396 / 5 (AS PER TSLR O. S. NO. 396/1, 396/2 & 396/3 PART)

N. TSLR NO. 1/2 PART IN BLOCK 1, WARD E, ZAMIN PALLAVARAM VILLAGE

PALLAVARAM TALUK, CHENGALPATTU DISTRICT WITHIN THE LIMIT OF TAMBARAM CORPORATION.

Report to

M/s. Casagrand Builder Pvt. Ltd.
NPL Devi
N. No. 111, O. No. 59, L B Road
Thiruvanmiyur, Chennai 600 041, TN.

For CASAGRAND PREMIER BUILDER LIMITED

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PRASAD ARMSTRONG YEN G E C (P) LTD.

821 (Old No. 439/4) Poonamallee High Road, Arumbakkam, Chennai 600 106.
Phone: 044 - 2363 7146; e-mail: paygec@yahoo.com
CIN: U74210TN1992PTC023645

Report No. 246a/GI/19-20.
July 24, 2023.

This is a Revised Report of Report No. 246/GI/19-20 dated October 31, 2019.
This report was revised for B + G + 5 floors instead of Stilt + 5 floors in initial report referred above.
Dwelling Units Correction done on 23-09-2023.

M/s. Casagrand Builder Pvt. Ltd.
NPL Devi
N. No. 111, O. No. 59, L B Road
Thiruvanmiyur, Chennai 600 041, TN.

Geotechnical Site Investigation
Boring 1 through 7

Proposed Construction of Group Development Residential cum Clubhouse Buildings Consists of 2 Blocks with Combined Single Basement

Block-1: G + 5 Floors, Total 95 Dwelling Units; Block-2: G +5 Floors, Total 107 Dwelling Units with Clubhouse: G + 2 Floors + 3rd Floor (Part) with Swimming Pool on the Ground Floor Level

Total 202 Dwelling Units

O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram Village, Pallavaram Taluk, Chengalpattu District within the Limit of Tambaram Corporation.

The Prasad Armstrong Yen GEC (P) Ltd., Chennai is pleased to submit this report on our preliminary geotechnical site investigation conducted at the above location. This study was authorized by your confirmation letter No. Nil dated October 05, 2019. This revised report was as per the e-mail request dated July 24, 2023.

Estimated capacities of the foundations recommended for the proposed buildings were 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

(246abrpt)
Copies Submitted: (3)

For CASAGRAND PREMIER BUILDER LIMITED

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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 •

(R.SHIVAKUMAR)
ASSISTANT PLANNER
CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
CHENNAI - 600 008

SELF ATTESTED
For PRASAD ARMSTRONG YEN
GEOTECH ENGINEERING CONSULTANTS (P) LTD.

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No.GTE/19/02/002
Managing Director

For CASAGRAND PREMIER BUILDER LIMITED

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CONTENTS

	Page
SUMMARY	i
INTRODUCTION	1
Purpose and Scope	1
Report Format	1
FIELD AND LABORATORY INVESTIGATIONS	1
Exploratory Borings	1
Field and Laboratory Tests	1
GENERAL SOIL CONDITIONS	2
Topography	2
Soil Stratigraphy	2
Interpretation of Soil Properties	3
DESIGN INFORMATION	5
GROUNDWATER AND SOIL CHECMIAL ANALYSIS	5
CONSTRUCTION CONSIDERATIONS	6
REFERENCES	7

ILLUSTRATIONS

	Plate
Bore Hole Location Plan	1
Log of Boring 1	2
Log of Boring 2	3
Log of Boring 3	4
Log of Boring 4	5
Log of Boring 5	6
Log of Boring 6	7
Log of Boring 7	8
Summary of Test Results	9
Grain Size Distribution Curves	10
Summary of Water Test Results	11
Sample Calculations for Recommended Foundation	12
Liquefaction Analysis Results	13

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SUMMARY

Prasad Armstrong Yen GEC (P) Ltd. performed a geotechnical site investigation at the **Proposed Construction of Group Development Residential cum Clubhouse Buildings Consists of 2 Blocks with Combined Single Basement. Block-1**: G + 5 Floors, Total 95 Dwelling Units, **Block-2**: G +5 Floors, Total 107 Dwelling Units with Clubhouse: G + 2 Floors + 3rd Floor (Part) with Swimming Pool on the Ground Floor Level. Total 202 Dwelling Units, O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram Village, Pallavaram Taluk, Chengalpattu District within the limit of Tambaram Corporation. The primary purpose of this investigation was to obtain data to select suitable foundations for the proposed B + G + 5 floors residential apartment building blocks planned for this site with a common basement floor. Typical maximum column for this type of buildings will be about 170 tons. In case of combined raft foundation expected average bearing pressure was about 10 ton/M^2. These details were used only for estimating the preliminary foundation size and type of foundation.

The field investigation was performed October 20 through 26, 2019. In July 2018 a preliminary investigation with three borings was performed at this site to generate data for general idea of foundation soils and foundation type. For the present investigation number and location of borings were selected and provided by the client to cover the proposed buildings area through a bore location drawing. Boring 1 through 7 were drilled to 8-, 8-, 6-, 8-, 8-, 5.5-, 8-, and 8-M penetration below the Existing Ground Level (EGL), respectively. Drilling of the borings was terminated after encountering hard stratum with SPT "N" $\geq$ 75 in at least four successive tests, and recovery of rock core pieces. NX TC bit and Diamond bit core barrels were used for drilling through the rocky formation. Borings were terminated after recovery of rock core pieces. Tests were conducted to determine the pertinent index and engineering properties of the soils and rock encountered. We then performed engineering analyses to develop the required design data.

Natural topography of the site reflects a relatively flat terrain. Visual observation infers that EGL of the site was about 0- to 0.45-M below the Existing Road Level (ERL) of roads along the site boundary. Many bushes and shrubs were present in the site. Fencing, compound walls and house walls were present along various parts of the site boundaries. Proposed construction will be the first major construction activity to cover this site. Soil stratigraphy at the borings is tabulated below:

Boring – 1:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Silty Fine Sand with Clay Binder
II	1.0	1.75	Red Fine to Coarse Sand with Silt
III	1.75	8.0+	White Blue Brown Weathered Rock

Boring – 2:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Silty Fine Sand with Clay Binder
II	1.0	8.0+	Red White Blue Brown Weathered Rock

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Boring – 3:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Silty Fine to Medium Sand with Gravel
II	1.0	6.0+	White Blue Brown Weathered Rock

Boring – 4:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Silty Fine Sand with Clay Binder and Gravel
II	1.0	8.0+	White Blue Brown Weathered Rock

Boring – 5:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Silty Fine to Medium Sand with Gravel
II	1.0	1.75	Brown Gravely Fine to Coarse Sand with Silt
III	1.75	8.0+	White Gray Brown Weathered Rock

Boring – 6:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Red Fine to Coarse Sand with Silt
II	1.0	5.5+	White Gray Blue Brown Weathered Rock

Boring – 7:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Fine to Medium Sand with Silt
II	1.0	1.75	Red Silty Fine to Coarse Sand
III	1.75	8.0+	Brown Gray Weathered Rock

For the proposed building's basement floor height and slab thickness at least 4-M height will be required. Site's highest EGL was at ERL itself. Site's Finished Ground Level (FGL) can be at 0.9-M above ERL of road in front of the site. The Finished Floor Level (FFL) of the ground floor can be 0.3-M above FGL of the site. With this configuration from EGL itself a height of 1.2-M will be available for the basement floor. **Therefore, bottom of the basement floor from EGL will be at about 2.8-M below EGL.** For encountered soil conditions and column loads it was recommended to provide either "Isolated Column Footing" or "Combined Raft" foundation based on site conditions, over lapping of footings, depth of excavation, groundwater conditions, construction time, cost, etc.

In case of "Isolated Column Footing" foundation minimum 1.5-M width and at 4-M below EGL and with at least 1.5-M thick footing embedment (below basement floor bottom level.) For these conditions and considered foundation estimated ultimate and recommended allowable bearing capacities were 175 and 35 tons/M^2, respectively. Estimated total settlement was about 7 mm. Estimated total settlement was less than 60 mm, the IS: 1904 - 2006 code limiting settlement for isolated column footing foundations for framed structure with panel walls. Hence, isolated column

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footing foundation can be used for the proposed buildings at this site. All the footings should be interconnected in both directions. It was also recommended to provide continuous lintels in each floor for better resistance to seismic forces. **For any depth beyond 4-M below EGL the allowable bearing capacity was limited to 35 tons/M^2. The basement floor slab at about 2.4-M below EGL will have to be designed for 2.4 tons/M^2 uplift water pressure.**

In case of "**Combined Raft**" foundation a raft of **25- by 75-M** at **3-M below EGL** was considered. For these conditions and considered foundation **estimated ultimate and recommended allowable bearing capacities were 1015 and 20 tons/M^2**, respectively. For the expected bearing pressure estimated total settlement was about 7 mm. Estimated total settlement was less than 75 mm, the IS: 1904 - 2006 code limiting settlement for raft foundations on granular soils. Hence, combined raft foundation can be used for the proposed buildings at this site. **The raft should be designed for 3 tons/M^2 uplift pressure due to groundwater.**

Groundwater was not clearly seen in the borings due to ongoing frequent rains. In the site a bore well of unknown depth was present at a distance of about 17-M from Boring 7. Groundwater sample was collected from this bore well for construction suitability test as per IS: 456 – 2000 guidelines. Test results on groundwater sample from **same bore well performed in July 2018 preliminary investigation** inferred that groundwater from the bore well was **not suitable** for construction purposes due to high alkalinity as inferred by the methyl orange titration test, and **very high sulphates**. However, groundwater sample collected during **this investigation from the same bore well** inferred that groundwater from the bore well was **suitable** for construction purposes. Such drastic variation inferred dilution of bore well groundwater by the accumulated rainwater. Therefore, as an abundant precaution it was **recommended** to use cement and steel resistant to sulphates in the structures upto first slab level of the buildings. Groundwater from the site should be checked at regular intervals from the beginning and during construction period to confirm groundwater's construction suitability. Suitable groundwater treatment may be adopted to have water of acceptable quality for construction purposes. Soil samples from Boring 1, 3, and 5 at 1.75, 2.5-, and 1.75-M depths, respectively were tested for pH, Chlorides, and Sulphates to check if the soils at foundation can affect the planned foundation elements in contact with the site soils. Test results infer that the tested soil had acceptable pH, low concentration of chlorides and sulphates.

Site bore holes profiles infer mainly sandy soil profile with N_{avg} > 100 from 3- to 8-M below EGL. In the borings lowest N value was 16 at 3.25-M below EGL in Boring 1 in weathered rock. Actual "Sub-Grade Modulus" value was influenced by thickness of substrata layers in the influence zone, size and rigidity of foundation. Since it is not possible to estimate the same with variable strata, as a general guideline following sub-grade modulus values as per IS: 2950 – 1998 were provided. As per IS code in case of granular sand material with SPT "N_{avg}" 10 and 30 in **saturated condition Sub-Grade Modulus "K_s" was 0.9 to 2.9 kg/cm^2/cm (900 to 2,900 tons/M^3/M)**, and with SPT "N_{avg}" > 30 in **saturated condition Sub-Grade Modulus "K_s" was 2.9 to 10.8 kg/cm^2/cm (2,900 to 10,800 tons/M^2/M.)** Therefore, for the encountered soil profile in **saturated condition** a conservative **Sub-Grade Modulus "K_s" of 7.0 kg/cm^2/cm (7,000 tons/M^2/M)** was **recommended** for the proposed raft structural design.

We do not expect construction problems at this site due to soil and groundwater conditions in non-rainy seasons. Site's EGL was at about 0- to 0.45-M below ERL of roads near the site. The

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Finished Ground Level (FGL) of the site should be at least 0.6-M above ERL of roads near the site with proper design of surface drainage system to drain rainwater runoff. Slopes of site's internal roads, rainwater channels, drainage channels should be suitably designed with due consideration to ERL of public road in front of the site. Open areas around the building should be at least 0.2-M above the Finished Road Level (FRL) of the site's internal roads. Building's stilt floor's Finished Floor Level (FFL) may be maintained at a minimum 0.2-M above FRL of site's internal roads. This will minimize rainwater road runoff flooding into site and building.

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 compacted with heavy duty rammer or heavy roller to compact the exposed surface that gets loosened by mechanical excavation activities. This is to minimize the settlements that can arise if the loosened soil in foundation excavation is not removed or compacted. New foundations should rest on virgin soil and not on old foundations or filled up soils. In case of any filled up open well, pits, ditches or any other loose pockets were encountered then the loose pockets of soils encountered should be replaced till denser material with well compacted PCC. **Inspection of all foundation excavation's bottom surface should be strictly followed to confirm the exposed surface was hard weathered rock and not loose material**. Excavated silty sand soil and weathered rock can be used for foundation and site filling purposes. However, **compaction of the silty sand should be done without flooding** at soil's optimum moisture content to avoid slush formation on top of the fill due to separation of silt from sand. **Site filing should be completed before casting of first slab of the buildings.**

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 is recommended to provide rigid plinth beams in ground level, 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. The site soil profile infers **"No"** seismic susceptibility. Under a seismic event of **6.0 Richter scale**, and IS code recommended peak ground acceleration of **0.16g** the total estimated vertical settlement. Iwasaki liquefaction potential was 0.0 inferring **"No Liquefaction."** As per IS code for **Zone III** design horizontal acceleration was **0.16g**.

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INTRODUCTION

Purpose and Scope

Prasad Armstrong Yen GEC (P) Ltd. performed a geotechnical site investigation at the **Proposed Construction of Group Development Residential cum Clubhouse Buildings Consists of 2 Blocks with Combined Single Basement. Block-1**: G + 5 Floors, Total 95 Dwelling Units, **Block-2**: G +5 Floors, Total 107 Dwelling Units with Clubhouse: G + 2 Floors + 3rd Floor (Part) with Swimming Pool on the Ground Floor Level. Total 202 Dwelling Units, O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram Village, Pallavaram Taluk, Chengalpattu District within the limit of Tambaram Corporation. The primary purpose of this investigation was to obtain data to select suitable foundations for the proposed B + G + 5 floors residential apartment building blocks planned for this site with a common basement floor. Typical maximum column for this type of buildings will be about 170 tons. In case of combined raft foundation expected average bearing pressure was about 10 ton/M^2. 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 through 7 were drilled 8-, 8-, 6-, 8-, 8-, 5.5-, 8-, and 8-M to explore subsurface stratigraphy and obtain soil and 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 through 7. Boring location details are presented on Plate 1. In July 2018 a preliminary investigation with three borings was performed at this site to generate data for general idea of foundation soils and foundation type. For the present investigation number and location of borings were selected and provided by the client to cover the proposed buildings area through a bore location drawing. Boring 1 through 7 were drilled to 8-, 8-, 6-, 8-, 8-, 5.5-, 8-, and 8-M penetration below EGL, respectively. Drilling of the borings was terminated after encountering hard stratum with SPT "N" $\geq$ 75 in at least four successive tests, and recovery of rock core pieces. NX TC bit and Diamond bit core barrels were used for drilling through the rocky formation. Borings were terminated after recovery of rock core pieces. Tests were conducted to determine the pertinent index and engineering properties of the soils and rock encountered. We then performed engineering analyses to develop the required design data. Groundwater was not clearly seen at the borings due to rains during field work. Log of Boring were presented on Plate 2 through 8.

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Field and Laboratory Tests

Boring was drilled using Calyx drilling unit. In the boring SPT was performed at 0.75-M interval upto 4-M, and at 1-M interval beyond 4. Soil and weathered rock 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.

Soil-testing program was designed to evaluate pertinent index and engineering properties of the foundation soils and rock. During field operations soil and weathered rock samples were collected at 0.75-, and 1-M interval either disturbed or undisturbed as the case may be. All soil and rock 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 8. Grain size distribution curves of tested soil are presented on Plate 9. Summary of Water Test and Soil Chemical Test results were presented on Plate 11.

GENERAL SOIL CONDITIONS

Topography

Natural topography of the site reflects a relatively flat terrain. Visual observation infers that EGL of the site was about 0- to 0.45-M below ERL of roads along the site boundary. Many bushes and shrubs were present in the site. Fencing, compound walls and house walls were present along various parts of the site boundaries. Proposed construction will be the first major construction activity to cover this site.

Soil Stratigraphy

Soil stratigraphy disclosed by our field and laboratory investigations of the boring are presented on the Log of Boring on Plate 2 through 8. 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	1.0	Red Silty Fine Sand with Clay Binder
II	1.0	1.75	Red Fine to Coarse Sand with Silt
III	1.75	8.0+	White Blue Brown Weathered Rock

Boring – 2:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Silty Fine Sand with Clay Binder
II	1.0	8.0+	Red White Blue Brown Weathered Rock

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Boring – 3:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Silty Fine to Medium Sand with Gravel
II	1.0	6.0+	White Blue Brown Weathered Rock

Boring – 4:

Stratum	Penetration, M From	To	Description
I	0	1.0	Red Silty Fine Sand with Clay Binder and Gravel
II	1.0	8.0+	White Blue Brown Weathered Rock

Boring – 5:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Silty Fine to Medium Sand with Gravel
II	1.0	1.75	Brown Gravely Fine to Coarse Sand with Silt
III	1.75	8.0+	White Gray Brown Weathered Rock

Boring – 6:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Red Fine to Coarse Sand with Silt
II	1.0	5.5+	White Gray Blue Brown Weathered Rock

Boring – 7:

Stratum	Penetration, M From	To	Description
I	0	1.0	Brown Fine to Medium Sand with Silt
II	1.0	1.75	Red Silty Fine to Coarse Sand
III	1.75	8.0+	Brown Gray Weathered Rock

Detailed soil descriptions that include textural variations and inclusions are noted on the log of boring presented on Plate 2 through 8.

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. Unit weight (soil density) profiles of 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 for the proposed buildings were based on the soil properties encountered in Boring 1 and 5. **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.

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Boring – 1:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\phi = 29^o$; $\gamma_{sat} = 1.6$ tons/M^3
II	1.0	1.75	$\phi = 34^o$; $\gamma_{sat} = 1.9$ tons/M^3
IIIa	1.75	2.5	$\phi = 35^o$; $\gamma_{sat} = 1.95$ tons/M^3
IIIb	2.5	3.0	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
IIIc	3.0	4.0	$\phi = 32^o$; $\gamma_{sat} = 1.7$ tons/M^3
IIId	4.0	6.0	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3
IIIe	6.0	8.0+	$\phi = 39^o$; $\gamma_{sat} = 2.25$ tons/M^3

Boring – 2:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\phi = 29^o$; $\gamma_{sat} = 1.6$ tons/M^3
IIa	1.0	1.75	$\phi = 36^o$; $\gamma_{sat} = 2.05$ tons/M^3
IIb	1.75	3.25	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
IIc	3.25	8.0+	$\phi = 39^o$; $\gamma_{sat} = 2.25$ tons/M^3

Boring – 3:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\phi = 28^o$; $\gamma_{sat} = 1.6$ tons/M^3
IIa	1.0	1.75	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
IIb	1.75	3.0	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3
IIc	3.0	6.0+	$\phi = 39^o$; $\gamma_{sat} = 2.25$ tons/M^3

Boring – 4:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\phi = 27^o$; $\gamma_{sat} = 1.5$ tons/M^3
IIa	1.0	1.75	$\phi = 36^o$; $\gamma_{sat} = 2.05$ tons/M^3
IIb	1.75	3.25	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3
IIc	3.25	5.0	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3
IId	5.0	8.0+	$\phi = 39^o$; $\gamma_{sat} = 2.25$ tons/M^3

Boring – 5:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\phi = 28^o$; $\gamma_{sat} = 1.6$ tons/M^3
II	1.0	1.75	$\phi = 33^o$; $\gamma_{sat} = 1.75$ tons/M^3
IIIa	1.75	2.5	$\phi = 36^o$; $\gamma_{sat} = 2.0$ tons/M^3
IIIb	2.5	4.0	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3
IIIc	4.0	8.0+	$\phi = 39^o$; $\gamma_{sat} = 2.25$ tons/M^3

Boring – 6:

Stratum	Penetration, M From	To	Properties
I	0	1.0	$\phi = 34^o$; $\gamma_{sat} = 1.8$ tons/M^3
IIa	1.0	1.75	$\phi = 37^o$; $\gamma_{sat} = 2.1$ tons/M^3

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IIb	1.75	2.5	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3
IIc	2.5	5.5+	$\phi = 39^o$; $\gamma_{sat} = 2.25$ tons/M^3

Boring – 7:

	Penetration, M		
Stratum	From	To	Properties
I	0	1.0	$\gamma_{sat} = 1.6$ tons/M^3
II	1.0	1.75	$\phi = 32^o$; $\gamma_{sat} = 1.75$ tons/M^3
IIIa	1.75	2.5	$\phi = 36^o$; $\gamma_{sat} = 2.0$ tons/M^3
IIIb	2.5	3.25	$\phi = 38^o$; $\gamma_{sat} = 2.2$ tons/M^3
IIIc	3.25	8.0+	$\phi = 39^o$; $\gamma_{sat} = 2.25$ tons/M^3

DESIGN INFORMATION

For the proposed building's basement floor height and slab thickness at least 4-M height will be required. Site's highest EGL was at ERL itself. Site's FGL can be at 0.9-M above ERL of road in front of the site. FFL of the ground floor can be 0.3-M above FGL of the site. With this configuration from EGL itself a height of 1.2-M will be available for the basement floor. **Therefore, bottom of the basement floor from EGL will be at about 2.8-M below EGL.** For encountered soil conditions and column loads it was recommended to provide either "Isolated Column Footing" or "Combined Raft" foundation based on site conditions, over lapping of footings, depth of excavation, groundwater conditions, construction time, cost, etc. In case of "Isolated Column Footing" foundation minimum 1.5-M width and at 4-M below EGL and with at least 1.5-M thick footing embedment (below basement floor bottom level) was considered in the analysis. In case of "Combined Raft" foundation a raft of 25- by 75-M at 3-M below EGL 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

In case of "Isolated Column Footing" the estimated ultimate and recommended allowable bearing capacities were 175 and 35 tons/M^2, respectively. Estimated total settlement was about 7 mm. Estimated total settlement was less than 60 mm, the IS: 1904 - 2006 code limiting settlement for isolated column footing foundations for framed structure with panel walls. Hence, isolated column footing foundation can be used for the proposed buildings at this site. All the footings should be interconnected in both directions. It was also recommended to provide continuous lintels in each floor for better resistance to seismic forces. For any depth beyond 4-M below EGL the allowable bearing capacity was limited to 35 tons/M^2. The basement floor slab at about 2.4-M below EGL will have to be designed for 2.4 tons/M^2 uplift water pressure. Foundation capacity calculations were presented on Plate 12.

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In case of "Combined Raft" foundation the estimated ultimate and recommended allowable bearing capacities were 1015 and 20 tons/M^2, respectively. For the expected bearing pressure estimated total settlement was about 7 mm. Estimated total settlement was less than 75 mm, the IS: 1904 - 2006 code limiting settlement for raft foundations on granular soils. Hence, combined raft foundation can be used for the proposed buildings at this site. **The raft should be designed for 3 tons/M^2 uplift pressure due to groundwater.** Foundation capacity calculations were presented on Plate 12.

GROUNDWATER AND SOIL CHECMIAL ANALYSIS

Groundwater was not clearly seen in the borings due to ongoing frequent rains. In the site a bore well of unknown depth was present at a distance of about 17-M from Boring 7. Groundwater sample was collected from this bore well for construction suitability test as per IS: 456 – 2000 guidelines. Test results on groundwater sample from **same bore well performed in July 2018 preliminary investigation** inferred that groundwater from the bore well was not suitable for construction purposes due to high alkalinity as inferred by the methyl orange titration test, and very high sulphates. However, groundwater sample collected during **this investigation from the same bore well** inferred that groundwater from the bore well was suitable for construction purposes. Such drastic variation inferred dilution of bore well groundwater by the accumulated rainwater. Therefore, as an abundant precaution it was **recommended** to use cement and steel resistant to sulphates in the structures upto first slab level of the buildings. Groundwater from the site should be checked at regular intervals from the beginning and during construction period to confirm groundwater's construction suitability. Suitable groundwater treatment may be adopted to have water of acceptable quality for construction purposes. Soil samples from Boring 1, 3, and 5 at 1.75, 2.5-, and 1.75-M depths, respectively were tested for pH, Chlorides, and Sulphates to check if the soils at foundation can affect the planned foundation elements in contact with the site soils. Test results infer that the tested soil had acceptable pH, low concentration of chlorides and sulphates. Summary of groundwater and soil chemical test results were presented on Plate 11.

SOIL SUB-GARDE MODULUS

Site bore holes profiles infer mainly sandy soil profile with N_{avg} > 100 from 3- to 8-M below EGL. In the borings lowest N value was 16 at 3.25-M below EGL in Boring 1 in weathered rock. Actual "Sub-Grade Modulus" value was influenced by thickness of substrata layers in the influence zone, size and rigidity of foundation. Since it is not possible to estimate the same with variable strata, as a general guideline following sub-grade modulus values as per IS: 2950 – 1998 were provided. As per IS code in case of granular sand material with SPT "N_{avg}" 10 and 30 in **saturated condition Sub-Grade Modulus "K_s" was 0.9 to 2.9 kg/cm^2/cm (900 to 2,900 tons/M^3/M)**, and with SPT "N_{avg}" > 30 in **saturated condition Sub-Grade Modulus "K_s" was 2.9 to 10.8 kg/cm^2/cm (2,900 to 10,800 tons/M^2/M.)** Therefore, for the encountered soil profile in **saturated condition** a conservative **Sub-Grade Modulus "K_s" of 7.0 kg/cm^2/cm (7,000 tons/M^2/M)** was **recommended** for the proposed raft structural design.

CONSTRUCTION CONSIDERATIONS

We do not expect construction problems at this site due to soil and groundwater conditions in non-rainy seasons. Site's EGL was at about 0- to 0.45-M below ERL of roads near the site. FGL of the

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site should be at least 0.6-M above ERL of roads near the site with proper design of surface drainage system to drain rainwater runoff. Slopes of site's internal roads, rainwater channels, drainage channels should be suitably designed with due consideration to ERL of public road in front of the site. Open areas around the building should be at least 0.2-M above FRL of the site's internal roads. Building's stilt floor's FFL may be maintained at a minimum 0.2-M above FRL of site's internal roads. This will minimize rainwater road runoff flooding into site and building.

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 compacted with heavy duty rammer or heavy roller to compact the exposed surface that gets loosened by mechanical excavation activities. This is to minimize the settlements that can arise if the loosened soil in foundation excavation is not removed or compacted. New foundations should rest on virgin soil and not on old foundations or filled up soils. In case of any filled up open well, pits, ditches or any other loose pockets were encountered then the loose pockets of soils encountered should be replaced till denser material with well compacted PCC. **Inspection of all foundation excavation's bottom surface should be strictly followed to confirm the exposed surface was hard weathered rock and not loose material**. Excavated silty sand soil and weathered rock can be used for foundation and site filling purposes. However, **compaction of the silty sand should be done without flooding** at soil's optimum moisture content to avoid slush formation on top of the fill due to separation of silt from sand. **Site filing should be completed before casting of first slab of the buildings.**

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 is recommended to provide rigid plinth beams in ground level, 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. The site soil profile infers **"No"** seismic susceptibility. Under a seismic event of **6.0 Richter scale**, and IS code recommended peak ground acceleration of **0.16g** the total estimated vertical settlement. Iwasaki liquefaction potential was 0.0 inferring **"No Liquefaction."** As per IS code for **Zone III** design horizontal acceleration was **0.16g**. Liquefaction Analysis results are presented on Plate 13.

For PRASAD ARMSTRONG YEN
GEOTECH ENGINEERING CONSULTANTS (P) LTD.

Dr. B. Ramprasad
ME, PhD (Texas A&M)
Reg. No.GTE/19/02/002
Managing Director

For CASAGRAND PREMIER BUILDER LIMITED

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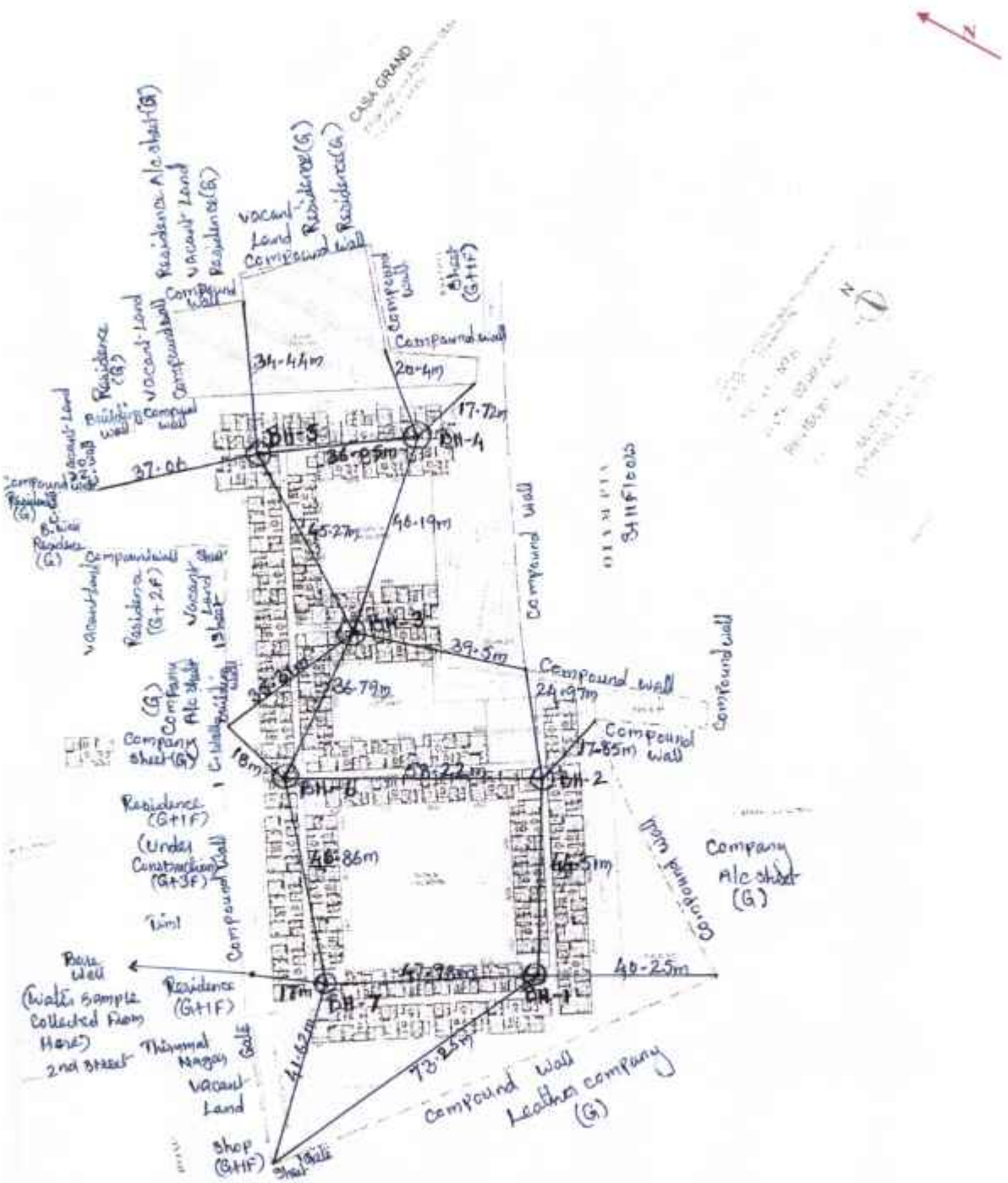
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Site Level is 0.0m To 0.45m Below From the Road Level.
Water levels are Not clear.

(Not To Scale)

Site EGL = 0- to 0.45-M Below ERL Road In Front of Site.

SITE PLAN WITH BORE LOCATION DETAILS.

PLATE 1

For CASAGRAND PREMIER BUILDER LIMITED

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LOG OF BORING

Project: O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram, Pallavaram Taluk, Chengalpattu District within the Limit of Tambaram Corporation.

Bore Hole No.: 1 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 20-10-'19 **Ended on:** 21-10-'19 **Field Work In Charge:** M Munivel
Final Depth: 8.0-M **Depth to G W S:** Not Clear Due to Rains **Remarks:** None.

DEPTH M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	RED SILTY FINE SAND with clay binder (To 1.0-M)	SPT @ 0.25 M 4/4/5 = 9 Blows		
1.0	0.0- to 1.0-m - ϕ = 29°; γ_t = 1.6 tons/M^3 (N_{eq} = 9)	SPT @ 1 M 14/15/18 = 33 Blows		
	RED FINE TO COARSE SAND with silt (To 1.75-M) (N_{eq} = 33)	SPT @ 1.75 M		
2.0	1.0- to 1.75-m - ϕ = 34°; γ_t = 1.9 tons/M^3 WHITE BLUE BROWN WEATHERED ROCK	9/15/22 = 37 Blows		
	(Below 1.75-M) (N_{eq} = 37) 1.75- to 2.5-m - ϕ = 35°; γ_t = 1.95 tons/M^3	SPT @ 2.5 M 24/ 4 cms for 10 Blows		
3.0	2.5- to 3.0-m - ϕ = 37°; γ_t = 2.1 tons/M^3 (N_{eq} = 75)	4 cms for 10 Blows SPT @ 3.25 M		
	3.0- to 4.0-m - ϕ = 32°; γ_t = 1.7 tons/M^3	7/7/12 = 19 Blows		
4.0	(N_{eq} = 19)	SPT @ 4 M 3 cms for 10 Blows		
	-drilled from 4- to 5-m in 45 minutes	2 cms for 10 Blows (Hammer Rebound) SPT @ 5 M		
5.0	4.0- to 6.0-m - ϕ = 38°; γ_t = 2.2 tons/M^3 (N_{eq} > 100)	2 cms for 10 Blows		
	-NX Diamond bit drilling from 5.5-m -blue and brown color, 5.5- to 8-m	2 cms for 10 Blows (Hammer Rebound)		
6.0	-drilled from 5.5- to 6-m in 30 minutes	SPT @ 6 M (SNR) 1.5 cms for 15 Blows		
	-stone pieces recovered drilling to 6-m	0 cms for 5 Blows (Hammer Rebound)		
7.0	-drilled from 6- to 7-m in 30 minutes -stone pieces recovered drilling to 7-m	SPT @ 7 M (SNR) 0.5 cms for 5 Blows		
	6.0- to 8.0-m - ϕ = 39°; γ_t = 2.25 tons/M^3 (N_{eq} >> 100)	0 cms for 5 Blows (Hammer Rebound)		
8.0	-drilled from 7- to 8-m in 110 minutes	SPT @ 8 M (SNR) 0 cms for 5 Blows		
	-21 cms core and stone pieces recovered drilling to 8-m	(Hammer Rebound)		
9.0				
10.0				
11.0				

BORE HOLE TERMINATED AT 8.0-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 2

For CASAGRAND PREMIER BUILDER LIMITED

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LOG OF BORING

Project: O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram, Pallavaram Taluk, Chengalpattu District within the Limit of Tambaram Corporation.

Bore Hole No.: 2 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 21-10-'19 **Ended on:** 22-10-'19 **Field Work In Charge:** M Munivel
Final Depth: 8.0-M **Depth to G W S:** Not Clear Due to Rains **Remarks:** None.

DEPTH M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	RED SILTY FINE SAND with clay binder (To 1.0-M)	SPT @ 0.25 M 3/3/7 ~ 10 Blows		
1.0	0.0- to 1.0-m - ϕ = 29°, γ_t = 1.6 tons/M^3 (N_{avg} = 10)	SPT @ 1 M 15/25/ 4 cms for 10 Blows		
	RED WHITE BLUE BROWN WEATHERED ROCK (Below 1.0-M) (N_{avg} ~ 62)	4 cms for 10 Blows SPT @ 1.75 M 23/		
2.0	1.0- to 1.75-m - ϕ = 36°, γ_t = 2.05 tons/M^3	4 cms for 10 Blows 4 cms for 10 Blows		
	1.75- to 3.25-m - ϕ = 37°, γ_t = 2.1 tons/M^3 (N_{avg} > 75)	SPT @ 2.5 M 4 cms for 10 Blows		
3.0	-NX TC bit drilling from 3.25- to 4-m in 10 minutes	3 cms for 10 Blows SPT @ 3.25M (SNR) 1.5 cms for 15 Blows		
		0 cms for 5 Blows SPT @ 4 M (SNR)		
4.0	-NX Diamond bit drilling from 4-m	0.5 cms for 5 Blows 0 cms for 5 Blows (Hammer Rebound)		
5.0	-drilled from 4- to 5-m in 35 minutes	SPT @ 5 M (SNR) 0 cms for 5 Blows (Hammer Rebound)		
	3.25- to 8.0-m - ϕ = 39°, γ_t = 2.25 tons/M^3 (N_{avg} >> 100)	SPT @ 6 M (SNR)		
6.0	-drilled from 5- to 6-m in 30 minutes -blue and brown color, 6- to 8-m	0.5 cms for 5 Blows 0 cms for 5 Blows (Hammer Rebound)		
7.0	-drilled from 6- to 7-m in 70 minutes	SPT @ 7 M (SNR) 0 cms for 5 Blows		
	-18 cms core pieces recovered drilling to 7-m	(Hammer Rebound) SPT @ 8 M (SNR)		
8.0	-drilled from 7- to 8-m in 65 minutes	0 cms for 5 Blows (Hammer Rebound)		
	-22.5 cms core pieces recovered drilling to 8-m			
9.0				
10.0				
11.0				

BORE HOLE TERMINATED AT 8.0-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

For CASAGRAND PREMIER BUILDER LIMITED

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LOG OF BORING

Project: O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram, Pallavaram Taluk, Chengalpattu District within the Limit of Tambaram Corporation.

Bore Hole No.: 3 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm

Started on: 22-10-'19 **Ended on:** 23-10-'19 **Field Work In Charge:** M Munivel

Final Depth: 6.0-M **Depth to G W S:** Not Clear Due to Rains **Remarks:** None.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	RED SILTY FINE TO MEDIUM SAND with gravel (To 1.0-M)	SPT @ 0.25 M		
	0.0- to 1.0-m – $\phi = 28°$; $\gamma_t = 1.6$ tons/M^3	3/3/5 – 8 Blows		
1.0	($N_{cor} = 8$)	SPT @ 1 M 17/30/		
	WHITE BLUE BROWN WEATHERED ROCK	4 cms for 10 Blows		
	(Below 1.0-M) ($N_{cor} = 75$)	3 cms for 10 Blows		
	1.0- to 1.75-m – $\phi = 37°$; $\gamma_t = 2.1$ tons/M^3	SPT @ 1.75 M 32/		
2.0		2 cms for 10 Blows		
	1.75- to 3.0-m – $\phi = 38°$; $\gamma_t = 2.2$ tons/M^3	(Hammer Rebound)		
	($N_{cor} > 100$)	SPT @ 2.5 M		
		3 cms for 10 Blows		
3.0	-NX Diamond bit drilling from 2.95-m	2 cms for 10 Blows		
	-drilled from 2.95- to 3.25-m in 15 minutes	SPT @ 3.25M (SNR)		
	-blue and brown color, 3.25- to 6-m	0.5 cms for 5 Blows		
		0 cms for 5 Blows		
4.0	-drilled from 3.25- to 4-m in 65 minutes	SPT @ 4 M (SNR)		
	-7 cms core and stone pieces recovered drilling to 4-m	0 cms for 5 Blows		
	3.0- to 6.0-m – $\phi = 39°$; $\gamma_t = 2.25$ tons/M^3	(Hammer Rebound)		
	($N_{cor} >> 100$)			
5.0	-drilled from 4- to 5-m in 80 minutes	SPT @ 5 M (SNR)		
	-12 cms core and stone pieces recovered drilling to 5-m	0 cms for 5 Blows		
		(Hammer Rebound)		
		SPT @ 6 M (SNR)		
6.0	-drilled from 5- to 6-m in 145 minutes	0 cms for 5 Blows		
	-40 cms core 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 4

For CASAGRAND PREMIER BUILDER LIMITED

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LOG OF BORING

Project: O. S. No. 40/1 & 40/2, New TSLR No. 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram, Pallavaram Taluk, Chengalpattu District within the Limit of Tambaram Corporation.

Bore Hole No.: 4 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 23-10-'19 **Ended on:** 24-10-'19 **Field Work In Charge:** M Munivel
Final Depth: 8.0-M **Depth to G W S:** Not Clear Due to Rains **Remarks:** None.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	BROWN SILTY FINE SAND with clay binder and gravel (To 1.0-M)	SPT @ 0.25 M 2/2/3 = 5 Blows		
	0.0- to 1.0-m – ϕ = 27°; γ_t = 1.5 tons/M^3 (N_{avg} = 5)	SPT @ 1 M 19/25/ 4 cms for 10 Blows		
1.0	WHITE BLUE BROWN WEATHERED ROCK (Below 1.0-M) (N_{avg} = 62)	4 cms for 10 Blows		
	1.0- to 1.75-m – ϕ = 36°; γ_t = 2.05 tons/M^3	SPT @ 1.75 M 27/ 3 cms for 10 Blows		
2.0		3 cms for 10 Blows		
	1.75- to 3.25-m – ϕ = 37°; γ_t = 2.1 tons/M^3 (N_{avg} = 100)	SPT @ 2.5 M 32/ 3 cms for 10 Blows		
3.0		3 cms for 10 Blows SPT @ 3.25 M		
	-NX TC bit drilling from 3.25-m	3 cms for 10 Blows 2 cms for 10 Blows		
4.0	-drilled from 3.25- to 4-m in 35 minutes -NX Diamond bit drilling from 4-m	SPT @ 4 M 2 cms for 10 Blows		
	3.25- to 5.0-m – ϕ = 38°; γ_t = 2.2 tons/M^3 (N_{avg} > 100)	2 cms for 10 Blows (Hammer Rebound)		
5.0	-drilled from 4- to 5-m in 35 minutes	SPT @ 5 M (SNR) 0.5 cms for 5 Blows		
		0 cms for 5 Blows (Hammer Rebound)		
6.0	-drilled from 5- to 6-m in 40 minutes	SPT @ 6 M (SNR) 0 cms for 5 Blows (Hammer Rebound)		
	5.0- to 8.0-m – ϕ = 39°; γ_t = 2.25 tons/M^3 (N_{avg} >= 100)	SPT @ 7 M (SNR)		
7.0	-drilled from 6- to 7-m in 70 minutes -stone pieces recovered drilling to 7-m	0 cms for 5 Blows (Hammer Rebound)		
8.0	-drilled from 7- to 8-m in 80 minutes	SPT @ 8 M (SNR) 0 cms for 5 Blows (Hammer Rebound)		
	-17 cms core and stone pieces recovered drilling to 8-m			
9.0				
10.0				
11.0				

BORE HOLE TERMINATED AT 8.0-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 5

For CASAGRAND PREMIER BUILDER LIMITED

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LOG OF BORING

Project: O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram, Pallavaram Taluk, Chengalpattu District within the Limit of Tambaram Corporation.

Bore Hole No.: 5 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 24-10-'19 **Ended on:** 25-10-'19 **Field Work In Charge:** Y Saravanan
Final Depth: 8.0-M **Depth to G W S:** Not Clear Due to Rains **Remarks:** None.

DEPTH M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE
	BROWN SILTY FINE TO MEDIUM SAND with gravel (To 1.0-M)	SPT @ 0.25 M 3/4/20 = 24 Blows
	0.0- to 1.0-m - ϕ = 28°, γ_t = 1.6 tons/M^3 (N_{avg} = 8)	SPT @ 1 M 22/15/12 = 27 Blows
	BROWN GRAVELY FINE TO COARSE SAND with silt (To 1.75-M) (N_{avg} = 27)	SPT @ 1.75 M
	1.0- to 1.75-m - ϕ = 33°, γ_t = 1.75 tons/M^3	12/17/25 = 42 Blows
	WHITE GRAY BROWN WEATHERED ROCK (Below 1.75-M) (N_{avg} = 42)	SPT @ 2.5 M 3 cms for 10 Blows
	1.75- to 2.5-m - ϕ = 36°, γ_t = 2.0 tons/M^3	2.5 cms for 10 Blows
	-NX TC bit drilling from 3.25-m	SPT @ 3.25 M
	2.5- to 4.0-m - ϕ = 38°, γ_t = 2.2 tons/M^3 (N_{avg} > 100)	2 cms for 10 Blows 1.5 cms for 10 Blows
	-drilled from 3.25- to 4-m in 40 minutes	SPT @ 4 M 2 cms for 10 Blows
	-NX Diamond bit drilling from 4-m	0.5 cms for 10 Blows (Hammer Rebound)
	-drilled from 4- to 5-m in 45 minutes	SPT @ 5 M (SNR) 1 cm for 10 Blows
		0.5 cms for 10 Blows (Hammer Rebound)
	-drilled from 5- to 6-m in 50 minutes -stone pieces recovered drilling to 6-m	SPT @ 6 M (SNR) 1 cm for 10 Blows
	4.0- to 8.0-m - ϕ = 39°, γ_t = 2.25 tons/M^3 (N_{avg} >> 100)	0.5 cms for 10 Blows (Hammer Rebound)
	-drilled from 6- to 7-m in 65 minutes	SPT @ 7 M (SNR) 0.5 cms for 10 Blows
	-9 cms core and stone pieces recovered drilling to 7-m	0 cms for 10 Blows (Hammer Rebound)
	-drilled from 7- to 8-m in 80 minutes	SPT @ 8 M (SNR) 0.5 cms for 10 Blows
	-33 cms core and stone pieces recovered drilling to 8-m	0 cms for 10 Blows (Hammer Rebound)

BORE HOLE TERMINATED AT 8.0-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 6

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

LOG OF BORING

Project: O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram, Pallavaram Taluk, Chengalpattu District within the Limit of Tambaram Corporation.

Bore Hole No.: 6 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 24-10-'19 **Ended on:** 25-10-'19 **Field Work In Charge:** M Munivel
Final Depth: 5.5-M **Depth to G W S:** Not Clear Due to Rains **Remarks:** None.

DEPTH, M	SOIL DESCRIPTION	SPT / VANE & SAMPLE TYPE	SPT "N" PROFILE 25 50 75	INDEX TEST DATA 25 50 75
	BROWN RED FINE TO COARSE SAND with silt (To 1.0-M)	SPT @ 0.25 M 6/12/15 = 27 Blows		
	0.0- to 1.0-m - ϕ = 34°, γ_t = 1.8 tons/M^3 (N_{avg} = 27)	SPT @ 1 M 25/ 4 cms for 10 Blows		
1.0	WHITE GRAY BLUE BROWN WEATHERED ROCK (Below 1.0-M) (N_{avg} = 97)	3 cms for 10 Blows SPT @ 1.75 M		
	1.0- to 1.75-m - ϕ = 37°, γ_t = 2.1 tons/M^3	3 cms for 10 Blows		
2.0	-NX TC bit drilling from 1.75-m	2 cms for 10 Blows		
	1.75- to 2.5-m - ϕ = 38°, γ_t = 2.2 tons/M^3 (N_{avg} > 100)	SPT @ 2.5 M (SNR) 0.5 cms for 5 Blows		
	-drilled from 1.75- to 2.5-m in 40 minutes	0 cms for 5 Blows		
3.0	-NX Diamond bit drilling from 2.5-m	SPT @ 3.25M (SNR)		
	-drilled from 2.5- to 3.25-m in 70 minutes	0 cms for 5 Blows		
	-4.5 cms core and stone pieces recovered drilling to 3.25-m	(Hammer Rebound)		
		SPT @ 4 M (SNR)		
4.0	-drilled from 3.25- to 4-m in 70 minutes	0 cms for 5 Blows		
	-21 cms core and stone pieces recovered drilling to 4-m	(Hammer Rebound)		
	2.5- to 5.5-m - ϕ = 39°, γ_t = 2.25 tons/M^3 (N_{avg} >> 100)	SPT @ 5 M (SNR)		
5.0	-drilled from 4- to 5-m in 70 minutes	0 cms for 5 Blows		
	-30 cms core and stone pieces recovered drilling to 5-m	(Hammer Rebound)		
	-drilled from 5- to 5.5-m in 50 minutes	SPT @ 5.5 M (SNR)		
	-20 cms core and stone pieces recovered drilling to 5.5-m	0 cms for 5 Blows		
6.0		(Hammer Rebound)		
7.0	Note: bore was terminated at 5.5-m due to obstruction by stone pieces.			
8.0				
9.0				
10.0				
11.0				

BORE HOLE TERMINATED AT 5.5-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 7

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

LOG OF BORING

Project: O. S. No. 40/1 & 40/2, New TSLR No: 129 in Block 13, Ward A, ISSA Pallavaram Village and O. S. No. 396 / 5 (as per TSLR O. S. No. 396/1, 396/2 & 396/3 Part), N. TSLR No. 1/2 Part in Block 1, Ward E, Zamin Pallavaram, Pallavaram Taluk, Chengalpattu District within the Limit of Tambaram Corporation.

Bore Hole No.: 7 **Type of Boring:** Calyx Drill **Dia. of Hole:** 150 mm
Started on: 25-10-'19 **Ended on:** 26-10-'19 **Field Work In Charge:** Y Saravanan
Final Depth: 8.0-M **Depth to G W S:** Not Clear Due to Rains **Remarks:** None.

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 1.0-M)	DS @ 0.25 M		
	0.0- to 1.0-m - γ_t = 1.6 tons/M^3	SPT @ 1 M		
1.0	(N_{avg} = 8)	4/9/9 = 18 Blows		
	RED SILTY FINE TO COARSE SAND (To 1.75-M) (N_{avg} = 18)	SPT @ 1.75 M		
	1.0- to 1.75-m - ϕ = 32°, γ_t = 1.75 tons/M^3	5/16/31 = 47 Blows		
2.0	BROWN GRAY WEATHERED ROCK (Below 1.75-M) (N_{avg} = 47)	SPT @ 2.5 M		
	1.75- to 2.5-m - ϕ = 36°, γ_t = 2.0 tons/M^3	4 cms for 10 Blows		
		2 cms for 10 Blows		
3.0	2.5- to 3.25-m - ϕ = 38°, γ_t = 2.2 tons/M^3	SPT @ 3.25 M		
	(N_{avg} > 100)	2 cms for 10 Blows		
	-NX TC bit drilling from 3.25-m	1 cm for 10 Blows		
		SPT @ 4 M (SNR)		
4.0	-drilled from 3.25- to 4-m in 40 minutes	1 cm for 10 Blows		
	-NX Diamond bit drilling from 4-m	0.5 cms for 10 Blows (Hammer Rebound)		
		SPT @ 5 M (SNR)		
5.0	-drilled from 4- to 5-m in 45 minutes	1 cm for 10 Blows		
	-5 cms core and stone pieces recovered drilling to 5-m	0.5 cms for 10 Blows (Hammer Rebound)		
	3.25- to 8.0-m - ϕ = 39°, γ_t = 2.25 tons/M^3			
	(N_{avg} >> 100)	SPT @ 6 M (SNR)		
6.0	-drilled from 5- to 6-m in 45 minutes	0.5 cms for 10 Blows		
		0.5 cms for 10 Blows (Hammer Rebound)		
		SPT @ 7 M (SNR)		
7.0	-drilled from 6- to 7-m in 65 minutes	0.5 cms for 10 Blows		
	-11 cms core and stone pieces recovered drilling to 7-m	0 cms for 10 Blows (Hammer Rebound)		
		SPT @ 8 M (SNR)		
8.0	-drilled from 7- to 8-m in 80 minutes	0.5 cms for 10 Blows		
	-17 cms core and stone pieces recovered drilling to 8-m	0 cms for 10 Blows (Hammer Rebound)		
9.0				
10.0				
11.0				

BORE HOLE TERMINATED AT 8.0-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 8

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

SUMMARY OF TEST RESULTS

Boring No	Depth, M	w %	PL	LL	-75μ%	SAND			GRAVEL %	IS CLASS.
						Fine%	Medium%	Coarse%		
1	0.25	20			36					
	1.0	15			9	34	33	23	1	SP
	1.75	18			20					
	2.5	9			13	42	23	12	10	SM
	3.25	10			14					
	4.0	16			10	33	27	16	14	SP-SM
	5.0	21			11	31	31	19	8	SP-SM
	6.0	SNR	stone	pieces						
	7.0	SNR	stone	pieces						
	8.0	SNR	core	pieces						
2	0.25	27			25					
	1.0	14			34	51	13	2	0	SM
	1.75	7			6					
	2.5	8			13	42	26	16	3	SM
	3.25	SNR								
	4.0	SNR								
	5.0	SNR								
	6.0	SNR								
	7.0	SNR	core	pieces						
	8.0	SNR	core	pieces						
3	0.25	11			20					
	1.0	13			23	63	13	1	0	SM
	1.75	9			14					
	2.5	10			13	43	34	10	0	SM
	3.25	SNR								
	4.0	SNR	core	pieces						
	5.0	SNR	core	pieces						
	6.0	SNR	core	pieces						
4	0.25	15			24					
	1.0	9			10	42	28	18	2	SP-SM
	1.75	9			18					
	2.5	8			28	59	12	1	0	SM
	3.25	8			22	66	12	0	0	SM
	4.0	10			24	56	13	6	1	SM
	5.0	SNR								
	6.0	SNR								
	7.0	SNR	stone	pieces						
	8.0	SNR	core	pieces						
5	0.25	19			19					
	1.0	14			7	31	30	18	14	SW
	1.75	9			18					
	2.5	8			33	57	10	0	0	SM
	3.25	10			13					
	4.0	10			17	44	19	14	6	SM
	5.0	SNR	stone	pieces						
	6.0	SNR	stone	pieces						
	7.0	SNR	core	pieces						
	8.0	SNR	core	pieces						

PLATE 9a

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

SUMMARY OF TEST RESULTS

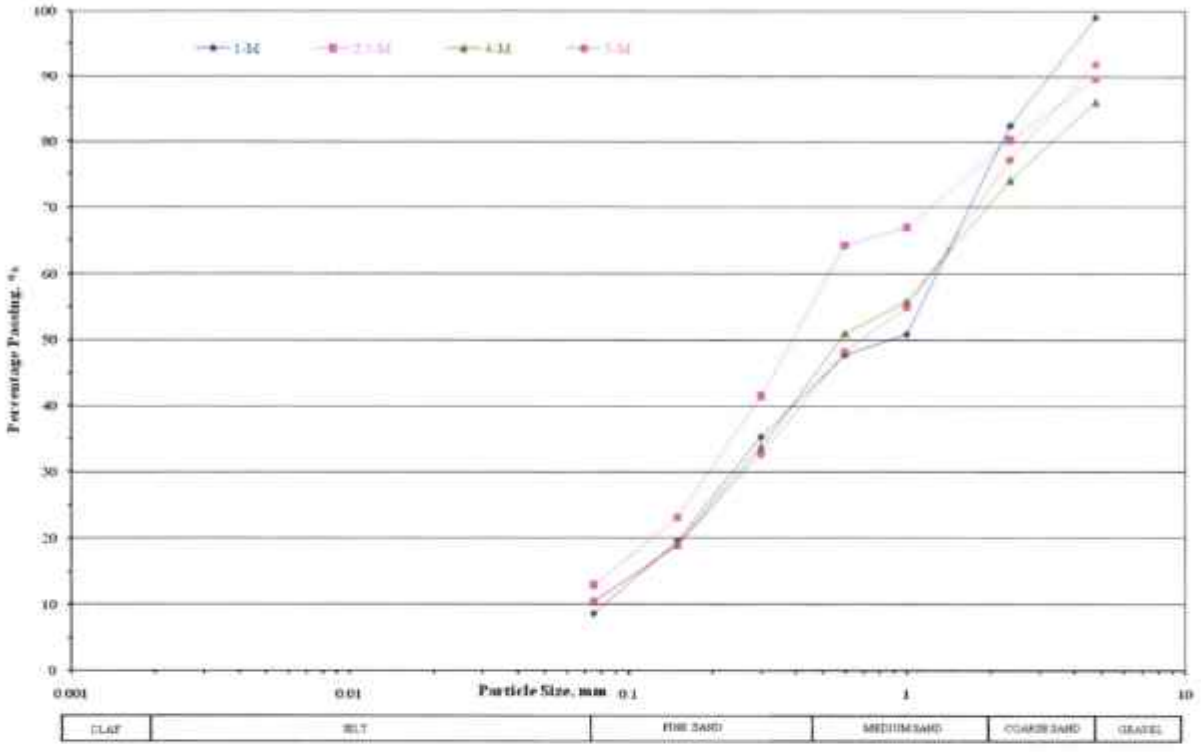
Boring	Depth,	w %	PL	LL	-75μ%	SAND			GRAVEL	IS
No.	M					Fine%	Medium%	Coarse%	%	CLASS.
6	0.25	20			8					
	1.0	7			12	40	33	13	2	SM
	1.75	4			9	29	23	22	17	SP-AM
	2.5	SNR								
	3.25	SNR	stone	pieces						
	4.0	SNR	core	pieces						
	5.0	SNR	core	pieces						
	5.5	SNR	core	pieces						
7	0.25	13			6					
	1.0	15			18	43	26	12	1	SM
	1.75	22			15					
	2.5	11			11	40	36	13	0	SP-SM
	3.25	13			9	29	39	15	8	SP-SM
	4.0	SNR								
	5.0	SNR	stone	pieces						
	6.0	SNR	stone	pieces						
	7.0	SNR	core	pieces						
	8.0	SNR	core	pieces						

PLATE 9b

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

Grain Size Distribution Curves
Boring 1



Grain Size Distribution Curves
Boring 2

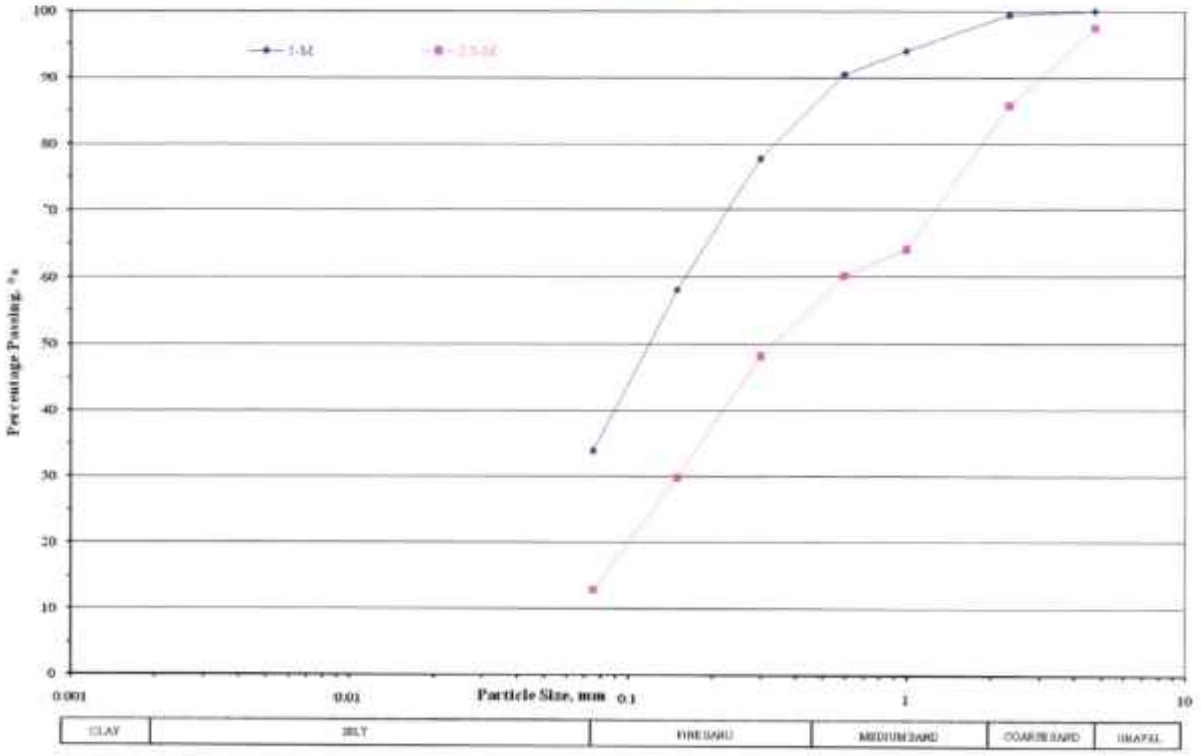
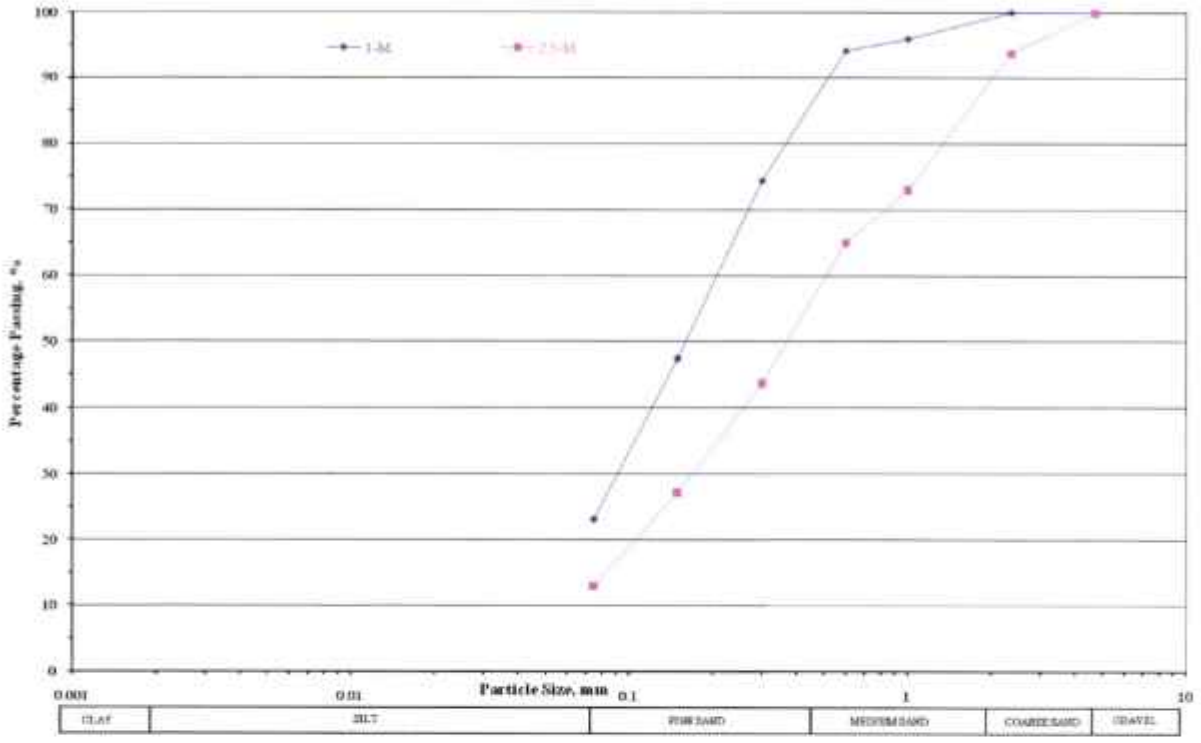


PLATE 10a

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

Grain Size Distribution Curves
Boring 3



Grain Size Distribution Curves
Boring 4

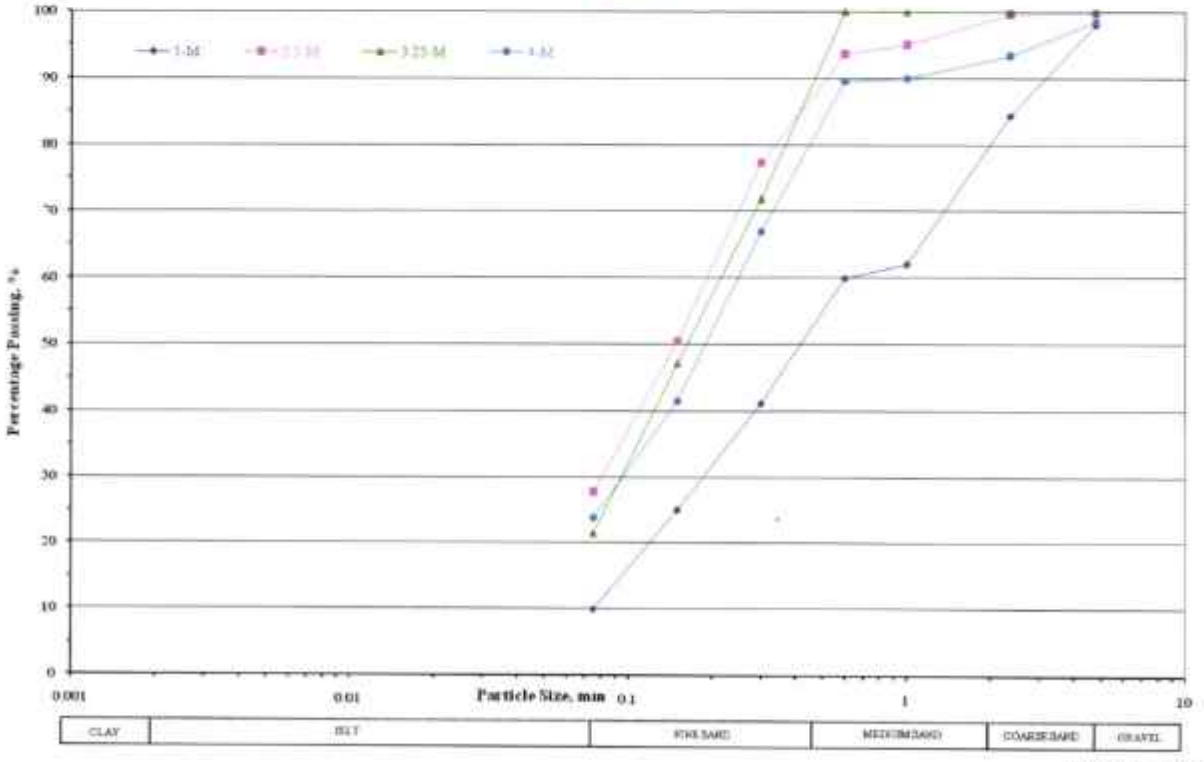
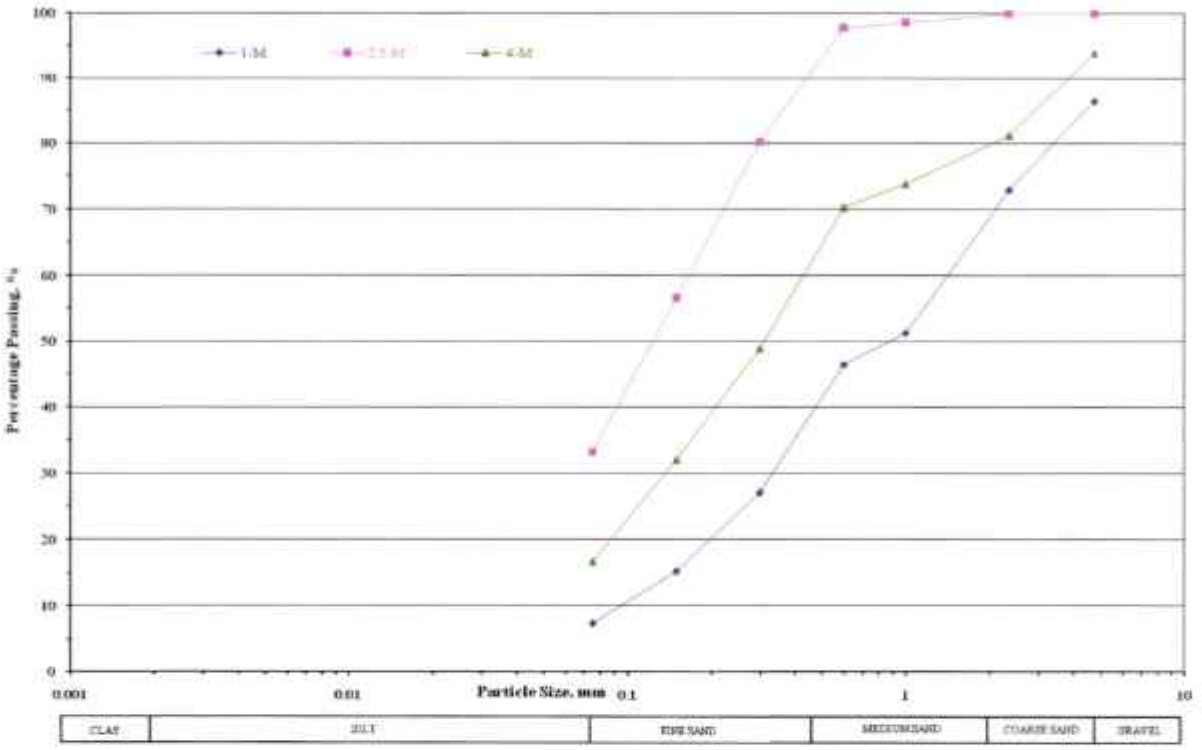


PLATE 10b

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

Grain Size Distribution Curves
Boring 5



Grain Size Distribution Curves
Boring 6

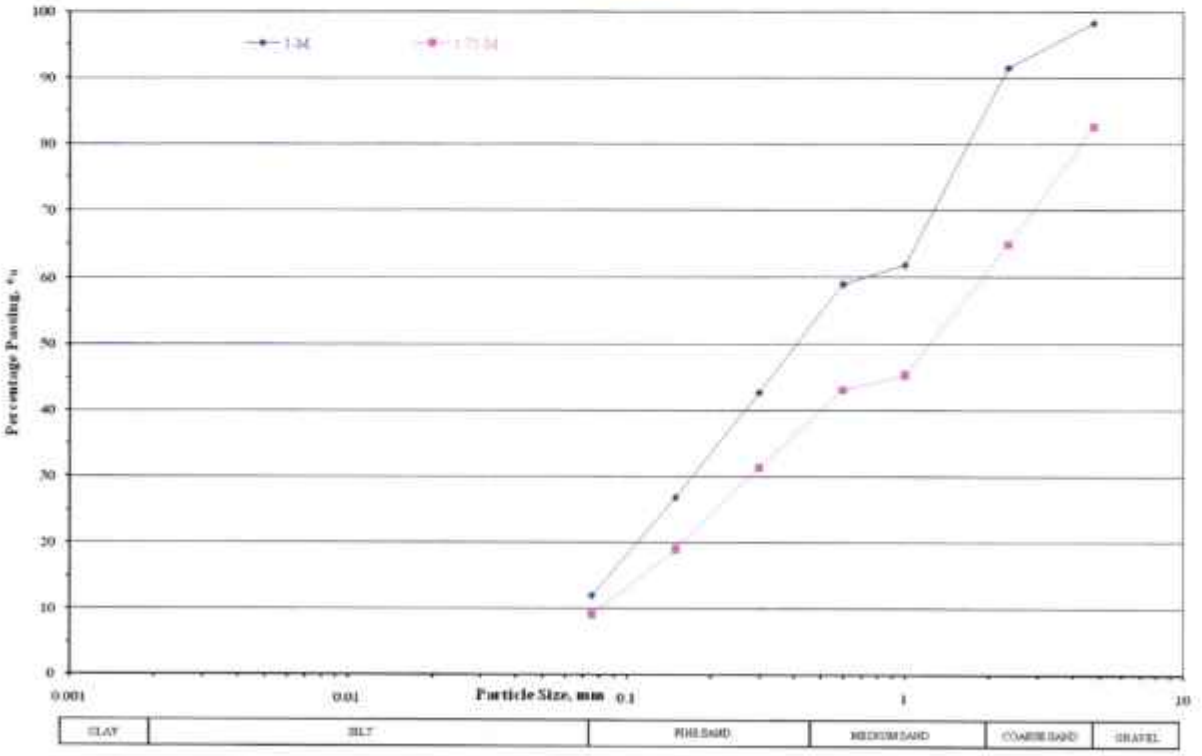


PLATE 10c

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

Grain Size Distribution Curves
Boring 7

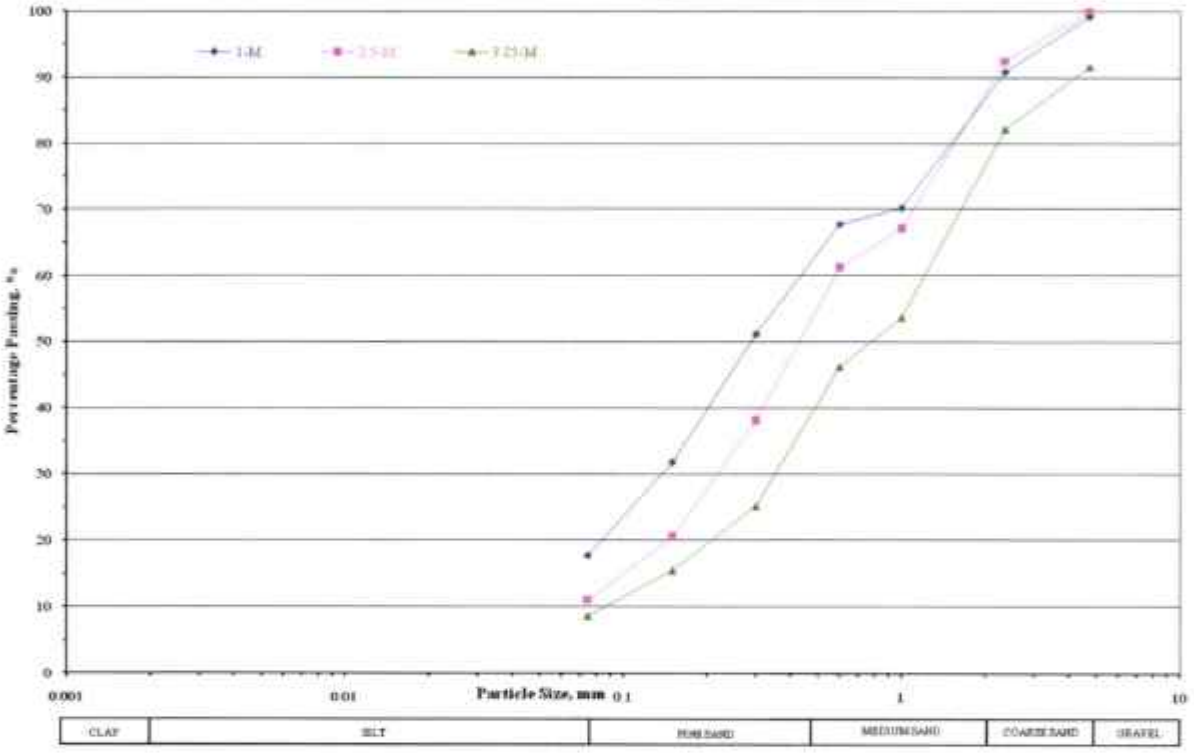


PLATE 10d

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

SUMMARY OF WATER TEST RESULTS

PLOT'S BORE WELL; DEPTH = UNKNOWN

WATER LEVEL ~ UNKNOWN; DISTANCE FROM BORING 7 ~ 17-M.

S. No.		Description	Results Obtained	As per IS:456 – 2000
1		To neutralize 100 cc of water using phenolphthalein as indicator	0.5 ml	Not more than 5 ml of 0.02N NaOH
2		To neutralize 100 cc of water using methyl orange as indicator	24.8 ml	Not more than 25 ml of 0.02N H_2SO_4
3	a	Organic Solids, mg/liter	22	200 Max.
	b	Inorganic Solids, mg/liter	402	3,000 Max.
	c	Sulphates as SO_3, mg/liter	0	400 Max.
	d	Chlorides as Cl, mg/liter	71	2,000 Max. - Plain Concrete 500 Max. RCC
	e	Suspended Solids, mg/liter	0	2,000 Max.
	f	pH	7.33	6 Min.

Remarks: Sample meets the requirements of above clauses. However, same bore well sample tested in July 2018 inferred very high concentration of sulphates. This significant variation is possibly due to ongoing frequent rains in Chennai. Water can be used for construction purposes as per IS 456 – 2000 only after frequent and regular checking.

SUMMARY OF SOIL CHEMICAL TEST RESULTS

S. No.	Boring	Depth, M	pH	Chlorides	Sulphates, ppm	
				ppm	SO_4	SO_3
1	BH-1	1.75	7.69	48	0	0
2	BH-3	2.50	7.20	40	0	0
3	BH-5	1.75	7.49	49	0	0

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 acceptable pH, and low chloride and sulphate ion concentrations.

PLATE 11

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

SAMPLE CALCULATIONS FOR RECOMMENDED FOUNDATION

For the existing footings with short pile below load carrying capacity was estimated using soil properties from Boring 1 and 5. Following is a list of design assumptions:

Case - 1: Isolated Column Footing Foundation

Type of Foundation	=	Isolated Column Footings;
Depth of Foundation **below EGL**	=	4-M;
Depth of Found. **below Basement**	=	1.5-M - Must;
Min. Width of Footing	=	1.5-M
Expected Maximum Load	=	170 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	=	38^o
C_u (Undrained Shear Strength)	=	0 tons/M^2
N_c (Bearing Capacity Factor)	=	N/A
N_q (Bearing Capacity Factor)	=	51.84
N_γ (Bearing Capacity Factor)	=	84.86
S_c (Shape Factor)	=	$1 + 0.2*(B/L) = 1.0 + 0.2*(1.5/1.5) = 1.2$;
d_c (Depth Factor)	=	$1 + 0.2*D_f/B * \tan(45 + \phi/2) = 1.36$
S_q (Shape Factor)	=	$1 + 0.2*(B/L) = 1.0 + 0.2*(1.5/1.5) = 1.2$;
d_q (Depth Factor)	=	$1 + 0.1*D_f/B * \tan(45 + \phi/2) = 1.18$
S_γ (Shape Factor)	=	$1 - 0.4*(B/L) = 1.0 - 0.4*(1.5/1.5) = 0.6$;
d_γ (Depth Factor)	=	$1 + 0.1 * D_f/B * \tan(45 + \phi/2) = 1.18$
q'(O B @ Footing)	=	$1.5*(2.1-1) = 1.65$ tons/M^2.

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

$q_{ult} = 0 + 1.65*(51.84-1)*1.2*1.18 + 0.5*1.2*1.5*84.86*0.6*1.18 = 172.86 \sim 173$ tons/M^2

$q_{all} = q_{ult} / 2.5 = 173 / 2.5 =$ 69.2 tons/M^2 **Use and Limit q_{all} = 35 tons/M^2**

Footing Size required for 170 tons = 170/35 = 4.86-M^2 or B = L = 2.21-M Say 2.25-M.

Settlement Calculations:

Zone of Influence from foundation level = 2*2.25 = 4.5-M below footing or 8-M below EGL or upto hard stratum level, whichever is earlier. There will be only elastic (immediate) settlement and no consolidation (long term) settlement as soil profile had only hard weathered rock in the influence zone.

Elastic or Immediate Settlement:

1. 3.5- to 8.0-M = H_1 = 4.5-M; SPT "N" > 100; (Wea. Rock); E_s = 9,000 tons/M^2

$E_{savg} = (9000*4.5) / 4.5 = 9{,}000$ tons/M^2

q_{Nett} = 35 tons/M^2; B = 2.25-M; L = 2.25-M; L/B = 2.25/2.25 = 1; H = 4.5-M; H/B' = 4.5/1.125 = 4.0;

μ = 0.20; E_s = 10,000 tons/M^2; I_f = 0.90; I_1 = 0.403; I_2 = 0.078; I_s = 0.436;

$\Delta H_E = 4*1.125*35.0*(1-0.2^2)/9000*0.90*0.436*1000 = 6.59$ mm

Total Elastic Settlement ΔH_E = 6.59 mm.

PLATE 12a

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

Consolidation Settlement: None.

Total Consolidation Settlement $\Delta H_C = 0.00$ mm.
Total Combined Settlement $\mathbf{\Delta H_T} = \Delta H_E + \Delta H_C = 6.59 + 0.00 = 6.59 \sim \mathbf{7\ mm}$.

Estimated total settlement for a 2.25-M wide isolated column footing at 3.5-M below EGL and at least **1.5-M below basement bottom level** was about 7 mm for a bearing pressure of 35 tons/M^2. Estimated settlement was less than 60 mm, the allowable limits for total settlement for isolated column footing foundation as per IS: 1904 - 2006 code. Hence, isolated column footing foundation can be used for the proposed buildings at this site. For better resistance to differential settlements and seismic forces it was recommended to provide rigid plinth beams in both directions, continuous lintels in each floor, and sill level beams under openings. Site and building basement filling should be completed before casting of first slab of the building.

As some loose pockets were encountered in Boring 1 between 3- and 4-M it was critical that all the foundation excavations bottom surface should be inspected and strictly followed to confirm the exposed surface was hard weathered rock and not loose material.

Case - 2: Combined Raft Foundation

Type of Foundation	=	Combined Raft Foundation;
Foundation Depth below EGL	=	3-M below EGL;
Worst Case Ground Water Level	=	At EGL;
Minimum Raft Size	=	25- by 75-M;
Expected Avg. Bearing Pressure	=	~ 10 tons/M^2.

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_{avg}	=	38^o
C_u (Undrained Shear Strength)	=	0 tons/M^2
N_c (Bearing Capacity Factor)	=	N/A
N_q (Bearing Capacity Factor)	=	51.84
N_γ (Bearing Capacity Factor)	=	84.86
S_c (Shape Factor)	=	$1 + 0.2*(B/L) = 1.0 + 0.2*(25.0/75.0) = 1.07$;
D_c (Depth Factor)	=	$1 + 0.2*D_f/B*\tan(45 + \phi/2) = 1.01$
S_q (Shape Factor)	=	$1 + 0.2*(B/L) = 1.0 + 0.2*(25.0/75.0) = 1.07$;
d_q (Depth Factor)	=	$1 + 0.1*D_f/B*\tan(45 + \phi/2) = 1.0$
S_γ (Shape Factor)	=	$1 - 0.4*(B/L) = 1.0 - 0.4*(25.0/75.0) = 0.87$;
d_γ (Depth Factor)	=	$1 + 0.1*D_f/B*\tan(45 + \phi/2) = 1.0$
q'(O B @ Footing)	=	Neglected.

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

$q_{ult} = 0 + 0 + 0.5*1.1*25.0*84.86*0.87*1.0 = 1015.14 \sim 1{,}015$ tons/M^2

$q_{all} = q_{ult} / 2.5 = 1015 / 2.5 =$ 406 tons/M^2 **Use and Limit $q_{all} = 20$ tons/M^2**

Expected Average Bearing Pressure ~ 10 tons/M^2

PLATE 12b

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

Settlement Calculations:

In case of raft foundation the "Zone of Influence" will extend to "2B" depth below raft, i.e., 2*25 = 50-M below raft or upto hard stratum level, whichever is earlier. In the present case very dense weathered rock stratum was present from raft bottom level itself. There will only elastic (immediate) settlement and no consolidation (long term) settlement as soil profile had only granular formation in zone of influence.

Elastic or Immediate Settlement:-

1. 3.0- to 8.0-M = H_1 = 5-M; SPT "N" > 100; (Wea. Rock); E_s = 9,000 tons/M^2
E_{savg} = (9000*5.0) / 5.0 = 9,000 tons/M^2
q_0 = 20 tons/M^2; H/B' = 5.0/12.5 = 0.40; L/B = 75.0/25.0 = 3.0; μ = 0.2; E_s = 9,000 tons/M^2
I_f = 0.90; I_1 = 0.026; I_2 = 0.074; I_s = 0.082;
$\Delta H_E = 4*20.0*12.5*(1-0.2^2)/9000*0.90*0.082*1000 =$ **7.87 mm**

Total Elastic Settlement ΔH_E = 7.87 mm.

Consolidation Settlement: None.

Total Consolidation Settlement ΔH_C = 0.00 mm.

Total Combined Settlement $\mathbf{\Delta H} = \Delta H_E + \Delta H_C = 7.87 + 0.00 =$ **7.87 ~ 8 mm.**

Estimated total settlement for a 25- by 75-M combined raft foundation at 3-M below EGL was about 8 mm. The estimated total settlement was less than 75 mm – allowable limits for the total settlements for raft foundations on granular material as per IS: 1904 - 2006 code. Therefore, combined raft foundations can be used for the proposed building.

As some loose pockets were encountered in Boring 1 between 3- and 4-M it was critical that all the foundation excavations bottom surface should be inspected and strictly followed to confirm the exposed surface was hard weathered rock and not loose material.

PLATE 12c

For CASAGRAND PREMIER BUILDER LIMITED

Authorised Signatory

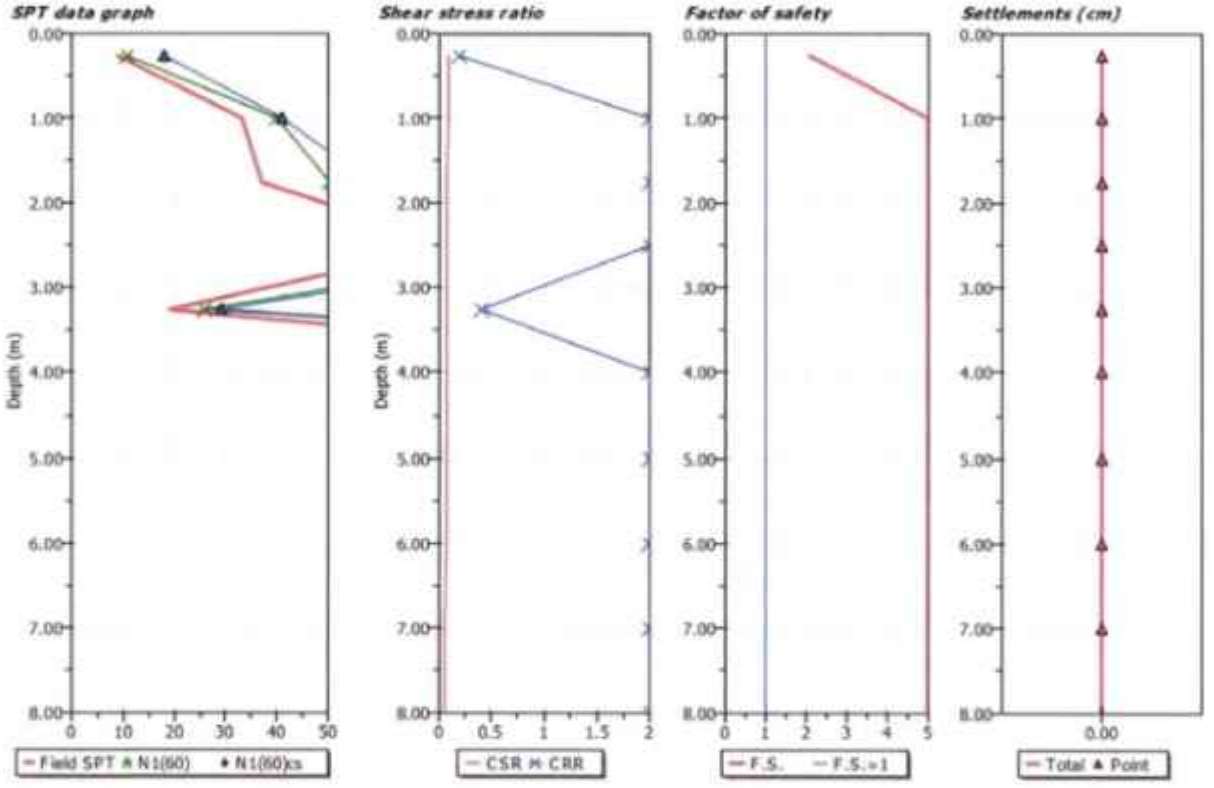
LIQUEFACTION ANALYSIS REPORT

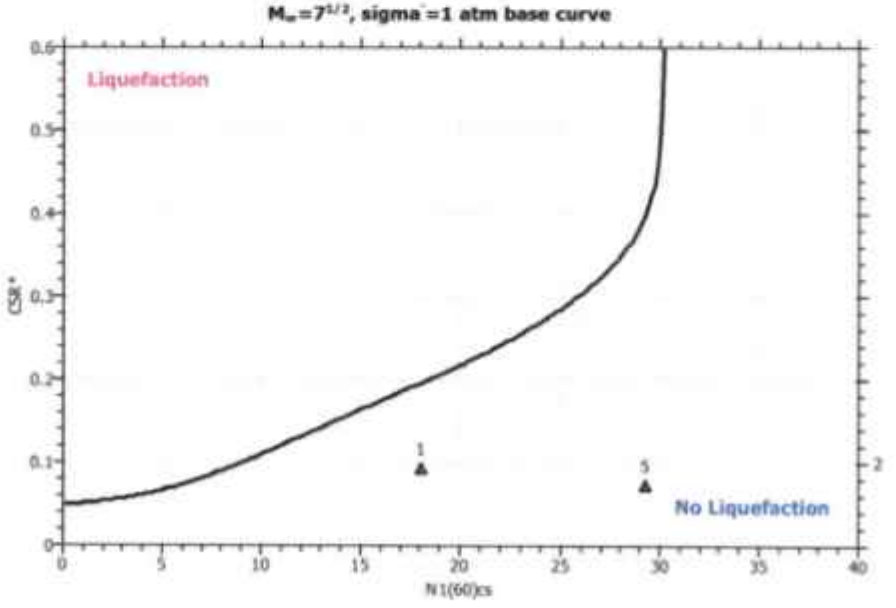
Project title : S. No. 396/1, 2, 3, 40/1, 2, 38/1, 397/3, 39/2, 3, 4, 21, GST Road, Jain Village, Pallavaram, Chennai 600 043. TN

Project subtitle : Boring 1 Soil Profile

Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	0.00 m
Analysis type:	Deterministic	Earthquake magnitude M_w:	6.50
Analysis method:	NCEER 1998	Peak ground accelaration:	0.08 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00





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Horizontal Acceleration, $A_h = 0.08g$

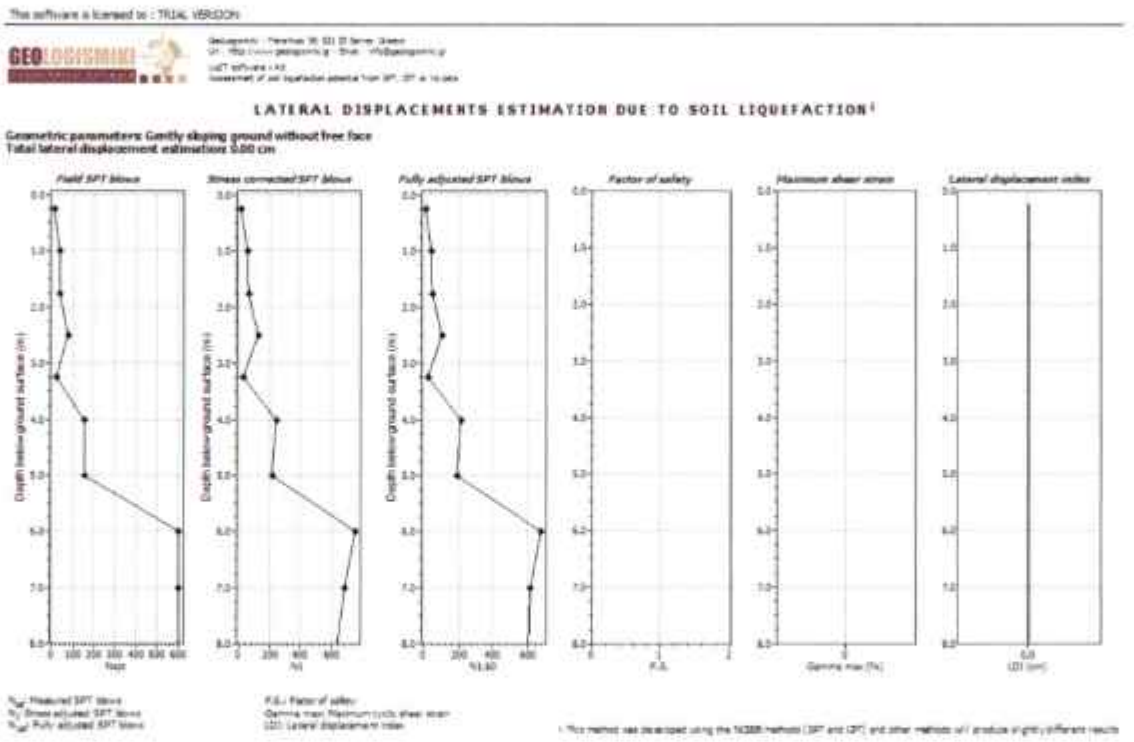


PLATE 13b

For CASAGRAND PRIMER BUILDER LIMITED

Authorised Signatory

PRASAD ARMSTRONG YEN G E C (P) LTD.
821 (Old # 439/4) Poonamallee High Road
Arumbakkam, Chennai 600 106.
Phone: 044 - 2363 7146; e-mail: paygec@gmail.com



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NRI & Investment Services

Escrow Services, Rentals, Litigation Solutions, Property Valuation and Property Management

Compliance & Special Services

Demolition, Vaasthu checks, regularization of unauthorized buildings, and office space solutions.



empowering your real estate decisions with smart tools

Property Valuation & Cost Estimation

Guideline Value, Apartment Composite Value, Stamp Duty & Registration Fees Calculator, Building Value Calculator, Capital Gains Calculator, Area Unit Converter, Length Unit Converter

Ownership, Compliance & Legal Verification

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

Zoning & Land Use Analysis

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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